Steve Austin's 1990 Guidebook – Now populated with Dr. Brown's previously discovered and published (1989): Lake (Grand Lake), its separation from Hopi Lake, its breach point (Marble Canyon), and elevation (5700 feet); all without attribution to Dr. Brown

Institute for Creation Research

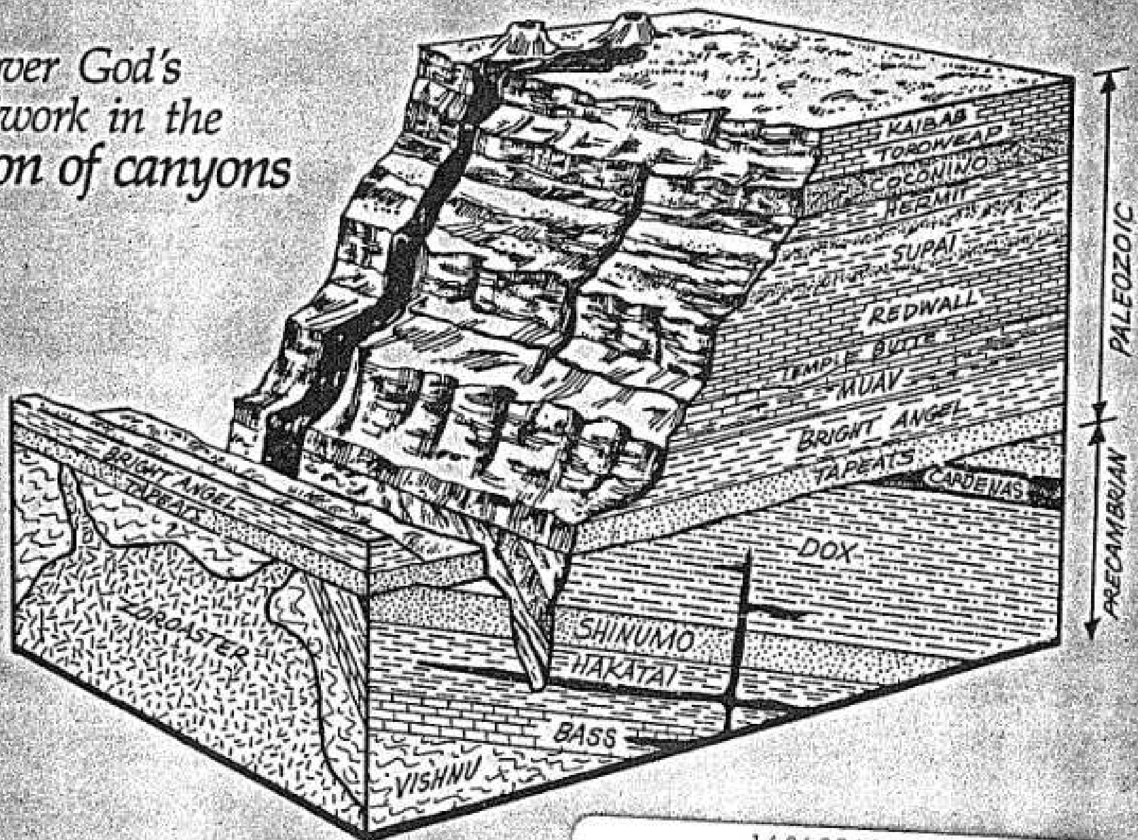
GRAND CANYON

FIELD STUDY TOUR GUIDEBOOK

APRIL 28 - May 6, 1990

Raft Trip on Colorado River
Bus Tour of Northern Arizona & Southern Utah
Hiking Groups on Grand Canyon Trails

Discover God's handiwork in the canyon of canyons



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MISS PENNY THOMPSON
2805 SOUTH WILKE
ROLLING MEADOWS IL
60008

How could an enormous canyon like Grand Canyon be eroded by a gully in just a fraction of one million years? Creationists, who have no commitment to the accuracy of potassium-argon dating, simply point out this important contradiction in uniformitarian theory. A complete analysis of radioactive dating is found in Chapter 5.

COULD THE LANDSCAPE ENDURE?

Although the gully theory does not require the Grand Canyon to be several tens of millions of years old, it still supposes that river erosion and the Laramide uplift of the plateau dated up to 70 million years. As mentioned previously, 70 million years of erosion should severely alter the uplifted plateau. There should have been intense erosion generally to the plateau lands, to a depth of several miles, not just deep erosion in one enlarged gully. The theory leaves this logical consequence unexplained.

WHERE ARE THE EVIDENCES OF THE ANCESTRAL UPPER COLORADO RIVER?

Because the gully theory assumes that the Kaibab Upwarp began to occur about 70 million years ago, while the amazing stream capture was accomplished less than 5 million years ago, we are obligated to have the ancestral upper Colorado River located east of the Kaibab Upwarp for as much as 60 million years. We would expect significant erosional and depositional features to be obvious. No abandoned channel for the postulated ancestral Colorado River has been found southeast or northeast of the Grand Canyon. The search for Miocene deposits from the ancestral upper Colorado River has been equally discouraging. Edwin Larson, William Bradley and Minoru Ozima write:

> *By contrast, unequivocal evidence for a Colorado River older than 10 m.y. has yet to be produced. It is a curious fact that older Colorado River sediments have not been recognized anywhere, even though Miocene deposits were accumulating in basins that now lie athwart or near the present river. For example, the Colorado River crosses Troublesome Basin in Middle Park, yet the only deposits which can be identified as belonging to the Colorado River are found near the top of the unit (Izett, 1968, and G.S.A. Memoir 144). Even if the Colorado had been transporting only sand and mud at that time, it should have left a recognizable record in the Troublesome Formation. Similarly, the 14 to 10 m.y. old sediments which are present in the State Bridge Syncline, now being dissected by the Colorado River, have characteristics that belie the existence of a large river at that location and time (Brennan, 1969). Nor do the sediments farther to the northwest give any sign that a Miocene Colorado River might have flowed into a basin in that direction (Kucera, 1962, 1968). . . . A southwesterly course for a Miocene Colorado River, similar to today's course, is refuted by volcanic evidence. . . .The question remains: where was the Colorado River in Miocene time?*[35]

One specific prediction of the stream capture theory is that deposits from the Miocene or Pliocene upper Colorado River would be found east of Grand Canyon in the Little Colorado River drainage basin. There we find the Miocene/Pliocene Bidahochi Formation, but it's silt, sand and volcanic ash layers have been interpreted as lake deposits, not as deposits from a through-flowing big river. Carol Breed writes:

> *The capture hypothesis was not in disagreement with the known facts of Colorado Plateau geology in the early 1960's. But at least one difficulty should be noted: the Bidahochi Formation stands in relation to the postulated southeasterly ancestral upper Colorado in much the same way as the Muddy Creek Formation stands in the way of a pre-Pliocene westward flowing Colorado River. There is a notorious lack of pre-Muddy Creek Colorado River sediments in the west; there is a similar lack of proven pre-Bidahochi upper Colorado sediments in the east.*[36]

In summary, we understand that the "stream capture" or "precocious gully theory" may make

Figure 4.7
A computer was asked to draw the shoreline of lakes which would form behind the Kaibab Upwarp today if the Grand Canyon were blocked at the 5,700 foot elevation. These lakes would occupy an area more than 30,000 square miles and contain three times more water than Lake Michigan. These computer-generated lakes approximate the outline of ancient lakes (Figure 4.17) which breached their dams to form Grand Canyon. (Plotted by Edmond W. Holroyd, III.)

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fascinating mental exercises, but it is deficient in empirical evidence.

THE BREACHED DAM THEORY

Both the antecedent river and the precocious gully theories for the erosion of Grand Canyon assume that the agents of erosion, and specifically the Colorado River, have been in operation for tens of millions of years. That assumption, however, ultimately worked contrary to forming the very geologic structures that the theories were trying to explain. Could geologists have been laboring with a concept of geologic time that did not exist? Is it possible that the Kaibab Upwarp, the erosion of Grand Canyon, and the operation of the Colorado River do not date back millions of years? Could catastrophic drainage have been responsible for most of the erosional features we see?

Theories for erosion of Grand Canyon by catastrophic drainage are not new. We are amazed to learn that the notion of catastrophic drainage is contained in legend and is the oldest explanation for the origin of Grand Canyon. According to the Havasupai Indians, who still tell the story in their villages within Grand Canyon, the immense chasm formed after the world was covered by a great flood. Details of this legend are found in the discussion of "Early Peoples of the Southwest" (Chapter 9 of this book). The Havasupai legend is immediately recognizable as one of hundreds of flood traditions which are known worldwide, of which the Biblical account of Noah's Flood is the most detailed and accurate. If catastrophic drainage was involved in forming Grand Canyon, then it would be a relict feature formed from erosive processes which had operated at rate and scale far greater than today. Grand Canyon would be a largely dead monument to the action of intense ancient processes, not a constantly evolving landform in equilibrium with slow, modern, erosive processes.

Of various catastrophic drainage models which can be proposed, the most fascinating is the theory of a breached dam. Figure 4.7 shows the high plateau land of Utah, Colorado, Arizona and New Mexico. Called the "Colorado Plateau," the region can be viewed as a saucer-shaped, uplifted basin, because around it are very high mountains. If Grand Canyon were blocked by material filling it to an elevation of

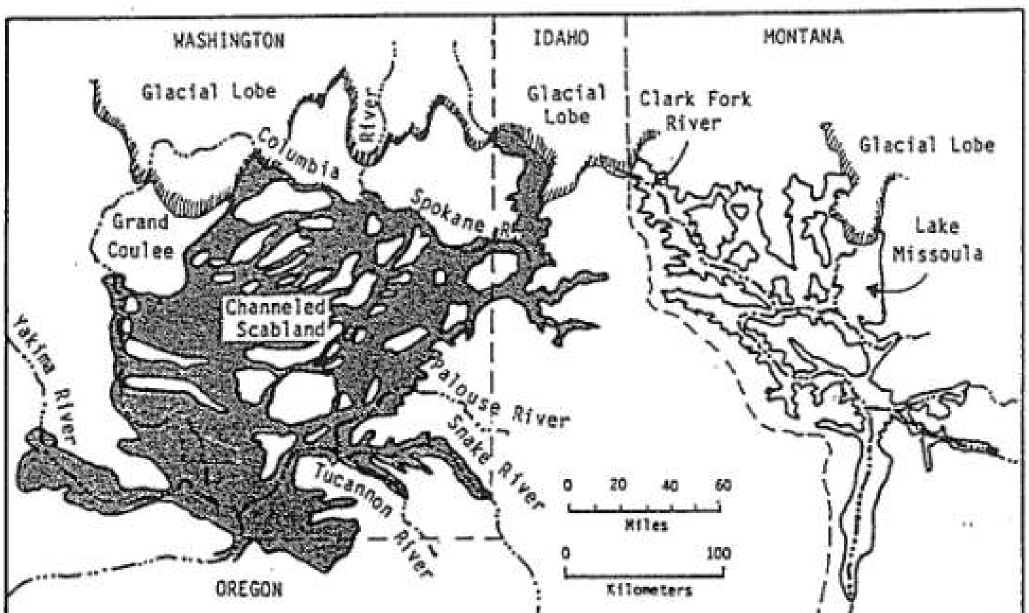

Figure 4.8

Area devastated by the Spokane Flood. The prehistoric breaching of a glacier ice dam in northern Idaho allowed Lake Missoula in Montana to catastrophically flood Washington State with 500 cubic miles of water (half the present volume of Lake Michigan) producing the Channeled Scabland of eastern Washington.

5,700 feet, an enormous lake, or series of lakes, would form on the saucer-shaped plateau. Figure 4.7 shows the outline of the lakes which would form today if Grand Canyon were blocked and the basin to the northeast was allowed to fill with water to an elevation of 5,700 feet.[37]

The breached dam theory proposes that in the past an enormous body of water existed on the Colorado Plateau northeast of the Kaibab Upwarp. The outline of these lakes were similar, but not the same as that shown in Figure 4.7. The theory proposes that the dam ruptured or was breached in the present Grand Canyon area. The breach of the dam caused catastrophic erosion and drainage of the lake.

The failure of both natural and man-made dams have been recognized to cause enormous erosion and deposition. The largest well-documented, prehistoric natural dam failure occurred during the time of continental glaciation in Washington, Idaho and Montana. Prehistoric glacial Lake Missoula (Figure 4.8) breached its ice dam in northern Idaho. Hundreds of cubic miles of lake water from Montana scoured across eastern Washington at hundreds of feet depth at speeds approaching 100 miles per hour.[38] In its wake the flood left 16,000 square miles of scarred terrain and deeply cut valleys which are today such a striking feature of the scabland of eastern Washington. Significant erosion even occurred in solid rock.[39] The dam in Idaho for the great glacial lake being composed of ice has long since melted away.

