__________ 1927. Der "Braunkohlenschaedel" in der geologischen Sammlung der Bergakademie Freiberg (Sa.). *Braunkohle* 26:311.
__________. 1940. Geology of coal. University of Chicago. Chicago.
Tanner, J. 1975. Views on creation, evolution and fossil man. Modern Microfilm Co. (now contact Utah Lighthouse Ministry, P.O. Box 1884, Salt Lake City, UT).
Taylor, I. T. 1984. In the minds of men. TFE Publishing. Toronto.
Taylor, P. S. 1989. The illustrated origins answer book. Films for Christ Association. Mesa, AZ.
von Fange, E. A. 1974. Time upside down. *CRSQ* 11:13-27.
______________ 1981. Time upside down. Published by the author. Ann Arbor. MI.
Whitcomb, J. C. and H. M. Morris. 1961 (1989 printing). The Genesis Flood. Presbyterian and Reformed. Phillipsburg, NJ. This book has been translated into both German and Spanish.
______________. 1961 (1977 printing). Die Sintflut. Haenssler-Verlag. Neuhausen-Stuttgart. Germany.
Williams, E. L. 1991. Boulder found in coal seam—implications. *CRSQ* 28:29-31.
Wysong, R.L. 1976. The creation-evolution controversy. Inquiry Press. Midland, MI.

COMMENTS ON THE BREACHED DAM THEORY FOR THE FORMATION OF THE GRAND CANYON

MICHAEL J. OARD*

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Abstract

A post-Flood breached dam theory for the formation of the Grand Canyon requires greater amounts of precipitation than at present. This requirement is likely met by a rapid Ice Age model following the Flood. Although the dam breach theory may be correct, at least five geological problems challenge its validity.

Introduction

The formation of the Grand Canyon is a mystery that confounds both evolutionist and creationist alike. Based mainly on geological relationships around the Grand Canyon, evolutionary geologists have come to the startling conclusion that the Colorado River is recent. They believe the river carved the canyon in only one or two million years, beginning about six million years ago. Lucchitta (1990, p. 331) states: "More likely, it began to cut shortly before five million years ago and was nearly as deep shortly after four million years ago as it is today." Even within the uniformitarian time frame, a mile deep canyon cut in only one to two million years is better labeled **catastrophic.** At the present time, solid uniformitarian theories to account for such rapid cutting are hard to find. This is why R.J. Rice (1983, p. 292) lamented: "After a century of study, we seem, if anything, to be further than ever from a full comprehension of how the Grand Canyon has evolved." Formation of the Grand Canyon, by whatever means, not only has significant geological implications, but also important biological effects as well (Meyer, 1985, 1987: Meyer and Howe, 1988).

As with other mysteries found in the rocks, uniformitarian assumptions most likely cause the enigma. Unfortunately, creationists also have difficulty explaining the formation of the Grand Canyon. However, I believe our paradigm is on the right track. A recent series of articles in the *Creation Research Society Quarterly* has reviewed uniformitarian and creationist theories and suggested that the catastrophic breaching of two or three large post-Flood lakes rapidly cutting the canyon is reasonable and plausible (Williams, Meyer, and Wolfrom, 1991, 1992a, b). These authors suggest the breaching of the dam possibly occurred at some point in the period from the end of the Flood to well within post Flood time. Austin et al. (1991, p. 87), who developed the breached dam hypothesis, favor a dam failure possibly several hundred years following the Genesis Flood. It may have taken several hundred years for the enclosed basins of the Colorado Plateau to have filled sufficiently from a wetter post-Flood climate—that is if they were empty following the Flood.

*Michael J. Oard, M.S., 3600 7th Avenue South, Great Falls, MT 59405.

In this article, I will speculate on the post-Flood climate, especially the amount of precipitation, that would he expected on the Colorado Plateau based on my Ice Age model (Oard, 1990). I also suggest five possible geological problems for a dam breach theory a few hundred years after the Flood.

The Post-Flood Climate

According to my Ice Age model, the climate would have been much different after the Flood than at the present. Trapped volcanic dust and gases, left over from the enormous volcanism of the Flood, would have reflected a large portion of solar radiation back to space. Less sunshine at ground level would have resulted in cooler temperatures over land areas, especially the interiors of mid and high latitude continents. Volcanism would have continued at a more or less catastrophic pace for awhile after the Flood. Thus, post-Flood volcanism would have reinforced the initial cooling.

Extensive ash beds and lava flows commingle with "Pleistocene" sediments, both on land and in the ocean (Charlesworth, 1957, p. 601). Pleistocene sediments in the evolutionary time frame generally correspond to the time of the Ice Age. Izett (1981) has discovered at least 68 large ash falls just in the western United States that apparently occurred mostly during the immediate post Flood period. These ash falls dwarf the ash fall from the 1980 eruption of Mount St. Helens. Also during this period, dust from large eruptions of Taupo, New Zealand, and Toba, Sumatra, would have blocked out all sunlight for weeks over large areas of the earth (Froggatt et al., 1986: Rampino, Self, and Stothers, 1988; Rampino and Self, 1992). Rampino, Self, and Stothers (1988, p. 90) state: "If only 10% of this dust [from Toba] were injected into the stratosphere, conditions of total darkness could have existed over a large area for weeks to months . . ." This is just the dust cloud, which coagulates and falls to the ground in a matter of weeks to months. The above scenario does not consider the sulfur gases and aerosols that would have remained trapped in the stratosphere for years. These gases and aerosols would have cooled the land surface, with little effect in the oceans because of the high heat capacity of the water and its circulation.

