EGU25-16706, updated on 21 May 2025
https://doi.org/10.5194/egusphere-egu25-16706
EGU General Assembly 2025

Decoding rheological controls on rifting and continental break-up

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Normal faults and extensional detachments, their formation and migration are coupled to the formation of rifted margins, eventually leading to crustal break-up and the birth of new oceanic plates. Where and how this process occurs depends on the composition of the lithospheric layers and thus on different aspects of crustal and mantle elastic, plastic and viscous rheology. Among such indicators, the role of the shear modulus of the various lithospheric layers and thermal expansion, i.e. the relation between temperature related volume changes are not well understood. The latter, together with compressibility (i.e. the relative volume change due to pressure change), becomes particularly important during coseismic slip events, when the rock undergoes a sudden change in temperature and pressure. The influence of such parameters, under the assumption of elasticity, on continental break-up and subsequent formation of oceanic crust leading to a fully developed spreading center is still not well understood and requires further investigation.

In our study, we aim to better understand the influence of different rheological parameters (such as shear modulus, compressibility or thermal expansion), assuming a visco-elastic-plastic rheology. A particular interest lies in the contribution of elastic, plastic and viscous deformation during break up and rifting. For this purpose, we perform a series of high-resolution pseudo-2D models (i.e., models based on a fully 3D code with a shortened third dimension) based on the petrological-thermomechanical model code i3ELVIS. These models include elasto-visco-plastic rheology with strain weakening, partial mantle melting, oceanic crustal growth, thermal contraction, and mantle grain size evolution.