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Lithosphere rheological constraints on the inward migration of faulting during rifting

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The evolution of continental narrow rifts is normally characterized by progressive narrowing of the tectonic activity, with activation of large boundary faults during the initial stages, followed by focusing of deformation within the rift floor with development of internal faults and abandonment of boundary fault systems. Although various parameters (e.g., boundary conditions, magmatism, rheology) have been suggested to control this evolutionary pattern, the dynamics and timing of the process are still not well understood. We analyse fault migration during rifting by using analogue models deformed in a centrifuge. The models simulate the stretched continental lithosphere floating and extending above a low-viscosity asthenosphere.

Model results reproduce the typical evolution of deformation during continental narrow rifting, with early activation of large boundary faults and basin subsidence, followed by their abandonment and localization of tectonic activity in internal faults nearer the centre of the rift. The experiments document the strong influence exerted by the thickness of both brittle and ductile crustal layers and syn-rift sediment accumulation on the evolution of deformation, namely on the amount of bulk extension (i.e, length of time under constant extension rate) preceding inward fault migration. Thin upper and/or lower crust and absent or low syn-rift sedimentation promote a rapid abandonment of boundary faults and a transition to in-rift fault development for low amount of extension; conversely, thick upper and/or lower crust and high syn-rift sediment accumulation favour prolonged slip on boundary faults and delayed development of internal faulting.

A preliminary analysis of these experiments suggests that the inward migration of faulting during extension of continental lithosphere results from the interplay between the stresses at the base of the brittle layer (which depend on the thickness of the ductile layer and increase with increasing extension) and the total resistance of the brittle layer (which scales directly with the brittle thickness and sediment accumulation).