

Interactive comment on “Advection heating by hot fluids of an Alpine fissure in Lauzière Granite (Belledonne massif, Western Alps)” by Emilie Janots et al.

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Reply to anonymous referee#2

A General comments : The main comment of referee#2 concerns the interpretation of the ZFT. To answer this comment, we extended the section of the fission track results to show the difficulty of dating the material such as : (1) Normally the objective is to date at least about 20 grains per sample, which was not possible because of poor sample quality with few zircons available, and many grains with strong U-zoning and inclusions. Therefore only rather limited number of grains could be analysed per sample, resulting in all samples showing a relatively high dispersion in the grain age distributions and

low χ^2 values. (2) Because of all these limitations the ZFT ages given here should be viewed with caution. Particularly the two samples collected further away from the cleft may have been affected by partial annealing only. Nonetheless, the observed single grain ages and central ages indicate that these zircons experience cooling since the mid-Miocene.

B Specific comments : (1) Introduction : as demanded, it is now divided in four paragraphs. The third paragraph was completely rewritten to clarify the different hypotheses that can account for the overlap between monazite and ZFT ages in different areas of the ECM. It must be noted that these ages are different depending of the massif considered, for example the ages in the Argentera massif (around 20 Ma) are much older than those in the Belledone massif (7-8 and 10-12 Ma). In the fourth paragraph, we now explain that microthermometric studies are obtained to determine the temperature of the cleft mineral precipitation. We precise now that monazite age was previously obtained by Grand'Homme et al. (2016) and that this age was used to reveal for the unusually hot fluids. (2) ZFT data : results section was extended (see general comment) . Concerning the duration, we are now much more cautious. Duration of the advective heating was removed of the abstract. In the discussion, it is mentionned that The difference between these two ages constrains the time range between the infiltration of the hot fluid and cooling down of the cleft wall to temperatures similar to the host-rock, i.e. it limits the duration of advective heating to around 1-3 Myr (Fig. 8), but given the uncertainty of the ZFT age, the heating interval may have been even shorter . (3) Sample coordinates were added at the beginning of the presentation of the geological settings (4) We have been rewriting the abstract, introduction, and discussion such as to show that fluids have no impact on exhumation rate but may impact the temperature and reset partially the ZFT data. We emphasize that in our study, the impact of the fluid circulation is however local and not seen at 30 m of the cleft. However, the role of the fluid may vary depending on the fluid flux, the volume, the temperature difference between the fluid and the host-rock and the duration of the circulation



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C Line Comments All line comments were taken into account. Only major changes are discussed below Title : we modify with \wedge Evidence of adevcive heating... Page 1, Line 30-31 : the duration is now more mentioned in the abstract Page 2, Line 26-27 : we didnt specify the ages because they differ depending on the massif and tectonic position Page 3, Line 10 : The ECM consist of blocks of Variscan basement of the European margin They correspond to the westernmost paleogeographic units and are distinguished from the Internal domains, consisting of more distal paleogeographic units that underwent higher metamorphic grade during the Alpine subduction-collision cycle. The ECM were thrusted under the internal domains.... Page 3, Line 25 : tectonic accident was replaced by fault Page 3, Line 30-31 : we rephrase and remove whilte mica and mention the mylonite instead : \wedge is evidenced by the pervasive retrogression in the mylonite \wedge Page 4, Line 1 : we now mention that the cleft has metric dimension but is variable in height and width Page 4, Line 17-23 : we deplace the paragraph and made small changes in the next one. Page 8, Line 7-12 ; 26-27 ; 32: here we did a significant extension of the text to better explain the concept of closure temperature and how to apply it for ZFT data : Lauzière granite had cooled below the zircon fission-track closure temperature of about 240-280°C during the mid-Miocene (Fig. 8). The closure temperature is considered as the temperature at which the fission-track system closes to the loss of fission tracks by annealing and is applicable in case of monotonic cooling (Dodson, 1973). The idea is that no fission-tracks are preserved in the zircon crystals at elevated ambient temperatures, but start to be retained as soon as the crystal cools below the effective closure temperature. The actual value of the closure temperature for the zircon fission-track systems depends on the rate of cooling and the amount of accumulated radiation damage (Bernet, 2009; Brandon et al., 1998 Rahn et al., 2004; Reiners and Brandon, 2006; Tagami, et al., 1998). For natural radiation damaged zircons and common alpine cooling rates on the order of 10-20°C/Myr the closure temperature is about $240 \pm 5^\circ\text{C}$, whereas for zircons with no or very low amounts of radiation damage the closure temperature is about $340 \pm 10^\circ\text{C}$ for the same cooling rates (Reiners and Brandon, 2006). The closure temperature should not be confused with

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the partial annealing zone, which is the temperature range over which fission-tracks are partially but not fully annealed, either during reheating or during very slow cooling through this temaprture range (e.g. Reiners and Brandon, 2006). If heating during the hydrothermal event was sufficiently high to anneal fission tracks completely in the zircons analysed in this study, then the ZFT cooling ages will reflect post-hydrothermal event cooling mainly related to exhumation, given that the hydrothermal heating event as relatively short-lived and with limited thermal impact of the surrounding country rock on a regional scale. Assuming a general regional geothermal gradient of $\sim 25^{\circ}\text{C}/\text{km}$ and a surface temperature of $\sim 10^{\circ}\text{C}$ the rocks of the Lauzière granite may have been exhumed from crustal depths of <10 km since 14-16 Ma, (Fig. 8). Figure 1 : Box were made larger that they dont overlay on the monazite and ZFT ages. We replace polygons by rectangles of the monazite age to make the lecture easier. We now mention in the legend that all monazite ages correspond to cleft monazite Th-Pb ages. The typo in the legend was corrected Figure 2 : White background was placed behind the text of panel A. We corrected the typo of Mesozoic. We add the orientations of the veins and foliations in the legend. Foliation can not be represented because it is subvertical and parrallel to the orientation of the picture (N-S). Figure 4 : the number of analyzed fluid inclusions appears now in the figure Table 2 : All rows have the same Na value estimated independantly from the average salinity determined from the microthermometric data (Table 1) on QzP2. This is this value that is used as internal standards for the other elements. It is now mention in the result sections, such as : The average T_m ice obtained for the QzP2 fluid inclusions (-7.3°C) was used to calculate the Na concentration of 43300 ppm. This value of 43300 ppm Na was used as an internal standard for the calculation of Li, K and Sr concentrations (Table 2).

D Editorial comments All corrections were taken into account

All the changes made can be found in the supplement.

Please also note the supplement to this comment:

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