A Dam Breach Unlikely for the Origin of Grand Canyon

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Abstract

The origin of the Grand Canyon is still being debated by uniformitarian and creation scientists. Two uniformitarian scientists have recently used pieces of previous research to suggest that the Grand Canyon was finally formed when the Kaibab Plateau was breached by water piping through limestone—a difficult task with little or no evidence. Several creation and uniformitarian scientists have recently defended the dam-breach hypothesis against published objections. These are reviewed, and another flaw is introduced: the absence of a huge cobble and boulder delta at the mouth of Grand Canyon. The Bidahochi Formation is interpreted as containing Lake Hopi bottom sediments, but most of its deposits are currently higher than its proposed elevation. Furthermore, the lacustrine interpretation is equivocal. Problems with the breach event are discussed. The late-Flood runoff erosion model still seems the best explanation.

Introduction

The Grand Canyon is truly one of the most remarkable icons of geology on Earth. Visually fascinating (Figure 1), it defies uniformitarian explanations of its origin. Uniformitarians have spent nearly 150 years cycling through unworkable hypotheses. One of the main problems is the way in which the Colorado River defies typical principles of drainage:

> The course of the Colorado River and its tributaries are remarkably independent of topographic and structural control, with mountains discordant to the course of the streams, or as stated by Dutton (1882, p. 73): "They run in a majority of cases against the inclination of the topographic slopes. They cut through mountains and plateaus; they enter cliffs, they emerge from them; they enter the lifts of monoclines, they cross faults from the up-thrown to the downthrown [side]. They run here obliquely up or down the structural slopes, and then they course along the strike" (Hill and Polyak, 2020, p. 2).

Hill and Polyak (2020) list five enigmas for each of the three segments of the Canyon. The most substantial include:

1. Where was the Colorado River before 6 Ma?
2. Why does the Colorado River make a 90° bend from south to west in the Desert View area?
3. Why does the route through the central Grand Canyon seem unrelated to structure and not affected by the Hurricane or Toroweap faults?
4. Is long distance headward erosion a viable concept for this location?
5. Why is there no delta at the mouth of Grand Canyon?

However, they do not include the elephant in the room—the canyon cut through the high Kaibab Plateau at an

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intermediate altitude, not at its lowest points.

Like others before them, assumptions of uniformitarianism and deep time stand in the way of a viable explanation for the Grand Canyon. In contrast, creation scientists have only been working (with a fraction of the budget and man-hours) on a Biblical mechanism for about 40 years. I published evidence that the Grand Canyon was carved by channelized Flood runoff (Oard, 2010 a,b,c,d, 2011, 2016a), like any other water gap. However, Austin et al. (2020) and Hill and Polyak (2020) offer other mechanisms, from creationist and secular viewpoints.

Figure 1. Grand Canyon, northern Arizona (view north from Yavapai Observation Station, South Rim). The side canyon is Bright Angel Canyon, caused by the Bright Angel Fault which the North Kaibab trail runs down.

A Uniformitarian Piping Hypothesis

One of the greatest difficulties for uniformitarian Grand Canyon origin theories is the dating of basalt and ash in the Muddy Creek Formation, Hualapai Limestone, and Bouse Formation west and southwest of the Grand Canyon at about 6 Ma (Longwell, 1946; Howard et al., 2008, pp. 391–410). These dates mean that the Colorado River did not flow out of its canyon until that time, implying the western Grand Canyon eroded 1,600 m down in only 6 million years (Karlstrom et al., 2007, 2008). This is extremely rapid though exceeded at the Colorado River upstream from the Grand Canyon. Aslan et al. (2019) propose a phenomenal rate of 2,188 to 3,706 m/m.y. between 85–144 kyr for the Gunnison River after it quit cutting the Unaweep Canyon wind gap through the Uncompahgre uplift of southwest Colorado.

The 6 Ma date has triggered complicated and controversial scenarios. After chiding creation scientists for "misinterpreting" various aspects of the Grand Canyon (Hill and Davidson, 2016), Hill admits uniformitarian scenarios still fail to explain its origin (Hill and Polyak, 2020). It is worth noting that practically all challenges to a creation-science origin of the Grand Canyon are based on the authors' slavish beliefs in uniformitarianism and deep time (Woodmorappe, 2016).

Hill and Polyak (2020) offer a more complicated story. They begin with a deep "Laramide paleo Grand Canyon" carved by the uplift of the Hualapai Plateau on the southwest edge of Grand Canyon about 85 to 80 Ma (Figure 2). Drainage started at Peach Springs and flowed northeast into the "Western Interior Seaway" in central North America or into "paleolakes" in Utah. Part of the drainage was underground. But Wernicke (2011) envisions a river starting in California and called it the "California River." Hill and Polyak (2020) say there is no evidence for such a river, since there is no evidence it crossed the Kingman Uplift in northwest Arizona.

Between 85 and 65 Ma, the Kaibab arch uplifted and diverted the northeast drainage of this paleoriver from the Coconino Plateau northward along the southwestern portion of the Kaibab uplift. Then, between about 65 and 17 Ma, Great Basin faulting and Rocky Mountain uplift resulted in multiple closed basin lakes. They claim a paleo Little Colorado River, east of the Kaibab Plateau, flowed north and northeast into "Paleogene Glen Lake" around Glen Canyon just northeast of Lees Ferry, although there is no field evidence for such a lake (Hill and Polyak, 2020).

About 28 to 18 Ma, the "Arizona river" flowed southwest to the Pacific Ocean and spread orthoquartzite to the southern California coast, now found in the Sespe Formation (Sabbeth et al., 2019). The only plausible source is the 1.1 Ga Shinumo Formation in the Mesoproterozoic Grand Canyon Supergroup strata, exposed only between Colorado River mile 75 and 109. River miles start with zero at Lees Ferry and go to 277 at the western entrance to the Grand Canyon. The existence of the Arizona River contradicts a paleo river not flowing out of the western Grand Canyon until after 6 Ma. Hill and Polyak (2020) do not resolve this problem.

