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Cenozoic Uplift, Erosion and Dynamic Support of Madagascar

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The physiography of Madagascar is characterised by high-elevation but low-relief topography; 42% of the landscape is above 500 m in elevation. Eocene (marine) nummulitic (marine) limestones at elevations of ∼400 m above sea level and newly dated, emergent 125 ka coral reefs suggest that Madagascar has experienced differential vertical motions during Cenozoic times. Malagasy rivers are often deeply incised and contain steepened reaches, implying that they have responded to changes in regional uplift rate. However, low temperature thermochronology and ^{10}Be derived erosion rates suggest that both Cenozoic and Recent average denudation rates have been low. Extensive laterite-capped, low-relief surfaces also suggest that there have been long periods of tectonic quiescence. In contrast, the modern landscape is characterised by erosional gullies (i.e. lavaka), with very high local erosion rates. To bridge the gap between this disparate evidence, we inverted 2566 longitudinal river profiles using a damped non-negative, least-squares linear inversion to determine the history of regional uplift. We used a simplified version of the stream power erosional law. River profiles were extracted from the 3 arc-second Shuttle Radar Topography Mission (SRTM) digital elevation model. Calibration of the stream power erosional law is based upon Cenozoic limestones and new radiometrically dated marine terraces. The residual misfit between observed and calculated river profiles is small. Results suggest that Malagasy topography grew diachronously by 1–2 km over the last 15–20 Ma. Calculated uplift and denudation are consistent with independent observations. Thus drainage networks contain coherent signals that record regional uplift. The resultant waves of incision are the principal trigger for modern erosional processes. Admittance calculations, the history of basaltic volcanism and nearby oceanic residual age-depth measurements all suggest that as much as 0.8—1.1 km of Cenozoic uplift in Madagascar is supported by mantle processes.