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The Origin of Grand Canyon

Part II:
Fatal Problems with the Dam-Breach Hypothesis

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Abstract

Uniformitarian explanations of the origin of Grand Canyon all appear improbable. Thus, we turn to published catastrophic options. The most popular of these today is the dam-breach hypothesis. There are three versions of this general hypothesis, but all face major problems, of which two appear especially critical: (1) the lack of evidence for the existence of the breached lakes, and (2) the presence of the long Kanab and Havasu tributary canyons that enter Grand Canyon at the level of the Colorado River. There are no diagnostic bottom sediments, shorelines, raised deltas, or other geomorphological features at the proposed sites of the breached lakes, despite their common occurrence at the sites of other Ice Age lakes. Also, the erosion of the Kanab and Havasu canyons, a mile deep and a quarter mile wide at their mouths, would require vast quantities of rushing water over a wide area to erode these tributaries along with Grand Canyon, since the heads of the tributaries lie about 50 miles from Grand Canyon and over 100 miles from each other. This area seems too large for a breached lake to have flooded with sufficient energy to erode the canyons. Another catastrophic alternative is needed.

Introduction

Part I of this series (Oard, 2010) demonstrated that despite nearly 150 years of research, the origin of Grand Canyon remains opaque to uniformitarian geologists. All of their hypotheses depend on the slow erosion of the canyon by the Colorado River over varying lengths of time, with different mechanisms to explain this process. However, none of them—the antecedent stream theory, the stream piracy theory, or the lake spillover hypotheses—can explain the relevant field evidence.

Since the hypotheses all share a bias toward uniformitarianism, it seems logical to see that connection as a possible point of failure of all their ideas. Thus, exploring a catastrophic origin for the canyon seems imminently reasonable. We will examine the four hypotheses proposed by creationists. Three of these are remarkably similar, and center on the abrupt failure of the dams of post-Flood, Ice-Age lakes. The other creationist hypothesis suggests the erosion

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Figure 1. Picture of the three lakes from display of the dam-breach hypothesis at the AiG museum.

of the canyon by the channelized flow of retreating Floodwater.

This paper will explain and assess the three dam-breach models. Since they face many of the same problems, these can be summarized as applicable to all three. Of these common problems, two major issues seem to invalidate *any* dam-breach idea.

The Three Dam-Breach Hypotheses

The dam-breach hypothesis is recent compared to uniformitarian ideas. It was developed in the mid 1980s, and proposes the formation of several post-Flood lakes northeast and southeast of the Kaibab Plateau in basins of the Colorado Plateau (Figure 1). "Lake Hopi," occupied the Little Colorado River Valley southeast of the eastern Grand Canyon. The name for this lake was borrowed from uniformitarian scientists, who think that a Miocene/Pliocene lake existed there based on their interpretation of the Bidahochi Formation found on the northern and eastern sides of the basin (Scarborough, 1989).

"Canyonlands Lake" is thought to have been located northeast of Grand Canyon (Austin, 1994b). It is also called "Grand Lake" by Brown (2001; 2008). Both authors suggest that the waters of this lake were dammed by the Vermillion-Echo Cliffs northeast of the Marble Platform, rather than the Kaibab Plateau. This location is farther northeast than shown in Figure 1, and seems a point of contention between Austin, Brown, and other advocates of the dam-breach hypothesis. The Vermillion-Echo Cliffs were assumed to have once been connected on a northwest-southeast line. A reconstruction of the area with a lake surface level of 5,700 ft (1,737 m) would flood the Marble Platform (Austin, 1994a; Holroyd, 1990a; 1994), as seen in Figure 1. However, if the two cliffs were once connected and were eroded during the dam-breach event, then it is reasonable that the southwest edge of the lake was blocked by the Vermillion-Echo Cliffs.

The total area of the two proposed lakes depends on their depth (Austin, 1994a, p. 110, note 62). Canyonlands Lake supposedly had an elevation of about 5,800 ft (1,768 m), while Hopi Lake was slightly higher, at a little above 6,000 ft (1,829 m). At those elevations, the lakes would have covered some 30,000 mi^2 (77,700 km^2) and contained 3,000 mi^3 (12,505 km^3) of water, 2.5 times the volume of Lake Michigan. These proposed elevations are just under the spillover points on the north and south edge of the Kaibab Plateau.

Austin (1994a) proposed a third lake just north of Grand Lake in northeast Utah. He named it "Lake Vernal" or "Lake Uinta." It was separated from "Grand Lake" by the Book and Roan Cliffs. He suggested that Lake Vernal was one of a series of lakes that deposited the Green River Formation (and its equivalents) in northeast Utah, southwest Wyoming, and northwest Colorado (Oard and Whitmore, 2006). Of course this implies that these formations were deposited after the Flood. However, if the Green River Formation was deposited *during* the Flood, then it is doubtful that there ever was a "Lake Vernal." If not, then some of the water needed to erode Grand Canyon must be found elsewhere (Oard and Klevberg, 2008).

In all three dam-breach models, the lakes emptied catastrophically, like the Lake Missoula flood in the Pacific Northwest (Oard, 2004b). The authors suggest this occurred within a few centuries after the Flood. The escaping lake water eroded a notch in the Vermillion-Echo Cliffs, continuing southwest to break through the Kaibab Plateau and the other plateaus of the southwest Colorado Plateau. This vast flood then turned west, eroding Grand Canyon.

There are significant differences between the ideas of Austin (1994a) and those of Brown (2001; 2008). These must be taken into account in a general critique of the dam-breach hypothesis. To further complicate the picture, other creationists have informally suggested yet another dam-breach model. Instead of lakes existing for centuries, it posits the ponding of Floodwater in the same area. These waters broke through the Kaibab Plateau, eroding Grand Canyon within weeks or months of the end of the Flood. It can be called the *ephemeral lake version*. But since this idea has not yet been published, this article will concentrate on the Austin and Brown models.

Austin's Dam-Breach Model

Austin's (1994a) mechanism can be broken down into three stages.

(1) Within a few centuries of the Flood, sediments damming Lake Hopi were breached by piping. "Piping" is an engineering term that describes the forcing of water through weak areas in a dam because of the water pressure behind the dam. Austin proposed that a tunnel formed initially by piping, and was rapidly enlarged by high-pressure flow before the roof collapsed, forming a channel.

Erosion would have been aided by cavitation (Holroyd, 1990b; 1990c; 1990d). Cavitation is caused by the implosion of "bubbles" or vacuum cavities formed by irregularities in a channel during extremely high flows. It multiplies the erosive strength of the water, plucking large sections of rock from the channel floor. However, once the tunnel collapsed, cavitation would cease, since it exists only in shallow, very fast currents. This dam failure led to the catastrophic emptying of the lake, cutting the drainage of the Little Colorado River.