A universally warm ocean from Antarctica to the North Pole and from the bottom to the top of the ocean would have existed following the Flood. The Arctic Ocean probably was warm enough to swim in comfortably—at least for several years following the Flood. The warm ocean would have resulted from hot water added to the pre-Flood ocean by the fountains of the great deep (Genesis 7:11) and abundant lava flows during the Flood. Widespread tectonism and ocean tides would have mixed the heat, although small pockets of cool water could have existed locally. So immediately after the Flood, cold mid and high latitude continents would have been juxtaposed against warm oceans. A unique climate would have resulted. One of the by-products of this climate would have been a rapid Ice Age (Oard, 1990).

A second climatic consequence would have been a much different hydrology over unglaciated land. After the Flood waters drained, lakes would have been left within enclosed basins in now dry areas of the world (Whitcomb and Morris, 1961, p. 313-317). These lakes are called pluvial lakes and were abundant worldwide. Figure 1 shows the pluvial lakes in the southwestern United States, believed to have existed between 10,000 and 25,000 years ago in evolutionary time (Smith and Street-Perrott, 1983, p. 191). The easternmost lake is ancient Lake Bonneville, 285 meters deeper than and 17 times the size of Great Salt Lake. Pluvial lakes during the Ice Age would have lasted much longer than the current climate would allow because of a shortage of sunlight and a wetter, colder climate (Oard, 1990, pp. 78-80). Pollen and plant fossils from ancient (post-Flood) packrat middens from the southwestern United States support this cooler, wetter climate in the recent past (Spaulding, Leopold, and Van Devender, 1983).

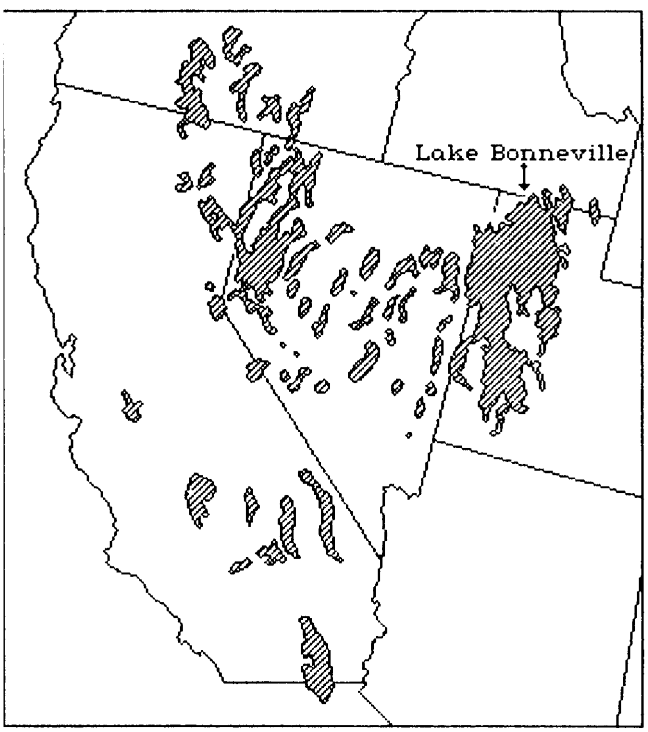

Figure 1. Pluvial lakes in the southwestern United States, 10,000 to 25,000 yr BP according to the evolutionary time scale (Redrawn from Smith and Street-Perrott, 1983, by David Oard).

Even the Sahara Desert appears to have had a radically different climate during early post-Flood time. In the eastern Sahara, abundant evidence exists below the sand for deep lakes and large rivers not long ago (McCauley et al., 1982; Kröpelin and Soulié-Märsche, 1991). This area presently receives rain once every 30 to 50 years! Among the many types of fossils recovered are the remains of hippopotami and crocodiles (Kerr, 1984; Pachur and Kröpelin, 1987). That this unusual climate occurred in the recent past is demonstrated by the existence of degenerate crocodiles that survived to modern times in isolated lakes of the western Sahara Desert (Charlesworth, 1957, p. 1113). Of interest also are countless human artifacts unearthed in the Sahara Desert. Rock pictures and carvings depicting long vanished animals are well preserved (Nilsson, 1983, p. 342). People obviously lived in the Sahara at this time. Consequently, pluvial lakes and rivers must have been maintained for hundreds of years following the Genesis Flood, because man did not spread over the earth until after the Tower of Babel debacle.

It may take a sophisticated climate model on a super computer to simulate the general features of the post-Flood climate. But even the best climate model may be limited because of the rough estimation of some variables and the inability to adequately describe the initial conditions of the post-Flood climate. Nevertheless, a climate simulation would add valuable quantitative knowledge of post-Flood climatology and hydrology. This climate simulation is in the planning stages (Larry Vardiman, personal communication).

Hydrology of Post-Flood Lakes in the Southwest U.S.

Three pluvial lakes have been proposed within the western Colorado River Basin [Austin et al., 1991]: 1) Hopi Lake, 2) Grand Lake, and 3) Vernal Lake (Figure 2). The Kaibab Plateau at the east end of the Grand Canyon is responsible for damming the first two lakes. Either at the end of the Flood or sometime within several hundred years afterwards, a breach in the Kaibab Plateau caused about 3,000 cubic miles of water from these lakes to catastrophically erode the Grand Canyon.

