2. THE GRAND CANYON

INTRODUCTION

The Grand Canyon of the Colorado River (Figs. 1-3), referred to below as "the Canyon," has been described as one of the world's grandest natural architectural masterpieces. President Theodore Roosevelt, who helped establish the United States National Park System, of which the Canyon is a part, declared that the Canyon is "the one great sight which every American should see." Some have not been that impressed, calling it just a bad case of soil erosion, or commenting that, once you get there, there is nothing to do but turn around and go back. These latter comments belie the fact that over four million people visit the Canyon every year. No one can stand on its edge and not be at least awed by its size. Pictures are but a poor substitute for the experience of actually seeing it.

FIGURE 1. View of the Grand Canyon looking north from the South Rim. The three arrows designate where major portions of the geologic column are missing between the layers. From top to bottom they represent assumed gaps of approximately 6, 14, and 100 million years (Ma). The Colorado River, which is not visible here, runs diagonally towards the lower left of the picture in the deep Inner Gorge seen through the middle of the picture.

The Colorado River winds its way for 446 kilometers through the region of the Canyon, dropping about 610 meters in the process. The Canyon is much deeper in the mid region where the river cuts through a broad dome, scores of kilometers wide, called the Kaibab-Coconino Uplift. Here the Canyon reaches a depth of 1.8 kilometers from rim to river, and a maximum width of nearly 30 kilometers. The size is impressive, although some of the transverse gorges of

the Himalayas reach nearly three times the depth of the Grand Canyon (Wadia 1975, p 27). However, what is especially important about the Canyon is how well it so openly displays many important geologic features beneath its rim. Rightfully it has been identified as the geologic showcase of the world.

FIGURE 2. View to the north of the Grand Canyon. The sedimentary layers below the tip of the arrow are Precambrian, while the parallel layers above are Phanerozoic. Note the extensive erosion to the north of the little river which is hidden in the small dark gorge in the foreground.

The size of the Canyon is most arresting, but, once one gets over that, one is duly impressed with the extremely parallel nature of the rock layers, and how small the Colorado River is as it courses its way through this huge canyon (Fig. 3). Two main aspects of this landscape are important to the study of the past: 1) How did the layers get there? And 2) how was the canyon cut? Many mysteries still lie hidden in the rocks of the Canyon, but there is a significant amount of available data that bears on these questions.

THE CREATIONISTIC INTERPRETATION OF THE GRAND CANYON

Most of the widespread layers of rock that we see in the Canyon are composed of various sediments, hence are called sedimentary rocks. They sometimes contain fossils that are occasionally quite abundant. The sediments that produce sedimentary rocks are most often transported by water. However, not all of the layers of sedimentary rock that one sees in the

Canyon are interpreted by those scientists who believe in creation as originating during the flood. In the lowest portions of the Canyon, especially towards the eastern end, we find thick layers of sedimentary rocks that have very few or questionable fossils in them. These are part of the lower rock layers we call Precambrian and are seen in Figure 2 as the layers below the arrow. Precambrian layers are usually considered by flood geologists to have been there before the biblical flood. The layers above the Precambrian are designated as Phanerozoic. They contain many more fossils and in the Canyon region are strikingly parallel in arrangement (Figs. 1, 2). Only the lower half of the Phanerozoic is represented in the Grand Canyon. Just beyond the Grand Canyon, especially to the north and east are thick sedimentary layers that lie above the rock layer that forms the rim of the Canyon. These thick layers represent a significant portion of the upper part of the Phanerozoic. Most of the Phanerozoic is considered by flood geologists to have been deposited during the biblical worldwide flood. Creationists believe the Canyon was cut by the receding waters of the flood.

THE STANDARD GEOLOGIC INTERPRETATION FOR THE FORMATION OF THE GRAND CANYON ROCK LAYERS

Most geologists believe that the rock layers of the Grand Canyon, and most other major sedimentary layers of the Earth were formed over many millions of years. For instance, the strikingly horizontal layers of the Phanerozoic of the Canyon are commonly represented as

FIGURE 3. The Colorado River entrenched in the Inner Gorge of the Grand Canyon.

having taken more than 300 million years for their formation. These layers have been extensively studied and the geologic literature covering them is vast. Three useful recent summaries are the publications by Beus and Billingsley (1989), Beus and Morales (1990, p 83-245), and Ford (1994).

