

This manuscript investigates the etch rates of fission tracks and apatite crystals through laboratory experiments. The presentation of specific values for the track etch rate (V_T) and the apatite etch rate (V_R) is valuable. Furthermore, the experimental evaluation of the effects of track shortening and radiation damage on these rates is original. Since apatite fission-track analysis is one of the most commonly used methods in thermochronology, this manuscript has the potential to make a significant contribution to the field and is suitable for publication in GChron.

However, there are some issues regarding the completeness of the manuscript, and there is considerable room for improvement in terms of readability for the audience. In addition, for some measurements and their interpretations, there is a risk of overinterpretation beyond the resolution limits of optical microscopy. These problems relate to the manuscript's structure, reasoning, and scientific soundness, and need to be corrected for it to be publishable.

Considering these points, I recommend a major revision.

General comments

- A) This manuscript does not follow the conventional structure of an original research article: Introduction, Methods, Results, Discussion, and Conclusion. Deviating from the format that most researchers are accustomed to places a considerable burden on readers who are trying to follow the authors' reasoning. Adhering to a standard section structure is also beneficial for clearly distinguishing between facts and interpretations, and between the authors' work and that of others. To maximize the logical clarity, transparency, reproducibility, and readability of the research, a restructuring of the manuscript is strongly recommended. Even if the authors insist on retaining the current organization, each of Sections 2-4 should at least include subsections for an overview of experiments, procedures, results, and discussion. Moreover, the manuscript generally lacks sufficient explanation, so even if certain points seem obvious to the authors, it is desirable to provide careful explanations for readers who may not be familiar with them.

- B) The authors should provide their perspective on the measurement errors. The manuscript frequently reports measurements and errors on the sub-micrometer scale, yet the resolution of a typical optical microscope is limited by the wavelength of visible light ($\sim 0.38\text{-}0.78\ \mu\text{m}$), as described by Abbe's equation, and is typically on the order of a few tenths of a micrometer. Generally, measurement results below $\sim 1\ \mu\text{m}$ cannot be expected to have reliable accuracy. This is not intended to dismiss the authors' data or arguments entirely, but unless the authors clarify the expected magnitude of errors and

the practical limits of their discussion, readers may find it difficult to judge how the results should be interpreted. Furthermore, as noted in some specific comments below, discussions that clearly exceed the optical resolution should be avoided.

- C) Some instances of unit notation in the manuscript do not conform to standard conventions, and the notation is not used consistently throughout the text. For example, in L54, “MeV.amu⁻¹” would be more appropriately written as “MeV/amu” or “MeV·amu⁻¹,” whereas L68 employs the “MeV/amu” format. Similar non-standard notations are also observed, to the best of my review, in L101, 108, 196, 197, 205, 217, 223, 224, 227, 236, 240, 272, 372 as well as in the labels of Table 3. I recommend that the authors carefully review the entire manuscript to ensure that unit notation is consistent and conforms to standard conventions throughout.

Specific comments / technical corrections

L26

The temperature of subsurface rocks and minerals is controlled not directly by basin subsidence and uplift, but by the burial and erosion associated with these processes.

L30

...suitable for counting and measuring --> ...suitable for counting and measuring with an optical microscope

L37

Tt-modelling --> time-temperature modelling

The same applies to “Tt-conditions” in L231.

L42-44

A brief explanation of the difference between V_R and V_B would be helpful. As currently presented, it is difficult for readers to understand the necessity of introducing V_R and the advantages it offers over the conventional V_B .

L46

Insert a paragraph break before “Here we investigate...”

Title of Section 2

Variation of V_T --> Variation of V_T along tracks

As the authors discuss in lines 130-134, “variation of V_T ” could also arise from other factors such as chemical composition and orientation, so it should be clearly specified what the variation is referring to.

L51

Before proceeding to the experimental procedure, a brief explanation of the purpose and design of the experiment is necessary. Otherwise, readers will continue reading the following sections without a clear sense of direction, carrying many unresolved questions. For example, the rationale for using Durango, the reason for not performing pre-annealing, the objective of employing step-etching, and the significance of measuring intersections with cracks are not self-evident to readers.

L74

“ $\pi/4$ ” would be more appropriate than “ $1/4\pi$.” In addition, since the caption of Fig. 3 expresses the angle as 45° (L83, 89), please consider unifying the notation throughout the manuscript.

L77-79

The authors should provide the values of the errors for d_D and d_s measurements, or at least their perspective on error estimation and measurement limits. Considering the errors in D_{par} shown in Tables 2 and 5, these values should also have an approximate standard deviation of $\sim 10\%$. Furthermore, for the 20s data in particular, it is possible that some measurements are too small relative to the resolution of an optical microscope.

L84

$D_{PAR} \rightarrow D_{par}$

L87

measure values \rightarrow measured values of I_M (Fig. 3b)

L87-89

Add an explanation of the gray symbols. Also, clearly indicate in the figure that the numbers in Figures 3a and 3b correspond to I_I and I_M , respectively.

