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Solid Earth
Discussions

Interactive comment on "Deciphering tectonic, eustatic and surface controls on the 20 Ma-old Burdigalian transgression recorded in the Upper Marine Molasse in Switzerland" *by* Philippos Garefalakis and Fritz Schlunegger

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Dear Editor, Dear Reviewer,

We would like to thank you for the very constructive review, which we have received with much appreciation. The comments and suggestions by the reviewer contributed to greatly improve the organization and the science of our paper.

We have addressed the points made by the reviewer point by point listed below.

Anonymous Referee #3

General comments: In this manuscript authors used new sedimentological and existing geological and geophysical data to assess tectonic, eustatic and surface controls on the Burdigalian transgression in the Molasse Basin. Even through most of the data and ideas appear interesting and important; there are some fairly significant items that need modification prior to publication. The comments provided below will require major revision of the manuscript. Manuscript structure needs reorganization. 1) There is no clear separation between existing data and author's own original data. Result and Discussion section include background information that should be presented earlier in Geological setting (section 2).

Our response:

This has been corrected. We improved the manuscript accordingly and provided more information on previously published geologic, chronologic and geodynamic data at the beginning of the paper. This concerns both the Alps and the Molasse basin. In this context, we have added new chapters and thus expanded the local setting significantly. We also restructured the paper such as that description of data and interpretation is clearly separated. The re-assessment of the Molasse chronology is shifted to the discussion section as a first chapter, as this could be considered as a discussion.

Referee:

2) a clear separation of observations and interpretations is missing in Result section;

Our response:

This has been done. Methods, Results and Interpretation are presented in separate chapters. We have also significantly expanded the Methods section to provide more information about how we have proceeded in the field, how we have measured paleoflow directions and how we have collected information on the facies patterns.

Referee:

3) Scientific methods and workflow are not clearly presented;

Our response:

This has been improved. The various sedimentological methods include logging, paleo-flow measurements, estimates of paleo-water depths and mapping, and taking field notes. We have provided more details on these aspects. The results are organized according to (i) analyzed sections (e.g., Entlen section, Sense section etc), and (ii) the methods applied in the field. Such a re-organization was also requested by reviewer 1. The interpretation follows the same structure. The discussion starts with a re-appraisal of the chronological framework (same as requested by reviewer 1), followed by a discussion of the basin evolution and a possible relationship to tectonic and eustacy controls. In this regard, we combined the erosional flux scenario with tectonic processes (i.e. tectonic processes that control significant shifts in the drainage network with a negative feedback on sediment flux). We have discussed these points more clearly as requested, and we have also refined the workflow, which appears now much clearer to us. Thanks for pointing this out!

Referee:

4) Headings are not informative;

Our response:

We have changed nearly all headings such as that they are more informative.

Referee:

5) Remove of unnecessary repetitions would cut text significantly. Manuscript needs clearer explanation of the links between their own data and conclusions. Authors often jump into conclusions without showing clear link to either their own field data or literature. First, key sedimentary features observed during this study, that could be used to decipher tectonic, eustasy and surface controls, should be better described. Most of important observations in that respect are mentioned for the first time in Discussion

section.

Our response:

This has been improved. We carefully streamlined the entire text and shifted published information on the architecture and evolution of the Alps and the Molasse basin to the setting section. We paid special attention on making explicit links between interpretation and observations in all sections of the discussion, and we updated and improved the text accordingly. We additionally paid special attention on carefully addressing all comments that in the annotated manuscript.

Referee:

Second, there is a confusing separation of the processes operating at the lithospheric - and crustal - scale like they are not interacting at all. These processes are poorly defined in the paper and their links to author's field data are not clear. This needs to be improved prior to publication. Detailed examples of problem areas in the text are given below and in the attached pdf.

Our response:

This has been solved. We presented the general knowledge about the processes on the surface of the Alps and at the crustal levels in the setting section. We then placed the surface and tectonic processes in one geodynamic framework, and we rephrased the discussion section accordingly such as that the reader gets a view of how lithospheric and surface processes were closely linked, which finally resulted in the transgression of the Upper Marine Molasse. We also considered all individual annotations in the attached PDF (see also response above).

Referee:

Specific comments Introduction. Opening paragraph of the introduction needs to be focused. Motivation to undertake this study is not clear. What is so controversial about Molasse Basin, i.e. Burdigalian transgression to be further studied? It is not clear what

is considered by term surface controls?