Various ancient environments are postulated for the deposition of these layers. The lowest (just above the arrow in Fig. 2) is considered to represent a combination of shallow marine and river deposits, although there is evidence of this having occurred in deeper water (Kennedy, Kablanow and Chadwick 1996, McKee and Resser 1945). The Layers above this, up to well past the middle of the Canyon wall, are interpreted as having been deposited mainly in a marine environment with seas repeatedly advancing and retreating over the area, while occasionally rivers deposited sediments in the environment. In this portion of the layers there is an upward trend towards less marine and more terrestrial environments.

One of the most striking rock units of the Canyon is the light-colored Coconino Sandstone found near the top of the Canyon (just above the top arrow in Fig. 1). This has traditionally been interpreted as an ancient desert dune environment, although questions about this have been raised (Brand 1978, Brand and Tang 1991). From the top of the Coconino Sandstone to the rim of the Canyon the layers are thought to have been deposited over millions of years in a marine or near marine type of environment. According to standard geologic interpretation the Canyon itself was cut by slow erosional processes over millions of years.

QUESTIONS ABOUT THE BIBLICAL FLOOD INTERPRETATION OF THE GRAND CANYON

1. **The abundance of sediments.** In the context of the biblical flood, one of the most obvious questions to be asked when viewing the Canyon is how all these thick sedimentary layers could be deposited in a singe event such as the Genesis flood which took only about a year. Also, as referred to above, beyond the Canyon region, there are layers of sediment, thicker than the horizontal ones seen in the Canyon itself, that lie above the layers we see in the Canyon. This is a lot of sediment to account for in a one-year flood. However, one needs to keep in mind that: 1) under rapid catastrophic conditions sediments can be deposited at the rate of meters per minutes or even faster; 2) the lowest sedimentary layers seen in the Grand Canyon are not considered to have been deposited during the flood; 3) in terms of thickness of sediments the Canyon region is not at all typical. Here the layers are several times as thick as the average over the earth. Some regions of Earth have virtually no sediments at all. Actually, the average thickness of the sedimentary layers resulting from the flood would form only a very thin veneer (a few hundred meters) on Earth's surface. Proportionately on an ordinary 30-cm globe, the thickness would be less than 1/4 that of an ordinary sheet of paper! It is still a lot of sediment.

2. **Karst surfaces.** Another question which has been posed for those who believe in a recent creation relates to the top of the Redwall Limestone which forms a prominent

reddish vertical cliff in the mid-region of the layers of the Canyon (just above the lowest arrow in Fig. 1). In places the top surface of that limestone is irregular. It is interpreted as an ancient "karst" surface that would normally require many years for erosion (see Jennings 1983). The term karst comes from the Karst region of the Adriatic coast where the limestone has been eroded into a characteristic irregular surface. Limestone is quite easily dissolved; that is why we often find cavities (Fig. 4), and even very large caves in it. One of the ancient erosional channels found in the Redwall Limestone is 122 meters deep, and there are many smaller grooves and cavities near the top of the Redwall (Billingsley and McKee 1982, Billingsly and Beus 1985, Beus 1986). How could these irregularities form if the layers of the Grand Canyon had to be all laid down during a one-year flood, as suggested by the biblical model? Two things need to be kept in mind. 1) During a worldwide flood there would have been plenty of water activity to cut a few channels in the top of the Redwall Limestone which may not even have been very hard then. 2) Also it appears that some of these irregularities developed after the layers that lie over the limestone had already been laid down. Hence they could have formed during the thousands of years since the flood. The evidence for this is that in places we find blocks from the layers above the limestone that have collapsed into the cavities dissolved out of the Redwall Limestone (Fig. 5). If the cavities had formed before the layers above had been laid down, as is assumed for a real karst surface, the cavities would have been first filled in with sediments, but not with hard blocks of rock from the layers above which would not yet have been formed. It appears that at least some cavities formed after the

