Answer to the comment https://doi.org/10.5194/egusphere-2022-949-RC1, 2022

First, the co-authors would like to thank the Anonymous Referee for its thorough comments on the manuscript and its detailed reading of it.

**Abstract**

L14: also Cenozoic rocks.
L14: Ok. We added Eocene to show the range of stratigraphic ages explored in our study.

L20: "lower plate sediments", do you mean sediments deposited in a basement that subducted, accreted sediments from the subducted plate? Please, clarify.
L20: Modified. We now specify that we are dealing sediments accreted from the downgoing plate.

**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 introduction does not aim to present the geology of the Alps, including a lithospheric-scale section of the Alps. We think the section shown in Fig. 1D presents most of the informations on the structure we need in introduction (main thrusts, tectonic units and strtigraphy) and the geological context. A precise description of the Alps is not relevant in the introduction but it can be found in the geological context.

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.

We reorganised and included a more lengthy presentation of the geological and tectonic evolution. These modifications are also based on comments by RC1.

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).

We added the references for thermochronological data in the caption of Fig. 1. We did not add the reference to Bogdanoff et al. (2000) because it is not relevant. Here, we are interested in providing constraints on the eroded cenozoic cover above the Digne Nappe not to present the timing of exhumation in the External Massifs which are all reset for AFT.

**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.

We added a brief description of the different units before describing the geological history of the Alps.

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.

L 67 and 65-68: the sentences have been modified as suggested by RC3 and other comments (RC1 and RC2).

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"?
L 83: We decided to let the word Helminthoid Flysch because it a so-called name for these formations known by every geologist familiar with Alpine geology.
Regarding the use sub-Briançonnais it means units very close to the Briançonnais units. It is also a so-called name of tectonic units in the Alps. It was mentioned in the caption of Fig. but we added another occurrence in the caption for more clarity.

**Samples and Methods**

L98: Add the number of samples in the beginning of the section.
L 98: modified as suggested.

L99: replace "in rare occasions" for something like: "additionally, two samples were collected in Eocene limestone".
L 99: modified as suggested.

L110: "… of the existing low-temperature fission-track analyses…", add apatite before fission-track.
L 110: modified as suggested.

**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.
L 127-129: modified as suggested.

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.

The thermal constants chosen for the sedimentary cover are typical values used in basin modelling approach, and they are those already implemented in TemisFlow. We chose to provide details of thermal parameters in the sedimentary cover because they correspond to the lithologies found along our stratigraphic sections. In contrast, the basement is treated as homogeneous with a granitic composition. This is obviously an approximation that is justified by the lithospheric scale.

**Results**

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

L169: Add the reference for the geothermal gradient assumption. For instance, Bigot-Cormier et al. (2006) considered a present geothermal gradient of 25-30 °C/km, and Valla et al. (2011) considered a gradient of 25 °C/km.
L 169: We have added refs to these studies. We note that these estimated gradients have their own limitations.

L181: replace to something like: "the comparison between the temperatures derived from RSCM data and from the numerical modelling…".
L 181: modified as suggested.

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.
L 195-186: modified for avoiding misunderstanding.

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…
L 205-209: Agreed. As also suggested by RC1 and in order to keep the interpretation as consistent as possible between nearby samples, we modified the discussion on the CAS section.

L211: "affecting the samples in nature", what do you mean?
We rephrased this part of the ms.

**Discussion**

Here I miss some discussion about the CAS section and why it is assumed to have experienced a constant geothermal gradient of 30°C/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.

Interpretation of the CAS has been modified and we agree with the reviewer that CAS thermal record also fit with CAS being positioned on the rifted margin. We added the reconstructed positions of the sections along with the restored Digne Nappe in Fig. 6A.

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).
In addition to Vacherat et al. 2024, only a few studies actually esitmated geothermal gradients (Hart et al., 2017 and Saspiturry et al. 2020). We however cite Ducoux et al. 2021 for reference to HT metamorphism.

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.
We do not intend to make a comparison with the Pyrenees or to discuss the issue of transfer zones. We just mention here the Pyrenees because the system is pretty well understood.

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).
Our models show that we don't need crustal break up and mantle exhumation to reproduce our data.

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).

These informations are already provided in the text.

Figure 6 can also be enlarged.

XXXXX

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

**igures:**

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.

We corrected the figure and provide details that were lacking.

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

Done.

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.

Done.

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).

Modified as suggested.

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

Modified as suggested.

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.

The projection of the sections has been added in the palaeogeographic map, as suggested.

**Other (minor) comments:**

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

Modified.

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

Modified as suggested.

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".

We homogeneised through the text.

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

Done.

L221: add **geothermal** before "gradients are about 80-90°C/km".

Done through the whole text.

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

They are calculated from our models values. We added a precision in the text for more clarity.

L276: remove the in "between the Europe and Adria".

Modified.