

Interactive comment on “Regional-scale paleofluid system across the Tuscan Nappe – Umbria Marche Arcuate Ridge (northern Apennines) as revealed by mesostructural and isotopic analyses of stylolite-vein networks” by Nicolas Beaudoin et al.

Nicolas Beaudoin et al.

nicolas.beaudoin@univ-pau.fr

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Anonymous Referee #2 Received and published: 9 June 2020 General Comments: This paper presents a multi-faceted approach to understanding the paleo-fluid history of the Tuscan Nappe region. A wide variety of data were used to fully evaluate the structural-fluid system, including: mineral vein petrography, oxygen and carbon stable isotopes, clumped isotopes, U-Pb dating of calcite veins, depth determination from stylolites, and Sr isotopes. The data appear to be good and the interpretations are generally supported by the data. All of the figures and tables are necessary. However,

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some of the data is not discussed in the text or presented in figures or tables Author response: We wish to thank the referee for this comment. In the new version all data are presented in the text, tables and figures.

Specific Comments: However, the paper was very difficult to read due to several issues:

1) The English grammar of the paper needs to be addressed, and be more consistent throughout. Some sections were well done, while others need work. In the detailed comments below, I address some of these, but a much more thorough review is needed. Also, maybe it was just my copy of the paper, but there were commonly no spaces after semi-colons in the reference lists.

Author response: The text has been carefully edited to address grammar and style issues, following both reviewers comments and beyond. Spaces were added after semi-colons in the reference lists.

2) The authors have explicitly not followed the standard paper format of methods, followed by results, followed by discussion. Instead, they have a method, followed by a brief results section, followed by another method, then another results section, and so on. This is very distracting, and the reader has to refocus on the results after each method. Similarly, the results are not fully discussed in their respective sections, and some results are in the methods sections, as well as in the discussion. I highly suggest that the authors redo in a more conventional format.

Author response: We agree that the format we used was not adapted and led to confusion. In the new manuscript, we reorganized and separated the methods from the results, and the interpretation from the conclusion. We believe it results in a clearer text.

Detailed comments (by no means complete): Line 40: ‘ubiquitous’ seems like an odd word to use here. Maybe ‘a variety’? We modified the sentence as follow (line 38): “The upper crust is the locus of omnipresent fluid migrations that occur at all scales”

C2

Line 47: instead of 'make', 'allow' or 'facilitate'
We replaced by "facilitate" in line 45

Line 52: instead of 'witness', maybe 'be influenced by'
We replaced by "influence by", line 50

Line 56: instead of 'for instance' use 'for example' as a lead off to the sentence.
Edited accordingly, line 55

Line 87: define 'LPS'
Done, line 85

Line 91: 'is' not 'was' also elsewhere tense agreement.
Edited accordingly line 87-89

Line 92: 'consider' not 'considered' (as above)
Edited accordingly line 87-89

Line 100: be careful about using 'for the first time'. I suggest leaving it out.
We left that out.

Line 119: should be 'piggy-back'
Edited accordingly line 116

Line 120 and throughout: please use dates in addition to stage/age names
Edited accordingly, ages are provided all throughout the text (line 117)

Line 121: 'convexity' is awkward.
Edited and modified as "convex shape", line 119

Line 128: what is meant by 'for long'?

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It was related to the long-standing debate over the subsurface structure of the ridge, we left that wording out to avoid confusion.

Line 134: maybe: 'Even if the interpretation of basement shortening is more accepted now'. . . .
Done line 131

Line 138: 'In these last views' is awkward
Edited as "For the latter interpretations" (line 136)

Line 144: 'Nowadays' is awkward
This has been replaced by "currently" (line 141)

Line 153-162: stage/age dates needed
Done from line 150 onwards

Line 179-180: this is a result
Thank you for pointing that out, this sentence is now in the result section (line 360)

Line 186: need parentheses around ' σ_1 '
Edited accordingly

Line 190: what is meant by 'regimes'?
We know clearly say what the stress regime can be (extensional, reverse, strike slip) line 185.

