

## ***Interactive comment on “Extensional reactivation of the Penninic Frontal Thrust 3 Ma ago as evidenced by U-Pb dating on calcite in fault zone cataclasite” by Antonin Bilau et al.***

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Thanks a lot to Rev. 2 for his careful reading and advise about our paper. We followed his propositions in detail.

abstract line 29-31: the discussion on the coeval extension in the internal zones and compression propagation in the external zone is not well constrained/dated and is not properly address in the discussion part of the ms. a specific paragraph could be added in the discussion. However, it is not a key point of the paper, and could be discarded. OK. Reworked.

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1. introduction line 46: does the PFT really acted as a “plate boundary”? eventually discuss and/or present the structural relations between the Briançonnais and the external zone. Right, modified: “as the major tectonic structure”.

line 48: also refer to Sue and Tricart (1999, *Elogae Geol. helv.* ;2003, *Tectonics*) for the reactivation of the PFT in extension and the description of the regional fault system. Read & Added.

line 51 also refer to Sternai et al. (2019, *ESR*) for the isostatic/buoyancy forces discussion. Read & Added.

2. Geological setting. line 64-67: the concept of “plate boundary” implies to consider the briançonnais zone as a single (micro)plate. I do think that this point deserves a longer analyze, specifically in terms of paleogeography. Quote also Tricart, (1984, *Am. J. Sci*) for the PFT top-to-the-west thrusting history. Right, modified: “As the major tectonic structure”.

line 68: Zhao et al (2016) is an important reference in the frame of this ms. but not on the nappe-related structure. Write a specific sentence for the lithospheric structure seen by Zhao et al. Completed with “Schmid and Kissling 2000, Lardeaux et al., 2006, Malusà et al., 2017”. And Ceriani et al. for the nappe structure.

line 80-82: also quote Agard (2002 *J. Metam. Geol.*). Read & Added.

line 94-95: also quote the synthesis of Bertrand and Sue (2017, *Swiss J. Geosci.*) Read & Added.

line 97-101: the overall seismotectonic local framework in the study area, including geodesy, should be better exposed. See for instance the recent paper by Mathey et al., (2020, *GJI*). the same matter arises in the discussion part. Read & Added.

line 96: Note that the very first reports of the briançonnais’s seismicity has been published by Rothè (1941). The seismotectonic regional frame is first described by Sue et al. (1999, *JGR*); these references could be added. OK, very well. These refs have

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been added.

line101: the Jenatton et al (2007) and Leclère et al. (2012)'s works focused on the Ubaye swarm, to the South of the study area, which actually occurred West of the PFT, with fluid circulation. This thematic could be discussed in the ms., but in a specific paragraph, as these works are not directly connected to the PFT reactivation. Right, removed.

line 120: the same Oreac section has been described by Sue and Tricart (1999, *Eclוגae Geol. Helv.*) in term of brittle deformation and related paleostress. Read & Added.

3. Sampling strategy and analytical method this part is well organized, precise and informative. Fine. Thank you.

4. Results fig4a: could you provide the corresponding photography? give also a close-up location map of the samples (smaller scale than fig.2). Modified, the original photography is in Fig.3c.

line 243 and following: better explain the stable isotope results, for a non-specialist. Addition of formulation of equation (1):  $\delta^{13}\text{C}$  calculation. And "The ratio of carbon and oxygen isotopes is related to the parental fluid of calcite and can be used as a fluid tracer."

line 262-263: the comparison with the Mont-Blanc ECM is very interesting. It must be better developed in the discussion part. In the present form, the last sentence of the paragraph is useless. Either discard it, or (better) develop a bit more. OK, discussion and links with the Mt-Blc have been developed.

line 275-276: better explain this sentence (re-write). Reworked and completed. The details pertaining to analytical proc. have been better explained in the corresponding section.

line 277-283: these ages are very good regarding the questions still under debate on the overall late extension thematic. Moreover, they represent the core of the paper. I

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would advise to better underline the quality and novelty of these pretty young ages. Thanks for this comment. We complemented this section and reworked the conclusion to highlight those ages and corresponding fluid history better.

Fig7 could be enlarged. The figures and words embedded in the panels are not legible. OK, this has been done. In addition, 2 more ages coming from new sample in the same area have been added, and elemental map see supplementary data.

5. Discussion the overall discussion is written with a pretty affirmative tone. I suggest the authors to use more careful words in their interpretations. Taken into account, sentences have been rewritten in a less affirmative way.

line 319-320: precise and rewrite the 3 points (i) (ii) and (iii) in a more logical way. Reworked and completed: "i) lack of large-scale structures (ii) pressure-solution microstructures (evidence of local fluid) (iii) presence of a shallow impermeable clay layer which isolate surface and deep systems".

line 332-333: this sentence is unclear. rewrite and develop a bit the concept you wanna describe. OK, rewritten.

line 340-345: the comparison with the Mont-Blanc ECM deserves to be better developed. I would suggest to write a complete paragraph on this comparison, eventually supported by a new specific figure, including a map view of the related MB vs. Briançonnais contexts. Concerning the MB's exhumation processes, quote at least Seward and Mancktelow (1994, *Geology*). This comparison has been precised, with some more details on the MB context. However, besides this is clear that fluids have a similar signature, the age of structures is different (15 Ma in Mt Blc) and so is the context (extensional here, compressional Mt Blc), so we don't think the comparison has to be so much extended.

Line 347, together with Zhao et al (2016), the references to the ECORS profile and related interpretations regarding the PFT at depth must be quoted (e.g. Mugnier et

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al., BSGF 1993). I also suggest to quote the ECORS cross-section re-assessed by Schmid and Kissling (2000, Tectonics). OK, these refs have been added.

line 380: the fault dated in the ms. “may” represent a paleo-HD fault. It is still an interpretation. Added.

line389-400: this very small paragraph on “evolution through time” (indeed from c.a. 3 Ma up to now and the active deformation) must be better developed and improved. A map of the active deformation at the local scale could be interesting. The paragraph should integrate discussion on the uplift, which is not restricted to the ECM, but also affect the inner area (Nocquet et al. 2016; Sternai et al., 2019), together with the extension seen both in geodesy (e.g. Walpersdorf et al., 2015, J. Geodyn) and looking at the focal mechanisms of earthquakes (Sue et al. 1999 JGR ; 2007 IJES). Indeed, such a discussion should bring the gap between the current activity of the Briançonnais area, which is well constrained, and the “late alpine” faulting, which is now well dated by the present paper. OK, we agree, we have enhanced this part.

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