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Comment on egusphere-2022-949

Anonymous Referee #3

Referee comment on "Rift thermal inheritance in the SW Alps (France): insights from RSCM thermometry and 1D thermal numerical modelling" by Naïm Célini et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-949-RC3, 2022

This paper presents a new dataset of temperatures based on Raman Spectroscopy on Carbonaceous Material and thermal modelling in Mesozoic and Cenozoic rocks of the southwestern Alps to unravel the thermal and tectonic evolution of this part of the mountain belt. I find this work interesting, relevant, and worth to be published in EGUsphere after some moderate revision.

However, this manuscript has some errata and contains some misleading information that I summarized below. The main issue that I find is the lack of a proper description of the geological setting, which is necessary to describe and justify the tectonic scenarios (number of rifting stages) tested for the modelling. The information is sometimes a bit disorganized along the text and the methodology description also needs to be improved. It lacks several references along the text which need to be added. In the following, I made some comments and suggestions that in my opinion will contribute to improve the manuscript and make it easier to understand for the reader.

Abstract:

L14: also Cenozoic rocks.

L20: “lower plate sediments”, do you mean sediments deposited in a basement that subducted, accreted sediments from the subducted plate? Please, clarify.

Introduction:

I find the introduction a bit short and that fails in emphasizing the relevance of this study to unravel the processes governing the accretion of sediments during collision in the SW Alps. The authors are referring frequently about the subduction processes and the accretion of sediments to the upper plate but there is none crustal-scale cross-section that shows the structure they are referring to. I also find the map of figure 1a too simplified.

The general description of the Alps and Digne Nappe is insufficient to understand the tectonic context the authors are studying. In this section I would also rather read about an overview of the geology of the western Alps and the rifting episodes with a reference to figures 1a-1c. A proper definition of the Valaisan and Vocontian domains would be useful, as the authors are often referring to them but are not properly described and are relevant to understand fig 6. Regarding the Digne Nappe, it should also be properly described in the geological setting.

It is not very clear what are the previous AFT studies considered in the study. Caption of figure 1b states that they are specified along the text, but until the "samples and method" section, there are no references. I suggest the authors include previous thermochronological studies in the caption of fig. 1, in the introduction as state-of-the-art studies, and maybe also add other reference such as Bogdanoff et al. (2000).

Geological setting:

This section needs to be reorganized. I would prefer to read first the description of the geology of the study area (crystalline massifs, nappes…) and after that, the tectonic evolution since the Jurassic. In addition, to support the 3 scenarios proposed for the numerical modelling, a more detailed explanation of the geology is needed, including a description of the cross-section of figure 1d.

L67: "Alpine arc", this term has neither been used before nor later, can it be changed to "Alps"?

L65-68: I suggest rewriting this sentence: "The second, Late Jurassic-Early Cretaceous in age, appears synchronous with the rifting of the Bay of Biscay and led to opening the Valaisan domain to the NE of the Alpine arc and renewed extension in the so-called Vocontian Trough of the SW Alps" to avoid confusion about the extensional phases affecting the NE and the SW Alps. In addition, is it relevant to mention the rifting of the Bay of Biscay here? In case it is, you need to provide references.

L83: "Helminthoid flysch" is only used here, is this relevant for the study? If not, I suggest to remove it. "sub-Briançonnais" does not appear in Fig. 1a, 1b, only Briançonnais, what do you mean with "sub"?

Samples and methods:

L98: Add the number of samples in the beginning of the section.

L99: replace “in rare occasions” for something like: “additionally, two samples were collected in Eocene limestone”.

L110: “… of the existing low-temperature fission-track analyses…”, add apatite before fission-track.

Subsection "Numerical modelling with basin model":

I would rather read first about the software used for the modelling and the parameters chosen, than the scenarios tested. As I am not a user of this software, a brief description of the input parameters, processing and outputs would be very useful.

L127-129: - “Mirabeau well” add the reference to figure 1b.

“We infer that it is 3 km at the Digne thrust front (Fig. 1b).” This sentence is a bit odd, re write, please.

L142-143: “crustal basement with homogeneous properties”, in base of what? A continental crust could be very heterogeneous in terms of lithologies, and therefore, feature different density values. A crystalline crust could imply densities ranging from 2.7 to 3.4 g/cm^3 (e.g., Barton, 1986; Rudnick and Fountain, 1995). Other type of models assumes a homogeneous crustal density that increases with depth between 2.6 to 3 g/cm^3 (Torne et al., 2015). At lease, provide a reference that supports the value chosen.

