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To the editor,

We thank the reviewers for their thoughtful comments and have revised our manuscript in accordance with their comments. We are encouraged that they generally agree the MDD_toolkit approach is an improvement over past fitting methods and that our manuscript is good fit for Geochronology.

Our most substantial revision to the manuscript was to add a discussion of critiques of the MDD model. We now review assumptions inherent to the MDD model as well as the ways they have been tested. Studies referenced by the community commenter were also incorporated.

Further revisions include rather minor clarifications about the methodology used by Wong et al., (2023). We now note that the models presented in Wong et al. (2023) were explicitly tuned to match independent thermochronological constraints. Because our approach removes this user intervention, one should not expect the thermal pathways generated by our MDD_toolkit to match these thermochronological constraints more closely than previously published models. We have carefully reviewed our language and now state only that our predicted thermal histories *also* agree with independent constraints.

The editor has asked that we provide a description of suggested revisions that we did not agree with. These comments are explained below with the original reviewer comment in blue and our response in black. We appreciate the reviewers' time and their constructive comments.

Best regards,

Andrew L. Gorin

Reviewer 1.

The cooling history for GR1 is initially pretty high temperature, especially when you compare it to the pre-existing BtAr date. The cooling history from Wong et al., 2023 would suggest that the sample experienced relatively monotonic cooling since BtAr closure. Is this realistic?

Given that GR1 is a part of a slowly cooled pluton, Wong et al.'s (2023) K-feldspar MDD prediction of monotonic cooling appears reasonable. That said, we do not find their prediction inconsistent with those made by our MDD-model framework. Looking first at the pathway predicted for GR1 from the $\%_{frac}$ misfit statistic, it is consistent with a monotonically-cooling system within the regions of error shown on Figure 4. While the history generated from the χ^2 misfit statistic may appear to contradict the Biotite $^{40}Ar/^{39}Ar$ closure age the actual uncertainty on this age is arguably larger than shown in Figure 4.

Our plot shows the uncertainty bounds proposed by Wong (2023), but these may underestimate the true uncertainty for a few reasons. First, the plotted biotite-Ar closure temperatures from Wong (2023) are calculated assuming a cooling rate of 10°C/Ma, however, Wong et al.'s (2023, Figure 3) suggests that this cooling rate may have been as high as 60°C/Ma, which would increase the predicted closure temperature. Additionally, others have found biotite-Ar closure temperatures can vary significantly based on mineral chemistry and can be as high as high as 400 – 450 degrees (Hess et al., 1993, Grove 1996). Without detailed geochemical studies, one cannot rule out closure temperatures this high (Grove, 1996). Finally, the Wong et al. (2023) biotite-Ar age is older than the emplacement age of the pluton itself (Banks, 1972), consistent with this age potentially requiring a higher associated closure temperature than published by Wong (2023).

Wong et al. (2023) also explicitly tune their models to best match the existing thermochronological constraints. Because our new method avoids this user bias, it is unsurprising that the agreement appears less impressive. Overall, given the sources of uncertainty in both the biotite closure temperature and in the MDD model results, we do not find our predictions to be unrealistic.

Reviewer 2.

Line 95: Note that some iterations of the MDD model used variable E_a see *(Lovera, O.M., Grove, M. and Harrison, T.M. 2002. Systematic analysis of K-feldspar Ar-40/Ar-39 step heating results II: Relevance of laboratory argon diffusion properties to nature. Geochimica Et Cosmochimica Acta,* ***66****, 1237-1255.)*

After rereading the referenced study, we cannot find any instance of Lovera using variable E_a in the referenced—or any other—study and therefore do not include references to this comment in our updated manuscript.

Line 171: Assuming the largest domain is similar to the size of the physical mineral grain the new approach (similar to earlier MDD models) indicates the smallest domains are commonly less than 1 micron. Given the known mineral and textural features of alkali feldspar of similar dimensions (e.g. Parson et al. 1999), please comment on the potential for 39Ar recoil affecting the estimates of the lower end of the output thermal history using the new approach.

The referenced line is describing how we created our synthetic dataset. We emphasize that this dataset is not a description of a real mineral and that our optimization should return the correct diffusion kinetics parameters regardless of whether the chosen kinetics might be considered "realistic".

That said, the point about alpha recoil has historically been raised in relation to MDD modeling (e.g. Harrison et al., 2014; Parsons et al., 1999; Villa et al., 1997). In our revised manuscript, we detail our view that the MDD model is largely empirical, focusing on the unsatisfying lack of a physical manifestation for the domains. As such, we hesitate to speculate on the effects of alpha recoil on predicted thermal histories.