Between 17 to 6 Ma, a complex series of events are believed to have

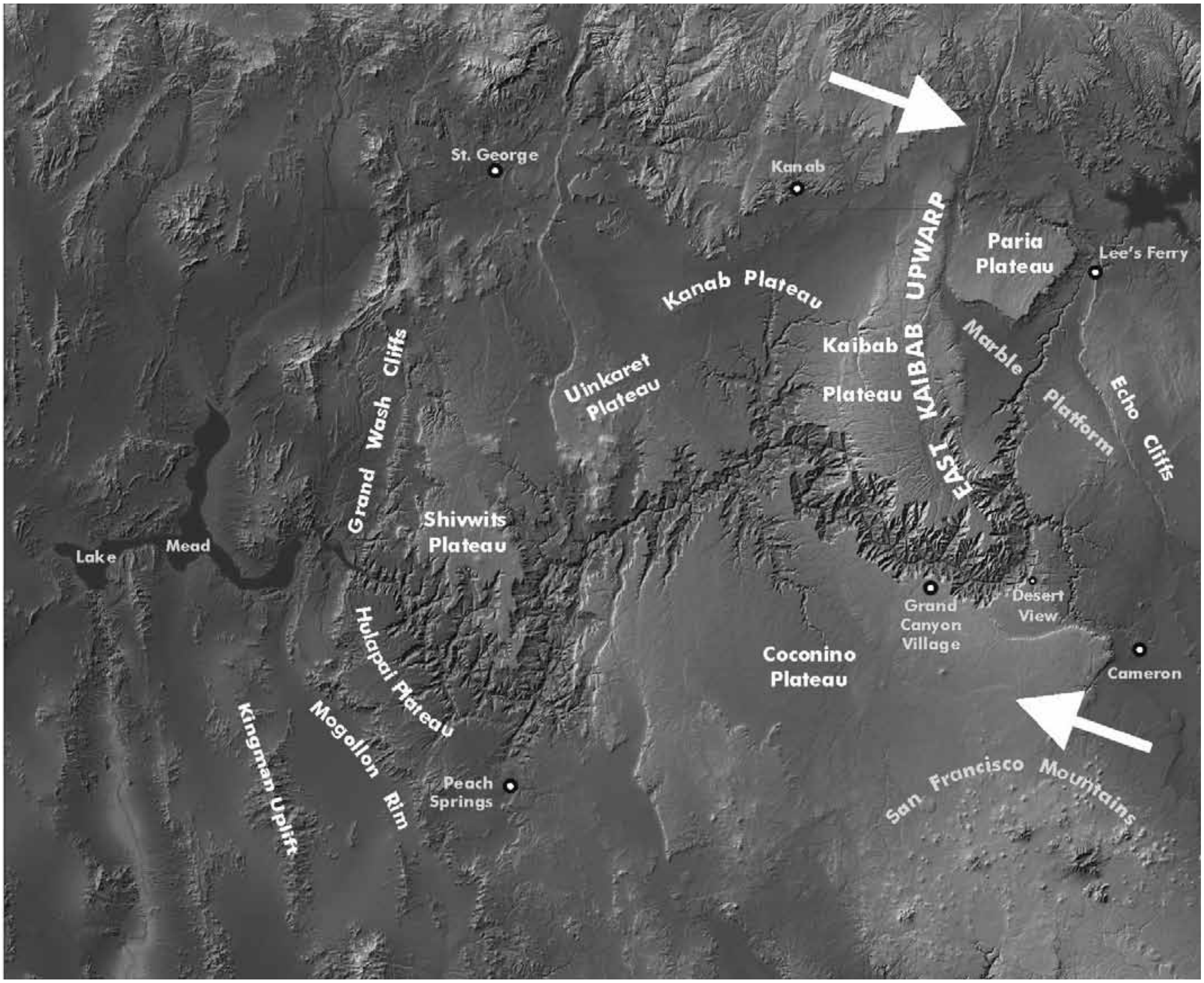


Figure 2. The Grand Canyon and the surrounding area with the main plateaus and prominent topographic features. The low point of about 1,700 m (5,577 ft.) asl of the northern Kaibab Plateau and the low point a little above 1,830 m (6,000 ft.) on the eastern Coconino Plateau marked by arrows (map background provided by Ray Sterner and drawn by Peter Klevberg).

taken place. It was at this time that a "precocious gully" supposedly eroded headward from the mouth of the Grand Canyon at the Grand Wash Cliffs all the way to the Kaibab Plateau, about 322 km (200 mi) (Larson et al., 2017), possibly following the Laramide paleo Grand Canyon. Hill and Polyak (2020) claim this, but many geologists believe that headward erosion, even in soft sediments, is slow, rare, and overutilized (Larson et al., 2017). At the same time, the deep Kanab and Cataract Creek tributary canyons, about 80 km long, also eroded headward from the "precocious gully." This scenario presents many challenges (Hill and Polyak, 2020). Then the Little Colorado River deposited the Bidahochi Fm in the eastern part of the "Lake Hopi" basin. Hill and Polyak (2020), along with many other geologists, maintain that the lower member of the Bidahochi was deposited in a playa lake (the middle member is volcanic and the upper member, fluvial). This is contrary to the views of Austin et al. (2020), who believe that the lacustrine Bidahochi is in the *upper* member.

Integrating prior research to address the most difficult uniformitarian prob-

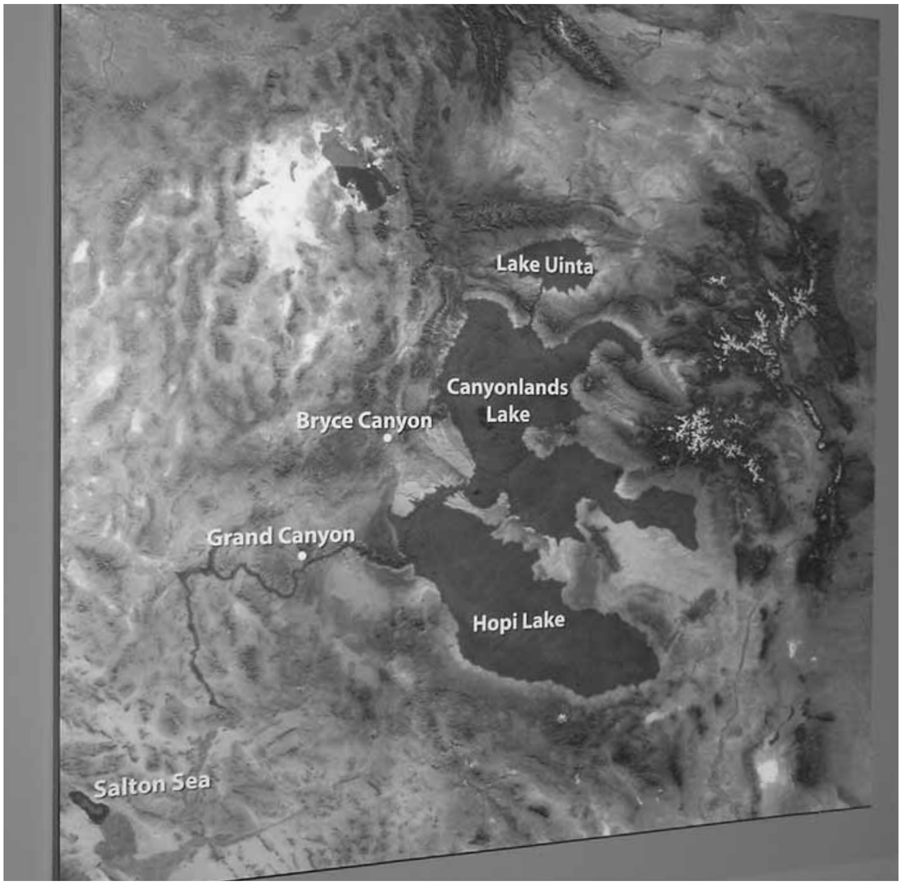


Figure 3. The three lakes that supposedly breached to carve Grand Canyon (from AiG museum display).

lem, eroding across the high Kaibab Plateau, Hill and Polyak (2020) propose that the Little Colorado River, flowing north at the time, diverted into a sinkhole near the southern Kaibab Plateau between 8 and 6 Ma (Hill et al., 2008). The river sank down to the Redwall/Muav limestones and then was piped westward under the high Kaibab Plateau to the westward drainage off the Kaibab Plateau. This is similar to Austin's early suggestion (1994, pp. 102–104) of piping that passed under the high Kaibab Plateau, where the Grand Canyon occurs at the current elevations of 2,285 m (7,500 ft) above sea level (asl) at Grandview Point along the south rim and about 2,500 m (8,200 ft) asl along the north rim (the plateau slopes down to the south). Austin et al. (2020) now advocate flow over the top of the plateau at a time when the Kaibab Plateau was 300 m lower (see below). There is no evidence of a sinkhole at the confluence of the Colorado and Little Colorado River today, which is said to be due to collapse of the strata all along the piping route. Hill and Polyak (2020) point to a dry sink hole, called the Hol Sah sinkhole/breccia pipe, on the northern Marble Platform, as an analog. They are the only uniformitarian researchers proposing this piping model. For other problems with the path of the Colorado River, see Oard (2010, 2016).