One particularly vivid recent example of a rapid breaching event comes from study of the recent eruptions of Mount St. Helens, also in Washington State. The valley of the North Fork of the Toutle River northwest of Mount St. Helens was blocked by landslide debris and volcanic ash on May 18, 1980. The valley was unblocked by a mudflow on March 19, 1982. The breaching event occurred when mud and water overtopped a landslide-debris dam.[40] The catastrophic event produced a wide assortment of canyons, some as much as 140 feet deep (see Figures 4.9 and 4.10). Even solid, prehistoric lava flows were incised at Mount St. Helens (Figure 4.11).

EVIDENCES FOR THE BREACHED DAM

If Grand Canyon was eroded largely by catastrophic drainage of large lakes as a breach occurred through the Kaibab Upwarp, three types of evidences would be expected. First, we would expect to find sedimentary strata diagnostic of a Pliocene lake east of Grand Canyon. Second, because major topographic features in Grand Canyon and also of the Colorado Plateau to the northeast were affected by catastrophic drainage, we would expect to see geomorphic evidence that increased water flow had occurred in ancient times. Third, we would anticipate finding evidences that many features of the present landscape are relict forms. These landscape elements would show a great degree of stability, rather than appearing to be in a process of continual change.

EVIDENCE FOR AN ANCIENT LAKE

Thin laminae of silt and mud are contained in Pliocene strata within a mudstone and sandstone formation of eastern Arizona. Named the Bidahochi Formation, its thin laminated silt and mud layers have been interpreted as deposits from "Hopi Lake".[41] The shoreline of the lake is not known because the margins of the Bidahochi Formation have been severely eroded, but the elevation of the lake is indicated by the present elevation of the deposits at 6,000 feet in the headwaters of the present Little Colorado River drainage basin. It would seem that Hopi Lake, a large Pliocene lake, existed at high elevation east of the Kaibab Upwarp. The lake could not exist there today because of the enormous breach (Grand Canyon) which occurs through the Kaibab Upwarp.

Other deposits on the Colorado Plateau may be interpreted as lake deposits. These occur at various places in the drainage basin of the Colorado River but are not as well understood. Do they represent the same or connected lakes? The evidence allows at least one lake to be documented. We continue to explore the evidence and marvel at its association with the present Grand Canyon.

EVIDENCE FOR ACCELERATED DRAINAGE

Many of the valleys upstream from Grand Canyon have rather sluggish streams positioned on very broad flood plains. These streams and rivers appear "underfit," the present discharge rates could not significantly modify these flood plains. Other streams above Grand Canyon have narrow bedrock channels but the beds of these streams are lined with an

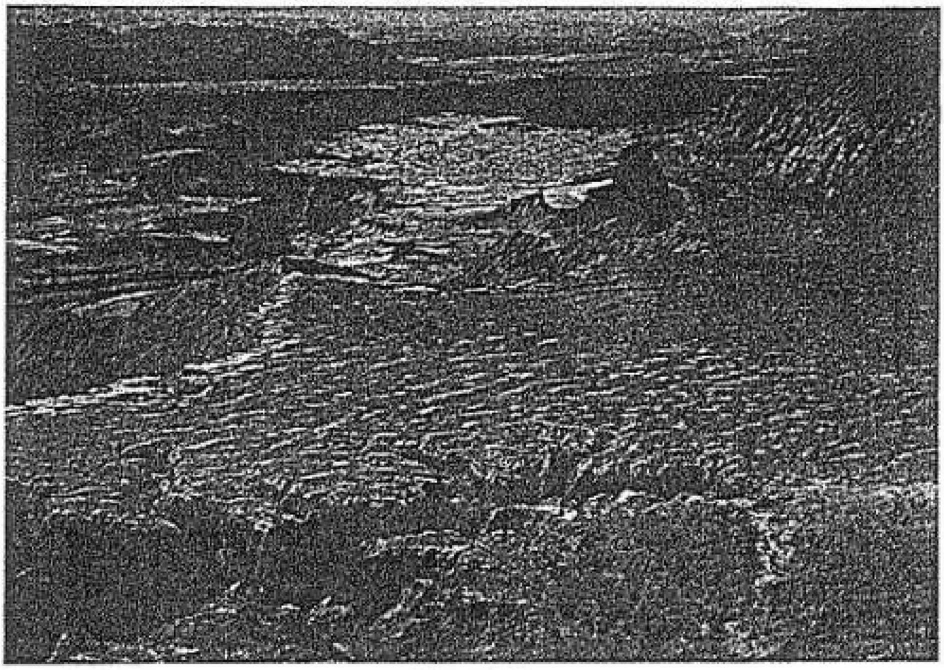

Figure 4.9

The "Little Grand Canyon of the Toutle River" is a relict canyon system on North Fork of the Toutle River just north of Mount St. Helens volcano. The rockslide and pumice deposits from the 1980 eruptions were breached by mudflow on March 19, 1982, to form a dendritic system of canyons up to 140 feet deep. (Photo by Steven A. Austin.)

