Solid Earth Discussions

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Reply on RC1

Lorenzo G. Candioti et al.

Author comment on "Buoyancy versus shear forces in building orogenic wedges" by Lorenzo G. Candioti et al., Solid Earth Discuss., https://doi.org/10.5194/se-2020-217-AC1, 2021

The authors thank Jianfeng Yang for his constructive comments. Implementing his suggestions improved the manuscript significantly. In the following, the referee's comments are denoted RC and the author's reply is denoted AR.

AR: The abstract has been shortened and rephrased for clarity.

RC: Line 23: "the increase of horizontal driving force", why results in subduction halting but not vice versa?

AR: We suggest that when the value of the horizontal force, required to drive the collision, exceeds the magnitude necessary to initiate subduction, a new subduction zone could be initiated in a nearby region. This would then cause a decrease in plate driving force and halt, or significantly slow down, the currently active subduction.

RC: Line 62: remove "lithosphere"

AR: This has been changed in the revised version of the manuscript.

RC: Line 82: "buoyancy forces" -> "density contrast" because buoyancy forces might result in misunderstanding (to negative buoyancy force due to the slab).

AR: We have changed "buoyancy forces" to "upward-directed, positive buoyancy forces" for clarity.

RC: Line 84: "at the topo of the mantle", a bit vague, the strength is only changed at the surface? You may rephrase it.

AR: This sentence has been rephrased during the review process.

RC: Line 97: the "thermal softening" = shear heating? If so, you may bracket with shear heating, otherwise additional explanation is needed or at least a reference is needed.

AR: The term "shear heating" has been added to the revised version of the manuscript.

RC: Line 112-123: as for the boundary conditions, it's better to show the details in this paper rather than referring to another paper. For example, I feel abrupt to see 1 cm/yr of total absolute extension in the later part, and the occurrence of calcite, mica is also very abrupt. But I do understand them only after checking your previous paper.

AR: The models presented here build upon models presented in a previous study. In the previous study, the large-scale and long-term modelling approach we apply here has been established and tested rigorously. For keeping the manuscript as concise as possible, we only mention the most important modelling aspects here and refer to our previous study for more detailed explanations.

RC: Line 146: "except that …" could be rephrased to, for example "except that a feldspar-dominated upper crust is replaced with a weaker rheology of quartz-dominated upper crust"

AR: This sentence has been rephrased in the revised version of the manuscript.

RC: Line 342-343: it's not easy to understand, please rephrase

AR: This sentence has been rephrased in the revised version of the manuscript.

RC: Line 350: which model shows the first-order feature? Put (Fig. xx) behind "Pyrenees"

AR: This has been addressed during the review process.

RC: Line 406: as for the overestimated topography, what's the erosion rate used (and observed from literature)? The overestimated topography is probably mainly due to the large subducted crustal volume, especially the upper crust. BTW, what's the justification for the upper and lower crust thickness with 25 and 8 km, respectively?

AR: We used a constant erosion rate of 0.5 mm/yr above an elevation of 2 km. This value agrees with averaged exhumation rate estimates in the European Alps since 35 Ma (see [1]). Values for the initial crustal thickness are also consistent with average estimates (see [3]). We list the erosion and sedimentation rates in the revised version of the manuscript.

RC: In the model configuration part, it's better to explicitly describe the correspondence of flow law (dry, wet olivine) vs. density (bulk DMM, hydrate peridotite). For example, feldspar (table 1) uses wet anorthite (table A1)? Quartz uses 'wet quartzite'?

AR: This has been changed in the revised version of the manuscript.

RC: Line 418-423, just a comment for future study: the resolution used here is fairly high, the large amount of crustal material subducting to mantle depth might be attributed to the boundary condition, if the inflow is only imposed on the lithospheric domain, while outflow for the asthenosphere, I suspect that the slab is probably free to advance or rollback, in this case, much less crustal material could be entrained to the mantle depth due to its buoyancy.

AR: Indeed, the type of boundary condition might also impact on the force evolution. Exploration of different types of boundary conditions was not the goal of this study but is indeed a potentially interesting topic of future studies.

RC: Eq. (A9): isn't it ½ rather than 1/3?

AR: We here used the diffusion creep law derived in laboratory experiments conducted under uniaxial conditions and therefore 1/3 is the correct conversion factor (see [2], p. 76).

RC: Line 491, as for the second invariant strain rate, do you miss ½?

AR: Indeed, this mistake has been corrected in the revised version of the manuscript.

RC: Fig. 3: do you correctly show the phase diagrams for the MORB, Hydr Peridotite, Andesite, Serpentinite, pelite? You may have to reshape the matrix

AR: The density tables are shown correctly, the results are consistent with the prediction of large density at high pressures (e.g. significant densification at the coesite field). The consistency of our results can be checked also by observing the almost-vertical (T-dependent) boundaries caused by dehydration of serpentinite minerals (for hydrous peridotites).

RC: Fig. 4: though the effective viscosity is shown, the most important part: the viscosity around the channel is not shown which inhibits better understanding, moreover, the relative strength of feldspar and quartz used (for example, no such description at Line 146) is not well known for readers (I suggest to plot either of the viscosity around the channel, or strength profile for different flow laws).

AR: We have added a new figure (new Fig. 7) to the main text, showing the viscosity in the channel and the crust. This clearly shows the low viscosity at the plate interface for weak serpentinites and a relatively stronger plate interface for strong serpentinites.

RC: Fig. 10: using different shading zones separating the timeline for those 5 stages may look better.

AR: We have tested various visualization techniques for this figure. However, the different stages are transient and partly overlap each other in time (f.e. subduction initiation and basin closure). Therefore, we chose the points 1-5 to only mark the onset of a stage. For clarification we have updated the caption of Fig. 10 during the review process.

REFERENCES

[1] Bernet, M., Zattin, M., Garver, J. I., Brandon, M. T., & Vance, J. A. (2001). Steady-state exhumation of the European Alps. Geology, 29(1), 35-38.

[2] Gerya, T. (2019). Introduction to numerical geodynamic modelling. Cambridge University Press.

[3] Huang, Y., Chubakov, V., Mantovani, F., Rudnick, R. L., & McDonough, W. F. (2013). A reference Earth model for the heat□producing elements and associated geoneutrino flux. Geochemistry, Geophysics, Geosystems, 14(6), 2003-2029.