I have summarized only the main points of Hill and Polyak's complex hypothesis and only dealt with the most obvious difficulties. Each step of their complicated scenario is difficult to accomplish in reality. But if nothing else, the necessity of such a theory shows that previous explanations are not having much success. It will be interesting to see how other uniformitarian geologists respond.

Some Creation Scientists Sticking with the Dam-Breach Mechanism

Uniformitarians are not the only ones working on an explanation for Grand Canyon. One creationary idea is the dam-breach hypothesis, which has two versions (Austin, 1994, pp. 83–110; Austin et al., 2020; Brown, 2008). I will address Austin et al.'s (2020) version, that is a little different from his previous version. The original Austin (1994) version believed that three lakes formed after the Flood, southeast and northeast of Grand Canyon. Those included: (1) Hopi Lake in the Little Colorado River Valley, (2) Canyonland Lake over Canyonlands National Park and vicinity, and (3) Uinta or Vernal Lake in northern Utah (Figure 3). In the Austin et al. (2020) version, the third lake is no longer included. It is very likely that the Green River Formation and its equivalents suggested as deposits from Lake Vernal are very likely from the Flood (Oard and Klevberg, 2008). Therefore, I will only be addressing the southern two lakes.

The southern lakes continued to fill for a while after the Flood, then emptied via dam breaching, and carved the Grand Canyon. The time for filling depends critically on the precipitation of the area, which I had previously estimated was roughly four times the current precipitation based on the warm Pacific Ocean (Oard, 1993). At this rate it would take a few hundred years to fill the lakes to overflowing from a lower level right after the Flood. Hypercanes could potentially increase the precipitation rate an order or two of magnitude.

Hypercanes are super-hurricanes that need sea surface temperatures in excess of 40°C (104°F) over an area greater than 500 km (310 m) in diameter. Multiple hypercanes per year would fill the lakes in a decade or two. However, hypercanes are very unlikely after the Flood, especially over the Colorado Plateau, for at least four reasons. First, a large source of hot sea surface temperatures off the Pacific Coast of the United States is unlikely. Second, the ocean currents and atmosphere must be close to rest for days (Emanuel et al., 1995). Hypercanes take time to develop, just like a hurricane. So, the initial storm would intensify *slowly* over the hot water. The developing storm must remain over the hot spot. This is unrealistic after the Flood. Third, if the tracks of hypercanes are similar to those of hurricanes, then hypercane erosion would be confined mainly to the east coasts of continents between about 40°N and 40°S. Fourth, as a hypercane moves inland, it would rapidly lose its moisture source.

Austin et al. (2020) apparently abandoned the piping idea and advocate that the Grand Canyon was carved at intermediate altitudes of the Kaibab Plateau when the southern part of the plateau was 300 m (1,000 ft) lower and the northern part 300 m (1,000 ft) higher.

I was once favorably disposed to the dam-breach hypothesis, but recognized problems with it (Oard, 1993). While studying a real dam breach, the Lake Missoula flood (Oard, 2004, 2014c), I became more skeptical of that explanation for the Grand Canyon. Out of about a dozen problems, three seemed fatal to the dam-breach hypothesis: (1) the lack of bottom sediments, (2) the deep tributary canyons of Kanab and Havasu Creeks, and (3) the lack of ancient shorelines. Austin et al. (2020) address the first two, and for the third claim that tufa near Cape Solitude and the Bidahochi formation are evidence of an old shoreline. Clarey (2020a) has recently pointed out that actual wave-cut terraces at generally the same altitude are required for the hypothesis to work, and they are missing.

Setting the Record Straight

Austin et al. (2020) disparage Clarey and me for our analysis, implying that we cannot be trusted in our critique of the dam-breach hypothesis or in the alternative of late-Flood channelized erosion. Before continuing, I will answer their objections.

Did Henry Morris Believe in the Dam-Breach Hypothesis?

Austin et al. (2020) claim that Henry Morris affirmed the dam-breach hypothesis in Vail (2003), and they criticize me for saying that Morris favored the channelized Flood-runoff hypothesis. Whitcomb and Morris, (1961, p. 153 and caption to their Figure 6) stated after Flood sediment deposition and rapid uplift:

> Subsequent rapid canyon downcutting then ensued while the sediments were still relatively soft and the rivers were carrying much larger discharges. … Following the Flood, while the rocks were still comparatively soft and unconsolidated, the great canyons were rapidly scoured out as the waters rushed down from the newly-uplifted peneplains to the newly-enlarged ocean basins.

This could be taken to mean channelized erosion during Flood runoff, depending upon what Whitcomb and Morris meant by "rivers" and "Following the Flood." Looking back on it now, the statements are equivocal, and I should not have used Whitcomb and Morris as directly advocating channelized Flood runoff.

I suppose then that Peter Sheele (2010) and/or myself (Oard, 2010 a,b,c,d, 2011) may be the originator(s) of the late-Flood channelized erosion hypothesis. Regardless, it does not matter whether Henry Morris advocated the dam-breach hypothesis or not. What matters is, do the available data support a particular hypothesis?

Who First Originated the Dam-Breach Hypothesis?

Austin et al. (2020) take me to task for not recognizing that Newberry was the first to advocate the dam-breach hypothesis back in about 1860, instead of Blackwelder (1934):

> A misstatement of historical fact occurs in Oard 2016, 39: "Geologist Eliot Blackwelder was the first to propose that Grand Canyon was eroded by rushing water derived from the spillover of a lake that was ponded northeast of the Kaibab Plateau." Mike Oard appears to be oblivious to the earlier work of John Strong Newberry (Austin et al., 2020, p. 157, note 5).

Blackwelder (1934, p. 562) was a bit obscure when he says that lakes ponded in the desert basins and "the lakes rose until they overflowed the lowest points of their rims and spilled into adjacent basins." He was most likely thinking of the multiple basins in the Lower Colorado River drainage west and southwest of Grand Canyon, and he may have also been thinking of Grand Canyon itself. This is probably why Blackwelder is given credit for the overspill hypothesis, although Grand Canyon did not spill over at the current lowest points on the Kaibab Plateau, as expected, but at an intermediate altitude.

I checked the Newberry (1862) paper referenced by Austin et al. (2020) and did not find any mention of the origin of Grand Canyon. Newberry's 1861 paper was too difficult to obtain. Regardless, overflow advocates Douglass et al. (2020, p. 2), clear up the situation:

> Blackwelder (1934) is often cited by others for proposing overflow to explain the formation of the Grand Canyon. However, in his paper, *he never directly states that overflow accounts for Grand Canyon incision.*

> Blackwelder proposed a model of drainage development eloquently described as, "a chain of lakes strung upon a river" (1934, p. 562). Newberry (1861) proposed a similar model, but again, *not directly related to Grand Canyon incision* (emphasis mine).

So, the history of the origin of the dam-breach hypothesis is confusing. Scientifically, it is not important who first suggested the hypothesis. Did Austin et al. (2020) mention this trivial point to discredit what I have said about the dam-breach hypothesis?

Bottom Sediments

Austin et al. (2020) criticize me for saying that there is no evidence for the lakes, no lake-bottom sediments, and no shorelines (Austin et al., 2020, p. 182, and note 55). The *CRSQ* was also criticized for letting "no evidence" statements be published. Clarey (2020b is also taken to task for agreeing with me on the origin of Grand Canyon, although he admitted there could be a *little* evidence (Austin et al., 2020). Clarey has mentioned the Bidahochi Formation as possible evidence, but believes it is weak at best.