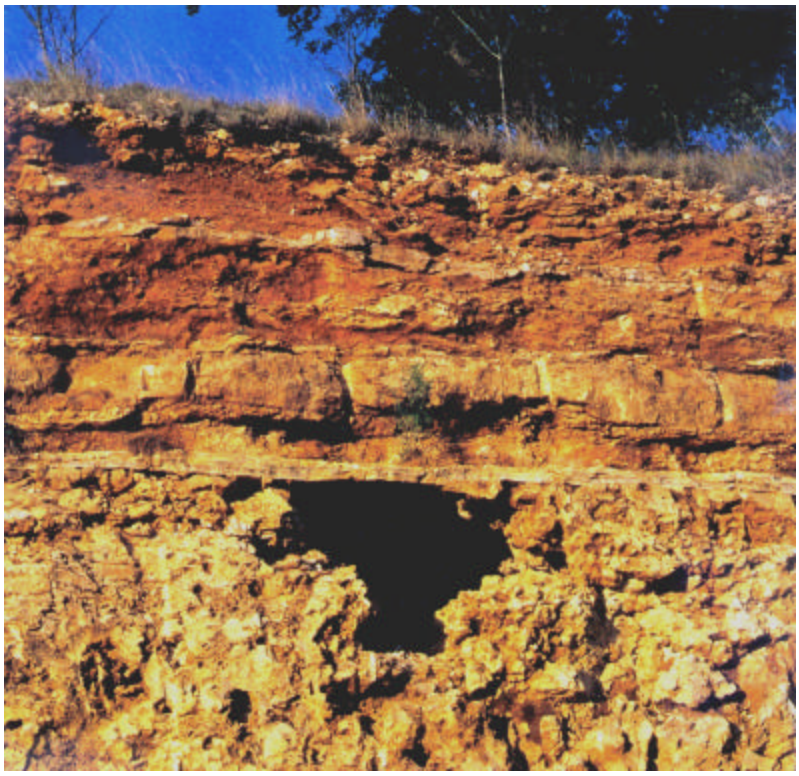

FIGURE 4. An example of a cavity dissolved in limestone (the Edwards Limestone) in central Texas. Note that the roof of the cavity, which is about a meter across, has not yet collapsed.

layers above the Redwall Limestone had been laid down (Eberz 1995). The traditional karst interpretation for a similar situation to the north of the Canyon region, but at the same location in the geologic column, has been challenged by a traditional geologist (Bridges 1982). He states: "In my opinion, the late Mississippian karst story in the Rocky Mountains is completely fallacious." He is of the opinion that the so-called karst features developed much later. Such a sequence of events would not require that much time be required for laying down of the Canyon layers. The interpretation of ancient karst surfaces is subject to reevaluation.

FIGURE 5. A collapsed area (collapsed breccia; dark red rocks in center, around the red pen) at the top of the Redwall Limestone in the Grand Canyon. The light-colored rocks are from the Redwall Limestone, while the darker ones are from the overlying Watahomigi Formation. The presence of blocks of Watahomigi suggests that the Watahomigi was laid down before solution of the limestone and collapse took place.

QUESTIONS ABOUT THE STANDARD, LONG-AGE INTERPRETATION OF THE GRAND CANYON ROCK LAYERS

1. **Widespread sedimentary layers.** The layers of rock exposed by the Canyon seem unusually widespread and horizontal (Fig. 3). In some cases this widespread pattern is more than meets the eye. For instance, on the basis of fossils and other characteristics, the Redwall Limestone, which forms the single steep cliff mentioned above, is commonly divided into four units lying one above the other. Many of the other major rock units are

subdivided into widespread subunits. Over a century ago, Clarence Dutton, one of the leading pioneers of geology in the United States, studied the Canyon district and commented on this:

> *The strata of each and every age were remarkably uniform over very large areas, and were deposited very nearly horizontally. Nowhere have we found thus far what may be called local deposits, or such as are restricted to a narrow belt or contracted area* (Dutton 1882, p 208-209).

Some local deposits such as those mentioned above found at the top of the Redwall Limestone have been described since Dutton's original survey, but these are small. This would be more consistent with rapid widespread catastrophic flood deposition, than with slow deposition over hundreds of millions of years. During such long periods, changing conditions such as the postulated movements of the continent, including the uplift and subsidence (Dickinson 1981), which would bring about the many advances and retreats of the sea postulated for the area, would seem to favor more local deposition.

