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Influence of the mechanical coupling and inherited strength variations on the geometry of continental rifts.

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The geometry of continental rifts is strongly controlled by the rheology of the lithosphere at the onset of rifting. This initial geometry will further control the development of ocean spreading centers and the structure of adjacent passive margins. Therefore, understanding the influence of coupling between the different layers of the lithosphere with and without laterally variable strength in the crust is key when investigating continental rifts. In this study we infer the influence of coupling in the crust on the rift geometry by means of crustal scale analogue experiments, where we characterize the response of the crust to deformation in terms of the strength ratio between brittle and ductile crust. The degree of coupling has been varied for setups containing or not a pre-existing weak zone. To allow a better description of the geometry obtained in our models, some key observations such as: a) the degree of tilting of the blocks, b) the total width of the graben, c) the displacement along the main fault and d) the distribution of thinning in the lower crust are monitored.

Models containing a weak zone are compared to natural examples of the inherited Mozambique Ocean suture zones (MOSZ) in the Red Sea rift. The modelling results suggest that deformation is not a-priori localized within pre-existing weak zones unless the coupling between the brittle and the ductile crust is high. With respect to the MOSZ, we infer that: (1) Jurassic NW-SE trending grabens developed parallel to but not within the MOSZ and hence reflect a low degree of coupling whereas (2) Eocene rifting in the Red Sea occurred under coupled conditions as deformation strongly focused within the MOSZ.

Models without weak zone shows that large-scale detachment faults can also form within a highly coupled crust, which is at variance to the common perception that detachment faulting demands strong decoupling. Our findings shed light on natural rift systems, which show a wide range of geometries that vary from grabens bounded by high angle normal faults (analogue to the geometry of the Upper Rhine Graben & North Sea Central graben) to listric faults rooting on a basal detachment defining a more asymmetric system (similar to the geometry of the golf of Corinth rift).