However, Austin et al. (2020) need to carefully read Oard (2010, 2016a). It is easy to miss something important in a manuscript. I do mention the Bidahochi Formation, as being potential lake bottom sediments, but point out that "there does not seem to be enough sediments to justify a lake as large as 'Lake Hopi'" (Oard, 2010, pp. 296–297). This statement is based on many uniformitarian scientists, who have claimed that only a small part of the formation is considered lacustrine and generally from a small playa lake (Dickinson, 2013). Moreover, the formation today (Figure 4) on the northeast edge of "Lake Hopi" is near and well above the suggested shoreline. The elevation of Lake Hopi is said to be about 1,860 m (6,100 ft.), but the Bidahochi Formation is as high as 2,250 m (7,380 ft) asl (Douglass et al., 2020).

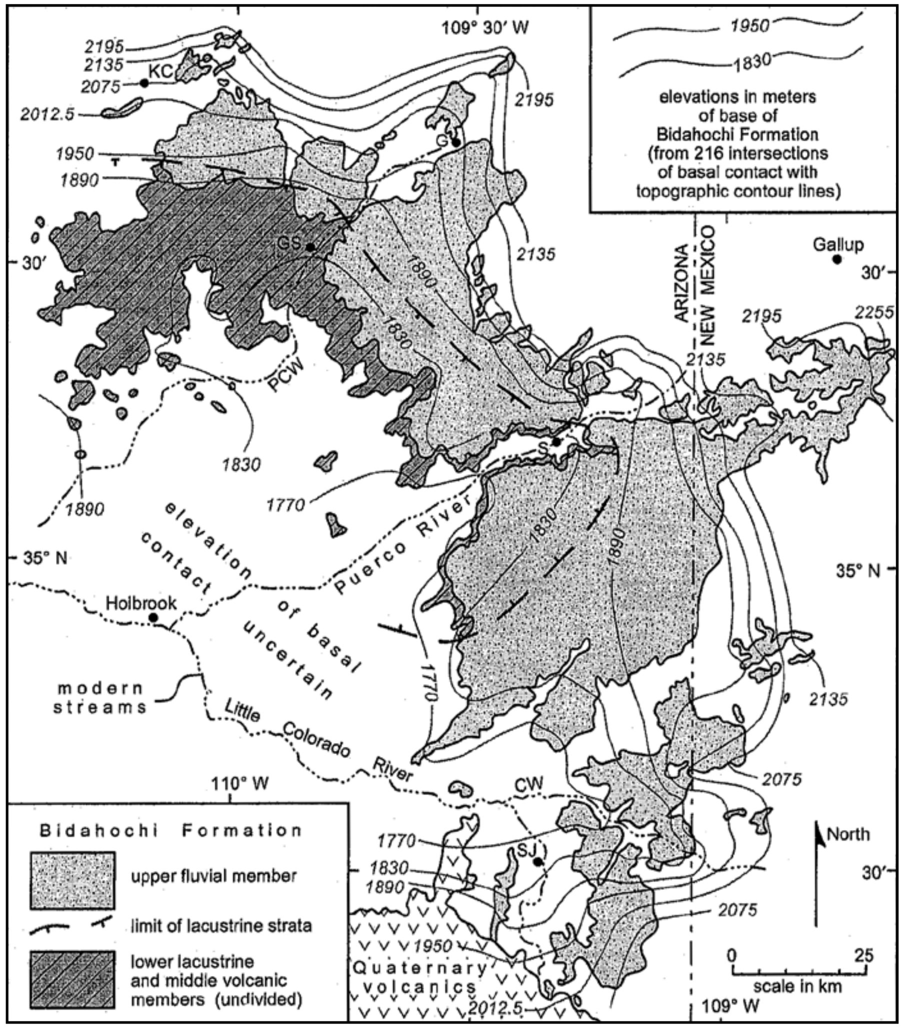


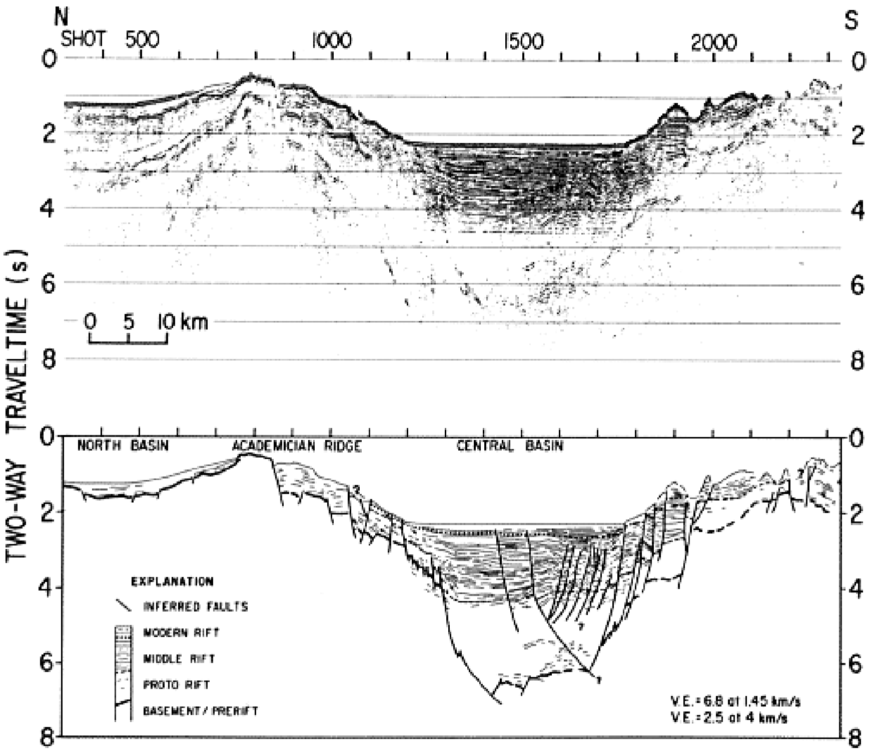
Figure 4. The lower/middle and upper Bidahochi Formation of Arizona and New Mexico, USA. The Hopi Buttes are in the lower/middle member in the northwest part of the formation (Copyright Dickinson, 2013, p. 3). Used in accordance with federal copyright (fair use doctrine) law. Usage by *CRSQ* does not imply endorsement of copyright holder.) Note that the Bidahochi Formation is also found up to 2,250 m (7,380 ft.).

Also, in the reference to "no lake bottom sediments," I stated:

> While the Bidahochi lake sediments are located near the northern and eastern "shoreline," there is [sic] no deposits in what would have been the deepest part of the lake—exactly where they would be most expected. There should be thick sediments at the bottom of the Little Colorado River Valley (2010, p. 297).

In Oard (2016a, pp. 65–66), I did admit that the Bidahochi Formation could be considered evidence:

> I said earlier that there is almost no sedimentary evidence for the lakes. There is a claim, however, that some sediments still exist for Lake Hopi.



Multichannel seismic reflection line across central part of Lake Baikal showing seismic data (top) and interpretation (bottom). The thickest deposits are confined to a narrow trough that is 15 to 20 kilometers (9 to 12 miles) wide.

Figure 5. Interpreted north-south profile through Lake Baikal, southern Siberia through the Central Basin (USGS).

> The rocks in question are part of the Bidahochi Formation…

I still stand by these statements from personal observations, and it is the lack of bottom sediments in the *deepest parts* of the lake, for instance from Cameron to Holbrook, that I believe is a fatal problem for the dam-breach hypothesis. No advocate of the dam-breach hypothesis has claimed any bottom sediments in the deepest part of Hopi and Canyonland Lakes. When glacial Lake Missoula emptied, it failed to scour bottom sediments around Missoula, Montana, and especially north of Missoula. Lakes typically accumulate thick bottom sediments in the deepest parts, for instance the Central Basin of the very deep Lake Baikal with about 7 km of mostly Late Cenozoic sediments (Figure 5). Lake Baikal is about 100 km (60 mi) wide perpendicular to the Central Basin, which is probably close to the width of Lake Hopi, but Lake Baikal is much deeper than Lake Hopi.