(2) Immediately after the draining of "Lake Hopi," "Canyonlands Lake" suffered a similar fate, cutting through the Vermillion-Echo Cliffs, probably also by piping. This event cut Marble Canyon and extended the Grand Canyon north and northeast from the Kaibab Plateau.

(3) Like toppling dominoes, "Vernal Lake" emptied too, cutting through the Roan and Book Cliffs. The combined water from these three lakes flowed west, eroding Grand Canyon and probably the Canyonlands area of southeast Utah, Black Canyon on the Gunnison River in western Colorado, and Flaming Gorge in Utah and Wyoming. The volume of water needed to erode Grand Canyon demands the simultaneous emptying of all three lakes.

Brown's Dam-Breach Model

Brown's (2001; 2008) hypothesis is more complex, involving seven key steps. It flows from his larger "Hydroplate" hypothesis and is thus dependent on its veracity.

(1) The initial elevation of the southwest Colorado Plateau was lower, at about 5,000 ft (1,524 m) msl. The top of the Kaibab Limestone was at 4,000 ft (1,219 m) msl, capped by another 1,000 ft (305 m) of soft Mesozoic strata. In other words, the Kaibab Limestone that today forms the surface of the Kaibab Plateau was 5,000 ft (1,524 m) lower than its present elevation of about 9,000 ft (2,743 m) just before the dam-breach event.

(2) During the Genesis Flood, continent-sized blocks of crust composed of large crustal plates moved west and downward off the rapidly rising ocean floor of the Mid-Atlantic Ridge, which rose 10 miles (16 km), initiating the lateral sliding of large crustal plates. Lubricated by subcrustal water, North America slid west at a relatively high speed and then came to an abrupt halt, as the western end was halted by friction. The rest of the "hydroplate" buckled and compressed within hours during the "compression event." Weaker portions were crushed, thickened, and forced upward, creating the new continents, which were then about twice today's elevation, which triggered the Ice Age. The Rocky Mountains would then have been roughly double their current elevation—similar to the Himalayas of today.

(3) The unstable mountains began to sink, forcing the mantle up on either side, causing the adjacent plateaus to rise—thousands of feet over several centuries following the Flood. The Colorado Plateau, and the remaining water ponded there, rose as much as a mile (1.6 km). This post-Flood isostatic adjustment caused extensive frictional melting and the volcanism around the perimeter of the Colorado Plateau. Brown suggests that block faulting during uplift caused most of the high east-west cliffs on the Colorado Plateau:

> Large blocks, when lifted and tilted, became cliffs and mountains—called *block-faulted mountains*. North of the Grand Canyon are many examples: Utah's Book Cliffs, Roan Cliffs, the Grand Staircase (Vermillion Cliffs, White Cliffs, Grey Cliffs, Pink Cliffs), and others (Brown, 2008, p. 191).

Figure 3 shows the Grand Staircase from Le Fevre Overlook, northwest of the North Rim of the Grand Canyon halfway up the northwest Kaibab Plateau (see Figure 3 in Part I for a diagram of the Grand Staircase). The scarps of the Grand Staircase in Brown's model were caused by faulting. But field data indicates that all of these cliffs are *erosional*; there is no evidence for significant block faulting. It is possible that minor faulting could have occurred along the Vermillion Cliffs north of Grand Canyon, but they are normal faults, down to the north—the opposite of the direction suggested by Brown. At any rate, Brown has "Grand Lake" rising to an elevation of about 5,700 feet (1,737 m) msl while Lake Hopi ended up at 5,950 feet (1,814 m) msl.

(4) The climate after the Flood produced more rain than is seen today, which caused the lake levels to rise, until "Grand Lake" cut through its southwest bank, spilled over the Vermillion-Echo cliffs, and catastrophically eroded 2,000 ft (610 m) of soft Mesozoic strata, forming an 18-mile (29 km)-long and up to 12-mile (19 km)-wide spillway, called the "funnel," between the Vermillion and Echo Cliffs (Figure 4). Lee's Ferry, where many rafting enthusiasts start their journey down the Colorado River (Figure 5), is located at the northeast end of the funnel. During catastrophic erosion of "the funnel," horizontal strata beneath its floor began to arch upward as the weight of overlying sedimentary rock was removed. Since the rock was not malleable, the arching caused the strata to split under tension, forming Marble Canyon parallel to the funnel axis.

(5) Southward flowing water from "Grand Lake" undercut the northwest corner of "Lake Hopi," triggering its catastrophic emptying. This flow formed a waterfall about thirteen times higher and possibly a hundred times the volume of Niagara Falls (Brown, 2008, p. 192). Catastrophically released water from both lakes swept west as a sheet, eroding at least 1,000 ft (300 m) of soft Mesozoic strata above the Kaibab Limestone over a wide area. This sheet erosion event stripped strata from northwestern Arizona, an area of 10,000 mi^2 (25,900 km^2). Brown points to the approximately 1,000-foot (305 m)-high erosional remnants of this Mesozoic sedimentary rock, such as Red Butte, which is capped by lava, as evidence for this sheet erosion event.

(6) The westward flowing wall of water converged at the lowest point of the "rising" Kaibab Plateau, cutting Grand Canyon. The removal of a 1,000-ft (305 m) sheet of strata from Kaibab Plateau supposedly helped generate the rapid 5,000-ft (1,524 m) rise in its elevation. The course of Grand Canyon was due to an anticlinal uplift along its path caused by the earlier sheet erosion. As the canyon was eroded downwards, the process was aided by the continuous creation of tension cracks and the anticlinal uplift of the strata, until Grand Canyon was excavated into the igneous and metamorphic rocks that mark its present bottom.

(7) Brown attributes some of the erosion of Grand Canyon to groundwater, which existed at that time in greater quantity than today. He thinks that up to 20% of the Flood's waters became groundwater. During the formation of Marble Canyon and Grand Canyon, this groundwater began to flow rapidly towards the newly eroding Grand Canyon, multiplying the erosional effects of the surface waters, and opening underground channels, which in turn collapsed and formed side canyons.

The Kaibab Plateau Uplifted Before Grand Canyon Formed

Austin's (1994a) version is the best developed of the two models. He begins with today's topography, with the Kaibab Plateau already at its current elevation. Brown's model (2001; 2008) proposes that the Kaibab Plateau uplifted during and after the breaching of the lakes.

