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Solid Earth Discussions

Interactive comment on "Influence of basement rocks on fluid evolution during multiphase deformation: the example of the Estamariu thrust in the Pyrenean Axial Zone" *by* Daniel Muñoz-López et al.

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Review for Muñoz-López et al. "Influence of basement rocks on fluid evolution during multiphase deformation: the example of the Estamariu thrust in the Pyrenean Axial Zone" submitted by Owen Callahan

Overview: Muñoz-López and co-authors document evolving fluid sources and conditions during multiple stages of deformation through a combination of field, petrographic, and geochemical analysis of an exhumed thrust in the Pyrenees. The manuscript is

generally well written, with only minor grammatical or stylistic edits, and the quality of the work is robust. I do think that the manuscript could be improved with relatively minor edits, specifically with regards to motivation, descriptions of geologic units, and inclusion of a better synthesis figure.

General Comments: The motivation for the study should be stated clearly and much earlier in the document. The clearest iteration that I found was on page 13, the first sentence of section 5.4. It would be helpful for this type of statement to appear in the abstract, and in the introduction.

For all the discussion of basement, the age, lithology, and metamorphic grade were only briefly discussed, and relatively late in the text. It would be helpful to expand and highlight the section on the basement geology, and specifically previously published geochemistry, instead of the broader regional tectonism. It is particularly confusing because you repeatedly refer to "crystalline basement" but we learn that the basement is composed of Paleozoic slates, phyllites, sandstone, mudstone, limestone, conglomerate, and shale in Figure 11 and at the very end of the background geology, and if these are not the basement rocks then I'm completely lost. This is perhaps relevant because the Sr data is really more about interaction with older rocks with a different radiogenic signature, not rocks that are "crystalline" or not, correct?

I would like to see a figure of chemistry/temperature/source and deformation/tectonic events through time, rather than the 3D block diagram. The source and direction of infiltration and upwelling are rather speculative, but putting your observations into a more linear, temporal framework would be really helpful for me (see for instance my quick quick sketch). Similarly, annotating the figures showing geochemistry with some additional information about the inferred timing of cements, or associated structures, would be very helpful.

What you meant by "timing" was a little misleading. At first, I assumed you were talking about relative timing from cross cutting relationships, but then you mention radiogenic

ages, but then you acknowledge that you did not get ages. . . I think it would be better to be more specific, and upfront, about these being relative ages that are broadly linked to specific styles of tectonism.

This was originally a specific comment, but I think it applies to the whole manuscript: Many hydrothermal systems are ultimately derived from meteoric fluids, and I agree that there is a clear and reasonable distinction between your cooler, younger fluids and hotter fluids, but a short sentence relating the importance of fluid-rock reaction and chemical evolution at higher temperatures and longer times would be helpful, because I think you are really making the point that you can track fluids because of that residence time at depth, not their ultimate source.

Specific Comments:

Line 13: "timing" is a bit vague here. Because absolute age in faults and fractures is such a hot topic, I think it is important to specifically describe relative ages throughout.

Lines 17-21: Crystalline basement is vague, especially in light of the abundance of low grade and unmetamorphosed rocks you show in later figures. Also, the distinction between deeply circulated meteoric and hydrothermal fluids. . . Is this just a matter of temperature or chemical evolution?

Line 33: I'm not sure how understanding past fluid flow helps use understand the current configuration of a mountain belt. Perhaps it informs the factors leading to the current configuration? Additionally, I think there is a missing comma after "through time"

Line 51: You say only a few, but cite 7 papers working on similar topics. Also, "On the other hand" does not seem necessary here.

Line 100: These are the crystalline basement rocks? I think the geologic background should be more clear about rock types much earlier.

Line 105: I'd like to see a short description of why samples were selected before

launching into all the analysis, i.e. the field methods component, which is well documented in your figures. You include a lot of structural context in "Results" but it is difficult to evaluate whether 35, 12, or 8 samples is enough without some description of the structures that are present.

Line 121: Extra comma in "then, they"

Line 138: Extra comma in "one, keeping"

Line 162: First mention of U-Pb geochronology. So is this about absolute age?

Line 191: I understand the shorthand for regional foliation being Sr, but it is unfortunate that this paper also discusses strontium. Perhaps use Sr?

Line 241: Perhaps "steeply" dipping?

Line 246: "frequently affect"? Commonly may be a better choice; frequent implies some element of time.

Lines 225-253: It may be imbedded in the figures, or I may have been tired at this point, but I felt like the cross cutting relations or structural context for sequencing was a bit week with veins and cements 3-5.

Lines 262-266: This could go in a table.

Line 301: Oh, there is NOT absolute geochronology. This passage should appear much earlier.

Line 304: An example of the basement lithologies and ages being clearly and simply defined.

Line 330. Capitalize "Calcite. . ."