No Geologists Have Proposed a Superimposed Submarine Canyon

Austin et al. (2020, p. 178) say that no geologist has proposed a superimposed submarine canyon model:

> In Mike Oard's view, Grand Canyon is a superposed submarine canyon! Oard's hypothesis is completely new to geologists, never before proposed in 150 years of Grand Canyon discussion.

At its heart, this is an appeal to authority. It assumes past geologists would have conceived of, and examined, every possible origin theory. We are always confronted with what uniformitarian interpretation we can accept (Oard and Reed, 2019). In this case, a superposed submarine canyon is not even on the uniformitarian radar. I would not expect them to have suggested such a hypothesis because it may imply channelized Flood runoff. We are looking for a *Biblical* solution, and the proposed mechanism is logically consistent with the Biblical account and is one that can be shown to consistently explain many geomorphological features on the Earth's surface (Oard, 2008, 2013).

I may also add that it does not matter whether uniformitarian scientists have suggested a submarine canyon model or that the dam-breach hypothesis is a creationist mechanism, as touted by Austin et al. (2020). If the dam-breach hypothesis is not consistent with the field data, it should be rejected.

The Lack of Lake Bottom Sediments

Austin et al. (2020) propose that an analog for their model is the breaching of Lake Manix, filled with water by the Ice Age Mojave River. The rock dam breached and carved a 135 m (440 ft.) deep outlet canyon, called Afton Canyon. Austin et al. (2020) note that there is a lack of fine-grained bottom sediments associated with the Afton subbasin just west of the dam breach, although there is coarse-grained sediment. This is thought to justify the lack of bottom sediments for Hopi Lake.

However, this example is flawed, since the breaching of Lake Manix not only cut down to the level or near the level of the bottom of the Afton subbasin, but also the canyon was almost the same width as the subbasin. During this dam breach, the fine-grained bottom sediments could easily have been scoured out, especially since the Afton subbasin is narrow (see Figures 13 to 16 in Austin et al., 2020, pp. 170–171).

This example is contradicted by the Little Colorado River Valley, a narrow slot canyon (Figures 6 and 7). Except for this narrow slot canyon, the wide valley of the Little Colorado River southeast of Cameron is surrounded by high terrain. It is true that the canyon was carved down to the level of potential lake bottom sediments, but because this canyon is so narrow and Lake Hopi so large, the narrow slot canyon would have prevented hardly any bottom sediments from being scoured out. If Hopi Lake filled to 2,135 m (7,000 ft.) asl, as estimated by Austin et al. (2020, p. 173) during the dam breach, the lake would have had an area of 51,200 km^2 (20,000 mi^2). Rapid currents through the narrow canyon of the Little Colorado River, before it enters Grand Canyon, would not have scoured out hardly any bottom sediments (Figure 8), if they existed.

Lake Hopi should have left tens of meters of bottom sediments in the deepest parts, since the formations around the putative lake are often soft. During the likely existence of the lake likely for several hundred years, erosion would have easily produced thick sediments in the deepest parts of the lake. This problem still stands, and by itself should tell us that Lake Hopi never existed, despite properties of the Bidahochi Formation (see below). It is no surprise that Austin et al (2020) ignore the absence of bottom sediments in what should have been the deepest parts of the lake, but instead focus on the Bidahochi Formation.

"Canyonland Lake," even larger than Lake Hopi, should also have left a record of massive bottom sediments. If the lake reached an elevation of 1,940 m (6,400 ft.) asl, as believed by Austin et al. (2020) (see below), many valleys would have been filled by the lake, including the San Juan River Valley into northwest New Mexico, the Colorado River Valley well past Grand Junction, and the Green River Valley up to the Book and Roan Cliffs (not counting the water gap through the Book and Roan Cliffs into the wide area with the Green River Basin in "Lake Vernal"). These valleys vary in width. The geological maps of the area often indicate the bedrock is Mesozoic sedimentary rocks. Figure 9 shows the bedrock around the confluence of the Green and Colorado Rivers showing no indication of expected lacustrine sediments.

Assuming a rock dam east of Lees Ferry (a late development in the hypothesis), the bursting of Canyonland Lake would have eroded this dam over a width of several kilometers, emptying the top half of the lake. However, the erosion of rock may have been slow and not a dam breach, as shown by the breaching of Lake Bonneville at Red Rock Pass, Idaho. But as Canyonland Lake lowered to the top of the western Marble Platform, the drainage would have been confined to

Figure 6. The narrow valley of the Little Colorado River Valley at a scenic overlook at milepost 285.7 on highway 64. The canyon at this point is a slot-like canyon about 365 m (1200 ft) deep.

Figure 7. Top of the slot-like canyon of the Little Colorado River Valley at milepost 277.7 on Highway 64.

the narrow Marble Canyon (Figure 10, also see Figure 11 in Austin et al. (2020)). So, just like with Lake Hopi, the current would be strong enough to have eroded and transported lacustrine sediments through Marble Canyon. However, upstream, the currents would have been sluggish, and lake bottom sediments would not have been scoured out during the dam breach. As far as I know, there are no bottom sediments associated with Canyonland Lake (personal observations). No matter what is claimed about the Bidahochi Formation, such lack of bottom sediments is strong evidence that the proposed lakes did not exist. If so, the dam-breach hypothesis lacks crucial evidence needed to argue its case.

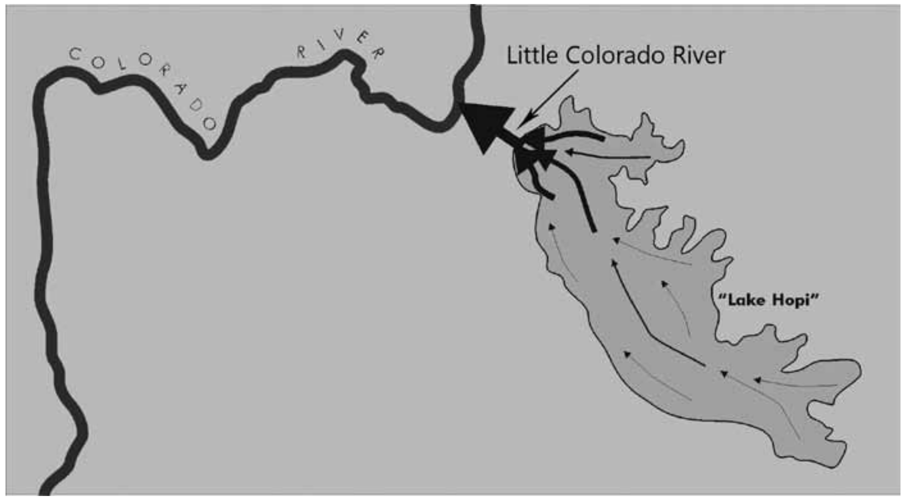


Figure 8. Schematic of postulated currents in "Lake Hopi" and the Little Colorado River Canyon (drawn by Peter Klevberg). The current would have been strong through the Little Colorado River Canyon because it is a narrow, slot canyon, but currents would have been very weak in the rest of the lake away from the entrance to the canyon and hence little erosion of lake bottom sediments would have occurred.

The Problem of Tributary Valleys

Austin et al. (2020) supposedly "answered" the argument that the long, deep Kanab and Havasu tributary valleys are inconsistent with the dam-breach hypothesis by claiming that tributary canyons were also formed during the March 19, 1982 mudflow in the upper Toutle River Valley, northwest of Mount St. Helens, Washington. They (pp. 168–169) state: "These big side canyons at Mount St. Helens are similar to Kanab Creek and Havasu Creek (see Figure 4) in the central Grand Canyon."