Austin is better supported by two pieces of field evidence. First, the Butte Fault (related to the East Kaibab Monocline) and the Colorado River between Nankoweap Creek and the Little Colorado River are parallel to each other (Figure 2). This is best explained by the uplift of the Kaibab Plateau *before* the Colorado River developed (see Figure 5 of Part I for the location of the East Kaibab Monocline). Ranney (2005, p. 71, emphasis and brackets mine) stated:

> In his [Walcott's] report he noted how the Colorado River in Marble Canyon exactly parallels the trace of the Butte Fault for ten miles from Nankoweap Creek to the Little Colo-

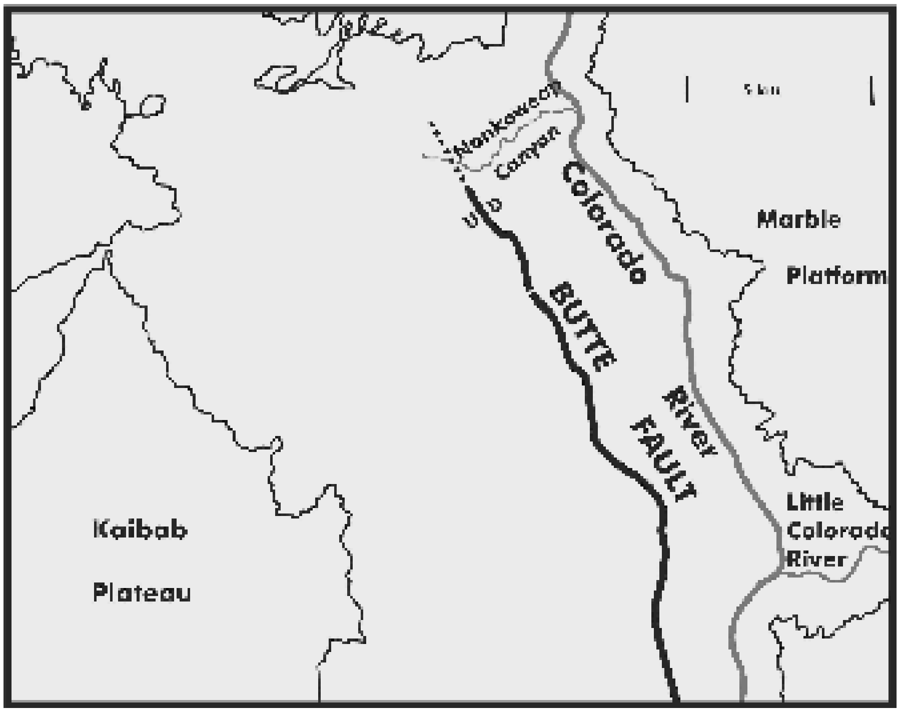

Figure 2. The Butte Fault parallel to Colorado River between Nankoweap Canyon and the mouth of the Little Colorado River Canyon, showing that the Kaibab Plateau was already uplifted before the Colorado River formed. Drawing by Peter Klevberg.

Figure 3. The Grand Staircase from Le Fevre Overlook. These cliffs represent about 10,000 feet (3,048 m) of erosion.

rado. This showed unequivocally that the river must have become positioned *after* that structure was formed.

Second, the northern part of the East Kaibab Monocline just east of Bryce Canyon National Park, Utah, is erosionally beveled. This surface is overlain by flat-lying strata believed at one time to be the Wasatch Formation (Austin, 1994a; Babenroth and Strahler, 1945). This formation has since been renamed the Claron Formation (Harris et al., 1997), because it is much different than the typical Wasatch Formation found farther north, being composed mostly of limestone with very few fossils and conglomerate lenses. In any case, the presence of these flat-lying strata, extensively eroded along the Grand Staircase (see Figure 3, Part I), suggests that the Kaibab Plateau was uplifted *before* the Claron Formation was deposited. And since this formation once covered over 2,000 mi^2 (5,100 km^2) north of Grand Canyon, it seems reasonable to attribute it to the Flood. Therefore, widespread Flood sedimentation was happening *after* the Kaibab Plateau uplifted (Oard et al., 2009), which would be hard for Brown's dam-breach hypothesis to explain.

My Journey Away from the Dam-Breach Hypothesis

Originally, I accepted Austin's dam-breach model. It seemed plausible, supported by published evidence. At the time, I was pursuing other projects and did not evaluate the model closely. In my first (generally favorable) examination of the dam-breach hypothesis (Oard, 1993), I noticed five geological problems and estimated Ice Age precipitation for the southwest United States. Precipitation then would have been about four times today's and evaporation less, due to cooler temperatures during the Ice Age. Higher precipitation and lower evaporation could have led to rapidly rising lake levels in the American Southwest. My climatological focus diverted attention from geological problems. I mentioned several as a means to spur Austin and others to answer them. Brown attempted to do so, but his explanations were not convincing. Over time, other research not directly connected to Grand Canyon began to raise other questions and

