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Linking Surface Geomorphology to Deep Lithospheric Processes beneath the Betic Cordillera (SE Spain)

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The Betic Cordillera of southeastern Spain experienced kilometer-scale surface uplift since the late Miocene, leading to widespread emergence of marine sedimentary units and contributing to the isolation of the Mediterranean Sea from the Atlantic Ocean at the end of the Miocene. Previous geophysical studies have linked this uplift to deep lithospheric processes, particularly the evolution and detachment of a subducted slab beneath the region. However, the geomorphic imprint of these processes across the Betic Cordillera has not been comprehensively characterized.

Here, we investigate the landscape response to late Cenozoic uplift using quantitative geomorphic analysis. We combine high-resolution topography with river longitudinal profile analysis, knickpoint mapping, and river network metrics such as normalized channel steepness (k_{sn}) and χ-values. This approach allows us to assess spatial patterns of landscape disequilibrium and to infer the evolution of surface uplift.

Our results reveal a clear obliquity between the trend of maximum topography and the main tectonic structures of the Betics, a relationship that differs from other Mediterranean orogens. This anomalous elevation pattern spatially coincides with the region of lithospheric slab detachment previously identified by seismic tomography, suggesting a strong coupling between mantle dynamics and surface deformation. River profile metrics show strong contrasts in k_{sn} and χ-values across the main drainage divide, indicating a transient, orogen-scale landscape and asymmetric erosion. These contrasts imply active migration of the principal drainage divide toward the Atlantic-facing basins, supported by the presence of wind gaps and river capture features.

Knickpoint distributions further indicate increasing landscape disequilibrium toward the southwestern Betics, consistent with a laterally propagating uplift signal. Together, these geomorphic observations provide independent evidence for epeirogenic uplift driven by slab tearing beneath the Betic Cordillera, with westward propagation rates estimated at approximately 100–160 km per million years.

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