Line 196: What are criteria for 'most representative fracture data'? and what about the other data?
The representativity of the veins is a statistical criterion given by Fisher statistical test.
We edited the text as "we gathered the statistically most representative fracture data"

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(line 191). The other data are simply not first order and can also relate to local structural complexity. That is what we say line. 192.

Lines 210-212: the authors say that this set will not be discussed further, but it is covered later in lines 464-470.

We removed the part line 464-470 and do not discuss this set later on.

Line 212: a better word than 'gathered' is needed

This paragraph was edited completely. We believe it to be clearer now.

Line 255: give equation a number and take out of sentence.

OK, this is now equation (3)

Line 257: remove 'classic'

Done

Line 284: instead of 'that filled up' use 'in'

Done line 248

Line 286: what are 'diagenetic states'?

We rephrased as follow (line 250-251): "possible post-cementation diagenesis such as dissolution or replacement were checked under cathodoluminescence"

Line 288: do not capitalize oxygen and carbon

Edited accordingly

Line 293: where were the host rock samples taken in proximity to the veins? Was there any vein-fluid host-rock interaction?

Host rocks where sampled on the same hand-cut, about 2 cm from veins. It is now explicated in the text line 258.

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Line 298: how long were samples held at 90 degrees?

30 minutes for calcite and 45 minutes for dolomite, as now stated line 263.

Line 307 and throughout: please be careful about using VPDB consistently.

This is now VPDB everywhere in text, table and figures.

Line 324: what are Mg-samples??

The paragraph about the methodology of Sr was completely edited. Mg-samples was a mistake.

Line 330: instead of 'spread on' maybe use 'distributed over'

Edited accordingly line 423.

Lines 333 to 340: be careful of the use of radiogenic. Not appropriate here.

We removed the term radiogenic from the paper as it was not adapted.

Lines 352-367: need some references here on the methods used.

We now cite (line 290) as follow: "The clumped isotopes laboratory methods at Imperial College follow the protocol of Dale et al. (2014) as adapted for the automated clumped isotope measurement system IBEX (Imperial Batch EXtraction) system (Cruset et al., 2016)."

Lines 390-399: difficult to read, maybe present these data in table form.

We understand that it is not easy to read, but as we need to present the results, we don't have a lot of choice. They are already reported in table 3.

Line 403: do not capitalize calcite

Edited accordingly.

Lines: 405 to 409: need more details on the method here

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We developed this method part line 322-332.

Line 425: define 'favorable'

The term favourable is not strictly bound to a numerical value of the ratio. It is usually accepted the ratio should be 100 at minimum, but this depends heavily on the absolute content of U and Pb. We do not mean to provide a debatable and ad-hoc value in this paper. Please refer to Roberts and al., 2020, for an in-depth explanation.

Line 445: instead of 'witnessing' maybe 'experiencing'

The form of this part was edited

Line 478: instead of 'propose' use 'will'

Edited accordingly line 510

Line 483: do not capitalize west

Edited accordingly

Line 484: what is 'abnormal burial'?

We rephrased for the sake of clarity (line 521-522): "revealed that most of this unit locally underwent more burial because it was underthrust below the Ligurian Nappe"

Lines 493-494: wording of this sentence is awkward

We rephrased as (line 530-534): "In the case of the UMAR, 800m is the minimum depth at which dissolution stopped along BPS planes, regardless of studied formations. That confirms that burial-related pressure solution (i.e., chemical vertical compaction) likely initiated at depth shallower than 800 m (Ebner et al., 2009b; Rolland et al., 2014; Beaudoin et al., 2019; Beaudoin et al., 2020). "

Lines 509-511: this sentence not clear

This part has been edited and reworded for the sake of clarity (line 547 onwards) : "We

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can therefore estimate an average duration of folding in the western-central part of the UMAR of ~ 3 Ma. Knowing the oldest record of post-orogenic extensional tectonics in the UMAR is mid-Pliocene (~ 3 Ma) (Barchi, 2010), we can also estimate the duration of the LSFT to ~ 2 Ma."