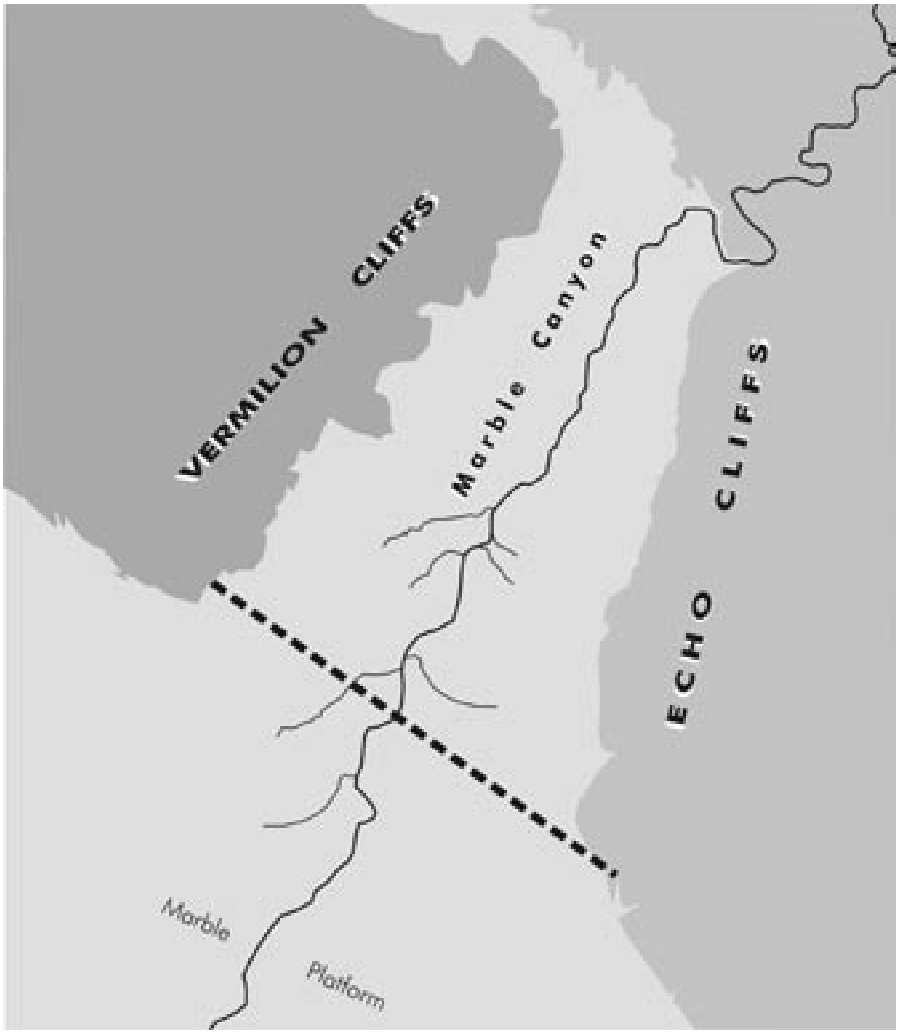

Figure 4. The "funnel" between Echo and Vermillion Cliffs. Note the tributaries entering Grand Canyon at an obtuse angle. Drawing by Peter Klevberg.

Figure 5. The start of a raft trip down the Colorado River beginning at Lee's Ferry, northeast of Marble Canyon.

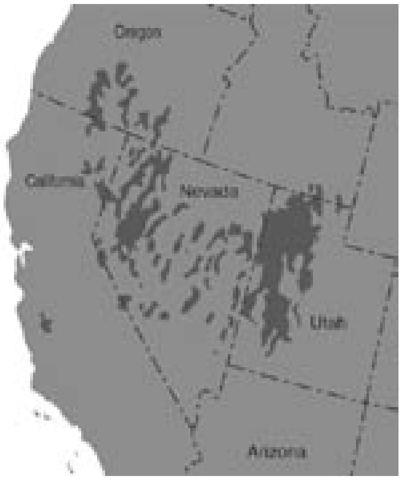

Figure 6. Pluvial lakes in the Basin and Range Province during the Ice Age.

uncover even more problems (Oard, 2004a; 2004b).

At this time, I was researching the Lake Missoula flood at the peak of the Ice Age and the resulting Channeled Scabland of eastern Washington. Years of field and literature research led to the conclusion that only one large Lake Missoula flood occurred (with some minor flooding possible later) (Oard, 2000; 2003; 2004b). That research spurred my interest in features of other post-Flood lakes of the Southwest United States (Figure 6). These *pluvial lakes* existed during the wetter part of the Ice Age, later shrinking or disappearing. They would have been located just west of the two "dam-breach" lakes, and so should share a generally common history. The pluvial lakes commonly exhibit well-developed shorelines and other features such as raised deltas at the mouth of tributary streams.

Glacial Lake Missoula and the pluvial lakes of the southwest United States are suitable analogs for Ice Age lakes on the Colorado Plateau. All of them existed during the early post-Flood period—many for several centuries, though glacial Lake Missoula probably existed for less than a century. All of these post-Flood lakes would have been growing and filling up until the peak of the Ice Age, experiencing rising water levels following the Flood due to heavy precipitation and melting ice.

Flooding occurred, as field evidence clearly shows. In addition to Lake Missoula, Lake Bonneville in western Utah broke through a rock barrier causing the Bonneville flood in the upper Snake River Valley of southern Idaho (O'Connor, 1993). There is well-documented evidence for the Lake Missoula and Bonneville floods. Austin (1994a) even referred to glacial Lake Missoula and the Channeled Scabland as an example for his dam-breach model, noting that Grand Coulee, carved during the Lake Missoula flood, was a small-scale example of Grand Canyon. Given these similarities, the Lake Missoula and Lake Bonneville dam-breaches should be good analogies of the dam-breach models for Grand Canyon. Therefore, the field evidence of this process should not be subtle, but obvious and overwhelming.

All dam-breach models fail at this point. Instead of the evidence being obvious and overwhelming, it is typically vague and inconclusive.

Numerous Problems

Exploring the problems of the dam-breach hypotheses requires more room than available here. However, they can be summarized as:

(1) Lack of evidence for the proposed lakes.
(2) Unexpected long, deep, narrow tributary canyons.
(3) Rapidly rising water after the Flood would most likely have eroded outlet(s) at low elevations of the Kaibab Plateau, precluding a later catastrophic release.
(4) Piping would have had to operate over nearly 100 miles (161 km). Thus, piping in man-made dams is a poor analogy. The Redwall Limestone has been suggested as the suspect formation, having a number of small caves. However, it would have been in the wrong position, several thousand feet deeper than the bottom of the lakes. Movement along the East Kaibab Monocline could potentially have broken up overlying strata, allowing the water to reach the Redwall, but the lakes were not banked against the monocline.
(5) Austin's model requires an improbable simultaneous release of lake volumes to provide sufficient water to erode the 1,000 mi^3 (4,169 km^3) of rock from Grand Canyon. The timing would have had to be perfect.
(6) Brown's model includes both sheet erosion and later channelized flow. He is hard-pressed to explain that volume of water.
(7) Large crustal movements and block faulting (Brown, 2008) are not supported by field evidence.
(8) The plethora of features such as gravel bars and slackwater deposits readily observed for the Lake Missoula and Bonneville floods are not present on the southwest Colorado Plateau.
(9) Widespread erosion, such as that on the southeast edge of the Kaibab Plateau (often higher than the proposed lakes) cannot be explained by Austin's theory.
(10) There is no massive gravel bar at the mouth of Grand Canyon, similar to the 200 mi^2 (518 km^2), 300-ft (91 m)-thick Portland Delta at the mouth of the Columbia Gorge. There are of course gravel bars downstream from the Grand Canyon and gravel on pediments, as found in many locations in southeast California and southwest Arizona far from the Colorado River. These features cannot differentiate between catastrophic models. Given the volume of water needed to erode Grand Canyon, the expected gravel bar at its mouth should be at least an order of magnitude larger than the Portland Delta.

Since the first two objections seem fatal to either dam-breach model, we will evaluate them in more detail.

No Evidence for the Lakes

Obviously, there needs to be upstream lakes if there was any breach. Is there any evidence for their existence?

No Lake-Bottom Sediments

Of the three proposed lakes, Lake Vernal is a special situation, as previously discussed. Thick sediments, both extant and eroded, are attributed to this supposed lake, which was one of several "lakes" that occupied 30,000 mi^2 (77,700 km^2) of northeast Utah, southwest Wyoming, and northwest Colorado after the Flood. However, sediments commonly attributed to this lake were very likely deposited by the Flood (Oard and Klevberg, 2008), not by a post-Flood lake.

