Geochronology Discuss.,
https://doi.org/10.5194/gchron-2020-35-RC2, 2020

Interactive comment on “Simulating sedimentary burial cycles: Investigating the role of apatite fission track annealing kinetics using synthetic data” *by* Kalin T. McDannell and Dale R. Issler

Anonymous Referee #2

Received and published: 15 December 2020

“Simulating sedimentary burial cycles: Investigating the role of apatite fission track annealing kinetics using synthetic data” by McDannell and Issler explores the potential of multikinetic AFT data to improve the resolution of time-temperature paths. In its simplest form, the paper argues that by increasing the number of thermochronometric systems sensitive to different temperatures, thermal histories are easier to infer. Here, each kinematic population could be viewed as a different system with slightly different sensitivity. This concept is reasonably well understood, however, these sorts of analyses are required given the recent discussions around thermochron reliability. The study is suitable for publication with minor revisions but it could be substantially shorter. The paper basically boils down to resolution tests. It has been previously pointed out that

Printer-friendly version

Discussion paper

the multikinetic data improve the quality of thermal histories and this paper builds on that point. However, a resolution test is only really valid for the specific test at hand. It is clear that by using all the data in the correct way, the correct path can be recovered for this specific path, but this does not mean that multikinetic data is important for all time-temperature paths. This is an obvious problem with this type of study and unless the resolution tests are for a specific problem at hand, it is unclear what we really learn from these tests. For example, if the burial conditions were ever so slightly different, the tests may imply that AHe data are more important that AFT data or something like that. This point should be acknowledged and maybe the details of why the forward model path is as it is should be discussed. It is also unclear whether we are learning something about the data or something about the specific algorithm used to interpret the data. One of the attractive things about QTQt is that you do not need to specify the number of nodes in the inversions or limit the rate of the cooling. However, the authors stress the importance of the maximum likelihood models and not the expected or maximum posterior models that benefit from the reversible jump component of the algorithm. No Bayesian statistics are required to find a maximum likelihood model, so it is unclear why QTQt is used. For example, in Figure 3e, the ML model is actually outside of the credible intervals around the EX model. This is probably an advantage of the EX model because often the ML model is wildly complex. If the EX models are taken as a suitable compromise between averaging data and resolution, all of the first 6 models in figure 3 (3a-3f) look very similar. This highlights some of the points made by Vermeesch and Tian (2014) and some discussion about which model to concentrate on might be useful. An additional set of models that use predicted data using one kinetic population and then invert them with the correct single population kinetics might help demonstrate the value added in having samples with multikinetics. I also think that in many cases detrital samples have multikinetic data because the apatites are from different source areas. In turn, there is the basic assumption that it is appropriate to treat all these crystals as having the same thermal history. In fact, the crystals may have distinct thermal histories that may or may not be important in the interpretation.

Printer-friendly version

Discussion paper

For example, Carter and Gallagher (Carter, A. and Gallagher, K., 2004. Characterizing the significance of provenance on the inference of thermal history models from apatite fission-track data-a synthetic data study. SPECIAL PAPERS-GEOLOGICAL SOCIETY OF AMERICA, pp.7-24.) describe this issue for the case of AFT data and Fox et al., 2019 (Fox, M., Dai, J.G. and Carter, A., 2019. Badly behaved detrital (UâĂŘTh)/He ages: Problems with He diffusion models or geological models?. Geochemistry, Geophysics, Geosystems, 20(5), pp.2418-2432.) describe this for AHe data. In many cases, it is unclear if sufficient temperatures have been reached to effectively remove all the previously accumulated "age" and any additional factors that may control age accumulation. It is not clear how noise is incorporated into the analysis. On line 236, are the dates of each individual measurement, for the case of AHe, shifted by a specified amount or are the uncertainties on the true age set based on the noise value. I think this is clarified on 249 where the ages are the correct age with an additional uncertainty. It would be interesting to know what happens when the input ages are drawn from a distribution given by the true age and a 10% uncertainty. But the 3% errors seem a bit small. Similarly, if a larger dataset of say 10 ages were measured, a larger spread in eU might be predicted and this would have important implications for the amount of information added by the AHe ages. Line Comments 63: mean etch figure width 68: I think you need remind people why AFT ages are ages and AHe are dates and not ages. My understanding is that date is preferred for AHe to reflect the idea that this does not correspond to a specific event. Surely this is equally true of AFT central ages? Why not just use age to be consistent with the AFT literature? 85-88: This sentence is a bit long. 256: It is not clear how the more complex models were rejected here. 285: "because the EX model undergoes a simple temperature weighting in QTQt,", this is not correct. The model integrates all parts of temperature weighted by posterior probability. 414: check that this is actually likelihood and not posterior probability. 415: greater uncertainty – this should really be greater certainty to mirror the idea that accuracy is closer to the true solution. 419: there isn't really an envelope of accepted models in a QTQt model. There will be lots of very bad models accepted during the burn in phase for example, and in order to approximate the extremes of the posterior distribution, bad models need to be accepted. 442: Please be more specific about how noise is added. 500: I guess that the conclusions of Green and Duddy would probably be correct if the temps during the second burial peak event were a bit higher. 542: Has CRH been defined in this manuscript? It is probably worth describing what that is.

Interactive comment on Geochronology Discuss., https://doi.org/10.5194/gchron-2020-35, 2020.