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Process interactions in continental rifts

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Continental rifts and rifted margins are governed by the complex interplay of a range of factors: thermo-mechanical processes control deformation at depth modulated by the emplacement of melt, while erosion and sedimentation reshape surface topography. Understanding the intricate links between geodynamic, magmatic and surface processes is essential to unravelling how rifts evolve, how they interact with the Earth system and under which conditions georesources are generated.

This presentation highlights latest technical advances and insights into the interaction of rift processes. It uses a recently established framework in which the open-source geodynamic software ASPECT is bi-directionally coupled to the landscape evolution code FastScape. This approach captures the dynamic interaction between faulting, surface loading, isostasy, rift-shoulder erosion and intra-basin sedimentation from rift initiation to rifted margin formation. In addition, dikes are incorporated via a one-way coupling scheme using two approaches: (1) a post-processing technique that infers potential diking pathways based on the modelled tectonic stress field, or (2) via user-defined input where dikes are represented as thin vertical domains with prescribed horizontal dilation.

These models reproduce the common finding that melts often rise sub-vertically to the surface in the form of dikes. However, compressional domains associated with block rotation are surprisingly common features in our models that result in the deflection of ascending melt. This process could explain the formation of sills in sedimentary basins and basement rocks, as well as the horizontal offset between melting zones in crust and mantle: features observed in several magmatic rifts. Our models suggest a complex interaction between diking, faulting, and sedimentation, which are compared to selected regions in the eastern branch of the East African Rift. These results illustrate how advances in numerical modelling techniques, combined with multidisciplinary field data can lead to new insights into the process interactions that control the structure and evolution of individual rift segments.