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The uplift of East Africa-Arabia swell: the signature of the mantle upwelling and spreading

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The East Africa - Arabia topographic swell is an anomalously high-elevation region of ~4000 km long (from southern Ethiopia to Jordan) and ~1500 km wide (from Egypt to Saudi Arabia) extent. The swell is dissected by the Main Ethiopian, Red Sea, and Gulf of Aden rifts, and characterized by widespread basaltic volcanic deposits emplaced from the Eocene to the present. Although most agree that mantle plumes play a role in generating the swell, several issues including the number and locations of plumes and the uplift signatures remain debated. We seek to address these questions and provide a general evolutionary model of the region. To this end, we conduct a quantitative analysis of topography to infer isostatic and dynamic contributions. When interpreted jointly with geological data including volcanic deposits, the constraints imply causation by a single process which shaped the past and present topography of the study area: the upwelling of the Afar superplume. Once hot mantle material reached the base of the lithosphere below the Horn of Africa during the Late Eocene, the plume flowed laterally toward the Levant area guided by pre-existing discontinuities in the Early Miocene. Plume material reached the Anatolian Plateau in the Late Miocene after slab break-off and the consequent formation of a slab window. During plume material advance, buoyancy forces led to the formation of the topographic swell and tilting of the Arabia Peninsula. The persistence of mantle support beneath the study area for tens of million years also affected the formation and evolution of the Nile and Euphrates-Tigris fluvial networks. Subsequently, surface processes, tectonics, and volcanism partly modified the initial topography and shaped the present-day landscape.