Geophysical Research Abstracts
Vol. 20, EGU2018-1592, 2018
EGU General Assembly 2018

The tectonic inventory of the greater Kenya Rift region investigated by 3D numerical models of plume-lithosphere interactions

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High-resolution numerical simulations of thermo-mechanical processes are nowadays capable of tracing localized crustal deformation as a response to the interaction of plume dynamics and far-field tectonic stresses affecting the lithosphere. The question we address is how inherited heterogeneities within the lithospheric plate of the greater Kenya Rift region that was impinged upon by an upwelling mantle plume and simultaneously subjected to far-field extension would be related to the development of observed tectonic and magmatic structures.
The structural basis for our numerical experiments is a 3D density and thermal model that is consistent with diverse geological and geophysical observations (such as gravity anomalies, refraction seismic profiles, mantle shear-wave velocity models). This model differentiates eight major lithological units: the sedimentary and volcanic cover, two upper continental crustal units, two lower crustal units, Indian oceanic crust as well as a lithospheric and sub-lithospheric upper mantle. In combination with rock type descriptions, the gravity constrained densities and seismic velocities of the different units provide the basis for our parametrisation of the thermo-mechanical models. The goal of this study is to test the hypothesis that the localization and propagation of rifting as well as the emplacement of magmatic structures are strongly controlled by the juxtaposition of thermal and rheological heterogeneities of compositionally different domains. These rheological domains at the crustal and upper mantle levels provoke complexities of tectonic evolution also emerging from the intrinsic dynamics of plume-induced continental rifting.
Hence, we make use of thermo-mechanical plume-lithosphere interaction models to improve our understanding of observed strain patterns. Given the complexity of the observed present-day 3D configuration of the region and the interaction of different strain-controlling factors, we run a suite of models that implement an increasingly larger number of these factors. These include, for example, the initial position of the mantle plume, the variable depths of the lithosphere-asthenosphere boundary, the internal differentiation of the upper and lower continental crust, the thickness variations across the upper and lower crust. We discuss the strain-rate patterns resulting from this ensemble of models with respect to the observed tectonic inventory including the variability in rift width and orientation (e.g. Tanzania Divergence, Nyanza Rift, Pangani Rift) and the distribution of volcanism (e.g. rift and off-rift volcanism).