Figure 9. View northeast from near the confluence of the Green and Colorado Rivers about a hundred meters above the river, showing no thick bottom sediments around the river within the area of "Canyonland Lake" (courtesy of Esther Fishbaugh). Alluvial fan on the left. River elevation about 1,370 m (4,450 ft.), well below the surface of the lake.

Their example does not satisfactorily answer the problem of deep tributary canyons at Grand Canyon. These tributary valleys are about 1,600 m (5,200 ft.) deep where they enter the Grand Canyon. There are several reasons to doubt their proposed analogy. First, the Little Grand Canyon, about 30 m (100 ft.) deep, and its tributaries of the Toutle River are a 1/40th scale of Grand Canyon. Second, they were curved by *a mudflow*. Third, they were cut into *unlithified landslide debris*. In contrast, Kanab and Havasu Creeks were likely carved in consolidated or near consolidated rock. Much evidence indicates the sediments through which the Grand Canyon and its tributaries were carved were lithified (Oard, 2016a). If the strata were unconsolidated, the sides of Grand Canyon, Kanab Creak, and Havasu Creek would have slumped inward. The problem still stands. On the other hand, tributaries (Kanab and Havasu Canyons)

Figure 10. The Colorado River flowing through the beginning of the narrow Marble Canyon.

Figure 11. Shorelines from glacial Lake Missoula on Mount Jumbo, northeast of Missoula, Montana.

merging downstream with the main trunk channel (the Grand Canyon) is "a fundamental outcome of erosion by flowing water" over a broad area (Perron et al., 2012, p. 100).

The Problem of the Lack of Shorelines

Austin et al. (2020) mostly ignore the lack of shorelines (wave-cut terraces) and raised deltas that should be evident in the rocks surrounding Hopi and Canyonland Lakes. Based on the numerous shorelines associated with the short-lived glacial Lake Missoula (Oard, 2004) (Figure 11) and the numerous Ice Age lakes of the Great Basin (Figure 12), such shorelines should be abundant (Clarey, 2020a). Multiple Ice-Age lake terraces occur in the Great Lakes region, ponded south of the Laurentide Ice Sheet (Clarey, 2020a). The Great Lakes area gets far more precipitation than Arizona and eastern Utah today and presumably after the Flood, yet these shorelines are preserved and traceable. It seems highly unlikely that all of the expected shorelines would have been erased in the areas surrounding the two lakes since shorelines are not greatly eroded from the other locations. Austin et al. (2020) cannot claim that the rocks were too soft to retain shorelines, since glacial Lake Missoula cut shorelines into both hard and soft rocks, and that those shorelines were preserved (Oard, 2004).

Even if the presumed lakes existed for as little as 10–20 years, lake shoreline terraces should have formed, and still be visible, marking the perimeter of the lakes (Clarey, 2020a). Clarey (2020a) quoted John Wyatt, who spent 40 years building hydroelectric plants. Wyatt commonly observed wave cut terraces forming around the margins of new reservoirs in just a few days or weeks as the lakes reached a relatively stable level. However, we see no terraces around the perimeters of either Hopi or Canyonlands Lakes as drawn.

Austin et al. (2020) point to what Austin claims is a shoreline tufa deposit near Cape Solitude as evidence of Lake Hopi. Tufa is, "A variety of travertine that is commonly spongy or porous due to precipitation around a variety of floral strictures, such as reeds, plants, roots, leaves, etc." (Neuendorf et al., 2005, p. 688). Tufa is considered to have been deposited in water at ambient temperatures and can be deposited on other objects besides plants, while travertine is denser and believed to have been deposited by hydrothermal or warm water with rapid CO_2 degassing (Figure 13) (Felton et al., 2006). A good location for the study of tufa is Mono Lake, California, and it occurs around the shorelines of pluvial lakes in the Great Basin.

Austin was looking for silt and limestone on the east side of Kaibab uplift, which he considered to be the "smoking gun" for the dam-breach hypothesis with Hopi Lake at an elevation of about 1,830 m (6,000 ft.) asl. He does not tell us how silt and limestone would be a smoking gun. Austin noted a 1.5-m (5-ft.) thick deposit of calcium carbonate near Cape Solitude just east of Grand Canyon according to Scarborough and Hereford that "appears" to be a lake deposit, namely tufa. Limestone and other fine-grained sediment were also found elsewhere on the Marble Platform. That these limestones represent a shoreline of Hopi Lake is an unsubstantiated claim. Austin must show that the limestone is really a tufa; whether it is continuous at the same elevation, not from an ancient spring; and that it compares with tufa deposited at Mono Lake and Great Basin pluvial lakes.

The main factors for tufa precipitation include water agitation:

> Shore-zone lacustrine calcium carbonate deposition is a function of water temperature, clastic input, calcium concentration of the water body, and local water pH, all of which are influenced by biological facts and *water agitation* [emphasis mine] (Felton et al., 2006, p. 384).

Outgassing of CO_2 must occur, which can be caused by wave agitation, as expected along shorelines. However, fast currents and turbulence may also cause degassing of CO_2 in carbonate-rich water. Thick travertine

Figure 12. Lake Bonneville shoreline at base of mountains north of Salt Lake City, Utah.

Figure 13. Mammoth Hot Spring travertine from Yellowstone Park, Wyoming.

speleothems, including dripstone, in caves is more rapidly deposited in fast currents with turbulence (Dreybrodt, 1988). Travertine is reported from upper Triassic sedimentary rock, interpreted as lacustrine (Leslie et al., 1992). Tufa is claimed from Lower Jurassic carbonate deposits within the Navajo Sandstone of the western United States (Totman-Parrish et al., 2017). The vast majority of Flood geologists would place these two occurrences in the Flood. So, tufa, or the interpretation of a tufa, is not necessarily a positive indicator of a shoreline, and could form during the Flood. Austin needs to show that tufa cannot form during the Flood.

A Fourth Problem—Lack of Coarse Deposits West of Grand Canyon

There are many other problems with the dam-breach hypothesis (Oard, 2010, 2016a). I will amplify one of these that I believe is also fatal: the lack of coarse-grained delta deposits at the mouth of the Grand Canyon. As shown by Austin et al. (2020), during the breach of pluvial Lake Manix, a large delta up to 55 m (180 ft.) thick was deposited just downstream of Afton Canyon. The delta thins eastward (Meek, 1989). If 4,100 km^3 (1,000 mi^3) of sedimentary rock was eroded from Grand Canyon, a huge delta should have formed at the mouth of the Grand Canyon, with thick, coarse sediments (boulders and cobbles) west of the Grand Wash Cliff and fining downstream sediments toward the Gulf of California. The delta should exist whether or not the water turned south toward the Gulf of California or continuing west/southwest toward the Pacific Ocean to be deposited in the Los Angelis Basin or the Anza Borrego Desert. This latter scenario assumes no significant ridges and mountains would block or divert the flow and that mountains and ridges rose after the dam breach. There is no delta west of the Grand Wash Cliffs (Hill and Polyak, 2020).

Austin (1994, p. 102) has pointed to fine-grained sediments, well downstream in the Imperial Formation west of the Salton Sea. The Imperial Formation is some 400 km (250 mi.) from the mouth of the Grand Canyon. There should be a generally continuous or at least contiguous sheet of fine-grained sediments from the mouth of the Grand Canyon to the Imperial Formation. But the sediments of the Imperial Formations could easily have been deposited during Flood runoff into deep basins and valleys. Regardless, thick, coarse sediments near the mouth of the Grand Canyon are *missing*, so the expected sediments from a dam breach and associated canyon erosion are not present.

