Solid Earth Discuss.,
https://doi.org/10.5194/se-2019-158-AC2, 2020

Solid Earth
Discussions

Interactive comment on "Large-wavelength late Miocene thrusting in the North Alpine foreland: Implications for late orogenic processes" *by* Samuel Mock et al.

Samuel Mock et al.

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Received and published: 2 May 2020

Dear editors, dear referee,

We thank the referee for his detailed and constructive comments on the manuscript. The referee is an expert in structural geology and on the tectonics of the Alps. We very much appreciate the suggestions and criticism brought forward by the referee and are convinced that with the revisions now implemented we can present a strongly improved version of the manuscript.

Based on the reviewer's comment we carefully revised the manuscript and adjusted the

text and the figures following the reviewer's suggestions. Where appropriate, we added references to literature, which we have not considered in the original manuscript. We carefully revised section 5.2.2 following the second referee. This section deals with the geodynamic implications for the Central Alps. We are convinced that we can now present a more robust discussion on this topic. Furthermore, we updated section 5.1 on the mechanical stratigraphy and its influence on the trusting pattern.

Being aware that each referee sets a different focus during his review, we are convinced that we can present now a well-balanced revision, which meets the requests and suggestions of both referees.

Extensive replies (R) to the reviewer's comments (C) are given below.

With kind regards on behalf of the authors,

Samuel Mock

General comment

C: This paper documents the thrust-related exhumation of the Subalpine Molasse during the late Miocene made by interpreting the thermochronometry results of 13 apatite (UTh-Sm)/He, contextualizing them into the regional structural geology and trying to make an upscale comparison with the broader geodynamics at the disputed transition between the western and eastern sector of the European Alps. As far as I know, the manuscript has not been published previously. The title is conforming with the contents of the Ms and the approach and results and conclusions intelligible from the abstract alone. I have proposed some changes in the text organization and minor changes in figures. The manuscript presents an interesting topic, which should catch the attention of the readers of Solid Earth. It is based on some fieldwork and it is quite well structured although field evidences would deserve a to be more deeply described. I found the results too short with respect to the discussion and the Introduction part. If

the aim is the attribution to the large-wavelength deformation style as responsible of exhumation in the Alpine thrust front, solving the upscaling problem is crucial. In that case, the authors could consider in their review to contextualize their study area on broader regional map and make considerations on the structures that have allowed exhumation. So far, they are not well documented in this paper. I found interesting the mentioned change of deformation with the lithotype involved in the Molasse units (i.e. conglomerates, sandstones, pelites), but it was not shown as it is in the field or tightly described as referred to the figures. In reinforcing the results section, this topic would be easily solved by the authors that have a great knowledge of the area and could possibly be strengthen in the discussion as associated to the exhuming structures (see later in the detailed comments). I found the geodynamic part not so essential for the general implications of the paper that would anyway fit, without it, a large public when the thermochronometric interpretation will be presented with a reinforced documentation of the thrust-related exhuming structures. After all, the general slab dynamics are still so debated as they nicely reported. The regional role of their structure is to me more interesting and could provide general information on how exhume at a thrust front a proximal molassic deposit affected by lateral facies changes. Notwithstanding these potential limitations, and considering that addressing these would lie beyond the intended scope of the manuscript, I feel that the paper needs some more work to have that detail for making an informative and well-balanced account that deserves publication in Solid Earth.

R: We thank the reviewer for the assessment of the manuscript and the suggestions. In the new version of the manuscript we have accommodated the points as follows:

- We updated section 5.1 regarding the mechanical stratigraphy along and across strike and its influence on the thrusting pattern in the Subalpine Molasse. We gladly follow the advice by the reviewer and added a section about the litho-tectonic architecture of the Subalpine Molasse in the Lake Thun area to the results, thus also extending the results part of the manuscript. However, as this paper has to some extent a review character

the remaining imbalance between the results and the discussion part is expected, since corresponding results from other studies are embedded in the discussion part of the manuscript.

- In order to put our sampling area and its significance into the broader context of the Central Alps, we added information about why we consider the Lake Thun area as a key area for understanding Subalpine Molasse tectonics (section 3.1 of the revised manuscript).

- We have carefully revised the part of the manuscript regarding the link to the geodynamic context. Based on the comments of both reviewers we have strengthen section 5.2 of the revised manuscript.

Please see our detailed responses to the technical points raised by reviewer below.

