



Impact of crustal rheology on oblique rift development and geometry: a numerical study

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Fault network orientations and three-dimensional geometries of oblique rift systems and oblique passive margins vary widely at the surface of the Earth. In fact, rift width and conjugate passive margins asymmetries also evolve along-strike oblique extensional systems. This evolution can be linked to either changes in tectonic forces and plate motion direction, or transitions between contrasting geological provinces such as mobile belts and cratons.

Here, we use high-resolution 3D forward thermo-mechanical modelling with non-linear viscoplastic rheologies to assess the importance of crustal rheology on low to moderate oblique rifts and non-volcanic passive margins deformation patterns and finite geometries. We compare two crustal end-members model series, one with a stiff crust, and the second with a weak crust. We find that the rheology of the crust strongly controls the width and timing of formation of oblique rifts and passive margins. Coupling between the frictional plastic crust and upper mantle in the stiff models promotes narrow rift systems, while decoupling in the weak models promotes wide rifts. In these wide rifts, strain partitioning in the upper crust favours the development of an interconnected wide anastomosed shear zones network with a long lifespan. While stiff crustal rheology promotes Type I narrow margins, weak crustal rheology promotes the development of Type II margins, with a delayed continental crust breakup compared with the lithospheric mantle breakup. With increasing obliquity this transition in rifting style is accompanied by an evolution of the mantle lithosphere necking behaviour from cylindrical at low obliquity to segmented at higher obliquity. We compare these results with natural oblique rift systems and passive margins in order to decipher the relative impact of crustal rheology along different terrains.