The question I want to address is whether these large lakes could even have existed several hundred years after the Flood in an Ice Age climate? This question has two parts, depending upon the history of the Kaibab Plateau during the Flood. First, if the Kaibab Plateau upwarped at the end of the Flood and trapped the water in these lakes, would the lakes still exist several hundred years later? Or would they dry up quickly? Second, if the Kaibab Plateau rose after the Flood waters drained from the Colorado Plateau, would enough water be impounded in the three lakes to later

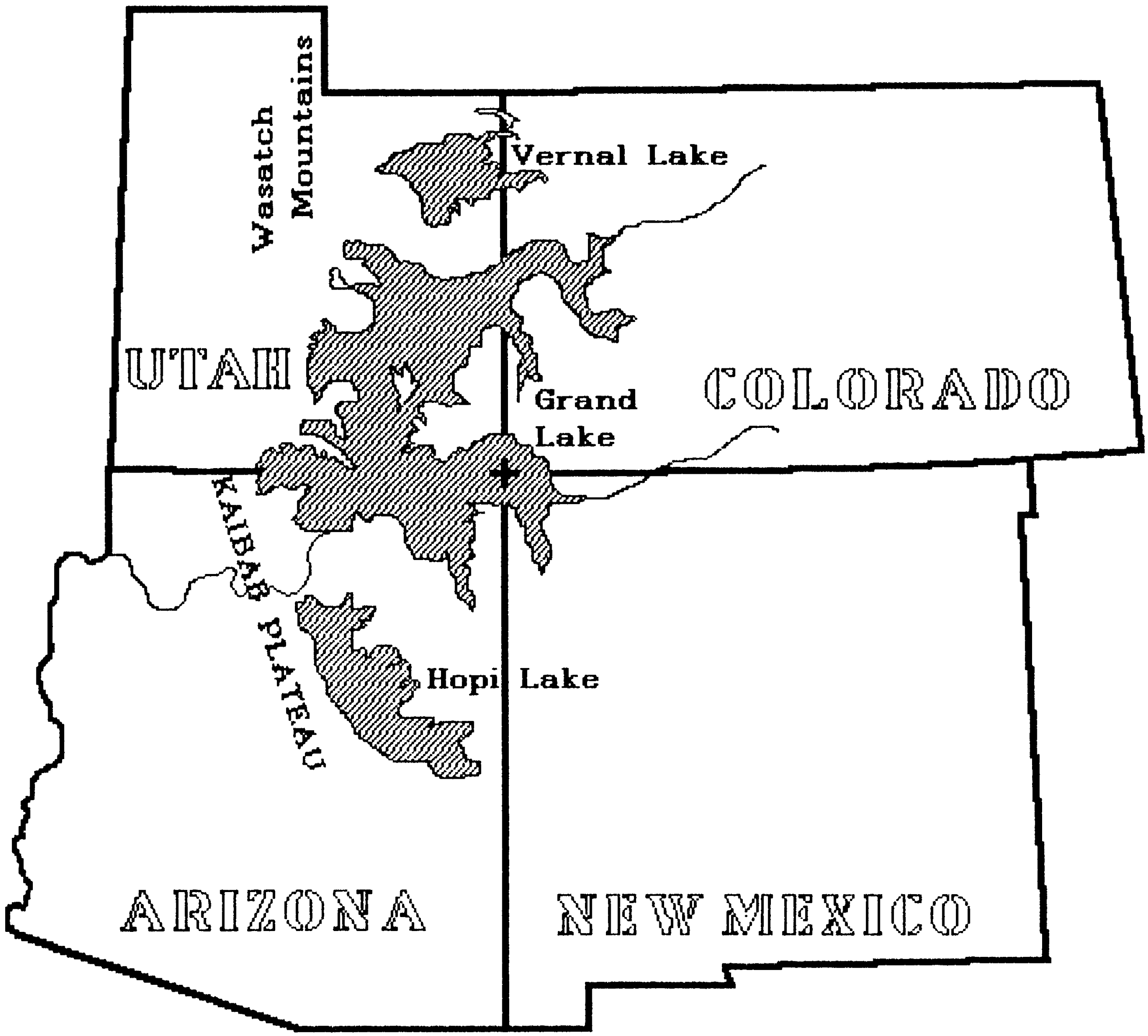

Figure 2. The three postulated lakes in the western Colorado Plateau (Redrawn from Austin et al., 1991, by Dale Niemeyer).

erode the Grand Canyon? I will speculate on these questions by comparing the Colorado Plateau lakes to ancient Lake Bonneville to the west of the Colorado Plateau (Figure 1). Then I will estimate whether an Ice Age climate following the Genesis Flood could potentially meet the hydrological requirement.

For ancient Lake Bonneville to either grow from tiny Great Salt Lake or to maintain its maximum size, investigators have estimated anywhere from two to 10 times the current basin runoff (Smith and Street-Perrott, 1983). The estimates vary widely because many interrelated variables influenced the size of these ancient lakes. The size of the lake depends upon the balance between runoff and evaporation. Runoff is not simply correlated to precipitation in the drainage basin. It also depends upon the seasonal distribution and intensity of precipitation, the proportion of snow and rain, the nature of the vegetation and soil cover, the topographic relief, the soil moisture, and the annual variation in temperature and precipitation. Lake evaporation depends upon the lake and air temperature and their difference, lake salinity, wind speed, relative humidity, cloud cover, solar radiation, atmospheric stability, and the amount of lake ice.

Smith and Street-Perrott (1983, p. 195). assuming a cool Ice Age climate, calculate a runoff of six times the present value to maintain Lake Bonneville:

> With the largest estimate of evaporation reduction [45%] and with precipitation on the lake offsetting 35% of the remaining evaporation, inflow requirements would be reduced to about 36% of apparent volumes, and this would reduce the input requirements to about 6 times present river volumes.

So to fill Great Salt Lake to the level of ancient Lake Bonneville, the present climate requires about 18 times the current runoff. But because of reduced evaporation during an Ice Age climate, the requirement is reduced to six times the current runoff. The inflow could be slightly reduced, perhaps to five times current values, if the presently dry tributaries were flowing during the Ice Age. Five to six times the current runoff is considered a minimum value. This large increase in runoff over the present inflow into Great Salt Lake is a strain on the uniformitarian principle, even during an Ice Age climate.