For table 1 provide also references and justifications for the values chosen.

Results:

L167: define the acronym AFT before. In addition, add a reference of the AFT study in this sentence.

L169: Add the reference for the geothermal gradient assumption. For instance, Bigot-Cormier et al. (2006) considered a present geothermal gradient of 25-30 ºC/km, and Valla et al. (2011) considered a gradient of 25 ºC/km.

L181: replace to something like: "the comparison between the temperatures derived from RSCM data and from the numerical modelling…".

L185-186: fig. 3 shows the results for the 3 scenarios, and figure 4 shows the two-rift scenario and one site for the no-rift scenario. Please, be precise.

L205-209: the CAS section is here explained as only burial during the Cenozoic, but how does this fit with the tectonic framework of the rest of the sections which are also located in the Digne Nappe and closer to it (e.g., DGN and CLN)? Maybe a cross-section along this area will help to understand the structure and discuss it more thoroughly…

L211: "affecting the samples in nature", what do you mean?

Discussion:

Here I miss some discussion about the CAS section and why it is assumed to have experienced a constant geothermal gradient of 30ºC/km if it is also located in a rifted margin.

I would like to have some more information/discussion about the paleogeographic reconstruction of fig. 6 regarding the location of the rift axis, and transfer zones. It could also help to include in fig. 6a the location of the study sections. I am aware that they are already included in fig. 6b, but its tentative position in the map would give the reader a better spatial location of the dataset. In addition, a more detailed description of fig. 6b is needed. That would also help to address my previous comment on the explanation of section CAS.

L232. Geothermal gradients of 80-90 ºC/km in the Pyrenees led to high-temperature metamorphism (Ducoux et al., 2021, a reference that the authors cite), and it is accompanied by mantle exhumation to the base of the sedimentary basin or even to the seafloor (e.g., Lagabrielle et al., 2010; DeFelipe et al., 2017, 2019; Teixell et al., 2018). The rift domains defined there, and the role of transfer zones are topics that are being highly discussed. If you want to make a proper comparison with the tectonic setting of the Pyrenees (and Bay of Biscay as they also mention it without any reference in L66), you

need to add more refences and discuss all these topics.

Therefore, in your study area, how was the rift system? Which rift domains are described? Is there any evidence of mantle exhumation? To the east of their study area, ophiolite complexes include serpentinized peridotites with ophicalcite (e.g., Lafay et al., 2017).

In Figure 6a, thinned continental crust is divided into "thinner" and "thicker", can you provide a thickness estimate? Can you also indicate this in fig. 6b? How is it related to the domains of a rifted margin? (e.g., Tugend et al., 2015, a reference that the authors cite).

Figure 6 can also be enlarged.

Conclusions:

The authors would better summarize their main results here: samples collected, paleotemperature data, scenarios modelled and chosen as representative, and geothermal gradient estimations.

Figures:

Figure 1: please reorganize the figure to have image "1a" in the top left part of the figure.

1b: - What do broken red lines indicate?

- Please, change the colour of the stratigraphic sections (DEV, SLC, …). They have the same colour as the reconstructed isopachs.

- Add the definition of the acronym AFT for apatite fission track in the caption.

Figure 2: rewrite the caption. Suggestion: "stratigraphic sections along the front of the Digne Nappe with the RSCM-derived peak temperatures".

Figure 3: define the tectonic models as two-rifts, one-rift, no-rift along the text to homogenize terms. Place this figure after it is first called (so after L180). Check spelling of color/colour in the caption.

Figure 4: change the tables of each diagram to something like: “thickness of the crust” and “thickness of the lithospheric mantle”. Otherwise, it looks confusing (thickness vs. time).

Figure 6: in the last two lines of the caption: “dashed lines”, can you provide a tentative value for each isotherm colour?

In fig. 6b the stratigraphic sections are projected for reference, but I suggest projecting them also on the map of fig. 6a. In the legend, separate the “cover” box into Jurassic and Cretaceous.

Other (minor) comments:

L25: “ Where details of basin evolution are lacking high-temperature record…”, add a comma after lacking.

L55: “This study combines 80 new RSCM measurements…”, remove the word new.

L79: “currently running between the variscan…”, remove currently.