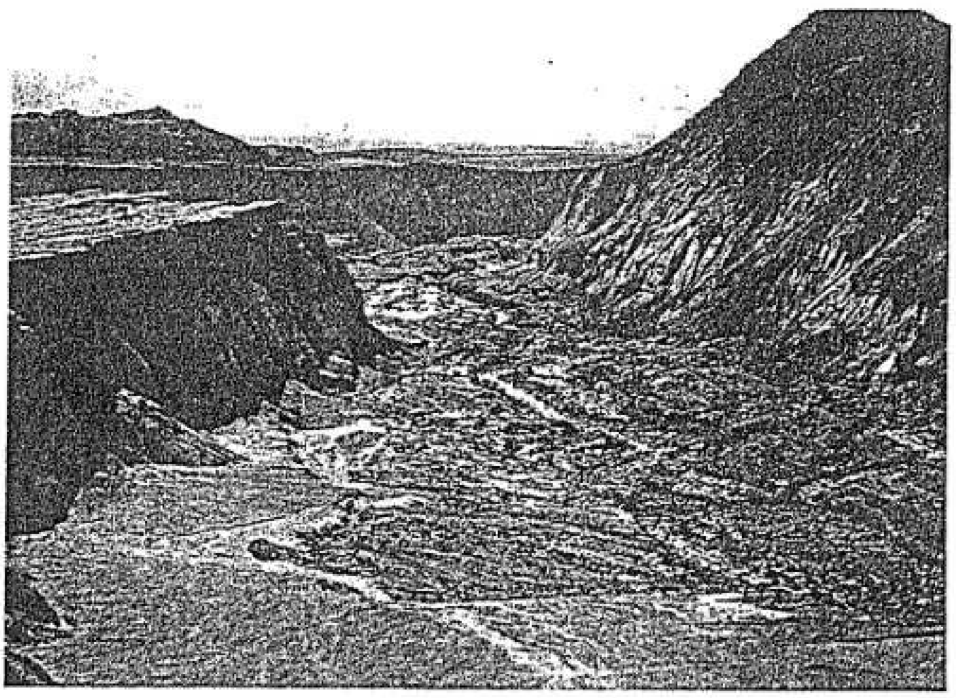

Figure 4.10

Detail of one of the relict canyons at Mount St. Helens. The volcanic deposits had been eroded over 100 feet deep to form this canyon within two years. The small stream in this canyon did *not* erode this canyon. (Photo by Steven A. Austin.)

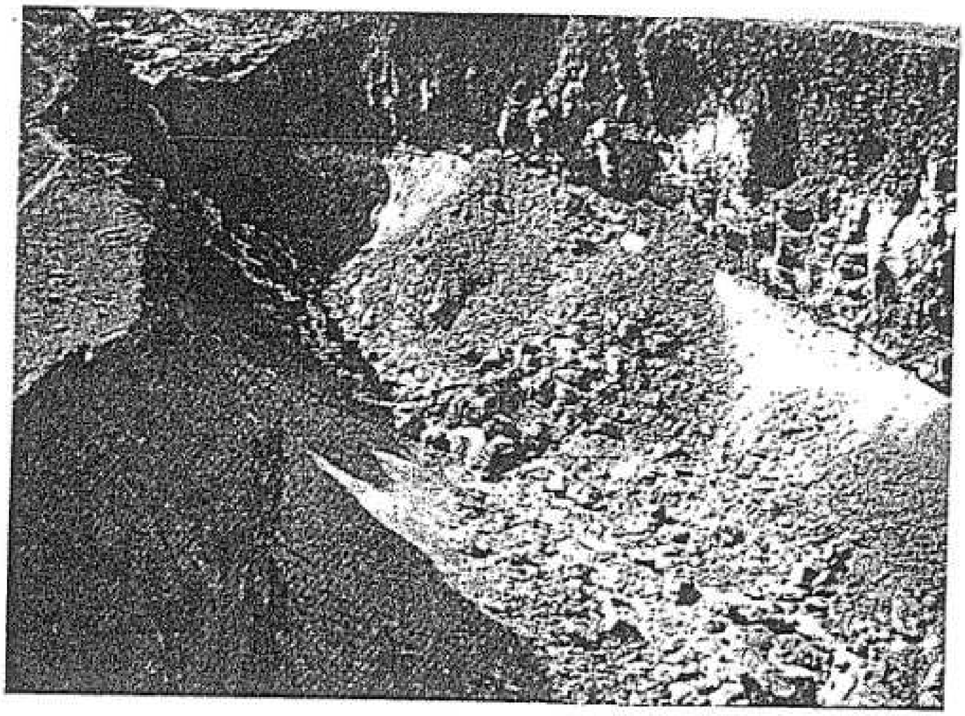

Figure 4.11
New canyon north of Mount St. Helens which was eroded after the summer of 1980 through solid rock. (Photo by Steven A. Austin.)

accumulation of boulders and cobbles. Thus, these present streams do not have enough water velocity and water volume to remove the buffer of boulders and cobbles that line their beds in order to erode the bedrock beneath their channels (see Figure 4.12). Again, this evidence indicates that these present streams are underfit, and that there was at least one episode of very high discharge.

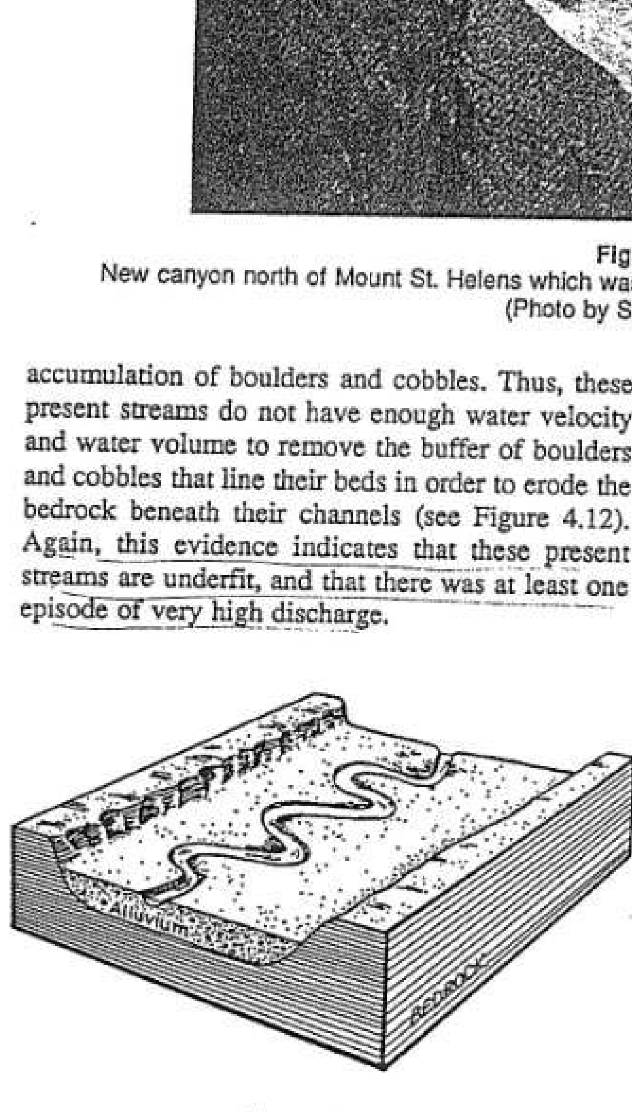

Figure 4.12
Block diagram showing an underfit river in a wide valley.

