

Geochronology Discuss., referee comment RC3  
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## Comment on gchron-2021-16

Anonymous Referee #3

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Referee comment on "Deformation recorded in polyhalite from evaporite detachments revealed by  $^{40}\text{Ar}/^{39}\text{Ar}$  dating" by Lachlan Richards et al., Geochronology Discuss., <https://doi.org/10.5194/gchron-2021-16-RC3>, 2021

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**General Comments:** This study applies the  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  dating technique to crystals of polyhalite from the Salt Range Formation in northern Pakistan. The aim is to determine the age of the formation and to determine diffusion parameters and a closure temperature for Ar in polyhalite. The study did not yield any crystallization ages due to disturbances to the Ar-Ar system, suggested to be from repeated episodes and deformation (as well as the difficulty associated with dating evaporite minerals in general). The authors were able however, to present minimum ages suggested to represent primary crystallization, and a suggested maximum age of deformation. There are several issues with the study that require clarification, further information and revision (see below), but study is still a useful stepping stone, particularly because of the paucity of geochronologic data for evaporite minerals in general. Clarification on the determination, and meaning of, the reported range of closure temperatures determined for polyhalite is required. In the introduction, the authors are suitably cautious "Though these results are semi-quantitative, they are contextualised with the structural history of the host formation to form a speculative interpretation of deformation history" and generally I think this is fair. As reliable Ar-Ar ages for polyhalite would be useful for, e.g., formation ages, reconstructing deformation histories, the qualitative to partially quantitative data provided in this study would likely be of use to future workers pursuing Ar-Ar applications of these complex minerals. As the results are largely qualitative, however, the discussion could be shortened in places.

### Specific Comments:

Line 132: Was the "homogenised temperature" determined – was it specifically monitored?

Line 138: It is mentioned that "contemporaneous step heating experiments" using the same parameters as described in the analytical methods were used to determine diffusion parameters. Much more information on these experiments is needed here. It would be very helpful to describe (as above) how the temperature was monitored, e.g, pyrometer?, as this is essential for these experiments.

Line 153: You describe 9 samples but only descriptions for SRLR-05 and SRLR-06 are given in section 2.2. If the 9 samples are aliquots of these two samples, perhaps say nine aliquots or repats from two samples. Looking at the filenames in the supplement, it looks like 7 from 05 and 2 from 06. It might be helpful to list the number (e.g., n=7) for each sample and also explain the uneven distribution (why only 2 analyses from sample 05?).

Line 155: If you denoted each panel with an (a) or (b) the description of data plots here would be less cumbersome.

Line 158: (Figure 5) If the data aren't used for anything, I would suggest moving these plots to the supplement.

Line 178: Can you explain why the flat K/Ca indicates a single Ar domain?

Line 185-187: Long sentence – a bit unclear, please revise. Also, seems more interpretative rather than “results.”

Looking at Figure 4 and 5, two samples of SRLR-06 have identical K/Ca to SRLR-05 of ~ 0.82 but the remaining 5 aliquots of SRLR-06 are entirely different. Can you shed light on the two populations?

Line 242: It still isn't clear how single domain diffusion was established – I might be missing something, so please expand/clarify.

Line 296: If the polyhalite is undergoing dehydroxilation at the same T range as the determined closure temperature, then much of this discussion could be shortened and perhaps out of caution the closure temperature shouldn't be reported in the abstract, or with a caveat.

Line 315: Perhaps step-crushing experiments alongside step-heating experiments could help here.

Line 324-330: Are you suggesting this? It isn't clear the way it is written. This section seems quite speculative.

Section 5.1/5.2 and section 5.3 could be reversed with the discussion/interpretation of the

ages first.

Section 5.1: Relating to the comment above regarding T steps, more information is required here. Also, its quite short to warrant its own section as it currently stands.

Line 333 onwards: The numbered points are confusing – are these possible scenarios, a suggested sequence, etc.? It also seems speculative given the nature of the data.

Line 351: I think 9 samples is a bit misleading, rephrase as above.

Line 354: “profiles consistent with pure diffusion kinetics from a single domain” I don’t think this has been adequately demonstrated. I’m not sure that attributing a specific process to the ~ 500 Ma age is warranted.

Line 370: I would delete “taken with a grain of salt.”

Line 371: “As such, they serve only as a first pass on polyhalite diffusion kinetics and cannot be used for geochronological works with any precision.” It seems this sentence negates all prior discussion. I think with different language you could frame this in a more positive light –it is a first study on very challenging samples and much can be learned from the experiments.

Figure 6 could do with revision. The fonts are too small, there are excessive decimal places in the y-axis, the legend is too small, and most of the data are in at the axis (could do with a zoomed in panel). The symbol colors of 06-1.2 and 06-2.1 are hard to differentiate. I would also remove the title.

Figure 7 would also benefit from revision. The two panels have different scales on both x and y making it difficult to compare visually. The diffusion parameters overlap with the data in panel A. I would also remove the titles.

The formatting of Table 1 makes it really difficult to read, perhaps adjust columns or delete “incalculable” and replace with “nd” for not determined.

Table 2 is a nice summary, but it isn’t exhaustive and many of the mineral phases are not particularly relevant to the geologic with discussion.

Supplement "Arrhenius Final" could be in better shape for a supplementary file. I can see that the required information is there, but it is quite hard to follow. It also isn't clear how some of the important parameters were determined (e.g., T). This requires clarification and improvement in the main text and in the supplement.

The references need some attention. They are inconsistent in formatting, contain many typos and often have incomplete information.

**Technical Corrections:** A few minor suggestions to improve clarity and formatting.

- Line 50: could delete radioisotope
- Line 56: could delete "process in an attempt"
- Line 60: I would remove (stratigraphy, composition, samples) from the Header
- Line 116: Superscript  $^{38}\text{Ar}$
- Line 120: Space, neutron fluence
- Line 131: Argon
- Line 132: Superscript  $^{-14}$ , also line 136
- Line 240: "Coincidentally these samples coincide" is a bit awkward, perhaps revise
- Line 254: I would use different notation here, e.g.,  $2.62 \times 10^7$
- Line 256: "Ar datable minerals" sounds a bit awkward, perhaps revise.
- Section 4.2, lines 220, would suggest not using "E" notation in the main text.
- Line 276: delete repeated degree symbol
- Line 338: "Deformation events resulting in deformation" could be rewritten