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The Kenya Rift revisited: new insights into the strength of the lithosphere through data-driven 3D gravity and thermal modelling

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The tectonically active Kenya Rift has evolved through the past 30-35 million years under the influence of a mantle thermal anomaly. It is also widely accepted that the localisation of the rift has been controlled by the juxtaposition of differently composed crustal domains, in particular the Archean Tanzania craton and the northern continuation of the Proterozoic Mozambique mobile belt. Our goal is to quantify and better understand the interplay between a complex crustal composition and a localised thermal anomaly, both ultimately exerting control on the rheology and strength of the lithosphere.

We follow a stepwise and data-driven approach to develop 3D numerical models capable of assessing the lateral strength variations in the lithosphere of Kenya. First, we integrate multi-disciplinary data such as surface geology, borehole, reflection and refraction seismic data, and seismological observations to perform 3D gravity modelling and to infer the density configuration of the crystalline crust. For example, based on observed differences in lithology and compaction state, our models differentiate six domains of sedimentary and volcanic rocks on top of the crystalline crust. On the other hand, seismological models constrain the complex density configuration of the underlying mantle. We will present 3D density models that are consistent with such diverse geophysical observations from the sediments, the crust and the mantle and likewise reproduce the main characteristics of the measured gravity field. Accordingly, the modelled crystalline crust reveals six density domains. The upper and the lower crust thereby show a general west-to-east trend towards denser rocks.

We interpret these results in terms of lithologies and assign thermal properties (heat production and thermal conductivity) to the corresponding geological units to calculate the lithospheric-scale 3D conductive thermal field across the region. This finally allows us to consider temperature dependent (brittle and ductile) rheological laws and calculate the 3D strength configuration of the lithosphere. The 3D models show how far the assessed variations in lithology and temperature find their expressions in the present-day rheology of the lithosphere. Finally, the regional strength variations will be analysed with respect to present and past tectonic observables (seismicity, volcanism, fault distribution etc.).