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Interactive comment

Interactive comment on "Stress rotation – The impact and interaction of rock stiffness and faults" *by* Karsten Reiter

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General comments

The article addresses an interesting problem of tectonic stress deviation due to the contrast in mechanical properties and fault motion. To explore this problem the Author designed models built of elastic and contact elements, loaded with body forces and tectonic strain. The models have a very simple structure and seem to be correctly constructed and solved. Some of the obtained results are interesting. However, this study, as well as the text itself, has many significant drawbacks, which I will focus on below. I do not mention language issues as I have no competence in this area.

Critical remarks:

Chapters 1. 2. and 3. Introduction

The Introduction is very long and exhausting, resembles an academic lecture. There are summarized various aspects of stress generation and measurement, very loosely related to the research subject. In my opinion, such chapters as 2.1, 2.2, 2.3 are not necessary and should be altogether shortened to one paragraph. On the other hand, the geodynamic context of stress rotation is poorly introduced. It would be better to present several natural examples of stress rotation and their possible reasons. The passages related to stress rotation in mechanical models can also be extended. Also chapters: 3.1. and 3.2 should be shortened significantly, as the European regional context, as it turns out at the end of the article, does not play an important role in the evaluation of the modeling results. Instead, more patients should be paid to the realistic crust profiles which determine ranges of material properties like density, stiffness, and to the effective friction coefficient of regional fault zones. I would suggest focusing on the key factors important for this modeling study.

Chapter 4. Model Setup

The structure of the model and boundary conditions are not sufficiently described. E.g. it is not clear how the faults terminate at the model boundary and what is a dip of them. In my opinion, the definition of constant elastic properties and density for the entire crustal thickness based on the property of rock present in the upper crust is a bad idea. Among the lithologies presented in Fig. 3 only granite can build the entire crust. Even the simple models should consider a realistic range of material properties, evaluated from typical lithologies of the Earth's crust. Neither in the introduction nor in the model setting chapter there is no reference to the realistic lithological profile of the Alpine foreland plate, based on geophysical constraints. Some references are in the discussion but without references to the lithological composition of the crust. The densities are given in Table 2 like 2.1. - 2.2 g/cm3 are typical for salt rock but for the crystalline crust !. The constant density across 30 km thick crust is also unrealistic. The results of modeling could be more significant when realistic and geophysically documented crust properties were used. The author should also justify such a dramatic change in YM across the entire crust. I can imagine that tenfold differentiation of effective stiffness can be produced by e.g. high heat flux variations, which are not present in the reference units. However, the assumption of elastic crust in the area with a moderate surface heat flow density is difficult to defend. The crust is probably rheologically layered, thus the larger part of the weaker crust unit is inelastic. Even accepting elastic simplification of the model the stiffness and structure of the model should follow from the realistic lithological and rheological profile of the crust.

Chapter 5. Results of modeling

The results of modeling for variable PR, and density, even for unrealistically high contrast of parameters did not give significant results. Also, the stress rotations at faults are negligible, which is probably caused by their orientation under a high angle to SHmax which is not preferential for reactivation and by their ideal planar geometry. The normal fault stress regime in the lower part of the model (mentioned by the author before) is additionally the reason why there is vanishing shear stress at the vertical plane of the fault. However, the understanding of modeling results needs a better explanation of the fault implementation in the previous chapter. More significant but quite obvious results were obtained for YM variation, although the contrasts in this parameter are unrealistically high. The more significant modeling results require closer examination. It would be good to check the sensitivity of the model to changes in YM and present it on graphs or in the table. The most interesting results were obtained for combined Young modulus and fault slip. The results point that stress rotations between units of contrasting stiffness can be reduced by active faults. However in this case the analysis and presentation of fault displacement are necessary. When exploring this on realistic parameters and geometries the paper could be more interesting.

Chapter 6. Discussion

In chapter 6.1, the Author honestly states that the adopted assumptions regarding the material parameters do not match the model of the Earth's crust. The elastic thickness

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fits more closely with the lithosphere than the crust. So the Author is aware of the weaknesses of these models but why not translate it into a realistic model setup. In this chapter the result of stress changes with depth are presented, which better match chapter 5. Such analysis could be interesting, but unrealistic material properties and especially pure elastic mechanics make them not applicable to the Earth's crust. The interesting results of experiments with coupled faults and YM changes could be better presented and the factors governing regularities in obtained results should be much deeper explored and explained.

Chapter 7. Conclusions

In conclusion, the author admits that the modeling results do not reflect the stress rotation in the reference part of the Alpean foreland. Conclusions are very modest in comparison to the volume of the paper.

Some detailed remarks.

135 "Density contrast and topography" The topographic stress is a separate and wide subject, not investigated in this study. It is better to skip this issue instead of just put a number of references. 140 " stresses due to topography and crustal inhomogeneities are in the order of tens of MPa,140 which are on a similar magnitude as the plate boundary forces". In this case, stresses should not be directly compared to forces. 153 "Mechanical strength describes the material behaviour under the influence of stress and strain. The focus here is on elastic material properties, characterized by the Young's modulus and the Poisson's ratio." Please consider that elastic properties do not characterize strength. 168 "Small differences between the horizontal stresses increases the effect of faults on the local stress pattern" To some extent, because low differential stress means also low shear stress at the fault plane. 368 "Fore sure it is really unlikely that such constant materials with such a thickness exists somewhere in the crust" YES for sure. Then why such unrealistic materials were tested? 371 "However, the overall geometry seems reasonable, as the brittle domain or elastic thickness of the

crust (Te), which is a measure of the integrated strength of the lithosphere" Please consider that this is a lithosphere but not the crust itself. The upper mantle often contribute to this elasticity, then the mechanical properties assumed for the model are even less appropriate. 410 "The observed radial stress pattern southward of the Bohemian massif (Reinecker and Lenhardt, 1999) agrees 410 well with this study" As there is a lack of good examples of data constraining presented modeling results, this special case could be illustrated in the figure. 455 "The observed stress rotation strongly depends on the depth. In the soft units, SHmax rotates counter-clockwise near the surface (0 to -8 km). In contrast to that a clockwise rotation can be observed in greater depth (18−30 km)" Such an interesting result can be presented in more detail in Chapter 5. However, only the results from the upper part of the models are significant, due to the inelastic effects prevailing in the lower part. 491 "but frankly speaking, the model results are not able to prove the significant influence of the material properties on the stress orientation for this region." That means, that the area selected for model evaluation is incorrect.

To summarize, the paper presents simple and unrealistic models of the Earth's crust. A large part of the text is too long or unnecessary, while the most interesting points are insufficiently described. I would recommend a major revision or rejection of this paper.

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