Among the most amazing erosional forms in the drainage basin above Grand Canyon are incised river meanders. At the Goosenecks of the San Juan River (Figure 4.13), for example, we see a meandering canyon which has been cut vertically hundreds of feet into sedimentary strata. Laboratory experiments have been conducted using a large flume which allowed a small stream to reproduce the conditions which erode incised meanders.[42] It was found that high discharge rate and lowering of base level (the depth to which a stream seeks to erode) cause meanders to incise vertically. Both causes would be initiated by breaching of a dam and drainage of a lake. When discharge is low and the alluvium in the channel is not swept away, the channel cuts horizontally, not vertically. Shepherd says:

> *The experimental results suggest that the vertically incised meanders of the San Juan may have resulted from downcutting during low-frequency discharges of large magnitude which entrained all of the alluvium in the channel.*[43]

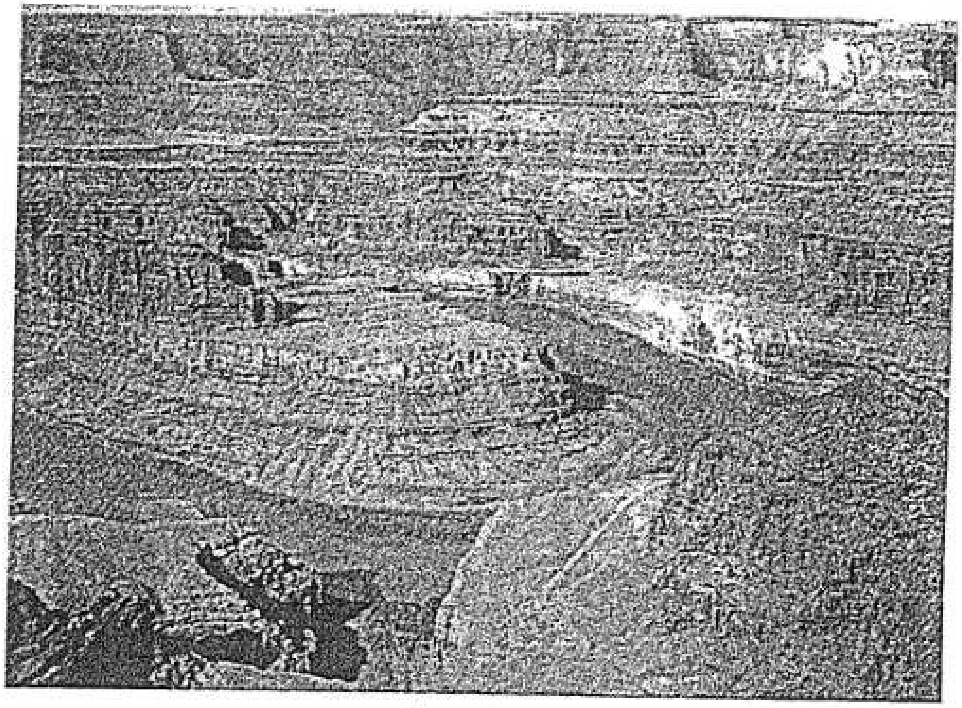

Figure 4.13
The Goosenecks of the San Juan River in southeastern Utah.
Incised meanders indicate greater water flow in the past.

Further evidence that incised meanders are eroded by catastrophic drainage comes from the Channeled Scabland of Washington State. We note that incised meanders occur on the Palouse River in southeastern Washington.[44] The Palouse River valley was very severely eroded into basalt by the catastrophic Lake Missoula Flood. The present Palouse River with low discharge did not erode the incised meanders.

EVIDENCE FOR RELICT LANDFORMS

If a lake or series of lakes on the Colorado Plateau rapidly drained, the water saturating rocks and soil along the shore and floor of the lake would quickly escape to the space previously occupied by the lake. Thus, along the former shore of the lake we expect to find large landslide scars and zones of failure caused by water oozing out of the earth. This type of failure would be expected within the breached area of the dam, along the spillway downstream, as well as along the shore of the lake. We immediately recall the severely eroded lip of the plateau which forms Bryce Canyon and countless other topographic features of Canyonlands in southern Utah. Might the enormous "monuments" such as occur around Monument Valley be topography accentuated by such slope failure?

Hundreds of smaller side canyons branch off from the Colorado River in Grand Canyon. What is interesting is that these side canyons are alcoves typically with short, rather wide and quite deep bowl-shaped heads ("amphitheater" or "theatre" heads). These side canyons of this shape are not typical of enlarged gullies which usually have narrow V-shaped heads. We have difficulty conceiving of a very old river canyon having such short and wide features. Instead, such theater-headed side canyons remind us of collapse features formed where water oozes out of wet sediment causing the supporting layers of sediment or rock to be removed so collapse occurs. Technically, this process is known as "sapping" and would have been an important process as greatly enlarged flow through the main canyon cut through the dam and caused material marginal to the canyon to dewater and slump into the main canyon.

Laboratory experiments illustrate the ability of escaping fluids to rapidly modify sediments. Figure

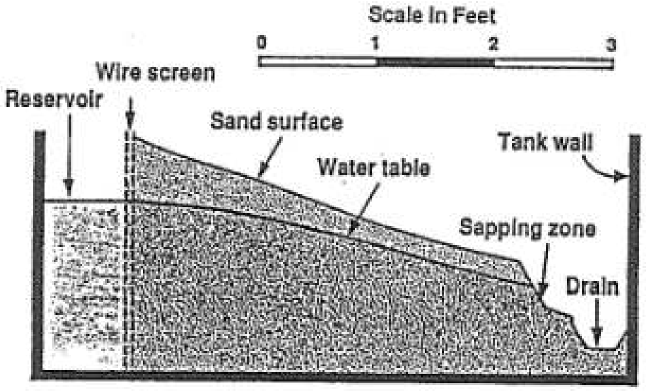

Figure 4.14
Cross section view of tank used to produce sapping structures in the laboratory. (After A. D. Howard, 1988.)

4.14 shows a cross-sectional view of a ground water sapping chamber built by Alan Howard.[45] Sand is accumulated within a tank to form a sloping pile against a wire screen. The reservoir on the opposite side of the screen is filled with water and a drain is opened at the base of the sand slope. Water begins to saturate the sand forming a water table within the sand (Figure 4.14). The sapping zone occurs above the base of the sand slope where water issues out of the sand. Failure of the sand slope occurs by sapping and produces alcoves ("theater-headed canyons") as seen in Figure 4.15. These resemble some of the side canyons formed by catastrophic erosion at Mount St. Helens in 1982, and are similar to erosion which has occurred at man-made dams which have collapsed. An assortment of theatre-headed canyons on Mars have been observed to issue into wide outflow channels. Carr[46] interpreted these sapping features to have formed by catastrophic release of Martian ground water.

