Constraining magmatism and migration patterns between the Ethiopia-Yemen & E. African plateaux from new seismic and geodetic data

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Introduction

Does a rift sector with low GPE evolve as a rift sector atop broad, dynamically supported plateaux? Turkana Depression at Kenya-Ethiopia border provides unique opportunity to test rifting models. Turkana Rift Arrays to Investigate Lithospheric Structure (TRAILS) deployed 32 seismometers and 9 continuous GPS in January, 2019.

Objectives

TRAILS – acquisition of seismic and geodetic data for lithospheric imaging, earthquake source mechanisms, surface kinematics.

Data and models will test:

A1) Gravitational Potential Energy (GPE) from isostatic and dynamic topography strongly influences the location, magnitude of surface deformation.

A2) Lateral variations in material properties strongly influence the location and magnitude of surface deformation.

B1) Two mantle plumes support the two plateaux with minimal dynamic support of the Turkana Depression.

B2) One super-plume underlies both the plateaux, and the Turkana Depression is a highly stretched and magmatically-modified zone that channels mantle flow.

Conclusions & Future Plans

- Active deformation (GPS, seismicity) and volcanism localized to narrow zones north and south of the NW-SE trending mantle lithospheric high velocity zone.

- Strain and magmatism migrated eastward from Archaean craton edge at 30-25 Ma to modern zone – influence of pre-existing mantle lithospheric structure.

- Largest amplitude anomalies appear deep - superplume related. Evidence for focused upwelling is lacking. Fast wave speeds at 100 km are potential evidence for Pan African mantle lithospheric suture.

- Future work will combine active and tine-averaged deformation behavior, and spatial and temporal distribution of hazards and resources associated with rifting.

Crust & mantle seismic structure

GPS, SKS-Splitting Results

Velocity solution in Nubia fixed reference frame with 95% confidence ellipses. Transects represented by colored lines and stations are shown below. Stars indicate the location of maximum strain rate defined by the inflection point in the sigmoid fit (Knapp et al., JGR, 2020). We find no evidence for the broad zone of strain predicted in rift inheritance models (Brune et al., 2017), but instead infer a time migration from W to E.

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Shear wave splitting results (blue) with respect to craton boundaries and earlier analyses (Topp et al., 2018; Walker et al., 2004; Gao et al. 1997; Homuth et al., 2016; Bagley et al., 2013; Reed et al., 2017). Smaller splitting delay, % nulls, and rotation of splitting direction occur at Tanzania and Bungwasi craton edges. Splitting rotates from NE direction parallel to plate motion to rift parallel (N-S, NNE) beneath thin rift zones where along-axis flow and melt-filled cracks are inferred. Splitting delay times increase northward in the Suguta –S Turkana rift and Ethiopia where melt volume in lithosphere increases, based on tomography and H-D stacking.