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Mid-Miocene Uplift of the East African Plateau

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The Cenozoic East African Plateau is an integral part of the East African Rift System and has an average elevation of approximately 1,000 m. It is located over a negative Bouguer gravity anomaly with a semi-circular shape and related to a mantle plume. The uplift and topographic history of the East African Plateau is tightly linked with the onset of volcanism, normal faulting, and rifting. In addition, located within the equatorial realm, topographic changes in this region must have influenced atmospheric circulation patterns and rainfall distribution. The uplift of this region has therefore often been associated with fundamental climatic and environmental changes in East Africa and adjacent regions. While the far-reaching influence of the plateau uplift is widely accepted, the timing and the magnitude of the uplift are ambiguous and are still subject to ongoing discussion. This dilemma stems from the lack of datable, geomorphically meaningful reference horizons that could record surface uplift. Here, we show evidence for the existence of significant relief along the East African Plateau prior to rifting, as inferred from modelling one of the longest terrestrial lava flows, the ∼300-km-long Yatta phonolite flow in Kenya. This lava flow is 13.5-m.y.-old and originated in the region that now corresponds to the eastern Kenya Rift flanks. The phonolitic flow utilized an old riverbed that once routed runoff away from the eastern flank of the plateau. Due to differential erosion this lava flow now forms a positive relief and stands above the Athi River, which flows parallel and thus mimicks the course of the paleo-river. Our approach of lava-flow modeling is based on the empiric equation by Hui and Zhang (2007), which simulates viscosity as a function of temperature, chemical composition, and water content. Combining this viscosity model with subsequent cooling and adjusting for the Yatta lava-flow dimensions and the covered paleo-topography (slope angle), we were able to model the pre-rift topography of the East African Plateau. Our modeling results yield a pre-rift slope of at least 0.2°, suggesting that the lava flow must have originated at a minimum elevation of 1,400 m. Hence, high topography in the region of the present-day Kenya Rift must have existed by at least 13.5 Ma. Interestingly, this inferred Mid-Miocene uplift coincides with the two-step expansion of grasslands, as well as important radiation and speciation events in tropical Africa.