We have found significant evidence that Grand Canyon and the region upstream have been eroded chiefly by catastrophic agents. This interpretation would imply that many features of the present landscape are in an arrested stage of development. Many features were formed in the past by catastrophic agents, but are now being only slowly remolded by gradual erosion occurring in the present. We would interpret these landforms to be relicts, features which are left over from the previous epoch of very significant erosion.

Examples of relict landforms in Grand Canyon and in the Canyonlands above Grand Canyon are abundant. Most of the theater-headed canyons or alcoves adjacent to Grand Canyon and those in the Canyonlands do not have active springs, so the sapping processes which formed them has essentially stopped. Howard and Kochel say:

> *The number and extent of active seeps in alcoves in the Navajo Sandstone appear to be less than would be expected for active valley development by sapping processes. Many major alcoves are presently dry or have small seeps that occupy only part of the alcove. Most of the alcoves in which cliff dwellings were built 800-1000 years ago by the Anasazi have few or no seeps. Although a dry environment may have been a factor in alcove selection, seeps must have been active at some time in the past to create the alcove. Similarly, rockfalls have occurred over only a few cliff dwelling ruins since their occupation, and most of those are small. The paucity of fresh rockfalls in general within alcoves on the Colorado Plateau has already been discussed.*[47]

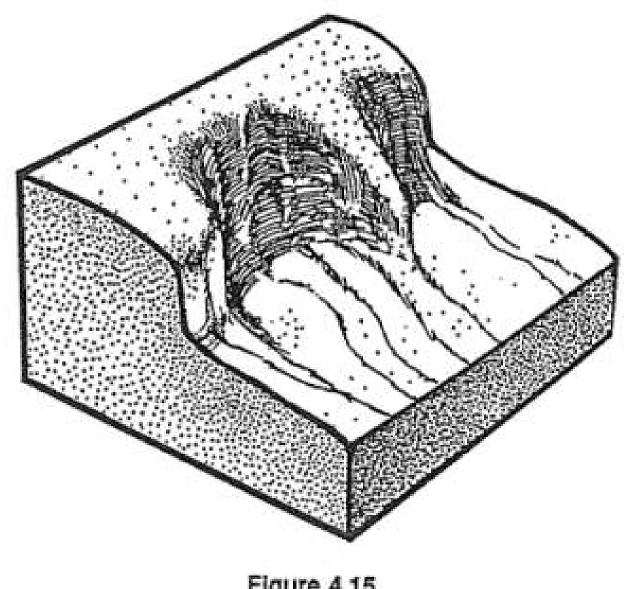

Figure 4.15
Example of experimentally produced sapping structures made in the laboratory. These resemble theatre-headed canyons of the Colorado Plateau.

Where modern springs do occur, the sapping forms are rather insignificant. Howard and Kochel say:

> *...the Weeping Wall at Zion National Park is an impressive seep emerging from the Navajo Sandstone, but the associated alcove and canyon are relatively small. Many other examples of fairly high discharge rates but only minor or nonexistent alcoves can be found throughout the Colorado Plateau.*[48]

Further evidence of the relict nature of the landscape comes from considering the stability of cliffs. Most major cliffs in Grand Canyon have only a small amount of talus indicating that intermittent rock fall accumulation over vast periods of time is not necessary. Figure 4.16 shows one example. If such cliffs are the result of slow erosion over hundreds of thousands of years, we might expect a progressive increase in the decomposition of talus on the benches away from cliffs. Such boulder aging has not been demonstrated. Instead, we see shale benches which appear to have been swept clean of larger rocks by large flooding. Then after significant flood modification, a recent talus has accumulated.

Another evidence of cliff stability in the Grand Canyon region comes from study of "desert varnish," an accretionary coating of minerals which attaches itself very slowly to stable rock surfaces. An excellent example is the cliff of Redwall Limestone which has the accretionary reddish coating derived from overlying Supai redbeds dominating its exposure. This cliff is not now slowly eroding back through a major extent of the canyon, otherwise the coating would not be so obvious. Another example is the Vishnu Schist of the inner gorge which is dominated by reddish-brown desert varnish.

HOW THE BREACH OCCURRED

The weight of the evidence favors the theory that Grand Canyon was opened by a breaching event, probably failure of the natural dam formed by the Kaibab Upwarp. How and when the failure of the dam occurred is a subject for continued geologic study and speculation. What we do know about dams is that when they fail, they fail catastrophically. Numerous historic examples of natural and

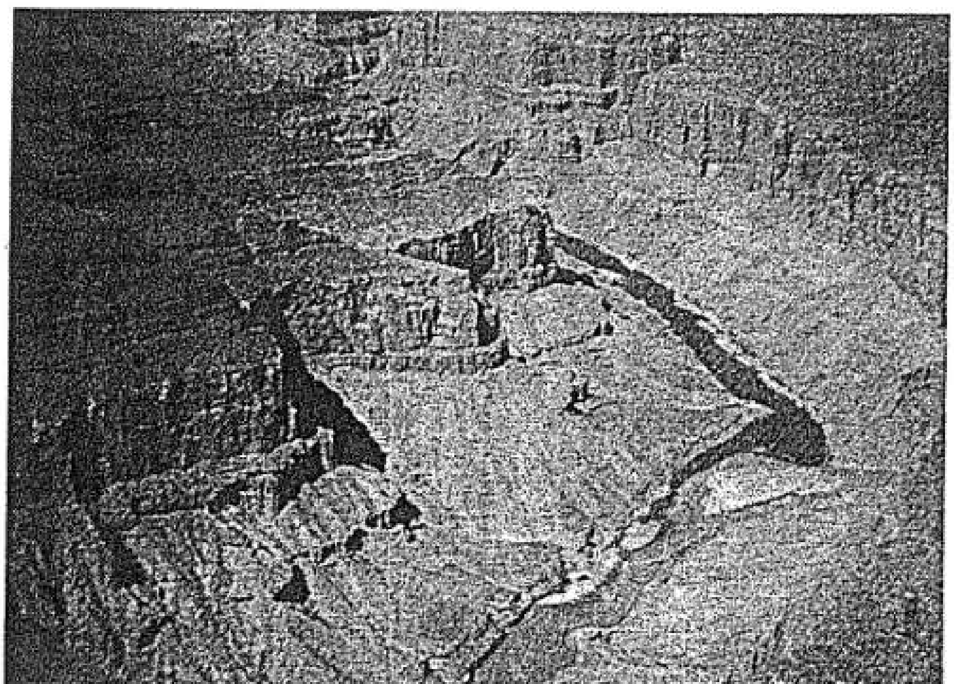

Figure 4.16
Cliff stability in Grand Canyon is indicated by absence of recent talus at the base of many cliffs.