Major points of strength/weakness

C: There are some points where a revision is necessary. In general, the Ms needs just some iteration to enrich a few aspects of the text in the results and shorten the geological setting, updating the literature with respect to the recent works (see detailed comments). The references are quoted finely although lacking of an update on some of the more recent works on the Pennine and Helvetic nappe emplacement recently reported in the Swiss literature and Alps). I found only a reference to check, the rest should be fine. The upscaling to faultâARfault and regional (and eventually) geodynamic setting relationships at map scale needs to be somewhat better shown. That could be due by following the more detailed suggestions and if possible including additional changes to figures combining simplified crossâARsections, mostly in the results. I have suggested some minor changes in the rest of the text. I believe that length is fine at this first review. Tables and figures look fine. Supplementary Data are used appropriately.

R: In our new version of the manuscript, we have accommodated all these comment. We have revised the geological introduction and updated our reference list and have revised the section on bridging the scales. See also detailed comments for more extensive replies.

Technical points

Suggestions for improving technical points have been provided with detailed comments that will help preparing the next version of the manuscript.

C: Page 1 – Abstract Line 20. tectonic forces: you can be more specific; Line 20. This resulted in a change: you may wish to specify what change you imply (i.e; time and space?)

R: We changed the sentence respectively to further specify that the change occurs from a buoyancy-driven tectonic regime, here referred to as vertical tectonics, to horizontal tectonics related to compressional forces and plate tectonics.

C: Page 1 – Introduction Line 26. Davies and von Blanckenburg, 1996 in the reference list

R: Davies and von Blanckenburg (1995) is already given in the reference list. As far as we are aware, there exists no Davies and von Blanckenburg (1996) publication.

C: Line 28. To consider eventually further on, you may wish to consider as well the implications related to asymmetric slap polarity with respect to the westward drift of the lithosphere (e.g. Carminati and Doglioni, 2012) in the frame of changes in the subduction polarity across the alps. Carminati, E., & Doglioni, C. (2012). Alps vs. Apennines: the paradigm of a tectonically asymmetric Earth.Âa ÌĘEarth-Science Reviews,Âa ÌĘ112(1-2), 67-96.

R: This is an interesting paper and the westward drift of the lithosphere is point, which

could influence the stratigraphic development of the Molasse. We mentioned this mechanism in the revised version, but decided not to fully discuss these processes as we expect a major signal east of Salzburg, which is beyond the scope of our paper.

C: Page 2 – line 3. considering the relevance of this concept and that you have it also in the title, you may consider to shortly describe what is large-wavelength deformation and to what is usually referred to.

R: The word wavelength describes here in relative terms the spatial extent of a certain process or feature, in this case tectonic processes. In order to clarify what type of wavelength we are referring to, we added the word “spatial” in the revised version of the manuscript. In the same sense, large-wavelength deformation describes the spatially large extent of a certain deformation event.

C: Line 4. North Alpine foreland basin - eg. citation Pfiffner 1986

R: Pfiffner (1986) is already listed here.

C: Line 12. have a look at Egli 2017, 2019 and Cardello et al. 2019 JSG on the nappe emplacement during Oligocene to Miocene time. In the latter, you can find also some more references if you find them interesting.

R: Many thanks for hinting us to these publications. However, we could not find a publication by Egli et al. (2019). We are aware that there are more publications which look into the timing of Alpine nappe emplacement. However, we want to address here the studies, which specifically addressed the deformation history of the Alpine foreland, i.e. the Subalpine Molasse, Plateau Molasse, Foreland Molasse, and Jura Mountains. We added an “e.g.” to the list of references in order to show that our selection is incomplete. We cite the study by Cardello et al. (2019) later in the manuscript.

C: Line 15. You may cite who was directly the first stating the link between ECM exhumation and Jura thrusting.

R: We added Laubscher (1961) and Boyer and Elliot (1982) to the list of references, as

these publications are to our knowledge among the first which made the link between ECM exhumation and Jura thrusting.

C: Line 25. You can cite a few works here who have so far the attempted to fulfil this aim? and why they did not succeed completely.

R: We added Burkhard (1990)

C: Page 3 – Line 6. which at a larger scale is also due to the curvature of the Alpine arc.

R: Between Lake Geneva and Salzburg, where the Subalpine Molasse is outcropping most prominently, the Alpine arc is not curving that much. Furthermore, we talk here specifically about local-scale variations in deformation styles, which occur over just a few kilometers.

