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Solid Earth Discussions

Interactive comment on "3-D thermo-mechanical laboratory modelling of plate-tectonics" *by* D. Boutelier and O. Oncken

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The paper deals with 3D thermo-mechanical analogue modeling of plate tectonics. The authors present a detailed description of the model setup, used materials, the geometrical and material properties scaling, the deformational mechanisms they account for and the limitations of these preliminary models where, for example, water has been chosen as an analogous for the asthenospheric mantle. Together with this, the authors introduce novel analogue modeling techniques like those that allow for the determination of the horizontal stress state of the plates and for controlling the temperature distribution on the upper surface. The whole system is coupled with a PIV camera that is useful for tracing particle trajectories and ongoing deformations. The preliminary tests presented show that with such kinematic models it is possible to control the rela-

tive contributions of different tectonic forces acting on the plates. In the final part of the paper the potential of the experimental set-up to investigate 2D and 3D geodynamical settings like lateral propagation of an arc-continental collision and deformation of the fore-arc/arc/back-arc along a curved plate boundary or to integrate further techniques to analyze, for example, the topography is discussed. The paper is well written. Furthermore, the model set-up description and experimental results are clearly exposed. I have few mild comments that I would like to see addressed by the authors:

1) The oceanic lithosphere is defined as elasto-plastic. The plastic yielding and the related softening/hardening are estimated. Such plastic behavior is similar to yielding in the brittle regime, therefore I think it would be worth to stress a bit more that the modeled plasticity pertain to the ductile regime, as indicated by the temperature dependence of the yield stress (fig. 4). In any case, is there any possibility to include and control the brittle behavior in these analogue materials?

2) Each model uses kinematic boundary conditions, where the imposed rate of convergence is scaled accordingly with the thermal diffusivity of the system. Such boundary conditions are useful for example to initiate subduction. On the other hand, however, they do not allow to investigate properly how the system would evolve dynamically without any imposed convergence rate after the subduction initiation (e.g., Faccenda et al., 2008, 2009). The authors could discuss if such dynamical and probably more realistic model is feasibly reproducible in the future with the present day techniques. In effect, by tuning the material parameters a fully dynamic analogue model should be able to reproduce the scaled convergence rates and stresses.

3) The authors aim at producing complex 3-D models by varying the material properties along the convergent margin, like for example by changing the friction along the plate interface that will transmit different horizontal stresses on the upper plate or with a curved margin. I believe that this approach will give certainly useful insights into the local scale variation of the upper plate deformation along the trench, but the regional scale behavior of the system would remain substantially 2D or in any case strongly

affected by the imposed initial geometrical set-up. Nowadays, most of the 3D numerical and analogue models regarding subduction zones aim at reproducing the observations with dynamic models accounting, for example, for the flow in the asthenospheric mantle that include a strong toroidal component (i.e., Schellart et al., 2007, Nature; Morra et al., 2006, Geology: Funiciello et al., 2003). With the present model set-up, where the plates are as wide as the tank, no toroidal flow can be reproduced (and, therefore, no realistic dynamic model can be run). Other important parameters that were found to be important for the dynamic of a subduction margin are the slab width (Schellart et al., 2007, Nature) or along strike variations of the slab thickness (e.g., Morra et al., 2006, Geology). The presented experimental apparatus has the potential to merge all these dynamic effects and along strike heterogeneities together with the novel techniques implemented. Once again, wouldn't be better, then, to set-up dynamic models that would give a more complete understanding of the 3D evolution of the whole system when compared to kinematic models?

Overall, I recommend publication of the present paper after minor corrections

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