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Interactive comment on "Beo v1.0: Numerical model of heat flow and low-temperature thermochronology in hydrothermal systems" *by* Elco Luijendijk

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Luijendijk presents an original modelling approach to assess the advective perturbation of the thermal field along a fault zone that acts as a fluid conduit, and the potential effect on observed surface low-temperature thermochronometer (apatite (U-Th)/He, AHe) ages across the fault zone. The manuscript is concise and clear, the model is original, well documented and open-source, and the potential applications are clear. The author includes two (positive) model-validation tests. I therefore feel that this could make a good contribution to GMD after only modest revision, which could address the following points:

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Discussion paper

The author appears unaware of the modelling study by Whipp and Ehlers (2007), which, although addressing a slightly different problem (bulk fluid advection through a mountainous rock mass, if such a thing actually exists . . .), was the first to my knowledge to explicitly address the potential effects of fluid flow on thermochronometer ages, and should therefore, I think, be referenced.

Throughout the paper, the reference to “low-temperature thermochronology” is a bit vague – it would be better to state more specifically what you mean, i.e.:

-In the abstract, line 3: “. . . do not include low-temperature thermochronometer age predictions . . .”

-Page 2, line 1: “. . . effect of hydrothermal activity on thermochronometer ages/data . . .”

-Page 2, line 11: “. . . to model heat flow and apatite (U-Th)/He ages . . .”

-etc.

Page 2, line 15: note that the latest version of HeFTy can simultaneously predict thermal histories of multiple (borehole) samples (Ketcham et al., 2018), and that the QTQt code (Gallagher, 2012) also has this capacity.

Page 3, line 2: only two subscripts (b and f), but they refer to three things (the bulk material, the fluid and the solid matrix)?

Section 2.5 on thermochronometer age predictions is relatively condensed. Some more detail could be provided here.

Page 12, line 5: what do you mean by “the strength of the thermochronological signal”? The amount of perturbation? How would you measure this? See also the next comment.

Figure 7 is a key figure as this shows the thermochronometer age predictions. It’s a pity that the predicted age pattern is reproduced so small that it is difficult to read.

I wondered how the background AHe age was set in these simulations? It seems strange that the background age is the same (∼30 Ma) for both the high and the low exhumation-rate cases. While this background age seems appropriate for the low exhumation-rate model, the model with high exhumation rate should have a background AHe age that is an order of magnitude smaller (i.e. ∼3 Ma). This is important because the relative perturbation of the age may be similar or even smaller in this case compared to the low exhumation-rate case. This also raises the question of whether such a perturbation could be resolved, either at the surface or within borehole samples. This may need some more consideration.

Linked to this, the model only explores the perturbation during a single interglacial cycle of 15 ky duration. This will only perturb thermochronological systems if very high temperatures (several 100 °C) are reached. Although it has indeed been argued that many hydrothermal systems in Alpine environments would have "switched off" during glacial times, there could still be the cumulative effects of multiple short-lived phases of activity throughout the Quaternary. It might be useful to explore such a scenario.

Linked to the previous two comments; Valla et al. (2016) have reported data from a drill-core close to a hydrothermal site in the Rhone Valley, Switzerland, and have argued that the hydrothermal system was too short-lived to significantly affect the thermochronological ages. They argued that besides limited shortening of fission-track lengths they did not see any effect of hydrothermal circulation on their samples. It could be interesting to use the model presented here to assess this inference more quantitatively.

References:

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