Our response:

This has been improved. We specify the non-solved problems regarding the Burdigalian transgression and then outlined more clearly the aim of our contribution.

Referee:

Settings. Section on geological background should be extended. I recommend starting by adding information on formation and geodynamic evolution of the Alps. Special attention should be given to Aar Massif, Simplon detachment and Lepontine dome (i.e. kinematic, geometry, evolution, lithology of the units involved in faulting etc.) that are in the further text marked as important controls on deposition in Molasse Basin.

Our response:

Done. We organized the setting such as that the architecture of the Alps is being presented first, followed by the geodynamic development. We did the same for the Molasse Basin. Please also see response above.

Referee:

Section 2.2 - Molasse Basin - state of the art, particularly studied Upper Miocene Unit, is poorly defined, most of important back- ground information appears in Results and Discussion.

Our response:

We have shifted the relevant information from the discussion to the setting chapter.

Referee:

Methods. I suggest to explain and list all the methods used in your study. Also, list the methods in the same order that they will appear in the results. Avoid general sentences with vague point. Explain C2 which sequence stratigraphic approach was used.

Our response:

Done. Methods, Results and Interpretation are organized such as that the same line is being preserved throughout the paper. We have expanded the related sections and added additional information on our tasks in different sub-chapters. We actually identify parts within the analyzed Entlen and Sense sections that possibly record the maximum flooding conditions of the transgression. These were then used as correlation tools across the basin. This has been clarified in the revised manuscript.

Referee:

Subchapter 3.2. is not needed. It is difficult to distinguish background data and methods. It looks like reinterpretation of the literature data.

Our response:

We have removed this section.

Referee:

Results. I recommend to start with describing your data and avoid mixing it with interpretation in this section. As written - the text is currently hard to follow. Moreover, section 4.1. includes background information that should be part of Geological setting section and Discussion.

Our response:

Done. Results and Interpretation are now separated in different chapters. In addition, the description of the sedimentological data focuses on those aspects only that will be relevant for the discussion. All other detailed data is summarized in a table to give the reader the full sedimentologic information that can be extracted from the stratigraphic sections. Accordingly, the revised text presents the key information only, which will be used to link the basin stratigraphy to eustacy, sediment flux and tectonics. All additional information on lithofacies is presented in a table together with full references to

previously published work.

Referee:

In the subsection 4.2. please systematically lay out your observations. I suggest grouping already defined lithofacies types into facies associations that are typical for particular depositional environment. This should be followed by definition of stratigraphic sequences that can be further link to suggested controls. Furthermore, this should be associated with illustrations such as your own logs or field photos that show characteristic sedimentary packages and/or stratigraphic surfaces. By doing so, you would be able to follow vertical and lateral transitions and interpret them in the light of tectonic and eustatic controls on the basin evolution.

Our response:

This has been done. The logs are presented on Figures 4a and 4b (summary logs); the details are outlined in a table, and additional photos will be included in the paper as supplement. We mark the location of the maximum flooding surfaces on Figures 4a and 4b.

Referee:

Very important in the section 4.2 Interpretation part – references are completely missing!

Our response:

They were all presented in the table, which we originally have placed in the supplement. However, we see the necessity to present all information in the main text. We thus reorganized our table, shift it to the main text and add references there. We see this as compromise between a clear acknowledgment of previously published work, and the readability of the text (which can be complicated if there are too many references).

Referee:

Discussion. Section 5 should be moved to Discussion. I recommend starting this section with the ideas on basin evolution based on your own findings. Some basin features e.g. backstepping of the alluvial mega fans are described for the first time in this section. Furthermore, it is not clear which mechanism controlled it.

Our response:

This has been done. We also paid special attention on the 'backstepping' issue and have presented the argumentation and the underlying observations more clearly. In addition, we have specified the underlying controls on the transgression in the revised manuscript. We see subduction tectonics as the principal driving force, with contributions by the uplift of individual crustal blocks (here the Aar-massif) and tectonic exhumation, all of which are related to the subduction processes. In addition, the reduction of sediment flux was likely to have been controlled by the tectonics as well through reorganizations of the drainage network when the basement blocks became uplifted. Eustatic changes in sea level possibly explain the hiatus. We have carefully modified the manuscript to make these points clearer.

Referee:

Figure comments: Minor comments are included in attached pdf. Figure 5. How did you construct mean water depth curve? In some instances, you have contradiction between your sedimentological and paleo-depth data. Please revise curve.

Our response:

We considered all figure comments and revised the bathymetry curve as requested.

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