2. **Cracks at the top of the Hermit Shale.** The dark-colored formation called the Hermit Shale lies just below the light-colored Coconino Sandstone referred to above. The contact between the two is indicated by the top arrow in Figure 1. Over the Canyon

FIGURE 6. Cracks in the dark Hermit Shale of the Grand Canyon (arrows) filled in with sand from the lighter-colored overlying Coconino Sandstone seen in the top of the picture. Note that the white sandstone in the crack to the left has caused some discoloration of the surrounding rock. Only part of a filled crack can be seen towards the right. The cracks are over a meter deep.

region one finds fine elongated vertical cracks in the Hermit Shale that are filled with sand grains from the Coconino (Fig. 6). Some of the cracks are as much as 7 meters deep. One might wonder if the presence of these cracks in the Hermit Shale does not require that the Hermit Shale had first dried out before the Coconino was laid down, thus posing a problem for a flood model. This is not necessarily the case, since cracks can form underwater in soft mud due to the cohesion of clays as the process of dewatering (removing the water) takes place. The presence of the cracks actually seems to pose a problem for the long-geological-ages model, especially since it is assumed that there is a gap of several million years between the Hermit and the Coconino (Fig. 1 in Blakey 1990a, and Figs. 4 and 16 in Blakey 1990b would suggest around 6 million years). How could the cracks in the Hermit remain open for millions of years until the Coconino was laid down? Any rain or strong winds carrying sediments during that time would tend to fill them up. What we have here seems to fit well with rapid action. A possible scenario is that the Hermit was covered with Coconino very soon after it was laid down, then the shrinkage cracks formed due to dewatering of the Hermit, and the still-soft Coconino sediments filled the cracks as they formed.

3. The scarcity of erosion where significant parts of the geologic column are missing. When looking at the flat-lying Phanerozoic layers of the Grand Canyon, one does not realize that according to the standard geologic interpretation, major parts of the geologic column, representing millions of years, are missing between some of these layers. The way one tells that there is a gap is that the missing parts (layers) of the geologic column, which contain the appropriate fossils, are found in other parts of the world. During those assumed gaps of millions of years when there was no deposition, one would expect a lot of erosion forming gullies, valleys, and canyons (Roth 1988). There is no place on the surface of the Earth where we would not expect either erosion or deposition over these long periods of time. If there is deposition, then there would be no gap in the geologic column. But if there is no deposition, we would expect significant erosion over such long periods of time, and the layers of the Grand Canyon should not appear so parallel. The Canyon itself well illustrates the dramatic effects of erosion. The three arrows in Figure 1 point at significant gaps in the layers estimated from top to bottom at approximately 6, 4, and 100 million years; yet, as can be seen, the underlying layers appear essentially free of erosion. The top arrow points to the gap between the Coconino and Hermit discussed above (see also Fig. 6). In referring to the gap at the middle arrow, a geologist (Beus and Morales 1990, p 158) comments: "Contrary to the implications of McKee's work, the locations of the boundary between the Manakacha and Wescogame formations [where the gap is] can be difficult to determine, both from a distance and from close range." In referring to some localities of the very long lower gap, another geologist (p 111, Beus and Morales 1990) states: "Here, the unconformity [gap], even though representing more than 100 million years, may be difficult to locate." Over these very long assumed periods of time a lot of weathering and erosion of the rock layers would be expected, but this is not what we see.

Average present rates of erosion for the region around the Grand Canyon would erode a layer as thick as the Canyon is deep in less than 12 million years. This means that,

according to the standard geologic time scale, the Canyon and the rock layers that form it should have been eroded long ago (Roth 1986). While there is considerable disagreement as to how the Grand Canyon itself was eroded, the geologist Lucchitta (1984) suggests that "most of the canyon cutting occurred in the phenomenally short time of 4 to 5 million years." The discrepancy between the expected erosion over the postulated millions of years, where parts of the geologic column are missing, and what is seen, suggests that those millions of years never took place. What is seen seems to favor the rapid deposition expected during the biblical flood.

