

Interactive comment on “Tracking geothermal anomalies along a crustal fault using (U-Th)/He apatite thermochronology and REE analyses, the example of the Têt fault (Pyrenees, France)” by Gaétan Milesi et al.

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This contribution presents new apatite (U-Th)/He (AHe) thermochronological data associated with rare earth element (REE) content in the same dated apatite along four transects cutting the Tet fault in the Pyrenees (France). The aim of the papers is to investigate the possible impact of geothermal fluids on affecting AHe age, using the evolution of REE along the samples.

The ms presents interesting new data on two mains zones (free fluids and hot fluids

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zones). However, the authors have already published similar contribution in 2019, where they present the impact of hot fluid on AHe data. Only at the very end of the text, the authors show that when hot fluids are not present, it doesn't affect the AHe data. It is difficult to really understand what the message of the contribution is. Is that a methodological paper? If yes, the authors need to go further as the impact of hot fluids in fault affecting the AHe system has been already proposed. In addition, the authors present new thermal history modeling of the area, but they don't really discuss the implications for the eastern part of the Pyrenees. I strongly suggest that the authors propose further investigation on the exhumation of the eastern Pyrenees and compare with the other thermochronological data. Or the authors could investigate past geothermal anomalies and better present the new result of their contribution (AHe data are not affected in area where fluids are absent).

Below are some additional comments:

Abstract. Add France after Pyrenees. The passage with the second sentence of the paragraph is odd. I suggest “in order to investigate the evolution of the geothermal gradient and fluid flow, we used AHe + geochemical analysis to ...

Paragraph 20: the authors gave sentences about exhumation for two zones, without using the data. What is the implication of the results? It is very unexploited.

Paragraph 25: it opens new perspective to what exactly? This could be a good angle to go to deeper investigation in the ms

Paragraph 30: I am not sure to understand why the presence of water is required to heat production. Perhaps, heat advection need water, but water don't produce heat.

Paragraph 50: about AHe temperature sensitivity range go higher than 90°C depending on the damage dose. I suggest adding 40-120°C and add Ault et al 2019 reference

Paragraph 55: the goal of the paper “the study wants to test this tool both in areas lacking of hot fluids ...”. Please rephrase better to see what is new in the study. Why

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above 60°C?

Paragraph 60: and in general, more recent citations on low temperature thermochronological data of the Pyrenees are missing. Please add other papers than Verges et al. 1995.

Paragraph 65: remove the) between Later,) two minor. . .

Figure 1: Homogenization of the scale bar for each figure (a, b, c) could be good. What is the white square on fig c?

paragraph 80, line 3: add Ma after the numbers 300.3 ± 3.1 and 291.2 ± 2.8 Reference of Ar/Ar ages are missing It is ZFT and not ZFt. Please replace

Figure 2: give the elevation or difference of elevation between samples. The addition of the AHe observed / predicted versus elevation could be nice.

Paragraph 85: it should be Apatite (U-Th)/He age yielded a large range of age between . . . and not apatite yielded a large range of AHe age. Add error on AHe ages

Paragraph 95: could also add error on Ar ages

Paragraph 100: please correct, it is not the low temperature data that reveal that the Canigou massif was exhumed and cooled but thermal modeling. What do you refer by rapidly cooled? Add values, like that it will be more homogenous with other given exhumation rates (see Paragraph 110)

Paragraph 110: add more recent references about uplift and erosion in the Pyrenees, e.g.: Vacherat et al. 2014, 2016, Ternois et al., 2019 etc for example

Section 2.2: since when hot fluids are circulating in the tet fault?

Figure 3: color legend is missing. What is the brown line at the bottom, in the footwall?

Figure 4: could the authors add on the figure, the location of the samples? It can be useful I am not really sure about the purpose of this figure. What the authors wants to

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show?

Paragraph 145: please add a little more information on how the numerical modeling has been done and with which data

Paragraph 180: the aim of this sampling . . . was to track the effects of recent hydrothermal circulation. . . but what is new in this study? The authors have already published this type of study, so it is important to go further.

Paragraph 210: why is the reference Taillefer et al., 2018, in bleu and italic?

Paragraph 245: because the authors also measured the Sm content, they can use the value to add them and calculate the (U-Th-Sm)/He age

Paragraph 260: the raw REE data should be add in the AHe data table for simplicity. Please add the raw values and not normalized to chondrite.

Figure 7: it will be nice, if the authors add directly on the graphic, the free hot spring and with hot spring.

Paragraph 295: about eU ($U + 0.234 \times Th + 0.0045 \times Sm$; Gastil et al., 1967), the presentation of the value could more simply presented 12 ppm instead of 12.3 ppm etc. What about the variation in the Th/U ratio? It can help to see if the Th and U have fractionated

Figure 8 et 9: both figures are really difficult to read. They look very similar. Perhaps so diagram can go in the supplementary diagram and only light/heavy REE ratio could be presented.

Paragraph 410-415: It will be interesting to add Cl measurement or compare the REE data from the apatite to discuss more about the dissolution / recrystallisation process. The reference Zeitler et al 2017 is good, but just is a summary of other studies (Shuster et al., 2006; Flowers et al., 2009; Gautheron et al., 2009; Gerin et al., 2017, Idelman et al., 2018, McDannell et al., 2018), that can be cited or for simplicity the reference Ault et al 2019 resumed all of other recent studies.

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Figure 11: are you sure about the sum of REE because 20000 ppm is 20%. It seems that it is chondritic normalized values. Please verify the value as 1000 ppm of Sm is quite a lot and if it is the case, it will strongly change the AHe age. What about AHe age vs Th/U, AHe age vs light/heavy REE ratio? It will be better to add also the data outside of the DZ rather than the purple square

Figure 13: same comment than for Fig 11

Figure 15: scale of the microscopic scale seems not be correct as the apatite crystal are really too small, or the scale

Paragraph 525: the last line that describe the fact that if not fluids are shown, it doesn't impact the AHe ages can be the angle of the paper. This is the main new result of the paper and it appears at the end. It is a shame, because it is very interesting. The authors could present this results in the beginning, and not focus to much about the influence of hot fluids, as it has been already published.

Supplementary: please report the raw REE content in ppm

Table 2; you can add directly the REE measurement in the same table

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