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Solid Earth
Discussions

Interactive comment on "A systematic comparison of experimental set-ups for modelling extensional tectonics" *by* Frank Zwaan et al.

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General comments: The manuscript by Zwaan et al., "A systematic comparison of experimental set-ups for modelling 1 extensional tectonics" describes and compares analogue experiments that simulate extension of the crust or part of the crust, focusing on the type of forcing (foam based, rubber sheet, velocity discontinuity) at the base of the experiments.

The manuscript will be a very valuable contribution for the modelling community at large, because it gives a good overview on common practice of modelling crustal extension and it comes with a set of recommendations that are particularly useful for starting as well as experienced modellers. I thus consider the above quoted manuscript as a

very useful paper and fully support its publication.

My comments as detailed below mainly concern the details provided on the initial strength of the layers. Other suggestions as outlined in the annotated manuscript are targeted towards gaining clarity.

Figure 3 provides an overview of experimental and corresponding natural strength profiles for the experiments that have been conducted. From the figure caption, I infer that these strength profiles are sort of estimates rather than calculated. I would much prefer seeing absolute values for brittle and ductile strength as these values can be compared by the community to what they calculate for their model. As such your models, would be a "frame of reference" to which others can easily compare their results to, find communalities as well as differences. It is not much of an effort to calculate brittle and ductile strengths for the initial conditions of the various experiments because the rheology data (your table 1 and table 3) are readily available. This would also allow you approach the item of coupling-decoupling from the strength ratio of brittle to ductile layers (see papers by Davy and co-workers,1995, JGR) point of view next to the BD ratio.

Along these lines, I am not convinced about the geological meaning of the high velocity experiments in which, if correct, the strength of the ductile layer is about the same as the brittle layer. When converted to natural systems, I think this is not a realistic choice of brittle and ductile strength combinations. A young/hot/weak lithosphere as labelled in Fig. 3e would more likely be characterized by a strength profile where the integrated strength of the ductile crust is distinctly lower than the peak strength in the upper crust (see the papers on the crème brule versus jelly sandwich discussion or the paper by Burgmann and Dresen 2008, which you quote). Possibly this inconsistency solves itself ones you calculate the strength profiles for the experiments.

I hope that my comments are useful to the authors and look forward to seeing your response. Ernst Willingshofer

Specific comments:

Meaning of VD: the often-used velocity discontinuity is not necessarily a pre-existing basement fault; it can be a substitute for any irregularity (geometric, compositional, rheologic etc) in the system.

Experiments (eg. P and C series) where the structures develop at the outside and propagate toward the inside are probably controlled by boundary effects. As such you should not assign much value to them.

Make sure to refer to the correct figures; eg. when describing the experiments of section 3.3; you need to refer in many instances to fig. 3 instead of figure 1.

Almost all top-view figures are quite dark in printed form. Maybe you can enhance the brightness to make the structures clearer.

In context of wide-versus narrow rifting or localized versus distributed deformation the following papers might be useful:

Lithosphere-scale: Beniest A, Willingshofer E, Sokoutis D. and Sassi W (2018) Extending Continental Lithosphere With Lateral Strength Variations: Effects on Deformation Localization and Margin Geometries. Front. Earth Sci. 6:148. doi: 10.3389/feart.2018.00148

Cappelletti, A., Tsikalas, F., Nestola, Y., Cavozzi, C., Argnani, A., Meda, M., Salvi, F., 2013. Impact of lithospheric heterogeneities on continental rifting evolution: Constraints from analogue modelling on South Atlantic margins. Tectonophysics 608, 30–50. doi:10.1016/j.tecto.2013.09.026

Nestola, Y., Storti, F., Cavozzi, C., 2015. Strain rate-dependent lithosphere rifting and necking architectures in analog experiments. J. Geophys. Res. Solid Earth 120, 584–594. doi:10.1002/2014JB011623.

Crustal scale experiment with VD: Gabrielsen H.R., Sokoutis D., Willingshofer E. &

Faleide J.I., 2016. Fault linkage across weak layers during extension: Examples from analogue experiments and their consequence for fault analysis in the Barents Sea. Petroleum Geoscience, 2015-029, doi: 10.1144/petgeo2015-029.

Please also note the supplement to this comment:
https://www.solid-earth-discuss.net/se-2018-96/se-2018-96-RC1-supplement.pdf

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