We can extrapolate the results for Lake Bonneville to the three proposed lakes on the Colorado Plateau. If Hopi Lake, Grand Lake, and Vernal Lake were at an elevation of 5,700 feet before their breach (Austin et al., 1991, p. 79), then these lakes would have been about 700 feet higher than Lake Bonneville. Therefore, evaporation during an Ice Age climate would have been less than that from Lake Bonneville. The reason for less evaporation is because of cooler air and lake temperatures, higher relative humidity and cloudiness, greater lake ice, and less solar radiation caused by higher elevation. Runoff into the three lakes would also have been higher than in Lake Bonneville because the three lakes are mostly surrounded by high mountains. Similar to today, these high mountains would have received a much greater amount of rain and snow than the Lake Bonneville drainage basin. Except for the western Wasatch Mountains, Great Salt Lake is surrounded by terrain that receives light annual precipitation. If the above considerations are taken into account, two to three times the current precipitation during a cool Ice Age climate is likely all that would be required to either maintain the three lakes or fill them from nothing.

The question now reduces to how much precipitation the upper Colorado River Basin received for the first 200 years in the post Flood climate. There is no way to estimate this quantity accurately, since it was not observed and recorded by the ancient Indians and depends upon many unknown variables. However, a crude qualitative estimate can be derived. For a 500-year period of ice buildup. I roughly calculated the precipitation rate for land areas north of 40°N at 1.4 meters/year (Oard, 1990, p. 99). This is close to three times the present average for this area (Peixoto and Oort, 1992, p. 168). If I simply include the Colorado Plateau in this estimate, there is likely enough precipitation to maintain the three lakes on the Colorado Plateau for 500 years. However, I will attempt a more quantitative estimate.

Cool season precipitation over the Colorado Plateau comes predominantly from storms that move east to southeast into the area from the eastern Pacific. These storms mostly gather their moisture from the northern Pacific Ocean. A minor amount of precipitation falls from summer thunderstorms, which would be rare in a cool Ice Age climate because of greater atmospheric stability. Since thunderstorms mostly occur in hot weather, their hydrological impact for lake storage is diminished. Most of the runoff that would fill an ancient lake, therefore, is due to cool season precipitation. With much cooler summers on the Colorado Plateau as a result of volcanic dust and gases in the stratosphere, we can assume a cool-season atmospheric circulation pattern even in summer. Thus, the amount of precipitation during an Ice Age climate would depend on the number of storms that impact the region each year and the amount of water vapor these storms would carry compared to today.

Mid and high latitude storms are generated in areas of moderate to strong horizontal temperature difference in the troposphere, the lower three fourths of the atmosphere. They more or less propagate in a direction parallel to the isotherms with the colder air on the left in the Northern Hemisphere. In the post-Flood climate with warm oceans and cold continents, the lower tropospheric isotherms would parallel the shorelines of mid and high latitude continents (Figure 3). This temperature pattern would remain all year with only small seasonal changes. It would also have a tendency to force itself into the upper troposphere and form a jet stream that parallels the isotherms. Because of terrain effects and the tendency for storms to be stronger and more frequent in a southwesterly jet stream, the storms that impact western North America would have been weaker and less frequent than storms along eastern North America.

For western North America at the beginning of the Ice Age, storms would have tended to develop south of Alaska and move southeastward into southern British Columbia or the northwestern United States, as depicted by the thick arrow in Figure 3. After crossing the Rocky Mountains, these storms would have turned more eastward and passed south of the Laurentide ice sheet, which covered central and northeastern North America. As the Cordilleran ice sheet of western North America developed, storms would have tended to track farther south as the temperature gradients shifted slowly southward. Since these storms would have covered large areas, many storms would have collided with the Colorado Plateau during the Ice Age.

Storms develop frequently within a strong horizontal temperature gradient. In the stormy northern North Pacific 3 to 5 storms of varying intensity can impact an area each week. At present, these storms move eastward into either the northern, central, or southern portions of western North America. If they move into northwestern Canada, the central and southern areas of western North America normally do not receive any precipitation. An average of 1.8 storms a week bombard the Colorado Plateau during the cool season. This is based on a survey of weak, moderate, and strong storms for the years 1980 to 1984 from the *Daily Weather Maps* series. September 15 to May 30 was the period sampled for each year, since large-scale storms during summer are weak and cause little precipitation over the Colorado Plateau. Since the average storm track during the Ice Age (thick arrow in Figure 3) would have favored storms to move into southern and central portions of western North America, one would expect more storms slamming into the Colorado Plateau than today.

Fifty percent of the time today, the area is influenced by a dry upper ridge. During the Ice Age the area would be dominated by a permanent upper trough. So, twice as many storms as at present likely impacted the area during the Ice Age due to this factor alone. The number of storms during the Ice Age would correspond more to the number of present-day storms that move eastward through the northern North Pacific Ocean. Therefore, a minimum estimate of the number of storms that would move into the Colorado Plateau