The debatable sedimentary evidence for "Lake Vernal" is the best evidence for the proposed lakes. But, no sedimentary evidence exists for "Grand Lake." Even its proponents, as well as uniformitarian scientists who believe in the spillover hypothesis (see Part I), admit the absence of "Grand Lake" sediments.

Austin (1994a) claimed that the Bidahochi Formation contained sedimentary remains of "Lake Hopi" in the Little Colorado River Valley. But geologists think that only a small part of the formation was deposited by a lake and that this lake was only a small desert lake (Dallegge et al., 2001; White, 1990). Most of the formation is volcanic or laid down in moving water. Unless the Bidahochi Formation can be reinterpreted, there does not seem to be enough sediment to justify a lake as large as "Lake Hopi."

Furthermore, these lake deposits are near to or higher than the proposed elevation of the lake. While the Bidahochi lake sediments are located near the northern and eastern "shoreline," there are 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. Since the sediments of the watershed surrounding "Lake Hopi" are easily eroded, another explanation for their absence needs to be developed.

Some might argue that the missing sediments were scoured away during the breach of Lake Hopi's dam. But the outlet of "Lake Hopi" is the Little Colorado River Canyon—a narrow canyon about half a mile (0.8 km) high and a quarter mile (0.4 km) wide where it enters the Colorado River (Figure 7). Figures 8, 9, and 10 show this narrow canyon at three locations above its junction with the Colorado River. Although water would be rushing through the constricted canyon of the Little Colorado River, this quarter-mile-wide outlet would allow only a small volume of water to pass through compared to the large volume of Lake Hopi. Thus, in the lake away from the outlet, the currents would be sluggish until they neared the outlet, minimizing scour of the lake bottom. It does not seem likely that the dam breach would have caused the complete scouring of the lake-bottom sediments. The same argument applies to "Grand Lake" and Marble Canyon. With restricted outlets, there is no reason not to expect thick deposits of lake-bottom sediments.

In contrast, Lake Missoula left abundant sediments in the broad basin of northwestern Montana. These are located at the lowest elevations northwest of Missoula, as expected (Figure 11). Although the lake sediments were eroded from the narrow valleys of western Montana, that is expected, given the current velocities of up to 60 mph (97 kph). Figure 12 shows a schematic of expected currents at various points within Lake Hopi and its outlet.

Figure 7. The mouth of the Little Colorado River from a raft on the Colorado River (view southeast).

Figure 8. The Little Colorado River valley west of Cameron as it enters the beginning of the canyon.

No Shorelines or Raised Deltas

In addition to the missing sediments, the proposed lakes left no geomorphological markers either. All lakes have shorelines, and when rivers flow into lakes they form deltas. If a lake empties, those shorelines and deltas will remain, carved or deposited on the surround hills. The Flood ended around 4,500 years ago. The lakes breached several hundred years later. That leaves slightly more than four millennia, which is not enough time to

Figure 9. 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 1,200 feet.

Figure 10. Top of the slot-like canyon of the Little Colorado River Valley at milepost 277.7 on highway 64.

Figure 11. Extensive, flat lake-bottom sediments (rhythmites) from glacial Lake Missoula in the Little Bitterroot Valley, about 75 miles (120 km) northwest of Missoula, Montana. These sediments were laid in the bottom of glacial Lake Missoula, over 1,000 feet (300 m) below maximum lake level. The catastrophic emptying of the lake failed to erode these sediments.

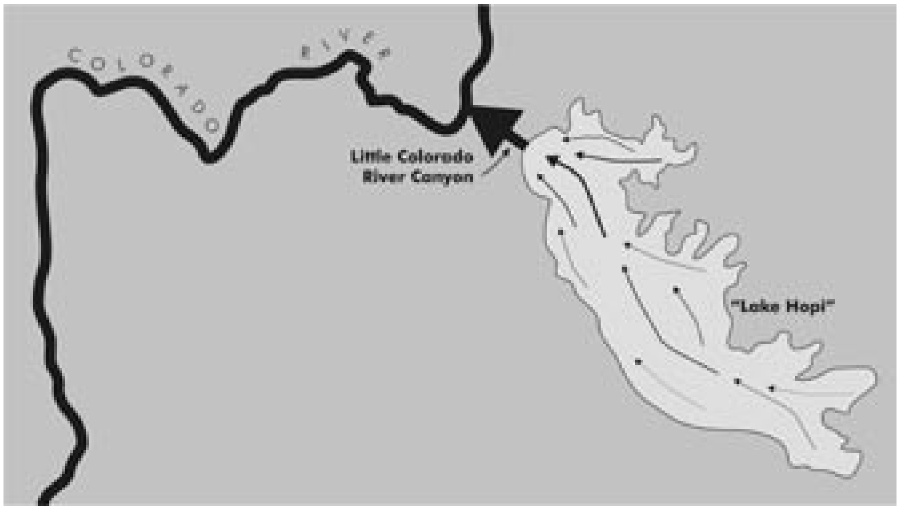

Figure 12. Schematic of theoretical currents in "Lake Hopi" and the Little Colorado River Canyon. The current would have been strong through the Little Colorado River Canyon because of its slot-like shape but much weaker away from the drainage point. Hence, little erosion of lake bottom sediments should have occurred. Thick arrows show high velocity, and thin arrows show relatively low current velocities. Drawing by Peter Klevberg.

erase all traces of these lakes, as is clearly seen in the remains of other pluvial lakes in the same region.

(1) Shorelines and Raised Deltas around Glacial Lake Missoula

How do we know that the shorelines and high deltas should still exist today? Simply by analogy; shorelines, raised deltas, and other shoreline features are abundant around *other* past Ice Age lakes. Even if the hypothetical dam-breach occurred before the Ice Age (a very unlikely idea), the same evidence should still be seen.

For instance, glacial Lake Missoula was most likely a very short-lived lake that rose each year during the peak of the Ice Age (Oard, 2004b). Although it burst and emptied in a few days, relict shorelines are abundant. A few examples are the shorelines found around the city of Missoula (Figures 13 and 14), in the Missoula Valley west of Missoula (Figure 15), and on the north slope of the National Bison Range (Figure 16). There are also raised deltas at the entrance of tributary valleys to the Bitterroot Valley (Weber, 1972).

Moreover, the host lithology makes no difference. The shorelines are etched equally clearly in hard rocks and in soft clay slopes—e.g., the north slope of the Missoula Valley. Alt (2001, p. 48) stated, "But the shorelines seem just as numerous on the weak clay slopes north of the Missoula Valley as on extremely stable slopes of Belt rocks." The shorelines on clay slopes are very similar in appearance to those shorelines cut on harder rocks. Thus, any appeal to absence from erosion seems unlikely.