Lines 355-361: Emphasis on channelized is a little confusing, because you also say that cements in different structural positions precipitated from the same fluids, which then begs the questions How wide are the fluid flow channels? Do you have samples

from inside and outside of these channels? I think this invites a lot of extra scrutiny, and as it is written it is too vague.

Lines ∼385-390: I think you do a good job defending your interpretation of fluid sources here.

Line 393: replace “than” with “as”?

Line 402: Probably the clearest statement of purpose in the manuscript.

Line 464: “Common reservoir” implies a system in hydrologic or pressure communication. I don’t think this is necessarily supported. Rather, you could claim that fluids are sourced or resided in similar basement rocks.

Lines 469-470: Great Basin and Basin and Range Province are not necessarily synonymous, but they are in this case and therefore redundant.

Line 495: Although you do include a caveat, I think the phrase “long-term” implies persistence, which is not necessarily true. I think places in the text that you describe long-term fluid flow should be revisited.

Line 790 (Table 1): alignment issue after sample C6.II in some columns impacts readability. Also check on reason for differences in significant digits for reported values of the same quantity (for instance, see d18O and d13C columns)

Line 800 (Table 2): check grammar “when is darker”. A scale bar for color might be useful so we know what is considered high or low or how divisions were made (are they quartiles, or relative to some standard?)

Line 805 (Figure 1): Including generic rock types instead of or in addition to ages would be helpful, see generic comment about describing the lithology of the basement rocks.

Line 855 (Figure 9): The relative timing of cements can be inferred from their order, but perhaps arrows on the graph showing fluid evolution over time, or some other way to relate these to types of structures or tectonic events would be useful. See general

comment about a timeline figure.

Line 865 (Figure 10): Again, this could be combined with a figure showing fluid evolution in the context of other events or structures, rather than leaving it to the reader to relate samples and setting. Add more text on the graphs to help guide me.

Line 874 (Figure 11). Shales and mudstones don’t seem particularly “crystalline”, but you refer to crystalline basement a few times in the manuscript. I can understand why dilatant crystalline rocks may be geothermal reservoirs, but why these low grade rocks? Is it just that these rocks exist at deeper, hotter depths? Brown line seems a bit high (it cuts off a few basement values), how was it chosen?

Line 885 (Figure 12). Again, I’d rather follow the changes over time, so instead of looking at changes in Mg, then Fe, then Mn. . . plot these values in the context of other events and features and then we could see what was happening with Mg when Sr goes up, for instance.

Line 890 (Figure 13). This is a fine figure, but I don’t know that it adds a great deal to the story, other than showing what you have already described fairly well in the text. If you do keep it, I think showing warmer colors for hotter fluids may be more intuitive.

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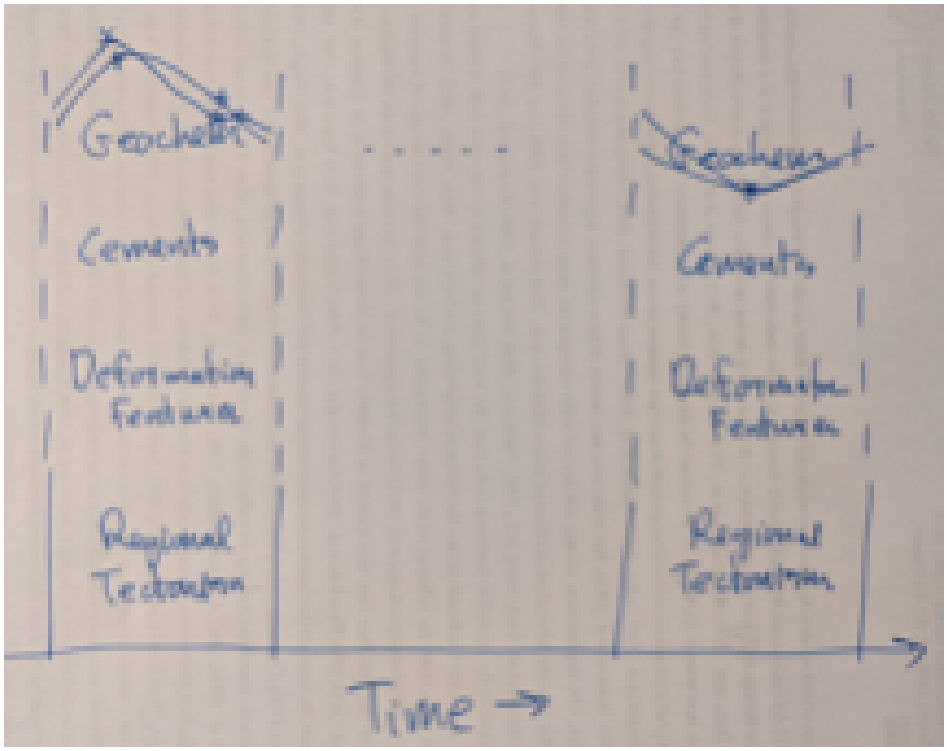
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Fig. 1.