C: Page 4 – Line 8. more recent studies to mention would be appreciated. You can find a summary of previous works in Cardello et al. 2019 (journal of structural Geology)

R: We added some text and the reference in the revised manuscript.

C: Line 16. You can possibly mention the role of the Penninine nappes. You can find references in the Matzenauer's thesis http://doc.rero.ch/record/32247/files/MatzenauerE.pdf and in the work of Jon Mosar.

R: We added information and references about the emplacement of the Penninic nappes in the preceding paragraph.

C: Line 18. see also Glotzbach et al. 2008..., Mancktelow and Seeward, Campani (Simplon), Cardello and Mancktelow 2014, Egli et al. 2016, 2017.

R: Thank you for hinting us to these interesting publications. We added here Egli et al. (2017) and Glotzbach et al. (2011). Cardelloand Mancktelow (2014) is a very interesting paper about syn-sedimentary normal faulting during the Cretacous in the Wildhorn nappe. However, we don't think that it is here a suitable reference with respect

to the Miocene exhumation history of the ECMs

C: Line 25. you mean prism growth? orogen-parallel to perpendicular stretching: have a look at Mancktelow's work on the Simplon Fault in the Central Alps.

R: We simply mean that in the late stages of the Alpine orogeny, deformation propagated into the Alpine forelands (comprising also the Subalpine Molasse and the Jura FTB). This goes together with a general widening of the orogen perpendicular to its strike, as the deformation front steps outward.

C: Line 28. isn't this a repetition from above?

R: We deleted this sentence in the revised version of the manuscript.

C: Page 5 – line 2. they are deposits derived from the progressive erosion of the Alps since...

R: Thank you for clarification. This has been changed accordingly.

C: Line 5. is this a distinction from Sinclair et al. 1991?

R: We define here the nomenclature for the Molasse Basin which we use throughout the manuscript. This is not a distinction from Sinclair et al. (1991). The term Foreland Molasse is generally used in German and Austrian literature and describes the portion of the Molasse Basin which is not detached from its substratum. Contrary to that, the Plateau Molasse describes the detached part of the Molasse basin and is mainly used in Swiss literature. Throughout the manuscript, we use the term "Subalpine Molasse" instead of "imbricated Molasse". The former term is mainly used in the Swiss literature, while the latter is used predominantly in German and Austrian literature.

C: Line 12. you may find interesting reading this thesis of Tobias Ibele, where you can find useful references and some fine detailed work on the high angle faults and structures of the Swiss Molasse. https://doc.rero.ch/record/28382

R: We are aware of the thesis of Ibele (2011). However, he mainly focuses on the

gently deformed Plateau Molasse, whereas this study has its focus on the imbricated and folded Subalpine Molasse. We correctly cited here the relevant work describing the geometry and architecture of the Subalpine Molasse.

C: Line 21. due to tear faulting or?

R: This is rather due to the existence or non-existence of an evaporite-cored décollement level within the Triassic units. With the development of the Jura FTB, a fundamental change in the tectonic setting of the Molasse Basin occurs. While the western Molasse Basin became detached above an intra-Triassic décollement zone, the eastern Molasse Basin remained in a non-detached configuration.

C: Line 26. Have a look at Fox's works http://www.ajsonline.org/content/316/6/505.short https://pubs.geoscienceworld.org/gsa/geology/article/43/5/379/131816/Rapid-exhumation-in-the-Western-Alps-driven-by

R: We added Fox et al. (2016) as they also describe fast exhumation for the same time window.

C: Line 28. paleomagnetic indications from Cardello et al. 2016 have shown similar indications in that sense, being the most recent ones associated with the Rhone-Simplon faulting in the ECM rear.

R: We thank the reviewer for hinting us to this publication. However, we think that this topic dealing with inneralpine deformation structures is not so evident with this respect to the Alpine front in the Molasse.

C: Page 6 – line 16. As so far you were mentioning time in Ma, you can help the reader by providing the age constraints in Ma to the two corresponding megasequences.

R: We adjusted the text accordingly.

C: Page 7 – Line 3. Why there are only 12 samples on the map of Fig. 3 and on Fig. 4 and here 13 samples?

R: Thank you for spotting this error. We adjusted the text accordingly.

C: Line 4. some are strangely positioned within the crystalline basement with no displacement associated to them. You may also consider about drawing the basal thrust trajectory as it is widely accepted that the basal thrust of the Jura is branching off the Alps thus at the base of the Molasse mesozoic cover. Further please have a look at the cross-sections B-B' and C-C' for the upper thrust and explain why, in your interpretation, is not propagating in this sections as in the A-A' cross-sections.

