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Rheological controls on faulting patterns and architecture at magma-poor rifted margins

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In this presentation we focus on the relationship between the overall deformation of the plate at lithospheric scale and the smaller-scale, shorter-lived faulting during extension at magma-poor margins. Seismic observations as well as kinematic reconstruction of margin architecture suggest that an array of ocean-ward younging sequential faults is responsible for the typical asymmetric architecture of conjugate sides (Ranero and Perez-Gussinye, 2010). Dynamic models of extension show that lower crustal rheology not only controls the initial rift style, but also the dynamics of fault sequentiality (Brune et al., submitted). At the start of extension, deformation is distributed along the whole width of the model, over an initial fault network and the underlying ductile crust and mantle. After some amount of extension, strain softening in both brittle and ductile layers causes coalescence of deformation into a dominant single normal fault with few antithetic faults. At the downward tip of the border fault, brittle and ductile deformation in crust and mantle are strongly linked. Hence, slip along the border fault results in severe lithospheric thinning and hot asthenospheric upwelling towards the downward tip of this major fault. This causes further weakening of the hangingwall of the border fault and the next fault generates in this area. Newer sequential faults successively form in the hangingwall of the previous ones. The period of activity of these faults is short, $\sim$1 Myr, and their velocity is very high, as they are absorbing all of the deformation within the rifting system. Lower crust successively flows into the tips of these sequential faults, thereby effectively preventing crustal thinning by brittle processes. Hence, once the system has localized into a major single fault, the weaker the lower crust, the more it flows towards the faulted area and the longer it takes the crust to thin to break-up. Weak lower crust is associated with long periods of sequential fault activity, and hence wide asymmetric margins, while relatively stronger lower crust leads to narrower asymmetric margins. The association of lower crustal rheology with margin width and its influence on fault pattern in time and space should be tested by using the sedimentary record and geophysical inversion of seismic data, heat-flow and Te using a dense grid of seismometers.