Along the text, the Digne Nappe is referred to with different names: “front of the Digne Nappe”, “Digne thrust front”, “Digne frontal thrust”, “Digne thrust sheet”, and “Digne main thrust”, please, unify. Please, do the same for “Vocontian Trough”, “Vocontian domain”, “Vocontian-Valaisan rifting”, “Valaisan extensional domain”, “Valaisan rift”, “Valaisan domain”.

L198: “the Earl**y**-Middle Jurassic” add the "y".

L221: add **geothermal** before “gradients are about 80-90ºC/km”.

L225-226: from where does the β-factor comes from? Literature or your own modelling?

L276: remove the in “between the Europe and Adria”.

References:

Barton, P. J. (1986). The relationship between seismic velocity and density in the continental crust — a useful constraint?, Geophysical Journal International, Volume 87, Issue 1, October 1986, Pages 195–208, https://doi.org/10.1111/j.1365-246X.1986.tb04553.x

Bigot-Cormier, F., Sosson, M., Poupeau, G., Stéphan, J.-F., and Labrin, E. (2006) The denudation history of the Argentera Alpine External Crystalline Massif (Western Alps, France-Italy): an overview from the analysis of fission tracks in apatites and zircons, Geodinamica Acta, 19:6, 455-473, DOI: 10.3166/ga.19.455-473

Bogdanoff, S., Michard, A., Mansour, M. and Poupeau, G. (2000), Apatite fission track analysis in the Argentera massif: evidence of contrasting denudation rates in the External Crystalline Massifs of the Western Alps. Terra Nova, 12: 117-125. https://doi.org/10.1046/j.1365-3121.2000.123281.x

DeFelipe, I., Pedreira, D., Pulgar, J.A., Iriarte, E., Mendia, M., 2017. Mantle exhumation and metamorphism in the Basque-Cantabrian Basin (N Spain): Stable and clumped isotope analysis in carbonates and comparison with ophicalcites in the North-Pyrenean Zone (Urdach and Lherz). Geochemistry, Geophys. Geosystems 18. https://doi.org/10.1002/2016GC006690

DeFelipe, I., Pedreira, D., Pulgar, J. A., van der Beek, P. A., Bernet, M., & Pik, R. (2019). Unraveling the Mesozoic and Cenozoic tectonothermal evolution of the eastern Basque-Cantabrian zone–western Pyrenees by low-temperature thermochornology. *Tectonics*, 38, 3436-3461, https://doi.org/10.1029/2019TC005532

Lafay, R., Baumgartner, L.P., Schwartz S., Picazo S., Montes-Hernandez G., Vennemann T. (2017). Petrologic and stable isotopic studies of a fossil hydrothermal system in ultramafic environment (Chenaillet ophicalcites, Western Alps, France): Processes of carbonate cementation, Lithos, Volumes 294–295, Pages 319-338, https://doi.org/10.1016/j.lithos.2017.10.006.

Lagabrielle, Y., Labaume P., de Saint Blanquat, M. (2010), Mantle exhumation, crustal denudation, and gravity tectonics during Cretaceous rifting in the Pyrenean realm (SW Europe): Insights from the geological setting of the lherzolite bodies, Tectonics, 29, TC4012, doi:10.1029/2009TC002588.

Rudnick, R. L., and Fountain, D. M. (1995), Nature and composition of the continental crust: A lower crustal perspective, Rev. Geophys. 33(3), 264-309, doi:10.1029/95RG01302.

Teixell, A., Labaume, P., Ayarza, P., Espurt, N., de Saint Blanquat, M., Lagabrielle, Y., 2018. Crustal structure and evolution of the Pyrenean-Cantabrian belt: A review and new interpretations from recent concepts and data. Tectonophysics 724–725, 146–170. https://doi.org/10.1016/j.tecto.2018.01.009

Torne, M., Fernàndez, M., Vergés, J., Ayala, C., Salas, M.C., Jimenez-Munt, I., Buffett, G.G., Díaz, J., 2015. Crust and mantle lithospheric structure of the Iberian Peninsula deduced from potential field modeling and thermal analysis. Tectonophysics 663, 419–433. https://doi.org/10.1016/j.tecto.2015.06.003

Valla, P. G., van der Beek, P. A., and Braun, J. (2011). Rethinking low-temperature thermochronology data sampling strategies for quantification of denudation and relief histories: A case study in the French western Alps, Earth and Planetary Science Letters, Volume 307, Issues 3–4, Pages 309-322, https://doi.org/10.1016/j.epsl.2011.05.003.