

## Comment on gchron-2021-24

Stephen Cox (Referee)

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Referee comment on "In situ-produced cosmogenic krypton in zircon and its potential for Earth surface applications" by Tibor János Dunai et al., Geochronology Discuss., <https://doi.org/10.5194/gchron-2021-24-RC1>, 2021

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This is an interesting and useful manuscript that presents a straightforward case for making greater use of Kr isotope measurements in certain situations in geochemistry. I think a more in-depth discussion of the geological implications would be useful but is not required for this to rise to the level of a valuable contribution, so I suggest it be accepted subject to a few minor corrections. That said, if the authors are willing to provide a longer discussion of the likely scope of applications for these methods in the earth sciences (more in Section 5.3, in particular), I think that would add to the usefulness of the paper. The results section includes a lot of material that belongs in the discussion, and I think moving this text and then expanding the discussion to look more broadly toward other applications would be appropriate for a paper that seeks to inspire others to use these techniques.

I am including line-by-line comments that amount to minor suggestions and also a few notes about grammar and punctuation that will improve readability.

---Content---

-Lines 36-37: This is not strictly true. Stable and short-lived isotopes of argon are also produced by cosmic radiation.

-Line 86: The 2002 Gilabert paper does not appear to address complex particle emission.

-Line 87: I find this wording confusing (energy bonus?). This is the alpha particle binding energy. I think more discussion (and sourcing) of the energy considerations is required to make this section understandable.

-Line 88: Is the (1) here meant as a placeholder for a citation?

-Line 88: Separation energy is both particle-specific and fairly different for different isotopes. The number given here appears to be the binding energy per nucleon, which is not the same thing. I think this merits a bit more discussion and needs a citation that is not just a database.

-Lines 90-100: I think this section could also use some expansion and direct reference (maybe even a figure) to the structure of the chart of the nuclides around krypton to make it more useful for the typical reader.

-Lines 109-110, 112-113, etc.: Again, the discussion here basically assumes the reader is either looking at a chart of the nuclides or has it memorized, which I doubt is true generally. I'd suggest simply providing the relevant portion of the chart as a figure and referring to it when making this type of statement.

-Line 113: This phrase is not understandable, partially because of the misplaced hyphens. If anything, one is needed only between the two items in the relationship ("Coulomb barrier" and "reaction probability"), but I think the only way to write this clearly without requiring the reader to look up the original paper and see what is actually plotted is to say "Using the relationship between Coulomb barrier and reaction probability observed by . . ."

-Lines 160-161: This phrasing sounds negative when in fact this is a strength of the dataset. I would say something like "Most of the data fall on the air-cosmogenic mixing line with no apparent influence from mass fractionation [no hyphen] or nucleogenic Kr."

-Lines 184-195: It would probably be fair to acknowledge that the suite of samples controlling the upper end of this array includes a sample with clear evidence of nucleogenic contamination.

-Lines 202-204: Please describe the regression model used and how the uncertainty was determined.

-Lines 220-234: Is there some geological context that could be discussed to address the question of which production ratio is more appropriate? It does not seem at all unreasonable that the samples would have experienced partial burial, especially given the range of 81/78 ratios in the rest of the sample suite.

-Line 228: Is "Table 2a of 5" a placeholder for something?

-Lines 236-249: Please include numbers when discussing sample concentrations and ages here rather than just referring to a figure and the appendix. What are the apparent production ratios of 81/78 for the Grimsel samples, for example? State the exposure ages suggested by these samples when comparing it to 13 ka.

-Lines 287-370: It would be good to have briefly described the samples before describing the measurements of them rather than first introducing them here. Some of this information (and some of Appendix A) belongs in Section 1.2.4, perhaps. There should be enough geological description in the main text to assess these conclusions about the meaning of the data. Much of this is interpretation or speculation that belongs in the discussion section. There needs to be a discussion of uncertainty surrounding the inferred exposure histories, especially the complex ones.

-Lines 292-294, 304-307: Need to discuss the measurements and describe how the sample results indicate these things, what the expectations would be for each (and why), and therefore how the results are consistent with them. Use numbers and discuss the nature of the patterns in figure 3.

-Lines 379-424: This belongs in the introduction. A lot of it is already there and does not need to be repeated.

-Line 427: Zircon is common, but not ubiquitous, in igneous rocks. It is pretty hard to find zircon in most basalt. I suppose you'd probably find one with a big enough chunk of any rock, but I would dial back the expectations a little here, especially since the following discussion is all about granitic rocks.

-Line 449: It might be common knowledge to most readers of this journal, but for others finding this on Google Scholar, why not state approximate closure temperatures for each noble gas and give the citations separately?

-Lines 457-463: Why not include a mention of the age-U parameters required for metamictization to become a problem?

-Line 483: Please give some quantitative hint for what is "notable"

-Line 492 etc: This figure caption is too long. It is hindering the ability of the caption to guide the reader in deciphering what is a pretty complex figure. I would simplify it to describing what is in the figure as succinctly as possible and move some of this detail to the discussion text.

Section 4 generally: A lot of this material should be moved from results to discussion, and I would suggest generalizing more from these specific cases as well to discuss the broader implications of the method for the earth sciences.

- Line 667-668: Please state the temperature or heating power used for the getters, and state the alloy used.
- Lines 693-694: Maybe the original plan was to use "m" more than once? I think this way of explaining how you arrive at the detection limit is unnecessarily confusing here. Just state that the detection limit is defined as three times the background.

Data reporting: Perhaps there is going to be a repository item attached that I cannot see yet. At minimum, report in the appendix the actual measured intensities for each species with the fit uncertainties for samples and accompanying blanks and standards.

### ---Grammar and Punctuation---

- Perhaps there's another convention of which I'm unaware, but I've always seen the symbol for half-life expressed with a lowercase t.
- Lines 29 and 38: typo in "half-life" ("half-live")
- Lines, e.g., title, 27, 32, 43: The manuscript is inconsistent on hyphenation in "in situ produced." Generally "in situ" should not be hyphenated. Some style guides might allow for compound adjectives like "in-situ-produced," but definitely not "in-situ produced." I would go with the version in the title, but whatever choice made should be consistent.
- Lines 49, 50, etc.: Not to harp on about hyphens, but "Kr-isotopes" (and "Zr-isotope," "Kr-data," etc.) and "Kr-concentrations" should definitely not be hyphenated, and ranges like 50–100 MeV should be written with an en dash and no space. I would also urge consistency on use of elemental abbreviations or not. Both "krypton" and "Kr" are used throughout.
- Line 128 and following: amu (or "AMU") isn't an accepted unit (<https://goldbook.iupac.org/terms/view/U06554>). Regardless, it seems odd to suddenly introduce units at this point after previously just stating mass numbers (e.g., lines 51, 93), and I would suggest sticking to the latter since amu/u/Da is defined as an exact rather than nominal mass and this usage appears in only this one paragraph.
- Line 131: Bromine should not be capitalized.
- Line 132: The Geochronology style guide says to use abbreviations for SI-accepted units.
- Lines 153-155: Remove all hyphens in this paragraph except in "U-Pb".
- Line 164: comma after 81Kr
- Line 181: remove hyphen
- Lines 221, 222: remove hyphens
- Line 315: do not capitalize "zircon"
- Line 329: remove hyphen
- Lines 423, 438, 440, 442, etc: remove hyphens
- Line 450: There should be a space in "600 oC"