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An integrated model for the post-Laramide evolution of the Grand Canyon and the Colorado Plateau

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Traditional near surface tectonics cannot fully explain certain large depositional basins or large scale orogenic plateaux such as the Colorado Plateau (CP). Deep buoyancy-driven dynamics are sometimes proposed to explain these large scale features, but the lack of critical data and the inherently non-observable convective mantle contribute to a lack of consensus on the forces that are responsible for such features.

Given recent advances in the dynamic interpretations of tomographic density variations in the mantle, we now have the ability to simulate realistic 3D mantle convection in response to the observed mantle heterogeneity, and to predict back- and forward in time the evolution of mantle flow, and thus mantle-driven dynamic surface uplift and/or subsidence. The retrodictions of the Moucha et al., 2009 mantle convection model carries intriguing implications for the post-Laramide evolution of the Grand Canyon (GC) and the Colorado River (CR) that may help reconcile numerous geologic, geomorphic, and low-temperature thermochronological data.

We present an integrated GIS study incorporating data from retrodicted dynamic topography, geology, thermochronometry, evolution of volcanism, denudation history, paleo-lake data and drainage evolution in an effort to evaluate how mantle-driven dynamic topographic variations over the last 30 Ma may have influenced the evolution of the CP and the CR. Our analysis based on the modeled dynamic uplift and the evolution of the CR profile inferred from the dynamic uplift retrodictions suggests 3 major events in the post-laramide evolution of the CP. 1) A regular and relatively homogeneous uplift (300 to 400 m) throughout the whole plateau occurred from 30 Ma to 15 Ma. Incision of the western GC probably commenced with tectonic relief development along the Grand Wash Cliffs ∼18 Ma. 2) Between 15 Ma to ∼8 Ma, dynamic retrodictions predict that further uplift is concentrated in the SW portion of the CP. This uplift tilts the plateau back to the east and possibly ponds the upper CR (100 to 250 m ponding), plausibly explaining the formation of Lake Bidahochi with ∼190 m of observed lake sediments and sustaining the incision of western GC. 3) From ∼8 Ma to today, retrodictions show that the wave of uplift migrates to the NE (at 10 km/Ma), tilting the southwestern CP back to the W. This tilting coincides with (and may have triggered)

hypothesized Lake Bidahochi spill over that may have caused the dramatic post-6Ma incision of the GC.