Colorado River chronostratigraphy at Lee's Ferry, Arizona, and the Colorado Plateau bull’s-eye of incision: COMMENT

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Notes

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Colorado River chronostatigraphy at Lee’s Ferry, Arizona, and the Colorado Plateau bull’s-eye of incision

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Pederson et al. (2013) report new optically stimulated luminescence and cosmogenic-nuclide dating of fluvial terrace deposits in the Lee’s Ferry area (Arizona, United States) and determine ages back to ca. 130 ka. They then compile data across the Colorado Plateau from deposits ranging in age from ca. 130 ka to 640 ka and suggest that incision rates reach a maximum (an “incision bull’s-eye”) near Canyonlands. They compare these data to patterns of isostatic rebound (Roy et al., 2009; Karlstrom et al., 2012) and suggest that the isostatic response to exhumation is responsible for the apparent maxima of enhanced incision rates in this region.

The additional terrace ages at Lee’s Ferry are a welcome contribution, as the Colorado river profile here exhibits a regional knickzone separating Marble and Glen Canyons (Cook et al., 2009; Karlstrom et al., 2012). The new data generally confirm relatively rapid rates of fluvial incision along this reach of the River over this time scale (Darling et al., 2012) as well as accretion/incision cycles, and hence non-steady bedrock incision, over the past 130 ka. We take issue with two aspects of the broader regional synthesis and interpretation.

First, their regional synthesis fails to consider existing constraints on the rates of fluvial incision across the Colorado Plateau at multiple time scales (Darling et al., 2012). Some of the supporting data for the “incision bull’s-eye” (points e, f, and h in Pederson et al.’s figure 4) rely on cosmogenic surface ages on terrace treads, the higherrorder of which have been strongly eroded (Darling et al., 2012). Cosmogenic burial ages from fluvial deposits in the Glen Canyon region are significantly older (Wolowinski and Granger, 2004; Darling et al., 2012). For example, at Pederson et al.’s point f, a cosmogenic burial age on gravel near the strath is 1.5 ± 0.13 Ma whereas a cosmogenic surface age on the tread is 479 ± 12 ka (Darling et al., 2012). This discrepancy may in part reflect limitations in one or both dating techniques, but accumulating data are suggestive of increasing incision rates through time (Darling et al., 2012). Elsewhere, older terraces (400–640 ka; points j, l, m) also yield slower incision rates (130–180 m/Ma) than younger (65–120 ka; points i and k) terraces (342 and 270 m/Ma). Moreover, cosmogenic nuclide data imply that paleo-erosion rates are not substantially faster inside, versus outside, of the purported “incision bull’s-eye.” Pederson et al.’s reported 9Be of 9.3 x 10^11 at/g suggests paleo-erosion rates of ~60 m/ka at the time of fluvial deposition, which is similar to detrital cosmogenic rates of ~150 m/ka reported by Nichols et al. (2011) downstream in Grand Canyon, and to a paleo-erosion rate of ~150 M/ma and a modern detrital cosmogenic erosion rate of ~180 m/ma near Glen Canyon (Cook et al., 2009). Overall, existing data support slower incision over million-year time scales; rapid incision appears to be limited to the past ~300 ka (Darling et al., 2012) and to be concentrated in the river corridor.

Second, we take issue with the speculative conclusion of this paper that isostatic rebound significantly increases incision rates within the “incision bull’s-eye.” The “matching bull’s-eye of isostatic uplift” (Pederson et al., 2013, p. 429) is based on models of isostatic rebound in response to post-10 Ma exhumation (Karlstrom et al., 2012). However, it is not reasonable to compare a post-10 Ma pattern of isostatic rebound with incision rates determined over ~130 ka, given that incision rates at the million-year time scale show different patterns. Spatially non-uniform erosion and resulting rebound (e.g., England and Molnar, 1990) can influence the regional pattern and duration of denudation, but enhanced river incision within the “bull’s-eye” would be controlled mainly by the differential rebound between the “bull’s-eye” center and the local baselevel for the upper Colorado River (the Lee’s Ferry knickpoint), which is limited to several hundred meters acting over the past 5–10 Ma (Lazear et al., 2013). Hence, we view isostatic rebound as a relatively minor contributor to differential incision rates and magnitudes.

In summary, to understand the evolution of the iconic landscape of the western United States, and the processes and scales by which mantle dynamics may be affecting Earth’s surface system, studies need to grapple with the feedbacks between differential incision and erosion, differential rebound, climate, and young deformation across time scales.

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