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# Comment on “Age and Evolution of the Grand Canyon Revealed by U-Pb Dating of Water Table–Type Speleothems”

Philip A. Pearthree,<sup>1\*</sup> Jon E. Spencer,<sup>1</sup> James E. Faulds,<sup>2</sup> P. Kyle House<sup>2</sup>

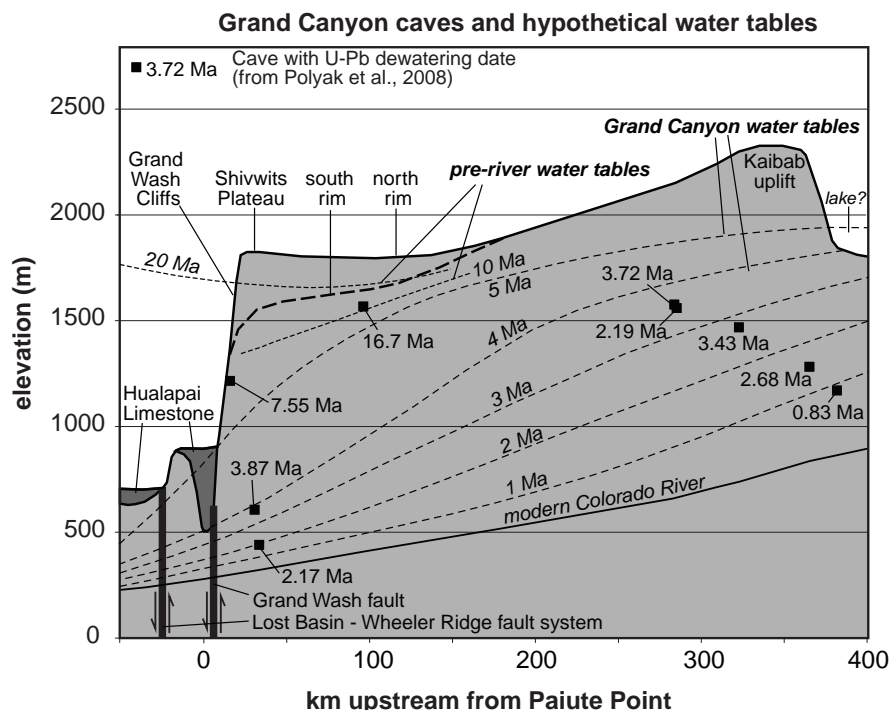
Polyak *et al.* (Reports, 7 March 2008, p. 1377) reported that development of the western Grand Canyon began about 17 million years ago. However, their conclusion is based on an inappropriate conflation of Plio-Quaternary incision rates and longer-term rates derived from sites outside the Grand Canyon. Water-table declines at these sites were more likely related to local base-level changes and Miocene regional extensional tectonics.

In their geochronologic study of carbonate speleothems from within and near the Grand Canyon, Polyak *et al.* (1) reported 9 uranium-lead dates that record the approximate time of cave dewatering due to water-table decline. Their work provides valuable insights into the usefulness of this methodology for estimating river incision rates in general and incision rates of the Colorado River in the Grand Canyon during the past few million years in particular. However, the data they presented do not support their interpretations about the age of initial canyon development and they did not appropriately consider the results of other geologic studies that provide insight into the Neogene history of the region.

Two sample sites used by Polyak *et al.*, located within the western Grand Canyon, yielded dates of less than 4 million years ago (Ma) (Fig. 1). These sites clearly are spatially related to canyon development and imply relatively low incision rates that are consistent with other recent findings (2). Incision rates inferred from these sample sites have no clear bearing, however, on the age of initial development of the western Grand Canyon. Geologic evidence indicates that the Colorado River arrived in the western Grand Canyon region 5 to 6 Ma (3–5) as a consequence of either upstream lake overflow (6, 7), drainage capture by headward erosion (3, 8), or some combination of these processes. The introduction of a major river into this area likely resulted in high initial incision rates followed by exponentially decaying rates, perhaps even including intermittent aggradation. Relatively low post-4 Ma incision rates in the western Grand Canyon are consistent with a pre-Colorado River canyon, rapid incision after introduction of the Colorado River, or both, but it is not appropriate to extrapolate these rates backward in time to estimate the age of the Grand Canyon.

The two sample sites that yielded older ages [sites 1 and 4 in (1)] are not in or directly connected with the western Grand Canyon and thus do not bear directly on Grand Canyon incision rates or the age of initial canyon development. Site 1 (7.5 Ma) is ~40 km north of the river in the Grand Wash Cliffs, in the footwall of the Grand Wash fault, a major normal fault that was active primarily between 16 and 10 Ma (9). From 11 to <7.5 Ma, limestone was accumulating in a large lake in the Grand Wash trough immediately west of the cliffs (10, 11), which implies that base level

in this area was relatively stable or slowly rising during that period. Given the location of site 1, water-table decline at 7.5 Ma may have been caused by local cliff erosion and retreat or base-level fall associated with spillover of the late Miocene lake and subsequent incision in Grand Wash trough, but any direct connection to Grand Canyon incision is unclear. Site 4 is about 90 km southeast of the mouth of the Grand Canyon and 30 km south of the Colorado River in the Grand Canyon. The 17-Ma date of water table decline is roughly coincident with inception of extension, surface lowering, and basin genesis in the Basin and Range province to the west (e.g., 9–14). For a proto-canyon related to displacement on the Grand Wash fault to cause water-table decline at site 4, it would have had to develop and rapidly propagate tens of kilometers upstream through resistant strata. Furthermore, no evidence of clastic-sediment influx due to proto-Canyon excavation has been documented in Grand Wash trough; this has been the primary evidence against a west-flowing proto-Grand Canyon (3). A more plausible explanation is that the slope of the water table changed from east-dipping to west-dipping and that the water table declined throughout the western Grand Canyon region in the middle and late Miocene because of large-magnitude extension and regional subsidence in the Basin and Range province directly west of the Grand Wash fault (Fig. 1).



**Fig. 1.** Locations of caves studied by Polyak *et al.* (1) and hypothetical groundwater tables showing descent over time. Restoration of displacement on western faults recreates the highlands to the west, which were the inferred source of water that sustained an east-sloping water table in the western Grand Canyon region at 20 Ma. By 10 Ma, this highland no longer existed and the water table sloped westward. We infer that the 7.5 Ma dewatering of the Grand Wash Cliffs cave site occurred because of local base-level fall, due to erosional cliff retreat and/or to spillover of the lake that occupied the Grand Wash Trough.

<sup>1</sup>Arizona Geological Survey, 416 West Congress Street, Suite 100, Tucson, AZ 85701, USA. <sup>2</sup>Nevada Bureau of Mines and Geology, University of Nevada, Reno, NV 89557, USA.

\*To whom correspondence should be addressed. E-mail: phil.pearthree@azgs.az.gov

The authors' interpretation that their data support middle Miocene development of the western Grand Canyon is based on the broad similarity of Plio-Quaternary incision rates with longer-term "incision rates." Unfortunately, the two samples indicating middle to late Miocene water-table decline probably have no direct bearing on Grand Canyon incision. Other interpretations for water-table decline before the arrival of the Colorado River are much more compatible with regional geologic relations.

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