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An attempt to model rift propagation

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Rift propagation is along-strike growth of an initial small rift structure. Since rift propagation is a major factor in continent-break up (e.g. the opening of the Atlantic) we started a series of models to investigate associated tectonic processes. These analogue models involve either standard extension (continuous along-strike) or scissor-like extension (with an along-strike gradient and a rotation axis).

Both the standard and scissor set-ups involve a base of foam and plastic components that transfers distributed extension to the overlying model materials as the model sidewalls are moved apart. The difference between the standard set-up and the scissor set-up is that the sidewalls move apart in a parallel fashion in the former, while in the latter, the sidewalls move around a rotation axis, causing a scissor-like deformation gradient. We use quartz sand layer for the brittle upper crust and a viscous sand/silicone mixture for ductile lower crust (total 8 cm, 1 cm = 5 km). Lines of semi-circular silicone (seeds) on top of the basal viscous layer act as weak zones along deformation focuses because the stronger sand layer on top is thinner and therefore weaker. These 0.75 cm thick seeds are situated at one end of the model (ca. 20 cm long on a model length of 80-90 cm), to initiate a rift structure from which rift propagation could start.

Both set-ups encounter the same problems. In contrast with our previous model series (e.g. Zwaan et al., 2016), the seeds cause little localization and almost no rift propagation. Instead, extensional faulting occurs mostly along the sidewalls, especially away from the seeds. Apparently, the models need a seed or weak zone to localize deformation, otherwise the model boundaries provide the weaknesses along which faulting occurs.

Tests with lower extension velocities (which should improve rift localization due to lower brittle-ductile coupling) did not improve the results. Neither did the application of a thicker seed (ø up to 1.5 cm) or a somewhat longer seed (up to 35 cm). Boundary effects dominate in every case. The only remedy seems to be the application of a continuous seed from one end of the model to the other. In this case however, the standard set-up does not produce a propagating rift, but immediately forms a continuous and symmetrical rift structure along the entire length of the seed. In contrast, the scissor set-up does develop a propagating rift along the continuous seed. The latter is a positive result, although the set-up is more controlled by the initial conditions as hoped for.

REFERENCES

Zwaan, Naliboff, Schreurs and Buiter, 2016, Insights into the effects of oblique extension on continental rift interaction from 3D analogue and numerical models. Tectonophysics 693, Part B, 239-260