If distinct shorelines for ephemeral glacial Lake Missoula are so abundant and obvious—even in soft rocks—surely we should see many obvious shorelines associated with the lakes proposed by Austin and Brown.

(2) Shorelines and Raised Deltas around Ice Age Lakes in the Great Basin

The Basin and Range Province lies west of the Colorado Plateau. It is composed of high mountain ranges separated by deep valleys or basins, with no external drainage. Today, the climate is hot in the summer and annual precipitation is

Figures 13. Shorelines from glacial Lake Missoula on Mount Sentinel, east of Missoula, Montana.

Figure 14. Shorelines from glacial Lake Missoula on Mount Jumbo, northeast of Missoula, Montana.

Figure 15. Shorelines from glacial Lake Missoula on the northern slope of Missoula Valley, just north of Frenchtown.

Figure 16. Shorelines along the northern National Bison Range, about 35 miles (55 km) north of Missoula, Montana.

Figure 17. Lake Bonneville shoreline at base of mountains north of Salt Lake City.

generally light. But during the Ice Age, enclosed basins within the Great Basin (as well as areas of southeast California) contained many deep lakes (see Figure 6). These lakes would have been partially filled during the final retreat of the Genesis Flood, as should have any lakes on the Colorado Plateau. Lake Bonneville was the largest, about 800 feet (244 m) deeper than Great Salt Lake; a mere remnant of Lake Bonneville, and only about 12 feet (3.7 m) deep on average.

All these lakes would have continued to grow during the Ice Age (Oard, 1990; 2004a). Heavy Ice Age precipitation caused Lake Bonneville to eventually overtop an outlet at Red Rock Pass (southeast Idaho) causing the Bonneville flood (O'Connor, 1993; Oard, 2004a; 2004b). Ice Age lakes in the Great Basin should have been similar to those on the Colorado Plateau, if the latter existed.

The existence of these pluvial lakes is shown by their abundant shorelines. Some are huge. The most impressive are those around Lake Bonneville (Figure 17), just west of "Grand Lake." Shorelines from other pluvial lakes of the Great Basin–such as Ice Age Mono Lake in Owens Valley, California; Ice Age Lake Lahonton in western Nevada; Ice Age Lake Manly in Death Valley (Figure 18); and Ice Age lakes in southeast Oregon (Figure 19)—are less distinct but still visible. Ice Age lakes in western Nevada and southeast Oregon also exhibit beach barrier bars, spits, back-barrier lagoons, rounded gravel and other shoreline geomorphological features (Adams and Wesnousky, 1998; Carter et al., 2006). The most prominent shoreline in Death Valley is located at 300 ft (91 m) above the basin floor, with possible shorelines much higher (Hooke, 1999). There is abundant and obvious evidence for their post-Flood existence.

(3) No Shorelines and Raised Deltas for Proposed Colorado Plateau Lakes

When we turn to the two lakes east and northeast of the Kaibab Plateau,

Figure 18. Lake Manly shorelines in Death Valley on lower slope to left.

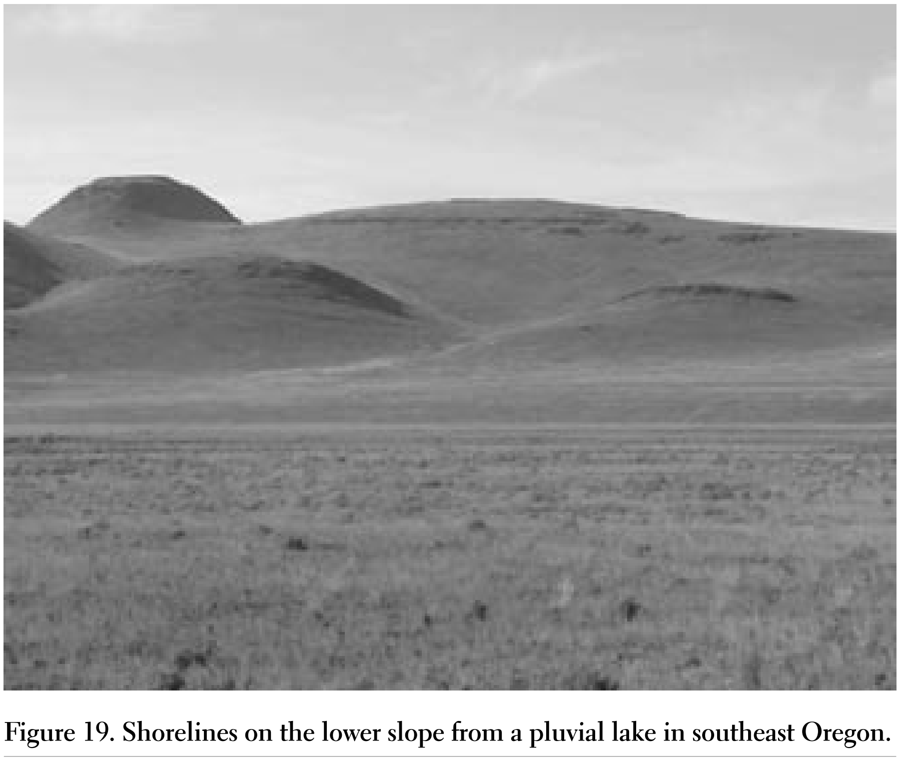

Figure 19. Shorelines on the lower slope from a pluvial lake in southeast Oregon.

there are *no* shorelines, raised deltas, or other beach geomorphological features (Holroyd, 1994). The ephemeral lake version is the only one of the three dam-breach hypotheses that can account for the observed evidence. But for other reasons, such as Grand Canyon carved at an intermediate altitude through the Kaibab Plateau and the long tributary canyons (described below), that version is unlikely. At best it depends on the absence of evidence.

(4) Are There Any Reasons Not to Expect Shorelines?

Brown (2008, pp. 201-202) responded to this lack of evidence. He first stated that after the Flood, the Colorado Plateau rose more than a mile (1.6 km), while the Rocky Mountains sank. Such uplift altered the shapes of the basins and caused the shorelines to shift so that the water level would not be at one location long enough to etch a shoreline. Pluvial Lake Bonneville and glacial Lake Missoula were supposedly not affected by these great vertical movements, though Lake Missoula technically lies in the Rocky Mountains and Lake Bonneville just to the west of Grand Lake and Lake Hopi.

But these movements are contrary to field evidence. Furthermore, if there had been such widespread tectonic instability, it seems unlikely that lakes would have formed at all. Brown (2008) countered by suggesting that oscillations in the lake waters would have eroded any shoreline features, but these same movements would have caused the lakes to overflow their natural barriers well before any dam breach. And if he is right, the same problems would have been faced at nearby Lake Bonneville. But that lake shows excellently preserved features and no evidence of large-scale vertical motions.