man-made dams confirm that they rupture rapidly. There is no such thing as a *slow* dam failure. A study of numerous historic dam failures showed they fail in two major ways: overtopping or piping.[49]

Overtopping occurs when water reaches a high enough level behind the dam that water flows over the dam. Erosion occurs rapidly as a spillway is formed and the volume of flow increases enormously as the notch in the dam is lowered and the lake behind it is drained. Rapid erosion, even of solid rock and concrete, occurs as high velocity flow causes cavitation (a rock-pulverizing process associated with fluid flows greater than 30 feet per second) and plucking (the yielding of jointed rock to macroturbulent flow). The volume of material that can be removed during overtopping is simply astounding.

Piping, the second way dams can fail, occurs when water pressure *within* the dam builds up to a sufficient level so that tunnels of water begin flowing through the dam. Usually one tunnel system predominates as a natural pipe is formed within the dam. The flow of water through the dam increases to a high velocity so that enough of the material within the dam is eroded, causing collapse of the dam into the piping channel. The collapse of the dam rapidly opens a spillway through the dam and the lake drains catastrophically. Then cavitation and plucking accomplish significant erosion.

The configuration of the lakes which appear to have existed east of the Kaibab Upwarp is suggested in Figure 4.17. Hopi Lake occupied a large area of the drainage basin of the present Little Colorado River. The deposits of Hopi Lake (the Bidahochi Formation) indicate that the elevation of the lake may have been above 6,000 feet and that it extended into New Mexico. It would appear that Hopi Lake overtopped a low point in the Kaibab Upwarp near Grand Canyon Village in the extreme eastern Grand Canyon area. The notching of the dam by overtopping caused significant downward erosion in the channel which excavated a major portion of the Grand Canyon by cavitation and plucking. At the same time, the drainage of Hopi Lake downcut the present drainage basin of the Little Colorado River.

North of Hopi Lake, separated from Hopi Lake by the Echo Cliffs Monocline was Grand Lake. It occupied a major area of the upper Colorado River drainage basin, including parts of the Green, Gunnison and San Juan Rivers. It appears that the catastrophic drainage of Hopi Lake caused the dam for Grand Lake formed by the Echo Cliffs Monocline to fail, probably by piping.

The rapid drainage of Grand Lake excavated Marble Canyon through its natural dam, added the connection of drainage with Grand Canyon, and caused further extensive erosion in Grand Canyon. The outline of Grand Lake is indicated by spectacular topographic features including cliffs at Bryce Canyon, Monument Valley, Mesa Verde and Grand Junction. Because breaching of the Echo Cliffs dam for Grand Lake caused significant lowering of the natural drainage, there was significant downcutting within this drainage including The Canyonlands area, the Goosenecks of the San Juan and the Black Canyon of the Gunnison River. Many of the spectacular sapping features of southeastern Utah appear to be related to the rapid drainage of this lake.

A third lake, Lake Vernal, appears to have been located north of Grand Lake within the Green River drainage in northeastern Utah. Drainage of Grand

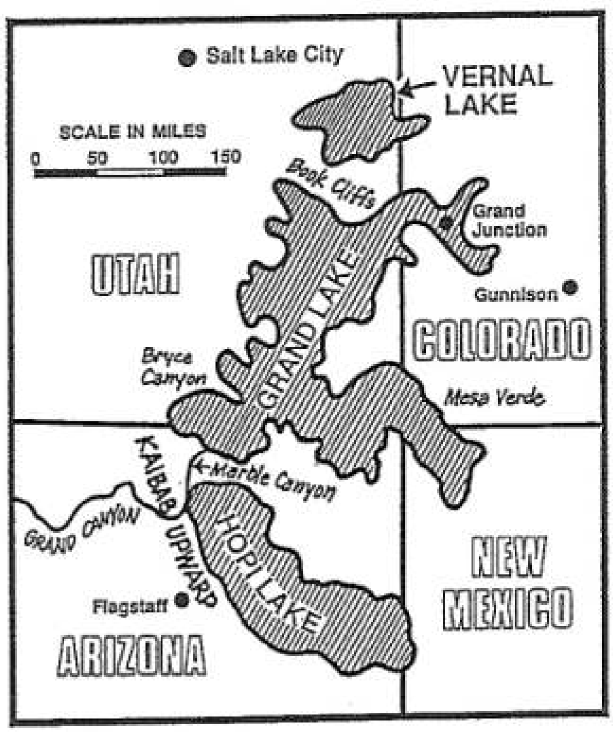

Figure 4.17
Former locations of Hopi,Grand and Vernal Lakes on the Colorado Plateau which breached their dams causing catastrophic drainage and erosion of Grand Canyon.

Lake could have initiated failure of the dam holding Lake Vernal. The breach through the Book Cliffs would have lowered the elevation of the upper Green River and caused downcutting in Flaming Gorge in Utah and Wyoming.

Together, Hopi, Grand and Vernal Lakes would have an area of over 30,000 square miles. The volume of water contained in these lakes is estimated to have exceeded 3,000 cubic miles, which is over three times the volume of Lake Michigan. Their drainage through Grand Canyon would have caused the significant downcutting through the plateaus of northern Arizona. As downcutting of the dam proceeded, large landslides from side canyons and sapping caused by outflow of water from wet strata would enlarge the Canyon. The drainage of three lakes through the Canyon would keep it free of obstructions.

How much erosion could occur as three lakes containing 3,000 cubic miles of water breached their dams? Could significant erosion of hundreds of cubic miles of both strata and crystalline basement rock occur within Grand Canyon? Many people, no doubt, will question the breached dam theory because of the inability to conceive of such massive erosion in a short period of time.