Line 529: specify 'calcite twins'

Edited accordingly line 566

Line 533: instead of 'history' use 'histories'

This part was rewritten for the sake of clarity and to make it more convincing (line 570-607)

Line 534: better explain 'clearly exhibit a singular history'

This part was rewritten for the sake of clarity and to make it more convincing (line 570-607)

Line 536: is there something missing at the beginning of this paragraph?

This part was rewritten for the sake of clarity and to make it more convincing (line 570-607)

Line 537: it is not clear how this value was obtained.

This part was rewritten for the sake of clarity and to make it more convincing (line 570-607). We believe it is much clearer now that we don't rely our interpretation only on the value of $d18O_{fluids}$ but on an array of data including Sr and ^{13}C as well.

Line 542: same as above

This part was rewritten for the sake of clarity and to make it more convincing (line 570-607). We believe it is much clearer now that we don't rely our interpretation only on the value of $d18O_{fluids}$ but on an array of data including Sr and ^{13}C as well.

Line 550: starting a sentence with 'That' is awkward

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This part was rewritten for the sake of clarity

Line 554-570: this entire paragraph is very confusing and not clear. Please rewrite and also be consistent in VPDB. Up to here, there has been no discussion of carbon values or the clumped isotopes.

This part was rewritten for the sake of clarity and to make it more convincing (line 570-607). Carbon isotopes are now represented on Fig. 6c, and discussed in this paragraph as an important part that our interpretation is built on. (lines 570-580)

Lines 574-577: careful of use of depleted, overprinted, 'very positive'

This part was rewritten with no jargon.

Lines 590-593: this is a very long sentence. Please break apart for clarity.

Done line 622-625.

Lines 594-595: this sentence is not clear. What is 'water table top difference in height'?

It is the difference in the water head, we edited to make it clearer line 627.

Line 650: remove 'unparalleled detail'

OK.

Comments of Figures and tables: Figure 3: should 'natural light' be 'plain polarized light'?

Indeed, thank you for pointing that out, it stands corrected.

Figure 4 caption: what is meant by 'red color scale'?

We meant that the red areas on the stereograms indicates the highest fracture pole densities. We reworded to make it clear.

Figure 6d: need 'VPDB'

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Done accordingly

Figure 7: placing formation seawater values on plot would be useful

The formation seawater values are given by the host rock values, it is indicated now in the caption.

Figure 8: contours are based on?

Contours are based on uncertainties, as stated now in the caption.

No figure or table with clumped isotope data

It is now in reported in table 3

VPDB is used throughout the paper, while V-PDB is used in the tables

Table have been amended.

Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2020-64>, 2020.

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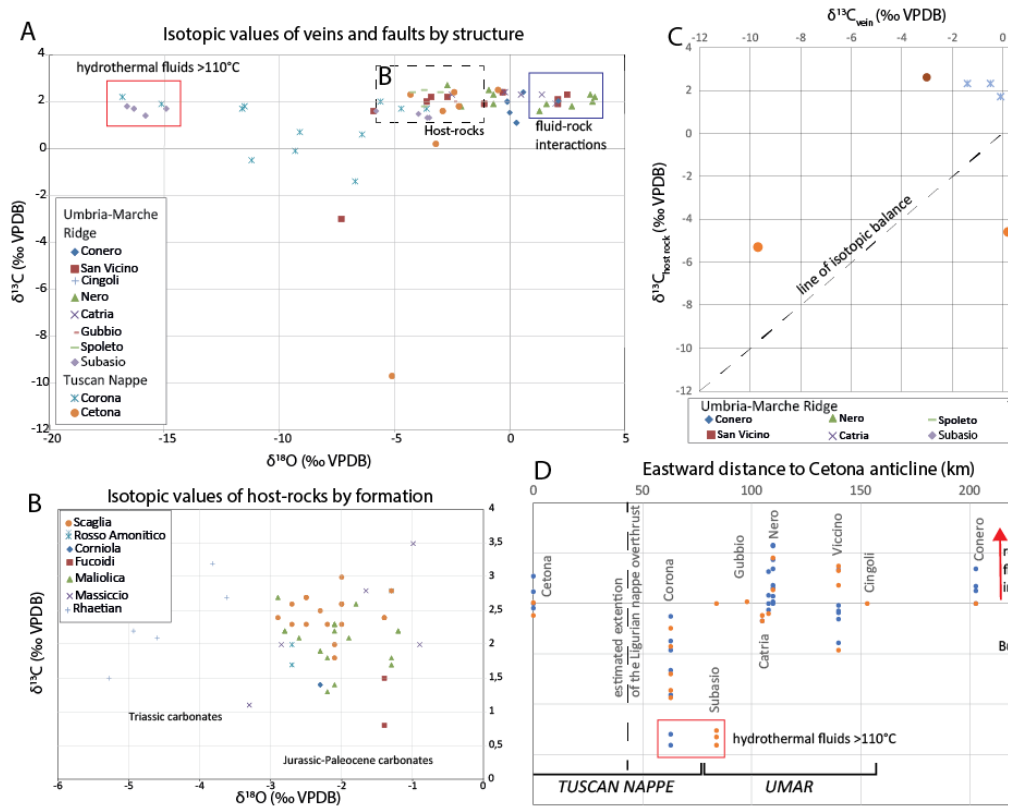


