Testing hypotheses for net Cenozoic rock uplift of the Colorado Plateau using the flexural isostatic response to erosion

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The Colorado Plateau physiographic province within North America stands at an average elevation of 2 km and exhibits minimal upper-crustal deformation since Late Cretaceous time. The mechanisms and timing of rock and surface uplift of the Colorado Plateau remain enigmatic and are the subject of ongoing debate. A fundamental constraint on surface and rock uplift may be derived from the observation that coastal sandstones were deposited across the plateau in Late Cretaceous time and therefore this is the last known time at which the plateau surface was at or near sea level. The post-depositional vertical motion of these shoreline sediments, estimated using geomorphology and stratigraphy, constrains the net Cenozoic rock uplift of the Colorado Plateau to be an average of 2150 meters. Our goal in this study is to quantify how much of this geologically-estimated net Cenozoic rock uplift of the Colorado Plateau can be explained by isostatic responses to Cenozoic erosion. We model the isostatic effect of Cenozoic erosion as a flexural response of the lithosphere and show that this mechanism contributes only about 405 to 328 meters of mean rock uplift across the plateau, with greater amplitudes towards the center of the plateau. This leaves an average 1850 meters of residual rock uplift to be accounted for by mechanisms other than erosion. The results of our model provide new constraints to previous estimates for rock uplift due to exhumation based on Airy isostasy alone. Furthermore, the average residual rock uplift is uniform across the plateau and is inconsistent with the hypothesis of rock uplift due to crustal thickening by east-directed mid- to lower-crustal flow. Instead, our findings suggest that a regionally uniform post-Laramide process, such as buoyancy modification in the mantle lithosphere, is responsible for most of the rock uplift of the Colorado Plateau.