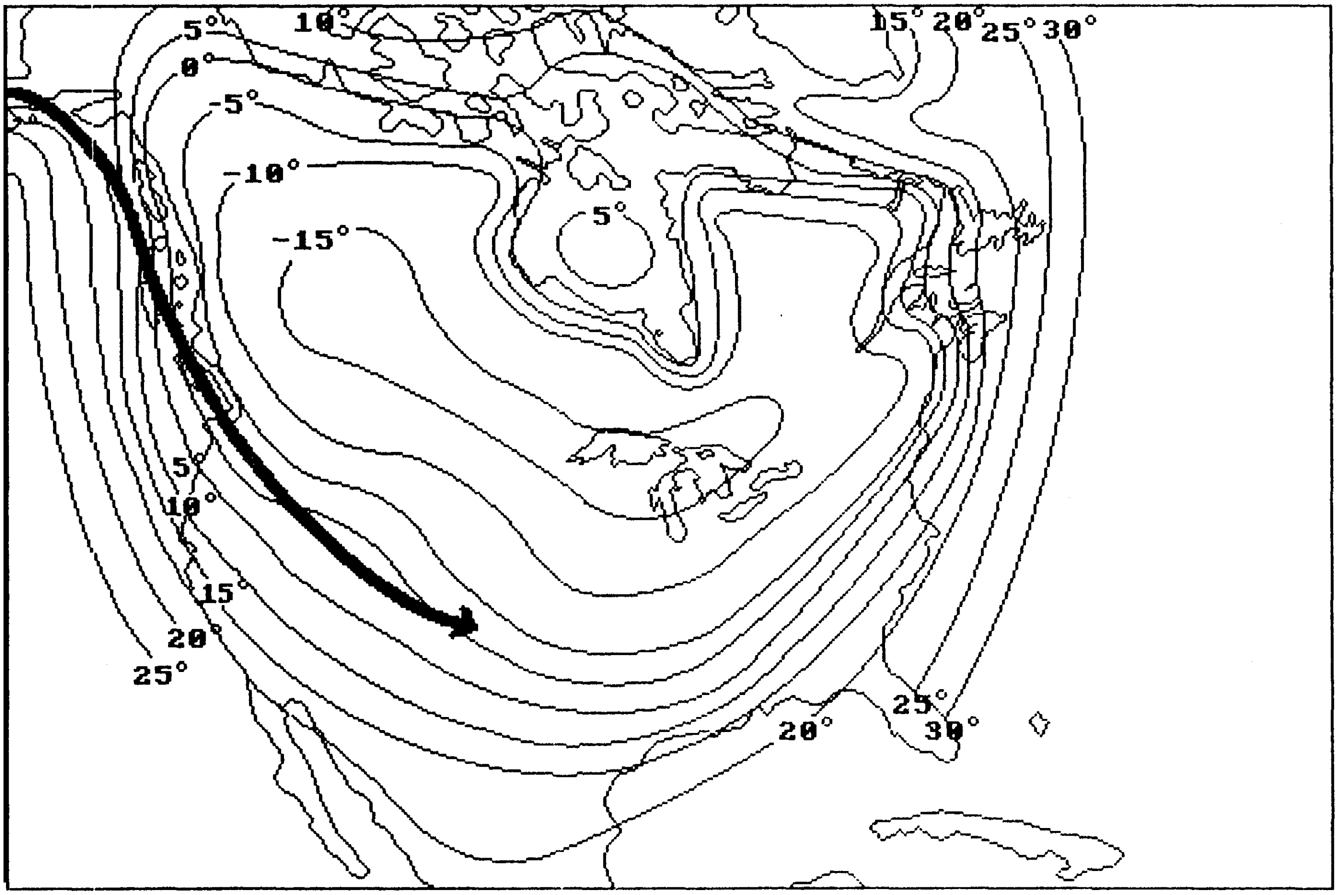

Figure 3. Postulated annual temperature (°C) for North America early in the Ice Age. Thick bold line from south of Alaska southeast into the central United States represents the postulated average storm track (Drawn by David Oard and Dale Niemeyer).

during the Ice Age would be two storms a week—all year. A maximum number would be five storms a week. This totals a minimum of 104 and a maximum of 260 storms per year. These figures are 1.6 and 4 times, respectively, the number of storms that move into the area at present.

The amount of precipitation from these storms mostly depends upon their intensity and the amount of available water vapor. Due to the strong temperature difference between North America and the eastern Pacific Ocean (Figure 3), storms moving into western North America should be more intense than today. To be conservative, I will assume that Ice Age storms average the same intensity as today. The amount of available water vapor in each storm depends mainly upon how much evaporation occurred in the northern North Pacific. Therefore, the precipitation in each storm will depend upon the difference between the evaporation over this area during the Ice Age as compared to today.

Neglecting any differences in the salinity, solar radiation, and cloudiness over the northern North Pacific during the Ice Age as compared to today, the bulk aerodynamic equation for oceanic evaporation is (Bunker, 1976, p. 1122):

$$E = \rho\, C_E(Q_S - Q_{10})U_{10} \qquad (1)$$

where E is the average evaporation, ρ is the air density, C_E is the empirically derived exchange coefficient for water vapor, Q_S is the saturation mixing ratio corresponding to the sea surface temperature, Q_{10} is the average mixing ratio at 10 meters above the ocean, and U_{10} is the average wind speed at 10 meters, usually the ship anemometer level. The mixing ratio is the actual amount of water vapor present in the air per unit mass. C_E can be considered a constant in an Ice Age climate (Bunker, 1976, p. 1126). Equation 1 indicates that evaporation is mainly proportional to the wind speed and the difference between the air and sea surface mixing ratio.

If relative humidity, wind speed, and atmospheric stability remain the same, the air-sea surface difference in the mixing ratio (Q_S - Q_{10}) is proportional to the sea-surface temperature. In my Ice Age model, I assumed a rough initial ocean temperature of 30°C following the Flood (Oard, 1990). This would also be the surface temperature in a uniformly warm ocean at mid and high latitudes immediately after the Flood. With all other variables remaining constant, evaporation at the initial Ice Age sea surface temperature would be more than three times the evaporation at a sea-surface temperature of 10°C and seven times more than at a sea surface temperature of 0°C (Oard, 1990, pp. 55-61). However, the ocean would not have remained at 30°C during the entire Ice Age, but would have gradually cooled, mostly by evaporation. After 500 years in my model, the average ocean temperature cools to 10°C, at which point the ice buildup reverses.

However, sea surface cooling is likely more rapid at the beginning because of higher evaporation, tapering off with time (Figure 4). Therefore precipitation over the Colorado Plateau would have been higher at the beginning of the Ice Age.

