Solid Earth Discuss.,
https://doi.org/10.5194/se-2020-202-RC3, 2021

Solid Earth
Discussions

Interactive comment on "How Alpine seismicity relates to lithospheric strength" *by* Cameron Spooner et al.

Anonymous Referee #3

Received and published: 12 March 2021

The authors implement a strength model for the Alpine area and surroundings and compare the results obtained with seismicity distribution. The main novelty of this study is the new input parameter (thermal model) used to calculate the strength and viscosity variations. I think that before the publication, the discussion should be improved providing some clarifications (see detailed suggestions below), referring to the other possible causes of strength variations (besides crustal/lithospheric thickness and temperature), and referring more to previous studies that afforded similar items. The authors interpret variations of the strength and parameters correlated as function of temperature and crustal thickness changes. To this purpose, we should consider that in the model an uniform stain rate is assumed and lateral variation of rheology is not included. These parameters could influence the strength variations and their possible effects should be discussed. Furthermore, since the Alps and surrounding areas are tectonically active, thermal steady state conditions are likely not present. The authors refer to the possible effects of the slab as well as of the fluids, but processes such as exhumation/erosion/sedimentation can affect the thermal field, especially that of the sedimentary layer. The authors should also specify if they calculated the strength for compressional or extensional stress conditions. Other specific suggestions are below: Section 2 Method: Line 120-125: The authors state referring to the Peierls creep mechanism: "however this was found to not affect the ductile strength of the plate..." What do you mean precisely? They cited Katayama and Karato (2008), but this article refers to an experiment on olivine under water satured conditions, which may not represent the conditions of the study area. However, other experiments (e.g., Demouchi et al., 2013) derived the Peierls creep mechanism on 'dry' olivine as well. There is a recent thermal model of the European lithosphere of Limberger et al., 2018 (Global and Planetary Change) with which the authors can compare their results. In Table 1, the authors display the rheological paramters used, but they do not specify the rocks' conditions (dry or wet), except for the sediments. Equation 3: Please, add a reference to the equation of the effective solid viscosity. Section 3 Results: About the strength results displayed in Fig. 5, it would be better to display the two figures using the same le range of values, possibly with another color scale (the one in use is too dark) to better compare them. At the moment, the lithospheric strength looks almost equal to the crustal strength. Lines 140-155: It would be intresting to correlate the ratio crustal/mantle strength with crustal thickness and temperature to better understand which of the two parameters influences more the strength. Line 165: 'The distribution of seismic event epicentres in the southern foreland strongly correlates spatially with the computed integrated lithospheric strength (Figure 5a) and not with crustal strengths,...' This is hard to say, according to the colour scale used for Figure 5. Furthermore, if the earthquakes occur in the crust, their distribution should correlate more with the crustal strength variations. Line 175: 'all cross sections show that the majority of seismicity occurs within the strongest region of the upper crust ($\sim$ 1 GPa),' I do not think that you can link the depth of seismicity with a strength value ($\sim$ 1 GPa), since this value is derived from a model based on assumptions, such as a fixed strain rate. Line 183 up to the end of the section: Since, as expected, there is a strong correlation between lateral strength and viscosity variations, I suggest to discuss these results together. Section 4.1 Mechanical strength: The concept that a thick crust (e.g., that one characterizing the orogens) retains more strength than the mantle lithsophere has been also discussed in previous studies (e.g., Tesauro et al., 2009, Tectonophysics for Europe and more recent studies 2 on global and regional scale). About the relationship between crustal thickness, temperature, and integrated strength check also Mareschal and Jaupart, 2013, (Tectonophysics). Lines 215-218: A lower geothermal gradient can result also in an increase of the maximum depth seismicity, due to the deepening of the BDT, and not necessarily in 'less seismicity'. Section 4.2 Relation to sesimicity: The location of seismicity at the boundaries of tectonic features having different rigidity/strength has been already observed in previous studies that the authors can check (e.g., Craig et al., 2011, Geophys. J. Int; Sloan et al., 2011, Geophys. J. Int.; Tesauro et al., 2015, G3). Lines 275-278: The presence/absence of decoupling conditions are more intuitive looking at the profiles of the strength variations than at those of viscosity variations. About the seismicity depth: it can be influenced by the presence of fluids, as in case of the Molasse basin, where the maximum depth is close to that of the Moho (check the study of Deichmann, 1992, Phys. Earth Planet.), besides by the strain rate (a higher strain rate than the one assumed by the authors would increase the BDT depth). Then, the temperature is not the only parameter that influences the seismicity depths.

Please also note the supplement to this comment:
https://se.copernicus.org/preprints/se-2020-202/se-2020-202-RC3-supplement.pdf

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