4. **The lack of food for animals in the Coconino Sandstone.** In the lower half of the Coconino Sandstone, hundreds of well-defined animal footprint trackways are found. These trackways were probably made by amphibians or reptiles. The surprising thing is that no plants appear to have been present. Aside from the footprints, the only other fossils that have been reported are those of a few worm tubes and invertebrate trackways (Middleton, Elliott and Morales 1990; Spamer 1984). If the Coconino had been deposited over millions of years as is assumed for the standard geologic interpretation, what nourishment was available for the animals who made all these trackways? There is no evidence for the presence of plant food. If simple footprints are well preserved, one would also expect to find the imprints or casts of roots, stems, and leaves of plants, if they were ever present (Roth 1994).

   Almost all of the trackways in the Coconino indicate that the animals were going uphill. Furthermore, there is good evidence that these trackways were formed underwater, instead of the usual interpretation that they were made on desert dunes (Brand 1978, Brand and Tang 1991). Is it possible that all these uphill trackways were formed by animals seeking to escape the waters of the flood? The bodies of the animals could have been swept away by flood activity. That may be why we don't find them. On the other hand, in the context of the standard interpretation of slow geologic processes, we would expect to find at least the imprint of the roots of the plants on which the animals had to feed, but these appear to be absent.

HOW WAS THE GRAND CANYON CUT?

The simple question of the cutting of the Canyon turns out to be very complex. Although geologists have been intensely studying this matter for over a century, no simple answer or consensus seems in sight. The details of the discussions are beyond the scope of our brief survey, but are well summarized in the professional geologic literature (Brown 2000; Beus and Morales 1990; Babenroth and Strahler 1945; Breed 1969; Elston and Young 1989; Graf et al. 1987; Hunt 1976; Longwell 1946; Lucchitta 1990, 1984, 1972; Perkins 2000; Rice 1983). Recent interpretations suggest much shorter times and catastrophic activities for the carving of the Canyon. These trends are in the direction of a creation interpretation. However, to most geologists the cutting of the Canyon is an unsolved mystery sometimes referred to as the "Canyon conundrum" (Rice 1983).

Among the vexing problems which the Canyon poses is the fact that the Colorado River, which courses through the Canyon, cuts right through a broad dome, instead of going around it. One would not expect that any "intelligent" river would go up over a dome instead of around it.

Another problem is the question of the past location and age of the river. Was it present before the dome formed? Evidence for an ancient Colorado River is notoriously sparse, especially west of the Canyon. Some have suggested that in the past on the east side of the dome the river came from the northeast to the edge of the dome and then went to the southeast towards the Gulf of Mexico without ever traversing through the dome itself. It has also been suggested that the dome was eventually eroded from the west to join the Colorado River from the east, but without much of a source of water to cut a deep gorge through the dome, this seems unlikely. On the west side, it has been suggested that the river may have left the Canyon region, going to the northwest before eventually changing its course and going to the southwest where it is now found. Also puzzling are the huge side canyons found especially on the north side of the Canyon (Fig. 1, 2 far side). These side canyons which end up in the high region of the dome have virtually no streams to erode them.

The Canyon is huge. Some 4000 cubic kilometers of sediment have been eroded to form the Canyon. Yet this is but a fraction of the erosion evident in the region for the layers mentioned earlier that must have been above those exposed in the Canyon (Dumitru, Duddy, and Green 1994). The erosion of these layers forms a broad valley, more than 200 kilometers wide, that lies above the Canyon. Probably 15 to 30 times as much sediment was removed to form the broad valley above the Canyon as was involved in the carving of the Canyon itself. Dutton (1882 p 61-77) called the erosion of this broad valley "the great denudation." According to standard geologic interpretations this great denudation would be considered to be a slow process of broadening of the valley over time as the valley walls retreated laterally as they were slowly eroded. But this does not seem to be the case. The sides of the broad valley do not have active talus (debris) at the base of the cliffs as would be expected for a slow process. The sides of the broad valley are clean as though the valley had been catastrophically washed out. Clean edges are more like what you would expect from the runoff of the waters of the flood than from a slow gradual weathering process. Besides, if the valley was the result of a slow weathering process, one has to explain why all the weathering and washout took place in the broad valley while the sides of the valley are left uneroded.