L88

track rate \rightarrow track etch rate

L103-104

Show the V_T values reported in Jonckheere et al. (2024).

L104

In the reference list, there are two entries for Jonckheere et al. (2024), labeled "a" and "b."
Please specify which one is being cited here. The same applies to L132 and 289.

L112

Figure 2 --> Figure 3

L114-115

Explicitly present the equation used to calculate I_E . Since this paper contains various similar parameters that may be confusing, it might be helpful to include a new table summarizing the definitions, symbols, and equations of the frequently used key parameters.

L115-117

Considering the errors shown in Figure 3b, it cannot be said that the agreement is good. If there are other uncertainties being taken into account, please explicitly indicate them.

L124

Please check the publication year of Somogyi & Szalay (1973). In the reference list, it is given as 1974. The same applies to Trilsch et al. (2024) in L305.

L125

Explain what dE/dx represents. Is this the stopping power, the energy a particle loses per unit distance traveled in a material?

Title of Section 3,4

Effect of ### --> Effect of ### on V_T and V_R

L142

C° --> °C

L142-144

Just to confirm, were all the measurements taken using TINT?

L144-146

Please provide the explicit equations for these parameters. Requiring the reader to check the original references is inconvenient.

L154-155

Do you mean “from host to the nearer track tip”?

L167

Figure 5b --> Figure 6b

Table 2

What does LSTD refer to? The same applies to Tables 3-4 and “DULU” in Tables 4-5. In addition, it would be helpful if the parameters in Tables 2 and 5 were listed in the same order, as this would facilitate comparison between the two.

L193-198

In the caption, please describe the parameters in the same order as they appear in the table.

L205

If I understand correctly, since etching progresses from the intersection toward both tips, wouldn't the length difference generated over 2s actually be twice that, $\sim 8 \mu\text{m}$?

L209-212

This statement and the following discussions (L212-235) may be an overinterpretation. It is difficult to discuss this level of precision with the resolution of an optical microscope (generally $> \sim 0.2 \mu\text{m}$). Even if we assume there is no issue with resolution, using mean values for comparison, the relative magnitudes do not show a distinct trend. Furthermore, the four Dpar values overlap within 1sd (Table 2), so the differences cannot be considered significant, whether using the mean or the median.

L217

meV --> MeV

L218

$1.22 \cdot 10^{-3}$ --> 1.22×10^{-3}

The same applies to L221 and 272.

L249

This data is not included in Table 4. Instead, it is appropriate to refer to Figure S07.

L249-252, 257-258

Given the limitations of measurement accuracy, this discussion might be overstretched.

L260-262

I did not quite understand what you're trying to claim here. I think you need to explain how parameters that do not affect the lengths of these tracks could influence the selection of tracks.

Table 4

The data from "DULU" is not used in the main text. The corresponding data are presented in Figures S15-16; however, they do not seem to be cited or discussed in the main text.

L265

$\Delta(.) \rightarrow \Delta(\dots)$

L267-269

Since this experiment investigates the effect of aging, please provide the reference ages of these samples.

L272

Are there data on the total alpha dose for AS-3? In order to compare the measurements of the two samples later and interpret their differences, the relative magnitude of radiation damage should be clearly established.

L280-282

You will probably need to cite Table 5 here.

L291, 298, 304, 315, 339

Table 3 \rightarrow Table 5

Table 5

Add the following to the caption: "For explanations of the parameters, see the caption of Table 2." In addition, while FT specialists may be able to infer this from the values, please clearly indicate which samples represent fossil-track and induced-track measurements.

L322-323

If I understand correctly, the shorter length of host tracks may also act to shorten the access distance to the confined tracks, thereby similarly increasing the effective etch time of the confined tracks.

L339

Dpar's --> Dpar values

L341

Replace ^{146}Sm with ^{147}Sm . Although ^{146}Sm also undergoes α -decay like ^{147}Sm , its natural abundance is nearly zero. Therefore, in methods such as U–Th–Sm/He dating, the contribution is mainly from ^{147}Sm (e.g., Flowers et al., 2022).

L344

I think it is necessary to explain the difference between Dper and Dpar.

L352

It appears that only the word "been" is in a different font. If this was not intentional, please fix it.

References

The following references do not appear to be cited in the main text: Donelick (1991) in L412-413, Jonckheere et al. (2020) in L455-456, and Ketcham et al. (1999) in L465-466.

Supplementary files

Except for Figures S07-S09, the other supplementary figures are not mentioned at all in the main text, making it difficult to understand the purpose of the data. For example, Figures S01-S02 and S05-S06 could be cited in the caption of Table 2, or otherwise linked explicitly to the relevant data or discussion in the main text.

I hope my suggestions contribute to enhancing the clarity and quality of the paper.