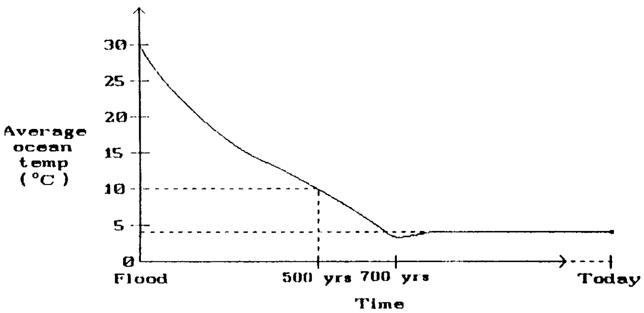

Figure 4. Graph of the postulated average temperature of the ocean following the Genesis Flood (From Oard, 1990, p. 112, drawn by David Oard).

Based on Figure 4, the sea-surface temperature for the North Pacific Ocean during the first 200 years of the Ice Age would have averaged about 24°C. The current annual average for the North Pacific Ocean north of 30°N is about 14°C (Peixoto and Oort, 1992, p. 178). If all other variables in the evaporation equation remain constant, post-Flood storms would carry a little less than twice the moisture of today.

Therefore, with a range of 1.6 times to 4 times the number of storms, each of which drops twice the precipitation, about three times to eight times more precipitation would occur on the Colorado Plateau during the first 200 years of the Ice Age as compared to then present. Although the approximations are rough, it seems that enough precipitation would occur for the first 200 years of the Ice Age to either fill or maintain Lakes Hopi, Grand, and Vernal.

In conclusion, the three postulated lakes likely would have existed for several hundred years after the Flood. They would have been available to be breached and to possibly form the Grand Canyon at that time as Austin et al. (1991) and Williams, Meyer, and Wolfrom (1992b) postulate. Two other ancient lakes in the western United States likely were breached during the Ice Age period. Lake Bonneville was catastrophically lowered 100 feet by a breach in southeast Idaho, according to J. Harland Bretz (1969, p. 531). It is also believed that glacial Lake Missoula was impounded by an ice lobe in the Purcell Trench of northern Idaho. When the ice dam collapsed, 500 cubic miles of water rushed over eastern Washington in three days (O'Connor and Baker, 1992).

Some Geological Problems with the Dam-Breach Theory

However, just because lakes could have existed on the Colorado Plateau for several hundred years following the Flood does not mean the dam-breach theory is correct. I see at least five potential geological problems with the dam-breach theory occurring well after the Flood. This does not mean that my mind is made up against the theory—it is not. Further geological data is needed.

First, if ancient lakes on the Colorado Plateau existed for several hundred years, the evidence should be abundant. However, the evidence appears to be skimpy. Austin et al. (1991, p. 80) suggest the laminated silt and mud from the "Miocene/Pliocene" (post-Flood?) Bidahochi Formation, located at about 6,000 feet above sea level in the eastern Little Colorado River Valley, is a relic of ancient Lake Hopi. But this formation is severely eroded. Further evidence in the Colorado River drainage basin is speculative. If these lakes existed for any length of time, shorelines etched into the rock should be evident. The shorelines of ancient Lake Bonneville are readily visible in some areas (Bretz, 1969, p. 533). River and stream deltas should also be found relatively high up along the sides of the ancient lakes. Clay, salt, and sand turbidites should cover the basin floor. This pattern should especially be true during a time of much higher sedimentation rates on the Colorado Plateau during the Ice Age.

During the Ice Age, pro-glacial lakes south of the ice sheet periphery would have formed in some areas. One of these lakes is glacial Lake Missoula, which filled the low mountain valleys of western Montana. The depth of this lake depended on the thickness of the blocking ice. Only as the Ice Age peaked would glacial Lake Missoula have been at its highest level. At this point, rapid melting of the ice would have catastrophically released the water from this lake. I have presented evidence, based on the energy balance over a snow and ice surface, that the southern periphery of the post-Flood ice sheets in North America would have melted rapidly within 100 years (Oard, 1990, pp. 114-119). Consequently, the highest wave-cut shorelines of glacial Lake Missoula would likely have been produced in a brief time. The highest wave-cut shorelines of this lake, although small, are readily seen on the slopes of Mount Sentinel just east of Missoula, Montana, and elsewhere in western Montana. If the highest wave-cut shorelines of glacial Lake Missoula were cut quickly and can still be seen, how much more should shorelines be notched along the edge of the three postulated lakes on the Colorado Plateau?

A second geological question I have is if the three postulated lakes on the Colorado Plateau burst. I would not expect a long, thin canyon. After breaking through the Kaibab Plateau, the water would have at first spread out horizontally upon the relatively flat Coconino Plateau, unless the water was constrained by a fault. The water should have slowed and ponded. As the water level rose in small basins, it would have eroded small notches between basins, all the while flowing to lower elevations as a large braided stream. The water should have flowed at times along the strike of the monoclines and down the dip of the other plateaus. It seems doubtful the water would have flowed along the current route of the Grand Canyon. When glacial Lake Missoula was catastrophically breached, sending 500 cubic miles of water across eastern Washington, it spread out over a width of 100 miles before ponding in the Quincy and Pasco Basins of central Washington (O'Connor and Baker, 1992). In this case, the water did not flow across a flat plain, but cascaded downhill through various low channels at an estimated speed of up to 100 mph. I would not expect the water from the breached dams to erode a thin, deep canyon with a length of 277 miles (not including Marble Canyon) over relatively flat terrain.

Third, it is hard to envision that the flow from these ancient lakes could cut such a deep canyon well after the Flood. The rocks very likely would have been consolidated by this time. If the rocks of the Grand Canyon remained partially unconsolidated for several hundred years, abundant flow structures should be seen in the rock layers. It is likely rocks hardened rapidly during and immediately after the Flood because traction currents and debris flows during the Flood picked up and redeposited sedimentary rocks of various lithologies. These sedimentary rocks likely were laid down in a previous sedimentary cycle of the Flood and were already well indurated.