R: We don't quite understand. No samples are positioned in the crystalline basement. All the samples are were collected at the surface and are from the Molasse deposits. In the revised manuscript, we added the intra-Triassic décollement zone as a stippled line. Regarding the differences in the tectonic style and thrust geometries from west to east please see the discussion part in section 5.1 of the manuscript.

C: Line 28. Very minor question: can the Saxon genitive be used in Solid Earth?

R: Yes, we think so. As far as we know, there are no guidelines regarding this issue.

C: Page 9 – line 25. notice of little importance, would you choose Aar or Aare? Please consider if it should be called Aar valley and Aar Massif consistently.

R: Both "Aare Valley" as a geographical term as well as "Aar Massif" as a geological term are well established, so we remain with them. The reasons for this difference are unknown to us.

C: Secondly, there are strike slip fault traces which could help partitioning the deformation at the edge of the Pennine Salient. You may consider mentioning them as one of the causes of different styles of deformation at the thrust front. By the way, in the block diagram they are not dashed but they are a continuous line crossing different structural units also in the more external part of the basin in the map. Possibly you have them in an en-echelon disposition and they have recorded right-lateral kinematics. If you have some measurements to add on that it would be great although not extremely necessary

for the purpose of this work.

R: As we mention in the manuscript, strike-slip faults have been proposed by some authors (Mock and Herwegh, 2017; Pfiffner, 2011; Vollmayr, 1992) to run along the Aare valley and the Lake Thun axis. This is mainly based on the interpretation of seismic lines and the observation of distinctive differences in the tectonic architecture west and east of the Aare valley. However, the quality of the corresponding seismic lines is very limited due to (i) the thick Quaternary cover resulting in a very poor signal to noise ratio and (ii) the poorly resolved Molasse strata as a result of the frequency, which was chosen in order to optimize for the targeted Mesozoic horizons below. We added some more information in the revised version of the manuscript.

For a quality assessment of the 2D reflection seismic data please refer to Mock and Herwegh (2017; Tectonics). By using the mechanical stratigraphies, i.e. the stark contrast in the well mapped lithologies east and west of the Aare valley to explain the E-W differences in the tectonic architecture, it is not necessary to invoke a strike slip fault. Instead, we can present a better constrained solution to explain the E-W differences in the Lake Thun area, one of the key areas of the Subalpine Molasse.

C: Page 10 – line 1 and 9. Aare valley

R: see reply to comment above

C: Line 8. would that fit with a lateral ramp similar to what experienced at the sw edges of the Molasse basin on the NNE-striking Vuache Mountains (see Charollais works), where you find a transpressive ramp overthrusting the carbonates on top of the Aquitanian sandstones of the Rumilly Basin?

R: The Falkenfluh-anticline is a thrust fault which dies out towards the east where mechanically stronger conglomerates are present. Strain is probably accommodated along thrusts further south. Hence, we probably have an en-échelon pattern here which resulted due to the lateral change in the mechanical stratigraphy. There is no need for

a lateral ramp. However, since the lateral distribution of mechanically weak lithologies is rather heterogeneous, we can expect that intra-Molasse décollement levels change laterally. Hence, in general, the occurrence of lateral ramps is very well possible.

C: Line 12. This is more of a result and would be nice to show if there is any space and if it is useful to support discussion.

R: We appreciate the reviewer's comment and are fully aware that it is not always so simple to decide whether something belongs into the results or the discussion part of a manuscript. We shortly describe the distribution of the lithotypes already on the description of the sampling area. Here, it is important to take this information up again in order to bring clarity to the discussion.

C: Line 16. constant through part of the dataset (specify please the samples you want to point at).

R: We added the corresponding sample numbers.

C: Line 17. can you please explain a little more on the relationship between deformation style and exhumation pattern, why should, in your case, one influence the other? Considering this is a crucial point of the paper you could show them as they are in the field and make a schema that shows this relationship (optional) and decide to put it here or in the introduction, depending if you want to make it a starting hypothesis or a proven outcome of your work.