In another attempt to deal with these difficulties, Brown (2008) also suggested that Lakes Bonneville and Missoula probably breached centuries after Lakes Grand and Hopi. He suggests that thunderstorms would then have had more time to erode the shorelines of the dam-breach lakes. But do the numbers add up? Grand Lake and Lake Hopi likely lasted 200 to 500 years. On the other hand, glacial Lake Missoula probably lasted only 80 years with each year's stillstand forming a shoreline (Oard, 2004b). It then obviously took less than a year to etch each still-visible shoreline of glacial Lake Missoula.

Glacial Lake Missoula was emptied at the peak of the Ice Age, about 500 years after the Flood. Pluvial lake Bonneville broke through Red Rock Pass a little earlier (O'Conner, 1993), since the deposits of the Bonneville flood are below those of the Lake Missoula flood around Lewiston, Idaho. Lake Bonneville dropped over 330 feet (100 m) during the Bonneville flood. The highest shoreline, as well as the next to the highest shoreline, is still very distinct. So, the highest shoreline of Lake Bonneville must have been carved within a very short time. It does not take long to make a shoreline. The many levels of shorelines from Grand and Hopi Lakes should be clearly preserved.

Furthermore, the same thunderstorms should have affected other preserved features across the western United States. And ironically, shorelines cut into slopes would be immune from the worst erosion from thunderstorms, which comes from water accumulating in *lower* areas and flooding down gradient. Most geologists would recognize that climatic conditions in Montana are much more conducive to erosion, yet the remnants of glacial Lake Missoula are still there.

Brown (2008) also appealed to elevated groundwater flow after the dam breach to erode the shorelines. With a sudden drop in base level, the surrounding groundwater would have destroyed shorelines and formed cliffs as the groundwater shot high into the air. But groundwater flow is usually very slow compared to surficial flow, and it is more likely that a rapid adjustment to the water table surface near the drained lake would slowly accommodate the change in base level. Even so, some shorelines would have certainly existed at high altitudes once the lake emptied and probably above the water table. Most groundwater discharge, especially in any volume, would occur at lower elevations.

Although Brown (2008) did not make the argument, someone may claim that shorelines would more easily erode on the Colorado Plateau because of the friable nature of the sedimentary rocks. But if glacial Lake Missoula's shorelines were preserved in both hard rock and soft clay (Alt, 2001), why should not Lake Hopi's and Grand Lake's? Furthermore, many of the rocks beneath the proposed

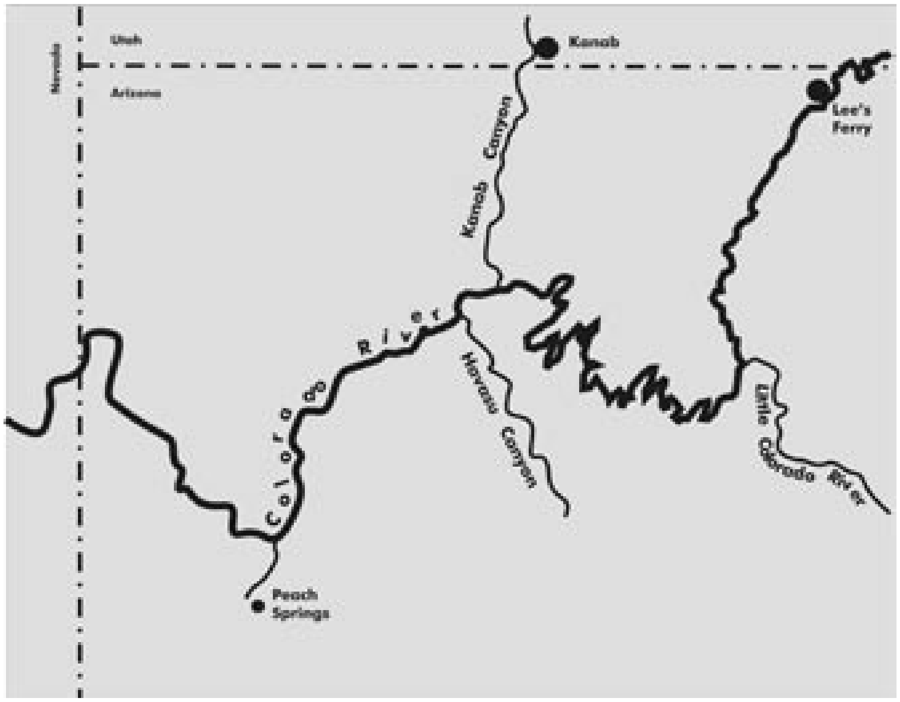

Figure 20. The four long tributary canyons of the Colorado River through Grand Canyon that gradually descend to the level of the Colorado River. Drawing by Peter Klevberg.

Figure 21. The mouth of Kanab Canyon from the Colorado River in Grand Canyon.

Figure 22. Havasu Canyon with Cataract Creek.

lakes on the Colorado Plateau are consolidated, and certainly hard enough to preserve shorelines from minimal erosion over 4,000 years.

(5) Summary

If Grand Canyon was carved by a flood from the catastrophic emptying of post-Flood lakes, then a primary test of that hypothesis would be indisputable evidence of these lakes at the right time and in the right place. That evidence would include the presence of lake sediments, shorelines, and other geomorphological features commonly associated with numerous dry lakebeds in the western United States. Analogies like glacial Lake Missoula and Lake Bonneville demonstrate the types of features we should expect, as well as their preservation potential. Their absence, especially given the quality of the analogies is a powerful argument against the hypothetical lakes on the Colorado Plateau.

Long Tributary Canyons: Another Major Hurdle for the Dam-breach Hypothesis

We will now look at another powerful argument against the dam-breach hypothesis—the presence of long tributary canyons (Figure 20). There are four long tributary canyons to Grand Canyon:

1. (1) Kanab Canyon, running about 50 miles (80 km) from Kanab in south central Utah
2. (2) Havasu Canyon, which starts about 60 miles (97 km) south of Grand Canyon near Williams, Arizona
3. (3) Peach Springs Canyon, about 20 miles (32 km) long
4. (4) Little Colorado River Canyon

Peach Springs Canyon is likely related to the Hurricane Fault. Since there is a structural component to its existence, and it was not formed completely by erosion, it will not be discussed in depth. But it is interesting to note that north of its intersection with the Colorado River, the path of Grand Canyon is unrelated to this fault, one of the most significant in the Grand Canyon area (Austin, 1994c). Furthermore, when Grand Canyon did intersect the trace of the Hurricane Fault, it did not continue along the fault, but turned west.