The estimated volume of water released from the three lakes is 3,000 cubic miles, while the amount of rock removed was about 1,000 cubic miles. That seems like too much rock to remove with too little water. The canyons cut by the breaching of glacial Lake Missoula and the mudflow erosion at Mount St. Helens were caused by fluid flowing downhill at rapid speeds. The water from the breached lakes would have flowed over either flat terrain or terrain sloped in the opposite direction. Besides, the lakes very likely would not have been breached at the same time. If Lake Hopi were breached first (Austin et al., 1991, pp. 86, 87), it would very likely have completely drained in a matter of days. Glacial Lake Missoula, a complex meandering lake, is believed to have emptied in three days, based on the height of the flow through Spokane and the Wallula Gap, near Pasco, Washington (O'Connor and Baker, 1992). It would have been awhile before Grand Lake burst due to the mechanism of piping. The same can be said for Lake Vernal. Therefore the water would have flowed over the Coconino Plateau in pulses, separated by a fair amount of time. Less water would have reduced its eroding capacity. Cavitation erosion would not be much help because cavitation is effective in water depths of only several meters moving at more than 30 m/s (Holroyd, 1990).

A fourth geological problem is that if the Grand Canyon were formed rapidly from a breached dam well after the Flood, why do some of the tributary valleys, like the long Havasu Creek Valley, descend gradually down to the bottom of the Grand Canyon? These long tributary valleys, which are either dry or contain small creeks at present, should be hanging valleys, like those seen in Yosemite Canyon. Tributary valleys to the catastrophically eroded Grand Coulee of central Washington are hanging valleys (Baker and Nummedal, 1978). This evidence implies that whatever mechanism produced the Grand Canyon concurrently eroded all the side canyons. A similar relationship of tributaries being cut to the same depth as the main channel can be seen within other rapidly eroded canyons (Thomas, 1990). This means that a considerable amount of water drained into the Grand Canyon from the north and south, which does not favor the dam-breach hypothesis.

A fifth geological difficulty is that a huge delta should exist just west of the Grand Canyon. Assuming the dam breach occurred after the rocks of the Colorado Plateau hardened, the water from the breached dams should have started as a gigantic waterfall from off the top of the western Colorado Plateau. As the Grand Canyon was rapidly eroded, much of the sediment, especially the coarse fraction above silt size, should have been deposited in the slacker water to the west of the canyon. The delta sediments should taper with distance from the Grand Wash Cliffs. Farther downstream from the delta, thick layers of silt and clay would be deposited. These may or may not exist, depending upon the interpretation of the downstream formations. Near the end of the event, the waning flood should have cut a canyon through the soft delta sediments.

Summary and Discussion

The formation of the Grand Canyon is a mystery to all. From geological evidence, partly based on dating assumptions for geological formations, uniformitarian geologists believe the canyon was cut in less than two million years. Although uniformitarian geologists have been stumped, creationists are just beginning to study the evidence and formulate theories. One theory, the dam-breach theory, has recently been proposed. This theory depends upon the existence of three lakes trapped in basins of the western Colorado Plateau. One version of the theory proposes that the dam breach may have occurred several hundred years after the Flood, during the period of the Ice Age. Based on my model of the Ice Age, the precipitation required to either fill or maintain these lakes likely was met in the post-Flood climate.

Five geological problems were presented. Ancient shorelines and hanging stream deltas appear to be nonexistent along the edge of the proposed lakes. Water spreading out over a long, relatively flat plateau should not have eroded a deep canyon. The volume of water, which should have spread out over the plateaus in pulses, does not seem sufficient to cause the erosion. If Grand Canyon were rapidly eroded, why are several long tributary valleys also eroded down to the bottom of the Canyon? Why is not there a large delta west of the Grand Wash Cliffs?

I am not against the dam-breach theory and will await further evidence before making up my mind. However, the geological evidence does not seem favorable to the dam-breach theory. A mechanism of rapid cutting in soft sediments seems more likely. This condition likely would be met only near the end of the Flood or immediately afterwards. It is possible that briefly ponded water in the western Colorado Plateau provided extra water to continue the digging of the deep canyon.

Draining Flood water that changed from sheet flow to channelized flow seems more plausible. Westward-moving sheet flow could have removed the 1,000 feet or more of sediment that existed above the Coconino Plateau, as indicated by the deposits on Red Butte (Austin et al., 1991, pp. 69, 70). The Muddy Creek Formation, including the Hualapai limestone, was deposited west of the Grand Canyon before the canyon was cut. This formation could have been deposited during the end of sheet flow. Alternately, there could have been sediments on top of the Muddy Creek Formation that were eroded away at the same time as sediments were eroded from off the Coconino Plateau.

After the sheet erosion was completed, or nearly so, the flow may have become more channelized, digging the Grand Canyon and its long tributary canyons in a short time. It seems to me that the erosion of the Grand Canyon must have begun at the **west** or downstream end and not the east or upstream end. The westward moving channelized flow would then have eroded the soft sediments headward or eastward, and downward. This could have occurred as the area was being uplifted and the Flood water draining westward from the Colorado Plateau at the end of the Flood. A good analog for this process would be the erosion of the lower Palouse River Canyon of southeast Washington during the breaching of glacial Lake Missoula (Baker and Nummedal. 1978). During this event, floodwaters in the Palouse River Valley overtopped a ridge between it and the Snake River Valley. A waterfall rapidly cut headward through soft loess and hard basalt below the loess. After the flood the Palouse River was diverted through this new canyon and the last vestiges of the waterfall can be seen at Palouse Falls.