R: This is a very important point, and we thank the reviewer for raising it, as we really want to convey the right message. It is not so much the exhumation which is controlled by the mechanical stratigraphy but rather the thrusting pattern and hence the geometry of the thrust belt itself (which arguably of course then influences exhumation). We can expect that we have a clearer picture of exhumation ages where we have large tectonic slices which were thrusted en-bloc, since we can clearly attribute multiple ages to one tectonic slice. In a sand- and mudstone dominated scenario, we observe more narrowly

spaced thrusts and the identification of tectonic slices is much more difficult. Hence, in this case it is not so straightforward to attribute exhumation ages to tectonic slices. The important point here is that although we can observe at least two exhumation events at ca. 10 and 6 Ma along the Subalpine Molasse, the location and geometry of the thrusts along which the rocks were exhumed are changing along-strike due to lateral changes in the mechanical stratigraphy. Please see our changes to the text in section 5.1 in the revised version of the manuscript.

C: Line 29. ‘s genitive Saxon, as above a very minor comments: can that be used in Solid Earth?

R: Yes, see also reply to comment above

C: PAGE 11 – line 14. what type of association?

R: We changed the sentence to make it clearer.

C: Line 15-16. is that a repetition?

R: Not as such. While we briefly mention break-back thrusting already in section 2.2, we pick it up here again in order to further elaborate the related mechanisms in this discussion part of the manuscript.

C: Line 19. is that implying that the backthrust was longer active and that was occurring over 16 Ma?

R: We see break-back thrusting starting at ca. 12 Ma, hence postdating the activity of the frontal triangle zone, which includes the frontal backthrust.

C: Line 25. In the next section, you dig some more into this concept but maybe this statement occurs too early here

R: We think since section 5.2.1 discusses the link to the exhumation of the ECMs, this statement is important here as it acts as a concluding remark of this section.

C: Line 30. please add some more references from Pfiffner et al. 2011, Egli et al. 2016, 2017 and the model of Cardello et al. 2016 and 2019. And more references more to the east?

R: We thank the reviewer for pointing out these papers and we have updated our work with articles, which we did not consider in the previous version. We specifically mentioned the Cardello et al. work where we discussed the Alpine processes in a broader context.

C: Page 12 line 14. you may find interesting having a look also at more recent findings ot out-of-sequence thrusting of the Pennine Nappes over the European foreland and the flip back to in-sequence thrust propagation in this time frame.

R: We thank the reviewer for his input. This is an interesting mechanism. However, we lack the required information from the Molasse basin to link these processes with the constraints we have from the basin.

C: Line 21. you may have a look also at recent papers on the Helvetic alps (2016 geological society of london)

R: We thank the reviewer for his input. However, we do not see here the immediate link of this publication with our work. The aforementioned article concerns the formation of the Rawil Depression based on findings from paleomagnetism and structural data, and we lack the required information to draw a straightforward link to our work.

C: Line 24 genitive Saxon

R: see reply to comment above

C: Line 26. indeed, Megathrust reactivation (Cardello et al., 2019) corresponds with the convergence rate deceleration from about 1.6 cm/a to âLij0.9 cm/a at âLij28 Ma reported by Stampfli et al. (2002) and recently discussed in the Journal of Structural Geology.

R: We discuss here the reported decrease in convergence rates at ca. 20 Ma.

C: Line 30. specify here please if related to strike-slip and/or reverse kinematics

R: Thank you for raising this point. The rise of the ECMs occurred along steeply dipping reverse faults. This occurred however in conjunction with strike-slip faulting as a consequence of strain partitioning in a transpressive framework. We added this information in the text of the revised manuscript.

C: Page 13 – line 6. How is that fitting with AlpArray tomographic results?

R: Thank you for this important remark. New tomographic results from the Eastern Alps (Hetényi et al., 2018) image the deep lithospheric structure at 13.3°E longitude and the author propose the presence of a steeply north-dipping slab being attached to the Adriatic plate. However, such an interpretation is highly debated (see section 5.2.3). We added the reference of these new findings here.

C: Line 12. Is that your observation or needs a citation?

R: We added the missing references here.

C: Line 22. You may wish here to specify what you mean as individual tectonic pulses? Why should have a broader implication related to plate tectonics or slab dynamics?

R: By tectonic pulses we refer to distinct thrusting events which can be traced by means of AHe dating at least from Lake Thun to Lake Constance. In order to clarify this, we added "i.e. distinct thrusting events" in the revised manuscript. However, the main point is that the large spatial wavelength (i.e. continuous over large distances) of these thrusting events needs also a major contribution of a large-scale driving force, such as plate tectonics or slab dynamics. We have clarified this in the revised manuscript.

