Geophysical Research Abstracts
Vol. 14, EGU2012-7936, 2012
EGU General Assembly 2012

Dynamic uplift and erosion history of the Colorado Plateau: New insights from a SW-NE thermochronologic transect

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The Colorado Plateau (CP), Paleozoic and Mesozoic sediments overlapped by Jurassic to Upper Cretaceous marine sediments is uplifted nowadays at ∼1.9 km mean elevation with extremely limited crustal shortening. Deep buoyancy-driven dynamics are sometimes proposed to explain part of this uplift, 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, [Moucha et al., 2009] simulate realistic 3D mantle convection in response to the observed mantle heterogeneity, and predict back- and forward in time the evolution of mantle flow, and thus mantle-driven dynamic surface uplift and/or subsidence. This 30 Ma retrodictions of mantle convection model carries intriguing implications for the post-Laramide evolution of the Grand Canyon (GC), the Colorado River (CR) and Lake Bidahochi that may help reconcile numerous geologic, geomorphic, and low-temperature thermochronologic data.

Our analysis of the CR profile inferred from the dynamic uplift retrodictions suggests 3 major events in the post-Laramide evolution of the CP. (1) 30 to 15 Ma: Regular and homogeneous uplift (300 to 400 m) throughout the whole plateau with potential incision of the western GC with Grand Wash Cliffs tectonic relief development ∼18 Ma. (2) ∼15 to ∼8 Ma: further uplift concentrated in the SW CP, tilting the plateau back to the E and possibly ponding the upper CR, plausibly explaining the formation of Lake Bidahochi (∼190 m of observed lake sediments) and sustaining the incision of western GC. (3) ∼8 to 0 Ma: NE migration of the wave of uplift, tilting the southwestern CP back to the W. It coincides with (and may have triggered) hypothesized Lake Bidahochi spillover that may have caused the dramatic post-6Ma incision of the GC.

We also obtained single-grains apatite (U-Th)/He thermochronological ages from 20 samples along a SW-NE transect roughly following the north side of the CR from the Vermillion Cliffs to Canyonlands National Park. For each Sample, wide spread of the grain-ages correlated to the eU concentration allows numerical modeling using the HeFty/RDAAM model showing that all samples stayed a long time in the partial retention zone, meaning that the CP experienced less than ∼1.5 km of erosion since 30 Ma. We also incorporate our dataset to the previously published apatite (U-Th)/He ages building a 700 km SW-NE transect relatively continuous from the western CP to the Book Cliffs. Thermochronologic ages become younger to the NE with 2 parts: (1) from SW to Lees Ferry knickpoint, the minimum apatite (U-Th)/He grain ages decrease from ∼60 to ∼5 Ma, and (2) minimum grain ages E from Lees Ferry follow a plateau ∼5 Ma, implying that erosion rates are more important since at least ∼5 Ma upstream of the main Colorado River knickpoint. Is this incision pulse related to the upstream-dipping lithologic boundary at the northern edge of the Kaibab upwarp or to the wave of dynamic uplift moving SW-NE through the CP?