TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

Final comments on the authors' replies to our review of gchron-2020-31

Confined fission track revelation in apatite: how it works and why it matters

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Our essential comments are contained in our review (RC2), to which the authors have replied (AC2). The manuscript discussion forum invites us, or at least allows us, to react to these replies. In the absence of comments from other scientist, this could result in an endless back and forth between authors and reviewers until a consensus is reached or the deadline expires and the editors must arbitrate. It appears to us that this could be an exhausting and unproductive process, as it is most improbable that agreement will ever be reached on what is, or is thought to be, right or wrong. Since our scientific differences are not the real issue, we *recommend that the manuscript be considered for publication*, with such corrections as the authors and editors think necessary.

Manuscript

Nevertheless, we one last time wish to draw attention to some points, unrelated to scientific content. Various issues contribute to the fact that the manuscript makes an unfavourable impression on an attentive scientist. There is an apparent disdain for the reader, who is expected to guess at the intended meanings of word strings that appear to have been made up on the run, with indifference. This could be avoided by rewriting the manuscript with the aim to be understood.

It is inevitable that readers will evaluate the approach followed in this manuscript as a quick fix. The claim that the goal is to determine track etch rates is unconvincing. Price et al. (1973) and Green et al. (1978) performed *actual detailed measurements of* v_T along ion tracks in minerals more difficult to investigate than apatite. Furthermore, suspicious emphasis is placed on incidental geometrical observations. The road to v_T is paved with precarious assumptions and precipitous leaps. The most unlikely and limited data (the mean lengths of etched confined tracks accessed via surface-intersecting host tracks and an intervening apatite segment) are used for estimating the model parameters. The resulting v_T profiles have at best the most tenuous of connections with real fission-track or apatite properties. It cannot be otherwise, considering how they are arrived at. The computer-generated v_T-models are used to calculate etched-track geometries, of which a subset is selected for calculating the mean track lengths. Instead of that, the calculated geometries could have been compared with countless images of step-etched tracks, eliminating the need for inventing selection criteria. Within the current concept, it would in fact be most efficient to start from observed track geometries, and trace back their individual v_T profiles, i.e. perform the reverse calculation from that illustrated in Figure 5. The authors are doubtless aware that it does not work. This should however also alert them to the weaker links in their approach.

The reader requires more detailed, unambiguous information. E*xactly* which cores does Table 2 describe? Fission tracks are created by nuclides with different masses, charges and energies, resulting in variable and anisotropic lengths. Are all tracks in one sample assumed to be the same? If not, are, e.g., the listed core lengths averages over all tracks in a single run? Must a set of related cores be assumed in order to allow for length variation, or is it an automatic outcome of the separation between the host and confined tracks and the locus of their intersections? How does length anisotropy emerge in an isotropic model? Are the cores perhaps scaled to different latent track lengths at the start; if so, how? Is the latent track envisaged as the traditional line segment of finite length, with variable v_T, but without structure, etching threshold or range deficit? Or are the v_T models in Figure 1 somehow also compatible with recent observations of unetched tracks?

How is it that a model predicting step-etch data cannot be applied to single-step experiments? Most datasets indeed do not present lengths for consecutive etch times, but the model should nevertheless fit the data. If, on the other hand, the fits depend on the observation function of one analyst to the point that all other data are excluded from consideration, then what is the significance of four digit etch-rate estimates? How are the step-etch experiments dealt with? Are the emersion, rinsing of the etchant and etch products, and re-immersion in fresh etchant without effect?

The authors are modest in their replies *(this is a first step; all models are wrong but some are useful),* but this does not help their manuscript at all. To abuse their image: yesterday we stood at the edge of the precipice, but today we made a great leap forward. It would greatly benefit the reception of this manuscript if the authors addressed the questions that all trackers will puzzle about.

The authors are right that this is the first calculation of its kind. However, in our opinion, no-one will be interested unless they can bring themselves to address the readers' obvious concerns. This could turn this manuscript from a wild shot into a considered and considerate paper that professionals will *want to read* and will appreciate for its *thoughtful assessment* of its methods and results.

Replies

1. The *conceptual model* fitted to the Laslett et al. (1984; Figure 8) step-etch data (albeit not to strictly identical confined track samples) corresponds, in terms of the present manuscript, to an average constant-core model with Δx_{Tmax} = 11.1 µm, $\Delta x_{Tmax\text{-}B}$ = 2.1 µm, V_{Tmax} = 1.67 µm/s, and V_B = 0.04 µm/s.

2. With some hesitation, the authors concur with the first reviewer that our geological context of the KTB is open to question. We wish that once, just once, a critic would come up with a single scientific fact.

3. Our last comment concerning the need for an appendix with model equations is not as bizarre as the authors think. More than 30 years ago one of us wrote a track-etch simulation program to investigate if the Dartyge et al. (1981) track model could account for some properties of etched confined tracks (it can). There was no host track and no distance to bridge to the confined track. The confined track itself was represented by a vector, with each position x corresponding to a fraction of a micron along the track that could be etched at a cost ~1/v_T(x). This approach could handle discontinuous v_T(x)-profiles resulting from the local densities of extended and point defects, much more complex than those in the present manuscript, without needing to solve equations.

Freiberg, 17 December 2020,

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