The question concerning the magnitude and speed of erosion has already been the subject of an intense geologic debate which lasted over 40 years (1923-1962). The Spokane flood controversy for the Channeled Scabland of eastern Washington centered on whether flood water could create enough scouring and irregular plucking of basalt bedrock to form what are today dry, deeply-incised channels.[50] J Harlan Bretz proposed in 1923 that these channels were eroded by a catastrophic flood. His critics, however, were solidly uniformitarian and refused to believe. This controversy formed one of the most interesting episodes in the history of geology. V. R. Baker wrote:

> *The role of floods in the erosion of stream channels has been one of the most controversial topics in fluvial geomorphology. . . . Indeed, the famous Spokane flood debate, concerning the effects of the greatest known freshwater floods on the planet, . . .centered on the issue of the erosive capability of running water. . . .Those who disbelieved the flood theory of J Harlen Bretz did so out of their experience that rivers did not behave as Bretz proposed. Subsequent work showed that their experience, not Bretz's theory, was inadequate. Bretz, not his critics, turned out to be the true uniformitarian. . . .*[51]

The debate concerning the magnitude and speed of flood erosion of bedrock was resolved largely by investigations of cavitation and plucking, two processes which dominate erosion during catastrophic floods. Figure 4.18 shows these

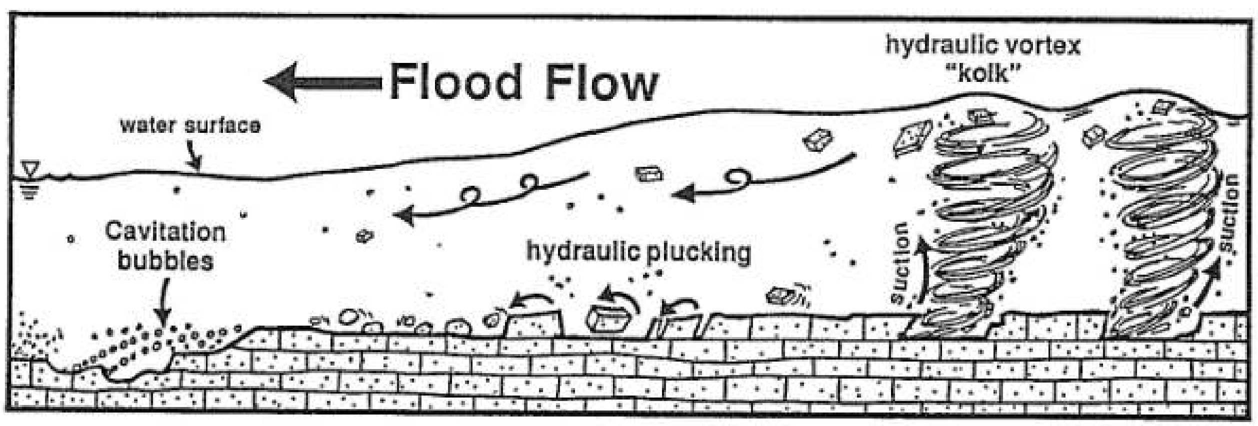

Figure 4.18
Major agents of erosion of solid bedrock during a large flood. High velocity flow produces cavitation downcurrent from an obstruction as vacuum bubbles implode inflicting hammerlike blows on the bedrock surface. Streaming flow impacts bedrock surface causing hydraulic plucking especially along joint surfaces. Hydraulic vortex action causes a "kolk" which exerts intense lifting force removing blocks of bedrock.

processes. Cavitation, the rock pulverizing process associated with fluid flows greater than 30 feet per second, occurs as the fluid detaches from irregularities in the bedrock channel. The detachment of the fluid produces vacuum bubbles which implode explosively inflicting hammerlike blows on the bedrock surface with pressures as high as 30,000 atmospheres.[52] Considerable disintegration of rock occurs. One example is noteworthy for Grand Canyon studies. Cavitation is known to have eroded 62,500 cubic feet of steel-reinforced concrete and bedrock within a few minutes in 1983 within a spillway tunnel at Glen Canyon Dam.[53] Because of its obvious catastrophic effects, engineers take deliberate steps to avoid the conditions which cause cavitation.

Plucking is the second erosive process which causes extremely rapid erosion in bedrock channels. High velocity flows are able to rip loose large blocks of bedrock along bedrock joint surfaces. Once a large block of bedrock is dislodged, the high velocity flow is able to move and abrade it. Perhaps the most energetic phenomenon associated with macroturbulent flow is the production of a "kolk," the underwater equivalent of a tornado.[54] The vortex of water producing a kolk has very low pressure beneath the flowing water. The suction power of the kolk exerts intense hydraulic lifting forces and can easily remove or pluck bedrock from the channel. A number of features eroded by the Spokane flood, as well as those eroded by modern catastrophic floods, have been attributed to macroturbulent flow processes.[55] Close study of some of the hard rock erosion features which formed recently at Mount St. Helens also gives us a hightened appreciation of plucking as a potent geologic process (see Figure 4.11). Evidence for rapid breaching of natural lava dams in western Grand Canyon is noteworthy and is the subject of ongoing studies.[56]

The breached dam theory for the origin of Grand Canyon can be integrated into a Flood model. Late in the Flood and in the immediate post-Flood, the Kaibab Upwarp was formed. It blocked the drainages of the Colorado Plateau. In the post-Flood period, possibly hundreds of years after the Flood, enough water had built up in these lakes so that dam failure could occur. Forests and animals may have been living on the plateau when the dam was breached. This breaching event may explain the unusual distribution of the tasel-eared squirrels on the Kaibab and Coconino Plateaus (see Chapter 7).

SUMMARY

For more than one hundred years geologists have attempted in a very deliberate manner to explain the erosion of Grand Canyon by uniformitarian agents. The elegant notion that the Colorado River eroded the Grand Canyon has been demonstrated repeatedly to be at odds with the empirical data. Most geologists familiar with the geology of northern Arizona have junked the ancestral river theory. The less-rational explanation of Grand Canyon erosion by stream capture (enlargement of a precocious gully) involves an accident of incredible improbability. Both the ancestral river and stream capture theories have the extraordinarily difficult problem of explaining where the products of 70 million years of river erosion went. The breached dam theory attributes the Grand Canyon and many other relict features of the Colorado Plateau to catastrophic drainage of lakes from the plateau. The breached dam theory has the added benefit of being able to be incorporated within a Biblical model of earth history.