

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.

Anonymous Referee #1

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The authors present an interpretation of the paleofluid flow history across the Tuscan Nappe, constrained by a multiproxy study. They integrate detailed structural analysis of stylolites fracture networks with isotopic (O and C stable isotope, Sr isotopes, clumped carbonate isotopes) and some limited U-Pb dating of calcite veins, cements, and fault coatings. Using the dates from this study in concert with other timing and burial constraints, the authors reconstruct a ~12 my history of fluid flow events that are linked to deformation. They identify evidence for both closed fluid systems and the open system flow of hydrothermal fluids.

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This is an interesting and comprehensive evaluation of the role and evolution of fluids during regional tectonic compression. The interpretations appear mostly supported by the data, the data is of good quality, and the methods thorough in most cases. The data are high quality and this is certainly appropriate for publication in Solid Earth, and will be of interest to structural geologists, geochemists, and those working on problems in regional tectonics. One of the big contributions is the careful linkage between deformation and closed versus open-system fluid-rock interaction.

However, the reviewed version requires moderate revisions to improve the impact of the paper. I outline the major issues here, and then provide some line-by-line comments below.

1) Writing: This paper needs a thorough technical edit paying particular attention to grammar, tense, subject-verb agreement, over-reliance on the passive voice, general clarity of sentences. Also, it still reads like it was prepared by multiple authors with different styles, and without careful review. In the line-by-line comments I point out many of the grammatical problems, but by no means are these comprehensive.

2) Organization: The presentation style of method-results, method -results, etc. is quite distracting to this reviewer. The authors state in the paper that this is intentional with the goal of improving clarity. However, in order to follow all of the different and related data sets, it is very distracting to switch gears to reading another methods summary. True, I could skip over, but I would rather have the option of reading a single methods section, and a single results section. Also, this has resulted in some of the methods sections actually containing results, so they are merging together in some places. This is a relatively complicated data set to understand as a reader, so the organization needs to be strong.

3) Over-reliance on “isotopic jargon”: For clarity to non-experts and experts alike, it is important to use proper language when presenting and interpreting the isotopic results. For example, the stable isotope community prefers writing " $\delta^{18}\text{O}$ values”. Avoid use

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of depleted, enriched, heavy, and light...be specific. If using enriched or depleted, please be specific as to what is enriched with respect to what. Similarly, for the Sr - isotopes...avoid the “radiogenic” term unless being specific – for example, rather than writing that a sample is less radiogenic than another, just provide the values.. Also, the term “signature” is really overused in this paper. Be careful with its use. A stable isotope delta value is not a signature...avoid “ $\delta^{18}\text{O}$ signature of X ‰”. It is OK to use phrases like “meteoric isotopic signature”.

4) Adding numeric ages to Geologic Ages: For those of us who do not work in the Miocene, referring to the Late Aquitanian and Messinian time lacks clarity. Please include the numeric ages as well. One, this helps the reader piece together the geologic history of your study, and it teaches some of use more details of the time scale!

5) Lack of adequate support/discussion for interpretations: The interpretation of the source fluids and degree of water-rock interaction are just stated. There is little discussion or justification and no examples from the literature. Please justify your interpretations. Also, the carbon isotope data is not discussed.

6) U-Pb dating – this is outside of my expertise, but my read is that these veins only yielded limited information?

7) Clumped isotope data: The $\Delta 47$ results need to be added to Table 2 or 3, and presented in the results.

line by line

40-48: Paragraph needs strengthening...currently a 2 sentence paragraph with a really long second sentence. Suggest breaking this down for more impact.

53: comma before and

87: Define “LPS” here

90 – 91: mixing tense: are and was in same sentence

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100: This reviewer cautions the claim of “provides for the first time” . . .this is rarely true.

120-121: please provide numeric dates along with “Late Aquitanian” . . .etc. Also, should Late be capitalized?

128: consider different and more active voice for “has been considered for long”

144: Replace “Nowadays” with Currently; “undergoes” with “is experiencing”

168 – 170: This reviewer finds this format difficult to follow.

179-180: This is actually a result, not a method.

186: need parentheses around sigma 1

197: How did you do the correction due to bedding dip – that is what program, or by hand. . .

212: Can be gathered? consider different word choice

221: New paragraph at “Finally”

255: Perhaps a complicated equation like this should be a numbered one.

288: Oxygen and Carbon should not be capitalized

293 – 303: need a method citation; specify dual inlet or continuous flow; probably not 105% or would crystallize. . .or did you measure density? How long were samples equilibrated at 90C?

