EGU23-12655, updated on 23 May 2023
https://doi.org/10.5194/egusphere-egu23-12655
EGU General Assembly 2023

Seismic Imaging of Heterogeneous Lithosphere Beneath the Unusually Broad Turkana Depression, East Africa

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Continental rifting is currently active in East Africa, where breakup of the African continent is generally occurring in relatively focused rift zones within two uplifted plateaus, with magma intrusions the primary mechanism for strain accommodation throughout the crust and mantle lithosphere. Linking the two narrow rift valleys is the low-lying, and as-yet poorly studied Turkana Depression - an unusually broad 300km-wide region of diffuse faulting, seismicity and magmatism. How the East African Rift has developed here remains elusive and is complicated by the fact the Depression was variably stretched by several superposed episodes of failed rifting since the Mesozoic.

Utilising data from the NSF-NERC-funded TRAILS seismic network, we produce the first detailed crustal and uppermost-mantle shear-wave velocity model below the Turkana Depression, illuminating Moho and lithosphere-asthenosphere boundary topography that ultimately shed light on rift development in a multiply-rifted region. We find Turkana's lithosphere is relatively melt-poor, unlike the Ethiopian rift and Plateau further north, which have undergone extensive lithospheric modification by voluminous Cenozoic flood-basalt magmatism and magma-assisted rifting. The lower crust below rift zones in Turkana is not associated with markedly slow (melt) or fast (cooled gabbroic intrusions) wavespeeds suggesting magmatic extension has not dominated rift development in Turkana. Throughout the Depression, the thinnest crust resides within failed Mesozoic rift zones which the present-day East African Rift appears to circumnavigate, not exploit. Fast uppermost mantle wavespeeds below the thinnest crustal regions indicate post-Mesozoic rifting, re-equilibrated and possibly melt-depleted mantle lithosphere, which now renders the

plate stronger and more refractory than regions not previously rifted. Refractory Proterozoic lithosphere also present in southern Ethiopia may have influenced strain localisation and the broad, complex rift zone between Ethiopia and Kenya.