Probing Deformation on the Flanks of the Main Ethiopian Rift

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A new deployment of broadband seismic stations on the flanks of the Main Ethiopian Rift allows us probe the nature of crustal and upper mantle structure over a vast area beneath and surrounding the Main Ethiopian Rift. This allows us to better inform models of continental rifting, as well as the transition from continental rifting to oceanic spreading. In addition, the region covered by our array allows us to explain and understand the extent of broad modes of deformation observed in previous studies, as well as reconcile the dichotomy between strain measured from GPS receivers and modeled from plate motion. Shear-wave splitting from SKS phases allows us to measure seismic anisotropy across the region and understand the distribution of strain at depth. Our results indicate consistent orientations of anisotropy far from the rift axis, suggesting fossil anisotropy from Proterozoic accretion may contribute to observations, but is also consistent with NE-oriented flow at depth. On the Ethiopian Plateau, forward modeling of splitting observations with backazimuth indicates two layers of anisotropy are required to explain measurements. Modeling structure using H-K stacking of receiver functions indicates anomalously thin crust bordering Sudan and thickened crust on the Ethiopian Plateau, as well as the presence of partial melt in the crust beneath Lake Tana. Forward modeling receiver functions indicates a high-velocity mid-crustal body throughout the study area. We also apply body wave tomography to generate models of seismic wavespeed beneath the study region, imaging a high-velocity rift shoulder on the Somalian Plate and a small-scale, low velocity anomaly beneath Lake Tana that shifts laterally with depth and is consistent with an additional layer of anisotropy and elevated Vp/Vs ratios from receiver functions. Overall, our studies offer us a diverse group of seismological observations that allow us to constrain deformation around the Main Ethiopian Rift and identify a laterally migrating mantle upwelling impinging on the lithosphere beneath the Ethiopian Plateau, that results in both magmatic underplating, quaternary volcanism, and the presence of melt in the crust.

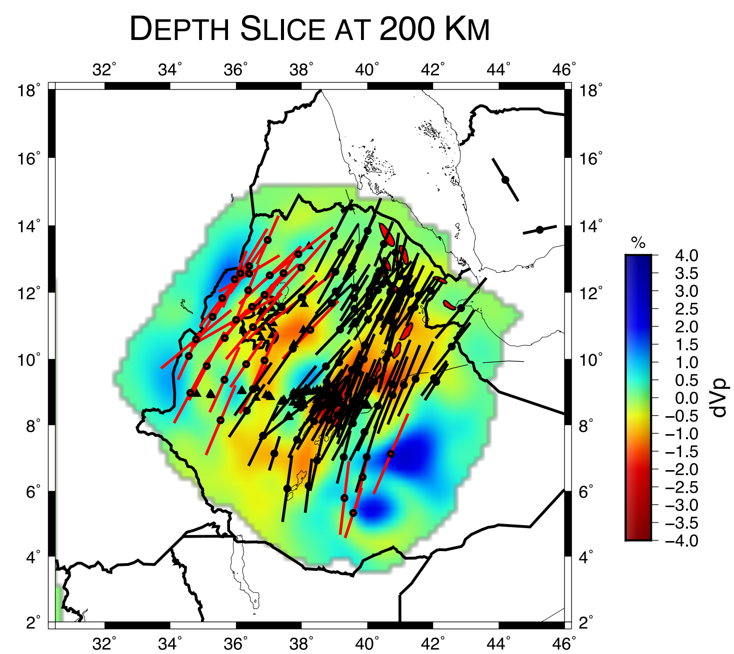

FIgure 1: Shear-wave splitting results overlain on our P-wave tomographic model at 200 km depth indicating a low-velocity anomaly on the Ethiopian Highlands, coincident with a rotation in fast axes. We also image a rapid transition to a fast rift shoulder on the East.