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References

Austin, S. A. et al. 1991. Grand Canyon, monument to catastrophe. Institute for Creation Research field study tour guidebook. April 20-28. 1991. Institute for Creation Research. El Cajon, CA.

Baker, V. R. and D. Nummedal. (editors). 1978. The channeled scabland. National Aeronautics and Space Administration. Washington D.C.

Bretz, J. H. 1969. The Lake Missoula floods and the channeled scabland. *Journal of Geology* 77:505-543.

Bunker, A. F. 1976. Computations of surface energy flux and annual air-sea interaction cycles of the North Atlantic Ocean. *Monthly Weather Review* 104:1122-1140.

Charlesworth, J. K. 1957. The Quaternary era. Edwarnold. London.

Froggatt, P. C. et al. 1986. An exceptionally large late Quaternary eruption from New Zealand. *Nature* 319:578-582.

Holroyd, III, E. W. 1990. Some simulations of the possible role of cavitation in catastrophic floods. *Creation Research Society Quarterly* 27:49-55.

Izett. G. A. 1981. Volcanic ash beds: recorders of upper Cenozoic silicic pyroclastic volcanism in the western United States. *Journal of Geophysical Research* 86 (B11):10200-10222.

Kerr, R. A. 1984. Climate since the ice began to melt. *Science* 226:326-327.

Kröpelin, S. and I. Soulié-Märsche. 1991. Charophyte remains from Wadi Howar as evidence for deep mid-Holocene freshwater lakes in the eastern Sahara of Northwest Sudan. *Quaternary Research* 36:210-223.

Lucchitta. I. 1990. History of the Grand Canyon and of the Colorado River in Arizona. In Grand Canyon Geology. S. S. Beus and M. Morales (editors). Oxford University Press. New York.

McCauley, J. F. et al. 1982. Subsurface valleys and geoarcheology of the eastern Sahara revealed by shuttle radar. *Science* 218:1004-1020.

Meyer, J. R. 1985. Origin of the Kaibab squirrel. *Creation Research Society Quarterly* 22:68-78.

__________ 1987. Shiva Temple: island in the sky? *Creation Research Society Quarterly* 24:120-125.

__________ and G. F. Howe. 1988. The biological isolation of Shiva Temple. *Creation Research Society Quarterly* 24:165-172.

Nilsson, T. 1983. The Pleistocene: geology and life in the Quaternary Ice Age. D. Reidel. Boston.

Oard. M. J. 1990. An ice age caused by the Genesis Flood. Institute for Creation Research. El Cajon, CA.

O'Connor, J. E. and V. R. Baker. 1992. Magnitudes and implications of peak discharges from glacial Lake Missoula. *Geological Society of America Bulletin* 104:267-279.

Pachur, H. J. and S. Kröpelin. 1987. Wadi Howar: paleoclimatic evidence from an extinct river system in the southeastern Sahara. *Science* 237:298-300.

Peixoto, J. P. and A. H. Oort. 1992. Physics of climate. American Institute of Physics. New York.

Rampino, M. R. and S. Self. 1992. Volcanic winter and accelerated glaciation following the Toba super-eruption. *Nature* 359:50-52.

_______________ and R. B. Stothers. 1988. Volcanic winters. *Annual Review* of *Earth and Planetary Science* 16:73-99.

Rice, R. J. 1983. The canyon conundrum. *The Geological Magazine* 55:288-292.

Smith, G. I. and F. A. Street-Perrott. 1983. Pluvial lakes of the western United States. In Late-Quaternary environments of the United States. Volume 1. H. E. Wright, Jr. (editor). University of Minnesota Press. Minneapolis. pp. 190-212.

Spaulding, W. G., E. B. Leopold and T. R. Van Devender. 1983. Late Wisconsin paleoecology of the American Southwest. In Late Quaternary environments of the United States, Volume 1. H. E. Wright, Jr. (editor). University of Minnesota Press. Minneapolis. pp. 259-293.

Thomas, J. 1990. Big rills have little rills . . . *Nature* 345:764-765.

Whitcomb, Jr., J. C. and H. M. Morris. 1961. The Genesis Flood. Baker. Grand Rapids, MI.

Williams. E. L.. J. R. Meyer and G. W. Wolfrom. 1991. Erosion of the Grand Canyon of the Colorado River: Part I — Review of antecedent river hypothesis and the postulation of large quantities of rapidly flowing water as the primary agent of erosion. *Creation Research Society Quarterly* 28:92-98.

____________________________________. 1992a. Erosion of the Grand Canyon of the Colorado River: Part II — Review of river capture, piping and ancestral river hypothesis and the possible formation of vast lakes. *Creation Research Society Quarterly* 28:138-145.

____________________________________. 1992b. Erosion of the Grand Canyon of the Colorado River: Part III — Review of the possible formation of basin and lakes on Colorado Plateau and different climatic conditions in the past. *Creation Research Society Quarterly* 29:18-24.

QUOTE

Sir Francis Bacon, Thomas Hobbes, John Locke, Jeremy Bentham, John Stuart Mill and the other formulators of the new ethos did not refute Anselm or Aquinas, they merely ignored them. Someone has quite truly said that "intellectual progress," as it is called, takes place not because of what we learn but because of what we forget. The great project of the 17th and 18th century bourgeoisie was not to understand existence but to make a living in it. The cultural focus shifted sharply toward the physical world. Anselm's ontological argument does not do much for the trade in spices or tobacco, but navigation certainly does. Metaphysical ultimates, at least in the short run, proved to be irrelevant to the economic enterprise. The empirical and utilitarian philosophies which reflected the dominance of this culture were designed not so much to understand the world as to control and possess it, and, at least in the short run, they were triumphantly successful.

Hart, J. 1976. Ideas in culture. *Imprimis* 5(11):3. Hillsdale College, Hillsdale, MI.