The Bidahochi Formation

The claim for the existence of a post-Flood Lake Hopi seems to revolve around how one interprets the three members of the Bidahochi Formation (Figure 4). Many geologists claim that the Bidahochi Formation is weak evidence for such a lake (Love, 1989; White, 1990; Dickinson, 2013). The lowest of the three members of this formation has been considered lacustrine or from a playa lake, while the middle member is volcanic and the upper member, fluvial. Austin et al. (2020) see lacustrine sediments in the upper member, which Douglass et al. (2020) show was deposited up to 2,250 m (7,380 ft.) asl. Austin et al. (2020) point to the following as evidence that a post-Flood lake deposited some of the upper member of the Bidahochi Fm:

- tufa deposits and limestone
- 300 volcanic maar craters, at least one having an ejecta ring
- a high strontium isotope ratio
- fossils of fish, lake and pond-dwelling snails, frog, toads, bird tracks, and beavers

Tufa has already been mentioned. As discussed above, it is equivocal in defining a shoreline. "A maar is a low-relief, broad volcanic crater formed by multiple shallow explosive eruptions" (Neuendorf et al., 2005, p. 386). Austin et al (2020) interpret these maars and the surrounding sediments as formed within the sediments of a lake bottom in standing water. If there was a current toward the west, ejecta rings around the maars would be destroyed. As evidence that the lake was large, Austin et al. (2020) emphasize the fish fossils in the Bidahochi Formation. The fish fossils are not found in the Los Angeles Basin but have a striking similarity with those in the Pliocene of the Snake River of southern Idaho, presumably from "Lake Idaho." Let's examine these arguments.

The Upper Member Mostly Deposited by Moving Water

Despite Austin et al. (2020) and Douglass et al. (2020) interpreting the upper member as being lake sediments, most geologists have described this member as "fluvial" sediments. The uniformitarian emphasis on a fluvial environment may mean the upper member has numerous cross-beds with only local fine-grained sediments, interpreted as lacustrine (see Austin et al. (2020), Figure 20). Austin et al. (2020) do mention cross-bedded sandstones, but they think these local. Uniformitarian scientists automatically consider cross-bedded sandstone, along with rounded conglomerate and other water-laid features, as "fluvial," since they view all the rocks and fossils through the lens of uniformitarianism. So, "fluvial" would predominantly mean laid down by moving water, which could suggest Flood deposition. In one of Austin et al.'s (2020) references for a lake environment, White (1990, p. 45) actually says that the upper member is "*characterized* by quartzose sandstones deposited in a southwesterly flowing fluvial system (emphasis mine)." I would take this quote to mean that the upper member overwhelmingly shows sediments laid down in moving water.

What About the Maars?

Austin et al. (2020) make a point that the maars would have erupted in the lake floor sediments, where there were few, if any, currents to spread ejecta. There are a variety of other possibilities. Eruptions could have occurred during the Flood, underneath the Floodwater. This would get back to the stratigraphic end-of-Flood debate (Oard, 2016b, 2017a,b, 2018b, 2019; Clarey, 2017, 2020b; Clarey and Werner, 2019). Also, water may have been ponded or slow-moving during Flood runoff during the uplift of the Kaibab Plateau. This probably happened in many basins or valleys in the mountainous west during late-Flood uplift. Such tectonism would likely have resulted in local and briefly ponded or slow-moving water, such as around Maudlow, Montana. Uplift of the Horseshoe Hills to the west resulted in slow-moving water with gravel bars 60 m (200 ft.) high deposited where fast-moving water that created three water gaps to the east slowed in the ponded water (Oard, 2018a).

What About the High Strontium Isotope Ratio?

Austin et al (2020) claim a high strontium isotope ratio ($^{87}Sr/^{86}Sr$) of the Bidahochi Formation is not the seawater ratio, but that of adjacent streams. The ratio for the upper member is about 0.7102 (Douglass et al., 2020) while the ratio for seawater is 0.7091. Douglass et al (2020, p. 10) interpret this high ratio as coming, not from local streams, but from "the exotic surface water sourced from ancestral upper Colorado River watershed." The modern river waters on the Colorado Plateau are comparable to the strontium isotope ratio of the Bidahochi Formation (Dickenson, 2013). The high strontium isotope ratio of the upper Bidahochi Formation does not seem significant, since it comes from the upper Colorado River watershed, which can easily be explained by Flood runoff from the north and east of the Bidahochi Formation.

Freshwater Fossils

Austin et al. (2020) point out that the fossils found in the Bidahochi Formation are what would be expected in a post-Flood lake and that many of them are still found on the Colorado Plateau and other areas of the western United States. These transported fossils could have been spread during the drainage of the Floodwater from what had been a terrestrial pre-Flood environment, similar to other terrestrial fossils that are sometimes mixed with marine organisms (Clarey, 2019). Very similar fish fossils associated with "Lake Idaho" would also have been deposited in the Recessive Stage of the Flood.

I twice looked for evidence of Lake Idaho with Brent Carter, who advocated a Pliocene lake. Other than fine-grained sediments or sedimentary rocks along the Snake River in a few locations, I did not see any significant evidence for such a post-Flood lake. There were no shorelines and no breached lava dam at the entrance to Hells Canyon, as Carter thought. Features considered as positive evidence for the lake, such as oolites or pisolites, are equivocal and could have formed in the Flood. They are found in rocks of all uniformitarian ages (Pettijohn, 1975, pp. 83–87).

Bird Tracks

Bird tracks occur in the Bidahochi Formation (Breed, 1973). One would normally expect tracks of vertebrates during the Flooding Stage (Walker, 1994). So, maybe the Bidahochi Formation was deposited during the Flooding Stage, especially in view of the average 2,500–5,000 m (8,200–16,400 ft.) of erosion of the whole Colorado Plateau, including the Grand Canyon area (Schmidt, 1989). This erosion would be expected to occur during the Retreating Stage, leaving what is left behind from the Flooding Stage. It is also possible that birds and even some mammals, probably small mammals, could have survived on log mats for a while during the Recessive Stage of the Flood? Genesis 7:21–23 may refer to all air-breathing land animals being dead by Day 150. Or could these verses be a summary statement for the whole Flood? I would expect that the Bidahochi Formation was deposited during the Channelized Flow Phase—the last phase of the Flood, since it was deposited on the northern and eastern edge of a basin that probably had already formed. Further research into these issues is required.

Why is the Bidahochi Formation Mostly Above the "Shoreline"?

Austin et al. (2020) point out that we must be careful about using the current landscape to explain Flood runoff or a dam breach after the Flood. This is true, but we need evidence of post-Flood topographical changes. Otherwise, we can willy-nilly postulate a change in topography to support our hypothesis. So, it is possible that the Bidahochi Formation was faulted upward or raised by monoclinal uplift, but the question remains: is there any evidence of a significant uplift of the area? I doubt it, and it is up to Austin et al. (2020) to demonstrate such uplift.

Uniformitarian advocates of the dam-breach hypothesis do not appeal to the subsequent uplift of the Bidahochi Formation, but instead believe Lake Hopi rose to 2,250 m (7,400 ft.) based on the highest outcrop of the formation (Douglass et al., 2020). Such a lake would allow the breach to occur near the minimum elevation of 2,285 m (7,500 ft.) through the Kaibab Plateau. However, they need the low point across the Coconino Plateau, currently at 1,975 m (6,500 ft.) to be raised to 2,290 m (7,510 ft.) while the elevation at Grandview Point at 2,285 (7,500 ft.) remained the same (Douglass et al., 2020). This allowed the spillover point to occur at

Grandview Point. This scenario seems *ad hoc*.