Figure 23. Tributary canyon to Havasu Creek. The headwaters of this canyon are in a fairly dry location with a very little drainage basin on the west side of Havasu Creek. It does not seem likely that such a deep canyon, tributary to Havasu Creek could form during the dam-breach or in the post-Flood climate.

The other three long tributary canyons are not related to any known fault. Practically all the significant faults trend perpendicular to the Grand Canyon, in a north-south direction (Huntoon, 1990; Shoemaker et al., 1974; Warner, 1978). There are some minor northwest trending faults detected in the upper Havasu Canyon drainage and west of Havasu Creek (Shoemaker et al., 1974), but they do not seem to have affected the path of Havasu Creek.

The Little Colorado River Valley is not included in this analysis since, as one of the dam-breach outlets, it presents no problem to the hypothesis.

Kanab and Havasu Canyons

That leaves Kanab and Havasu canyons. They are erosional, not fault related. The simplest explanation is that they formed during the same erosional event that carved Grand Canyon. Kanab Canyon enters Grand Canyon (Figure 21) as a narrow gorge about one mile (1.6 km) deep and a quarter mile (0.4 km) wide (Powell, 2005). Havasu Canyon is of similar dimensions (Figure 22). Both require significant erosion of hard rock. Cataract Creek runs down Havasu Canyon year-round, but Kanab Creek is dry most of the year and presents a problem to even uniformitarian geologists: "To make the question even more difficult, Kanab Creek, like most of the side canyons, and in contrast to the perennial Colorado, is usually dry" (Powell, 2005, pp. 63–64). Ranney (2005, pp. 50, 51) puzzled over the origin of these tributaries:

> How is it that much smaller tributaries, which have no water in their channels most of the time, can carve canyons just as deep as the Colorado River has carved the Grand Canyon?

Thus, the uniformitarian solution for this problem is "deep time" and flash floods (Powell, 2005; Ranney, 2005).

If Kanab and Havasu Canyon did not form during the dam breach, could they have formed after the dam breach? That would require their erosion by present-day processes operating over about 4,000 years. Early on, precipitation would have been higher but with very few summer thunderstorms that cause the erosive flash floods we see today. Toward the end of the Ice Age, the climate would dry and then the summer thunderstorm regime would set up about 4,000 years ago. But even with flash floods, erosion observed today in these canyons is modest at best. It does not seem possible that summer thunderstorms and flash floods could carve a mile-deep canyon, not to

Figure 24. Hanging valleys west of Banks Lake, upper Grand Coulee

mention the deep canyons tributary to Kanab and Havasu Canyons (Figure 23). We must conclude that it is highly unlikely that these tributary canyons formed by modern processes after Grand Canyon.

The Canyons Eroded at the Same Time as Grand Canyon

Since the tributaries reach the same depth as Grand Canyon, the most logical explanation is that they were eroded at the same time. Because they gradually descend to the exact depth of Grand Canyon from their upper drainage basins, they could not have formed before Grand Canyon. They had to form simultaneously with Grand Canyon.

The erosion of Grand Canyon required massive volumes of water. Apart from the Flood, that volume is difficult to explain. The presence of the tributary canyons exacerbates that problem, not least because the water would have had to be present at the upper ends of the drainage basins of the tributary canyons, and at the upper end of Grand Canyon at the same time—areas separated by over a hundred miles. In other words, water flowing at sufficient velocity for a sufficient time to erode a mile into indurated rock would have had to have been spread over a hundred miles (161 km) of the southwest Colorado Plateau or to have been derived simultaneously from three widely spread sources.

The relationship between Grand Canyon and its tributaries is mirrored in the erosional remnants of the Lake Missoula flood. Had the tributary canyons not been eroded at the same time as Grand Canyon, they would probably have created hanging valleys, such as those seen in the Pacific Northwest. During the flood that formed the Channeled Scabland, Grand Coulee, and Moses Coulee, about 10 miles west of Grand Coulee, formed rapidly (Oard, 2004b). Preexisting valleys were left as hanging valleys in the walls of the coulees (Baker, 1978; Hanson, 1970) (Figure 24). Those tributary valleys that slope to the floor of Grand Coulee do so because they were formed at the same time. For example, Northrup Canyon, along the northeast edge of Upper Grand Coulee, is not a hanging valley because it formed at the same time as Grand Coulee.

The necessity for multiple sources of flooding or for one extremely widespread source militates against the dam-breach hypothesis.

What about the Tributary Canyons on Marble Platform?

Brown (2008, p. 190) noted that the tributary canyons to the Colorado River through Marble Canyon are at an obtuse angle (see Figure 4), while in a normal drainage they should be acute. He interprets this angle to suggest that Marble Canyon tributaries were formed by a northeast flowing current. But how would such a river fit into Brown's hypothesis? This is the opposite direction to which the water of the dam-breach flowed. His objection is easily answered. The unusual obtuse tributaries could simply be a result of late Flood and post-Flood drainage flowing *downslope*, which is toward the northeast on the Marble Platform. The Colorado River flows south to southwest, but the top of the Marble Platform slopes the opposite way, quite different from a normal drainage network.

Summary

Uniformitarian models fail to explain to origin of Grand Canyon. Catastrophist alternatives have focused on the abrupt emptying of upstream lakes by a dam breach. But these models face many problems, too. Two especially severe objections to any dam-breach theory are the absence of evidence for the antecedent lakes and the inability of lake sources to account for the simultaneous erosion of tributary canyons. Counter arguments to the absence of lake features fall apart when met with the analogies of other nearby lakes existing at about the same time. Lake Bonneville and Lake Missoula left abundant evidence of their presence; proposed "Lake Hopi" and "Grand Lake" should do no less.

An unpublished hypothesis, the ephemeral lake version, offers a possible explanation of the absence of lake features but cannot explain the synchronous erosion of multiple canyons many miles apart. Nor can it explain the location of Grand Canyon at an intermediate altitude on the Kaibab Plateau or the fact that Grand Canyon was carved just west of the Kaibab Plateau perpendicular to the topographic slope. Furthermore, until it is published, it has not earned a place in the literature discussion.

The existence of such long, deep tributaries to the Grand Canyon is similar to (though at a greatly expanded scale) the formation of drainage channels on bare fields during runoff (Thornes, 1990). There is always a main channel with tributaries that cut down to the level of the main channel. Thus erosion by running water seems capable of explaining the canyon system, yet the scale of such an event seems well beyond a local release of water from a few lakes. Logic therefore pushes us toward a different explanation—that the canyon and its tributaries were all eroded during the closing stages of the Genesis Flood. This hypothesis will be fleshed out in Parts III, IV, and V of this series. As will be shown, it answers many of the problems that have baffled both uniformitarians and proponents of a catastrophic dam-breach event.

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