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Impact of rheological layering on rift asymmetry

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Although numerous models of rift formation have been proposed, what triggers asymmetry of rifted margins remains unclear. Parametrized material softening is often employed to induce asymmetric fault patterns in numerical models. Here, we use thermo-mechanical finite element models that allow softening via thermal weakening. We investigate the importance of lithosphere rheology and mechanical layering on rift morphology. The numerical code is based on the MILAMIN solver and uses the Triangle mesh generator. Our model configuration consists of a visco-elasto-platic layered lithosphere comprising either (1) only one brittle-ductile transition (in the mantle) or (2) three brittle-ductile transitions (one in the upper crust, one in the lower crust and one in the mantle). We perform then two sets of simulations characterized by low and high extensional strain rates ($5*10^{-15}$ s^{-1}, $2*10^{-14}$ s^{-1}).

The results show that the extension of a lithosphere comprising only one brittle-ductile transition produces a symmetric "neck" type rift. The upper and lower crusts are thinned until the lithospheric mantle is exhumed to the seafloor. A lithosphere containing three brittle-ductile transitions favors strain localization. Shear zones at different horizontal locations and generated in the brittle levels of the lithosphere get connected by the weak ductile layers. The results suggest that rheological layering of the lithosphere can be a reason for the generation of asymmetric rifting and subsequent rift morphology.