To keep the water from spilling southwest down the current topographic slope and taking a northwest route along the same elevation, Douglass et al. (2020) propose a "half-circular cuesta scarp" that directed the spillover water to flow west and then northwest around the southern end of the Kaibab Plateau. Where is the evidence of such a preexisting half-circular channel?

Another possibility for raising the Bidahochi Formation is isostatic rebound after Hopi Lake emptied. An analog would be pluvial Lake Bonneville. The isostatic rebound of Lake Bonneville, where scientists first discovered isostasy, has been about 80 m in the deepest part of the former lake, which was 300 m (1,000 ft.) deep (Austermann et al., 2020). Little rebound took place along the edge of the lake. Thus, the Bidahochi Formation, at the edge (and above) Lake Hopi, should not have been uplifted significantly by isostatic rebound.

The Mammal Problem in the Bidahochi Formation

Austin et al. (2020) only mention beaver mammal fossils in the Bidahochi Formation. However, there are also saber-toothed tiger, camel, antelope, rhino, and gomphothere fossils (Douglass et al., 2020). If the Flood ended at the end of the Cretaceous (Austin et al., 1994), mammals would have had to leave the "mountains of Ararat," multiply, spread, across the Bering Land Bridge, increase into the millions, die, and be buried in the top layer of sediments along the high Great Plains and in the mountain valleys and basins of the western United States.

How likely is this in the time available, especially since Austin et al (2020) believe the dam breach occurred only 10 to 20 years after the Flood? Migrating over the Bering Land Bridge early in the Ice Age soon after the Flood would have been feasible, since winters then would have been mild and a land bridge tectonically raised (Oard, 2020), but the rest is far-fetched. Furthermore, there is evidence that the mammal fossils in the top layer of the High Plains were buried (or re-buried) during Flood runoff (Oard, 2014b).

These mammals represent a significant diversification, as shown by Cenozoic fossils. This much diversity is unlikely soon after or any time after the Flood. Then there is the issue of the order of appearance and disappearance of numerous mammals at various times within the Cenozoic—*all over the world at the same time*, if the fossil order from the geological column is assumed to be a worldwide sequence. For instance, brontotheres are like rhinoceroses but with unique horns (Figure 14). They show up in the late Paleocene and go extinct at the very end of the Eocene. In addition, the end-Cretaceous position must address the evidence that very few mammal fossils would have been buried and fossilized during the Flood in the Mesozoic, but many millions of them would have been buried and fossilized *after* the Flood.

There are more than 35 evidences that the Flood/post-Flood boundary is in the late Cenozoic, often in the very late Cenozoic around the Pliocene/Pleistocene boundary (Oard, 2016b, 2017a,b, 2018b, 2019; Clarey, 2017, 2020b; Baumgardner, 2018, pers comm.; Clarey and Werner, 2019). A very late Cenozoic end-Flood time would imply that the Grand Canyon was formed by late-Flood channelized erosion (Oard, 2010, 2016a).

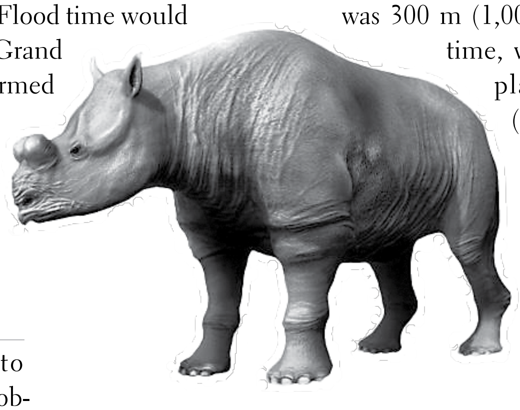


Figure 14. A brontothere, *Protitanops curryi* (Nobu Tamura, Wikipedia commons CC-BY-SA-4.0).

The Breach

In addition to all of these problems with the dam-breach hypothesis, there are questions about the actual event. When Holroyd (1994, pp. 243–254) first proposed water in the current basins northeast and southeast of Grand Canyon, he had Canyonlands Lake level at 1,700 m (5,577 ft.) asl (Figure 6 in Austin et al., 2020, p. 162). At this altitude, the lake would have been banked up to the pass on the northern Kaibab Plateau. Any higher, it would have spilled over the pass 32 km (20 mi.) east of Kanab, Utah. But Austin et al. (2020) propose a lake at 1,940 m (6,400 ft.) asl, held back by a rock dam east of Lees Ferry. This would keep the water from spilling over the pass on the northern Kaibab Plateau, assuming the same topography. However, Austin et al. (2020) claim this pass was 300 m (1,000 ft.) higher with the southern part of the Kaibab Plateau 300 m (1,000 ft.) lower.

Austin et al. (2020) say the breach occurred after the "higher" Canyonlands Lake spilled into the lower Lake Hopi; the currents producing the "fluvial" sediments of the Bidahochi and raising the level of Hopi Lake about 90 m (300 ft.). Hopi Lake then breached over the southern slope of the Kaibab Plateau at about 1,900 m (6,234 ft.) asl, significantly lower than advocated by Douglass et al. (2020). Today, the lowest point across the Kaibab Plateau on the south rim of the Grand Canyon is about 2,285 m (7,500 ft.) asl. Austin et al. (2020) then claim that the southern Kaibab Plateau was 300 m (1,000 ft.) lower at this time, while the northern plateau was 300 m (1,000 ft.) higher. It is as if the central part of the Kaibab Plateau was a fulcrum. This is supposed to account for the canyon being eroded at intermediate altitudes across the Kaibab Plateau. However, it needs to be demonstrated that such tectonic changes occurred after the Flood.

According to Austin et al. (2020), Lake Hopi then spilled into a "trough" west of the Kaibab Plateau forming "Lake Toroweap" that backwashed north onto the Kanab Plateau, west of the Kaibab Plateau, and south into the southwest Coconino Plateau (Austin et al., 2020, Figure 4, p. 156). Subsequently, Lake Toroweap breached west with the draining of the north and south plateaus carving the deep Kanab and Havasu Creek valleys, respectively, at the same time the western Grand Canyon was carved.

Conclusion

Uniformitarian scientists have made little progress in 150 years in attempting to explain the origin of the Grand Canyon. Hill and Polyak (2020) promote another hypothesis, while holding to some recent research on paleocanyons, an "Arizona river," etc. Their unlikely solution is piping underneath the Kaibab Plateau. The failure of uniformitarian scientists indicates that they are operating under the wrong paradigm; a catastrophic solution is more likely.

Any catastrophic solution requires immense volumes of moving water. Austin et al. (2020) think such water can be found in two post-Flood lakes and an abrupt dam breach. First, I answered several claims by Austin et al. (2020). The dam-breach hypothesis has numerous problems, four I consider major: (1) the lack of bottom sediments; (2) the origin of the long, deep tributary valleys; (3) the lack of wave-cut shorelines; and (4) the lack of a cobble and boulder delta at the mouth of the Grand Canyon. Austin et al. (2020) claim the lake bottom sediments are found in the Bidahochi Formation, but these are well above the top of the lake. Features found at other paleolakes, such as glacial Lake Missoula, and pluvial lakes of the Great Basin, are not present here. Bottom sediments that should have collected in the deepest part of the lake, such as from Cameron to Holbrook in association with Lake Hopi, and therefore preserved, are missing. It does not matter what the claims are for the Bidahochi Formation.

The challenging features of the Grand Canyon appear to be better explained by late channelized Flood runoff, especially since it easily accounts for the thousands of other water gaps across the Earth (Oard, 2020, 2016a).

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