C: Line 25. wouldn't be the other way around: the segmentation in the thrust front being the result of a change in the slab retreat dynamics.

R: We do not quite understand. Which other way around? This is how we write it. The

deep structure along the Alps seems to be segmented as observed by many studies (Handy et al., 2015; Kästle et al., 2019; Kissling et al., 2006; Lippitsch et al., 2003; Mitterbauer et al., 2011; Schmid et al., 2004). This in turn leads to different slab dynamics and hence to different upper crustal tectonic responses and an along-strike tectonic reorganization. We think, therefore, that our wording complies with the comment by the reviewer.

C: Page 14 – line 20. well you have structures accommodating doming and stretching paralellel to the orogen and with similar role also in the Simplon area and to some extent as well in the Engadine and Rawil depression, but if and how that is affecting the foreland evolution during collision, is to argue a little deeper.

R: Slip along the Simplon fault is indeed an important process, which yields in the rapid exhumation of the Lepontine dome at c. 20 Ma. However, we lack the required information to properly link this mechanism in the rear of the Alps to the tectonic processes in the Molasse basin. We made a related statement in the revised manuscript.

C: Line 23. tectonic processes such as.. try to link better this discussion with your data that may work as an example for...

R: We adjusted the text in the revised version of the manuscript in order to clarify that we talk about the processes discussed in section 5.2.2.

C: Line 25. you mean mantle-related slab dynamics vs. lateral extrusion of the eastern alps in the upper crust?

R: Yes, this is exactly what we mean. The Bavarian portion of the Subalpine Molasse is situated in a transitional domain, where the effects of processes exerted by the Central Alpine slab are supposedly masked by upper crustal processes of the Eastern Alps, i.e. lateral extrusion. The latter have been considered as a result of the indentation of the Dolomite indenter as well as slab retreat processes beneath the Carpathians. We adjusted the text slightly in order to make our statement clearer.

C: Page 15 – line 7-9. you can stress on how it is influenced, saying where salient and recesses occur with respect to the dominant lithology occurrence in the Molasse lithotypes.

R: We gladly follow your suggestion here and adjusted the text accordingly.

C: Line 13-14. Isn't that a repetition from second bullet point here above (line 7-9)?

R: It is indeed a short repetition of the second bullet point. However, we think is necessary here in order to contextualize the findings and put them in relationship to one another.

C: Line 16. sentence to rearrange

R: done.

C: Line 17. upper crustal signal - You may wish to say to what you refer to (i.e., the decollement at the base of the mesozoic cover deposits? or rather deeper into the crystalline and carbonate deposits? Maybe already in the block-sheme of Fig. 5 you can highlight what is the most relevant structure allowing the large-wavelength deformation

R: We refer here to the discussed late Miocene thrusting in the Subalpine Molasse (from where we presented AHe data) and the Jura FTB. We think it is not necessary to go more into detail in the conclusion part of the manuscript. We did, however, mention these points in the results and discussion part of the manuscript.

C: Line 18. As it is put here, it seems more a point of discussion rather than a concluding remark. In case you wish to leave it here, as it is relevant to the title, you may wish to explain the reason of this interpretation.

R: We discuss this more extensively in sections 5.2.1 and 5.2.2 of the revised version of the manuscript.

C: Line 21. I would suggest you here to simplify and reinforce what you mean as tectonic pulses in the first bullet point of the concluding remarks.

R: We adjusted the first bullet point in order to clarify.

C: Line 24. this is a major outcome of your work that should be more reinforced in the discussion (maybe reducing somewhat the geodynamic relevance and increasing the documentation on the lithotypes involved and their geometry and associated tectonics).

R: Based on the different reviews which we were given to and which were highlighting different parts of the manuscript, we had to find a balance to meet the requests and suggestions of the reviewers. We think that with the current revisions, we can present a well-balanced version.

C: Page 30 Fig. 1 Periadriatic is not correct being the name Periadriatic firstly used in literature as referred to main thrust in Friuli. Best would be to say Insubric (as you do for the Insubric Fault) or simply Tertiary Intrusions.

R: We use the term "Cenozoic intrusions" in the revised version of the manuscript.

C: Fig. 3 see comments in the text referred to the basal decollement and the role of tear faults

R: We added the intra-Triassic décollement level as a stippled line.

Interactive comment on Solid Earth Discuss., https://doi.org/10.5194/se-2019-158, 2019.