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Understanding the nature of mantle upwelling beneath East-Africa

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The concept of hot upwelling material – otherwise known as mantle plumes - has long been accepted as a possible mechanism to explain hotspots occurring at Earth's surface and it is recognized as a way of removing heat from the deep Earth. Nevertheless, this theory remains controversial since no one has definitively imaged a plume and over the last decades several other potential mechanisms that do not require a deep mantle source have been invoked to explain this phenomenon, for example small-scale convection at rifted margins, meteorite impacts or lithospheric delamination.

One of the best locations to study the potential connection between hotspot volcanism at the surface and deep mantle plumes on land is the East African Rift (EAR). We image seismic velocity structure of the mantle below EAR with higher resolution than has been available to date by including seismic data recorded by stations from many regional networks ranging from Saudi Arabia to Tanzania.

We use relative travel-time tomography to produce P- velocity models from the surface down into the lower mantle incorporating 9250 ray-paths in our model from 495 events and 402 stations. We add smaller earthquakes ($4.5 < mb < 5.5$) from poorly sampled regions in order to have a more uniform data coverage. The tomographic results allow us to image structures of $\sim$ 100-km length scales to $\sim$ 1000 km depth beneath the northern East-Africa rift (Ethiopia, Eritrea, Djibouti, Yemen) with good resolution also in the transition zone and uppermost lower mantle.

Our observations provide evidence that the shallow mantle slow seismic velocities continue trough the transition zone and into the lower mantle. In particular, the relatively slow velocity anomaly beneath the Afar Depression extends up to depths of at least 1000 km depth while another low-velocity anomaly beneath the Main Ethiopian Rift seems to be present in the upper mantle only. These features in the lower mantle are isolated with a diameter of about 400 km indicating deep multiple sources of upwelling that converge in broader low-velocity bodies along the rift axis at shallow depths. Moreover, our preliminary models show that the low-velocity feature in the transition zone and uppermost lower mantle beneath Afar trends to the northeast beneath the Red Sea and Saudi Arabia as opposed to being linked to the African Superplume towards the southwest.