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Cenozoic vertical motions of the western continental margin of Peninsular India

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Despite the cessation of rifting at ∼65 Ma and its remoteness from active convergence, the topography of Peninsular India is dominated by a dramatic, high-elevation escarpment along its western margin: the Western Ghats (∼1 – 1.5 km amsl). Inland of the escarpment, South Indian topography exhibits a long-wavelength (>1000 km), low-angle (∼0.1°) eastward tilt down to the Krishna-Godavari and Cauvery deltas on the eastern continental margin. Offshore, oceanic residual depth measurements show an identical long-wavelength asymmetry from highs of +1 km in the Arabian Sea to lows of -1.2 km in the Bay of Bengal.

Strong evidence from margin stratigraphy, dated palaeosurfaces, thermochronology, cosmogenic nuclides and marine terraces combine to suggest that, following a period of relative quiescence from 50 Ma – 25 Ma, the present-day topography evolved in response to Neogene uplift and erosion along the western Indian margin. By jointly inverting 530 longitudinal river profiles for uplift rate and calibrating our inversions against these geological constraints, we successfully place this Cenozoic landscape evolution into a more complete spatio-temporal framework. The results demonstrate slow growth of the eastward tilt from 50 Ma – 25 Ma (≤0.02 mm a^{-1}), preceding a phase of increasingly rapid development – initiating in the south – from 25 Ma onwards (≤0.2 mm a^{-1}). The onset of rapid uplift pre-dates the initial intensification of the Indian monsoon by >15 Ma, suggesting that rock uplift and not climate change is primarily responsible for the modern-day relief of the peninsula.

Previous studies have aimed to explain this topographic evolution by invoking flexural isostatic mechanisms involving denudation, sediment loading and/or underplating. However, seismological constraints show that South Indian topography deviates significantly from crustal isostatic expectations, while the $9.8^{+3.8}_{-2.2}$ km effective elastic thickness of the region generates ∼125 km flexural wavelengths; considerably shorter than required for a purely flexural driving mechanism. Instead, the ∼1 km amplitude, ∼2000 km wavelength and long-timescale (∼25 Ma) growth of the western Indian margin topographic anomaly are diagnostic of dynamic topography. This implication is confirmed by the excellent spatial correlation between upper mantle shear wave anomalies and residual depth measurements. The western Indian margin is one of several elevated passive margins that abut regions of anomalously elevated ocean floor, suggesting that mantle-derived vertical motions may be the major control on modern-day margin topography.