Fig. 1. Figure 6

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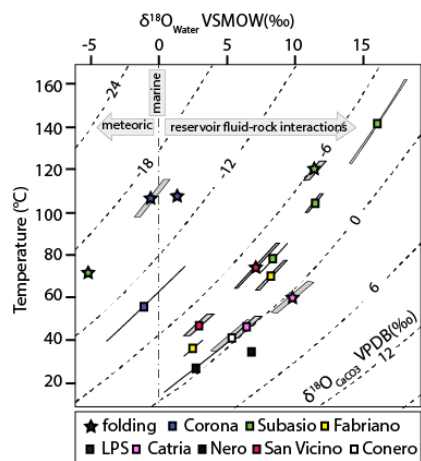
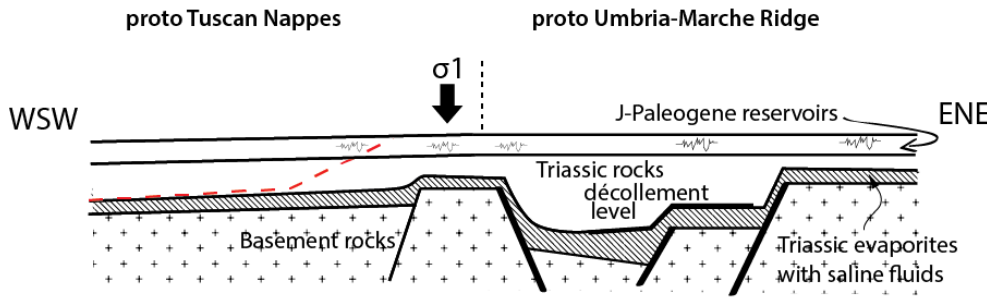


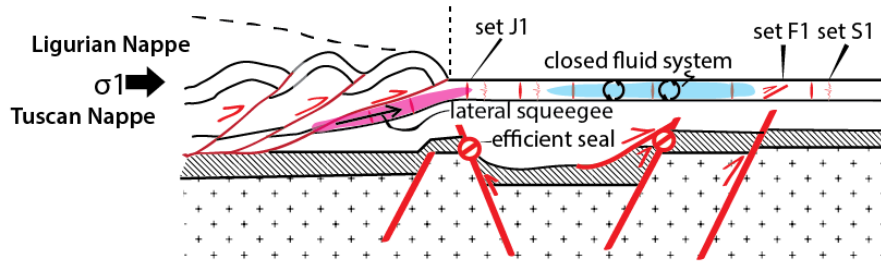
Fig. 2. Figure 8

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a) Burial up to Burdigalien - Serravalian (15 +/- 3 Ma)



b) LPS in the UMAR from Serravalian to Tortonian (~8Ma)



c) Folding in the UMAR from Tortonian to ~Messinian (5.5 Ma)