How did the Canyon get cut? We don't know for sure. We do know that the standard slow model poses a number of questions. It is also of interest that the lore of local Indian tribes reflects more rapid action. One writer, in referring to this comments that: "The Navajo, the Hualapai and the Havasupai still believe that the river is the runoff from a great flood that once covered the earth" (Wallace 1973, p 99). Some scientists who believe in the biblical account of beginnings also suggest that the carving of the Canyon and the surrounding region is the result of the runoff of the waters of the worldwide biblical flood. One model (Austin 1994, p 92-107) proposes that at the end of the flood a lot of water was ponded to the east of the Grand Canyon region. A natural dam on the west side of the ponded water was breached and a great volume of water flowed to the west cutting the Canyon. A second model proposes that the Canyon was cut under water, that is below the surface of the flood waters, as these were retreating to the west. This model may explain the origin of the many side canyons to the Canyon. Although we don't

see it, underwater erosion in the ocean is a common thing. We have many underwater canyons cut along the edge of our continental shelves. A submarine canyon, the Monterey Canyon, which lies off the coast of California, is as deep and as wide as the Grand Canyon. We may not know how the Grand Canyon was carved, but the action of the receding waters of the biblical flood present some interesting possibilities.

CONCLUSIONS

The Grand Canyon has much to say about the past history of life on Earth. This fascinating display of rocks has been interpreted in a variety of ways. Most scientists propose that one to many millions of years were involved in its formation. However, a number of questions about this interpretation can be raised when specific details are considered. The biblical model implying rapid formation of the rock layers and of the cutting of the Canyon provides some resolution to some of the questions posed by the standard model. While the Grand Canyon still hides many mysteries, and we still have much to learn about it, it also provides strong evidence that supports the truthfulness of the biblical account of beginnings.

REFERENCES

Austin SA, editor. 1994. Grand Canyon: monument to catastrophe. Santee, CA; Institute for Creation Research.

Babenroth DL, Strahler AN. 1945. Geomorphology and structure of the East Kaibab monocline, Arizona and Utah. Geological Society of America Bulletin 56:107-150.

Beus S. 1986. A geologic surprise in the Grand Canyon. Arizona Bureau of Geology and Mineral Technology Fieldnotes, Vol. 16, No. 3.

Beus SS, Billingsley GH.1989. Paleozoic strata of the Grand Canyon, Arizona. In: Elston DP, Billingsley GH, Young RA, editors. Geology of Grand Canyon, Northern Arizona (with Colorado River Guides). Washington DC; American Geophysical Union, p T115/315; 122-235.

Beus SS, Morales M, editors. 1990. Grand Canyon Geology. NY and Oxford: Oxford University Press; and Flagstaff, AZ: Museum of Northern Arizona Press.

Billingsley GH, McKee ED. 1982. The Supai Group of Grand Canyon: pre-Supai buried valleys. In: McKee ED, editor. The Supai Group of Grand Canyon. US Geological Survey Professional Paper 1173:137-147.

Blakey RC. 1990a. Supai Group and Hermit Formation. In: Beus SS, Morales M, editors. Grand Canyon Geology. NY and Oxford: Oxford University Press; and Flagstaff, AZ: Museum of Northern Arizona Press, p 147-182

Blakey RC. 1990b. Stratigraphy and geologic history of Pennsylvanian and Permian rocks, Mogollon Rim region, central Arizona and vicinity. Geological Society of America Bulletin 102:1189-1217.

Brand, LR. 1978. Footprints in the Grand Canyon. Origins 5:64-82.

Brand LR, Tang T. 1991. Fossil vertebrate footprints in the Coconino Sandstone (Permian) of northern Arizona: evidence for underwater origin. Geology 19:1201-1204

Breed CS. 1969. A century of conjecture on the Colorado River in Grand Canyon. Four Corners Geological Society Guidebook, p 63-68.

Bridges LWD. 1982. Rocky Mountain Laramide-Tertiary subsurface solution vs. Paleozoic karst in Mississippian carbonates. Thirty-third Annual Field Conference, Wyoming Geological Association Guidebook, p 251-274.

