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Comment on gchron-2021-42

Jonathan Tucker (Referee)

Referee comment on "Short communication: Mechanism and prevention of irreversible trapping of atmospheric He during mineral crushing" by Stephen E. Cox et al., Geochronology Discuss., https://doi.org/10.5194/gchron-2021-42-RC1, 2022

The short communication "Mechanism and Prevention of Irreversible Trapping of Atmospheric He During Mineral Crushing" aims to show through experiments and a simple model that while contamination of samples by exogenous He sources is possible during sample preparation, it is either relatively inconsequential or easily avoided in most cases. I am convinced by their experiments, and support its publication, however if possible, I suggest a few additional experiments that could test the proposed physical mechanism of He trapping. The paper is well-written and easy to follow (with one exception noted below), although I think some editing of the figures can help the authors make the case even more clearly.

Additional experiments:

The authors speculate that He (or other gases) is trapped within quickly annealing cracks, rather than adsorbed onto fine-grained surfaces. This makes sense and fits most of their data. It does not completely explain why the "Vacuum crushed then He soaked" experiment is more contaminated than the "N2 then He soaked" experiment, although this could be due either to the N2 saturating the cracks prior to introduction of the He or the timing of He introduction was inconsistent, and it just happened to be introduced later in the N2 experiment, after the cracks had fully healed. (This might be useful to point out on its own.) I was surprised that the vaccuum crushed experiments showed some contamination, but this observation allows for a test of the contamination mechanism. The authors could repeat the vacuum crushing experiment but vary the time of He introduction (perhaps ranging from seconds to several minutes or longer after crushing). They should see that the amount of contamination decreases after waiting longer. If possible to perform, I think this "time-series" could help elucidate the trapping mechanism. I don't think these additional experiments would be necessary for publication, but would enhance the paper's completeness.

Presentation of the figures:

In Figures 1 & 2, the experiment names are sometimes confusing. It should be clearly specified for each experiment (1) what condition the sample was crushed under and (2) what treatment after crushing was done (soaking, leaching, seiving, etc). This order of operations is important to the conclusions but not clear in some of the labels. For example, "N2 then He Soaked"--this was crushed under N2 and then soaked in He, but the label could be read as crushed first, then soaked in N2, then soaked in He. Another example, is "Lab Air" a sample crushed in air, or is it a measurement of lab air? Presumably the former.

Also in Figures 1 & 2, the "background level" color should be consistent (it's tan in 1 and grey in 2), and could be labeled on the figure. But this also raises the question, how was this background level determined? Some of the experiments have less He than this, so it's not really a "background". Does it even need to be included?

In Figure 1, I found the "foreground" and "background" an odd and confusing way of showing the two temperature steps. They could instead be shown simply by either stacked or adjacent bars.

Figure 3 is very hard to follow. The modeling exercise is useful, with caveats about the quantitative applicability clearly explained, and broad conclusions interesting and relevant. But the figure is too hard to read. If the authors wish to present the model calculations this way, at the very least, either the line styles should be more systematic (e.g. all 10 ppm U calculations in blue, all 0.01 ppm U calculations in red, or something like that) or their order in the legend should match the order in the plot so they can be more easily referenced. But I think there is an easier way to present the data. The crystal radius is not really a variable of interest because the way the model is set up, larger crystals would necessarily have less contamination, so it's kind of a waste of an axis. The variables of more interest to the conclusion are age and U concentration, so it would be more useful to have one of those as the x-axis. Here is just one idea off the top of my head that I think would make the results more intuitive: a two-panel figure where one panel is calculations for, say, 10 micron radius and the other for 100 or 1000. The x-axis is age and the y-axis is He contamination %. Then plot the calculation as points, using a consistent symbol for the various U concentrations, say triangles for 0.01 ppm, squares for 0.1 ppm, and circles for 10 ppm. Then it is easily demonstrated that contamination is only important for young and/or low U samples, and one does not need to hunt around the figure to find that information. If the authors are so inclined, perhaps the best way to present the results is as a contour or density plot, where the x and y axes are age and U concentration, and the plotted value is calculated contamination %; again doing two panels of this, one for small grains and one for large grains.

Conclusions:

The sentence "Our experiments demonstrate that this process is complete within a few minutes, and it seems likely that the entire process occurs on the sub-μs timescale of the

propagation of pressure waves through the minerals" is not supported by the experiments, as there are no hard quantitative constraints on the timescale of the processes occurring (without doing the time series I mentioned above). Furthermore, the sentence is confusing. Does the process take minutes or microseconds? Plus the mention of pressure wave propogation hasn't been mentioned before as a process. Therefore this is not a conclusion. This sentence needs some revision. Otherwise, the writing is clear and organized.