306: avoid using “signature” when reported delta values

307: VPDB; report consistent precision (-5.28 and 0.40 or -5.3 and 0.4) – based on your methods these should be reported to one decimal.

309: Delta values, not isotopic signatures

313: VPDB

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313, 314, 317: do not use “depleted”. . . the delta values are lower or higher

323-328: this method section seems a little incomplete compared to others. . . any citations on the method? What do you mean by “Mg-samples”. How were samples dissolved and what kind of column chemistry was conducted to create solution that is loaded onto filaments?

335: “less radiogenic” is jargon. . . stick to the values and whether they are higher or lower than others. . . radiogenic can be used in a discussion when referring to a source rock or fluid, etc., but not when reporting the isotope ratios.

342: clumped isotope section lacks citations for the methods used

352, 353: mixing past and present tense

352: carbonate = calcite, dolomite, ?

375: replace “can be” with are or were depending on what tense you want to stick with

375: what are the errors on computed temperatures?

377: which carbonate is this fractionation factor for?

382: spell out 13

381: This results section is incomplete. The data is reported in table 3, but where are the actual clumped isotope data? I cannot find them in any of the materials, just the calculated temperatures. Please provide these. Also, the text only mentions the calculated $\delta^{18}\text{O}$ value for the fluids, but do you want to also report in this text something about the oxygen vein isotope values? Perhaps this is covered prior to the methods for this section? This is an example of how the switching between methods and results is distracting to the reader.

388: include the “equation of Kim et al”

403: calcite should not be capitalized

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405 – 409: The level of detail for this method of U-Pb dating is far briefer than your second method. Please provide equivalent levels of detail.

425: define “favorable U-Pb” levels

464/465: Are these the vein sets you said you were not going to discuss further on line 211?

470: same comment – is this repetitive from line 211 or different?

483: do not capitalize cardinal directions

484: what do you mean by abnormal burial

509/510: poorly worded and repetitive sentence

529: calcite? twins

533: histories

536: Is this sentence complete? It starts with a lower case letter

537: So, this is an example of where you need to provide a discussion of why a $\delta^{18}\text{O}$ value of 5 permil supports this interpretation. Just stating this as your interpretation is not good enough.

542: same comment

549: Sentence that starts with “That” does not make any sense.

556 – 570: This paragraph is really problematic from various standpoints. First, the writing is poor – pay attention to grammar and subject-verb agreement. The use of signature is overused. The use of depleted must be changed. Be consistent with VPDB and VSMOW.

564: “characterized by negative $\delta^{18}\text{O}$ ” – so the negative sign is simply an artifact of the reference standard VSMoW. Why is a “negative” value significant here?

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559 – 562: this seems contradictory as presented. . .How do “very high signatures of the fluids” correspond to “very depleted signatures” of the cements. Where is the calculation that shows this? I am looking at Figure 8 for some help here, and it seems you are overgeneralizing. From 110 – 140 C, your plot suggests both meteoric and “basinal contamination”. . .cements from -17 to \sim -3, and fluids from \sim 0 to 15 ‰.

574 – 589: Again, pay attention to grammar. The prevalent usage of depleted, radiogenic, and signature need to be altered. Also, please provide discussion and citations for the claims that “very positive O isotope signatures” can be explained by your reasoning. This paragraph just needs reworking for clarification as it is really an integral part of your big interpretations.

590-594: This is a really long and confusing topic sentence.

594-595: consider using “difference in hydraulic head” rather than “water table height difference”

650: omit “unparalleled detail” – this is subjective to the reader

658: where are the “C isotope signatures” discussed? The $\delta^{13}\text{C}$ values are mentioned in the results and seemingly used in Figure 6, but what do they mean and how do they support the interpretations. Also where are the $\Delta 47$ data?

666-667: this last sentence is true of course, but many studies have shown this. Consider a more impactful final sentence that highlight what your study has provided.

Figures

Fig 8: Justify the 0 ‰ division between meteoric and basinal in text and with citations. This is certainly not always the case. There are sedimentary basins with $\delta^{18}\text{O}$ values that are both greater and less than 0 ‰.

Fig. 11. Please add numeric dates.

Table 2: Do not use signature in caption. These are delta values and sr isotope ratios.

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Why the change in carbon isotope precision in the table?

Table 3. See prior comments on using “signature” and please provide the $\Delta 47$ data + errors.

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