Brown D. 2000. How did that canyon get there? American Association of Petroleum Gologists Explorer 21(8):28-33.

Dickinson WR. 1981. Plate tectonic evolution of the southern Cordillera. Arizona Geological Society Digest 14:113-135.

Dumitru TA, Duddy IR, Green PF. 1994. Mesozoic-Cenozoic burial, uplift, and erosion history of the west-central Colorado Plateau. Geology 22:499-502.

Dutton CE. 1882. Tertiary history of the Grand Cañon district. US Geological Survery Monograph, Vol. 2.

Eberz N. 1995. Redwall Limestone karst and Colorado River evolution during Late Tertiary, Grand Canyon Nat. Park, Arizona. Geological Society of America Abstracts with Programs 27(6):A-211.

Elston DP, Young RA. 1989. Development of Cenozoic landscape of central and northern Arizona: cutting of Grand Canyon. In: Elston DP, Billingsley GH, Young RA, editors. Geology of Grand Canyon, Northern Arizona (with Colorado River Guides). Washington DC: American Geophysical Union, p T115-315:145-165.

Ford TD. 1994. The Grand Canyon of the Colorado. Geology Today (March-April), p 57-62.

Graf WL, Hereford R, Laity J, Young RA. 1987. Colorado Plateau. In: Graf WL, editor. Geomorphic systems of North America. Geological Society of America Centennial Special Volume 2:259-302.
Hunt CB. 1976. Grand Canyon and the Colorado River, their geologic history. In: Breed WJ, Roat E, editors. Geology of the Grand Canyon. 2d ed. Flagstaff, AZ: Museum of Northern Arizona Press.
Jennings JN. 1983. Karst landforms. American Scientist 71:578-586.
Kennedy EG, Kablanow R, Chadwick AV. 1996. A reassessment of the shallow water depositional model for the Tapeats Sandstone, Grand Canyon, Arizona: evidence for deep water deposition. Geological Society of America Abstracts with Programs 28(7):A-407.
Longwell CR. 1946. How old is the Colorado River? American Journal of Science 244:817-835.
Lucchitta I. 1972. Early history of the Colorado River in the Basin and Range province. Geologic Society of America Bulletin 83:1933-1948.
Lucchitta I. 1984. Development of landscape in northwest Arizona: the country of plateaus and canyons. In: Smiley TL, Nations JD, Péwé TL, Schafer JP, editors. Landscapes of Arizona: the geological story. Lanham, MD, and London: University Press of America, p 269-301.
Lucchitta I. 1990. History of the Grand Canyon and of the Colorado River in Arizona. In: Beus SS, Morales M, editors. Grand Canyon Geology. NY and Oxford: Oxford University Press; and Flagstaff, AZ: Museum of Northern Arizona Press, p 311-332.
McKee ED, Resser CE. 1945. Cambrian History of the Grand Canyon Region. Carnegie Institution of Washington Publication 563.
Middleton LT, Elliott DK, Morales M. 1990. Coconino Sandstone. In: Beus SS, Morales M, editors. Grand Canyon Geology. NY and Oxford: Oxford University Press; and Flagstaff, AZ: Museum of Northern Arizona Press, p 183-202.
Perking S. 2000. The making of a Grand Canyon. Science News 158:218-220.
Rice RJ. 1983. The Canyon conundrum. The Geographical Magazine 55:288-292.
Roth AA. 1986. Some questions about geochronology. Origins 13:59, 64-85.
Roth AA. 1994. Incomplete ecosystems. Origins 21:51-56.
Roth AA. 1998. Origins: Linking science and scripture. Hagerstown, MD. Review and Herald Publishing Association.
Sparmer E. 1984. Paleontology in the Grand Canyon of Arizona: 125 years of lessons and enigmas from the late Precambrian to the present. The Mosasaur 2:45-128.
Wadia DN. 1975. Geology of India, 45th ed. New Delhi: Tata McGraw-Hill Publishing Co.
Wallace R. 1973. The Grand Canyon. The American Wilderness Series. Alexandria, VA: Time-Life Books.