
MAKING MYSTERIES OUT OF MISSING ROCK

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S *CIENTIFIC CREATIONISTS HAVE REPEATEDLY* claimed that geological field evidence can best be explained in terms of a recent creation and a catastrophic global deluge. That claim has been made specifically for the Grand Canyon of northern Arizona. At least three similar "flood geology" models have been proposed for the Grand Canyon, and, according to Walter Lang, "All three, or combinations thereof, are permissible on the basis of Scripture. . . . Any of these models provides explanations which are superior to the uniformitarian model which claims that the bottom rocks are two billion years old and that the Colorado River, eroding at its present rate, carved the canyon over a period of from seven million to 36 million years."¹

To test flood geology's claim to superiority, we examine some illus-

trative aspects of the geology of the Grand Canyon. For several reasons, the Grand Canyon provides an ideal test case of the merits of the geological theories of scientific creationism: (1) many geological claims have been made about this area by scientific creationists; (2) the region is familiar to many laypersons; (3) the rocks are very well exposed; and (4) the geology is relatively simple and has been very thoroughly documented.²

The Grand Canyon region is part of the Colorado Plateau, a major geological province that occupies large portions of Utah, Colorado, New Mexico and Arizona. The plateau consists largely of nearly horizontal layers of a variety of sedimentary rocks that are stacked on top of one another. Due to extensive erosion, the layers are now well exposed in the spectacular cliffs, mesas, buttes, spires and canyons that abound throughout the plateau. Locally the layers of the plateau have been warped into broad dome-shaped uplifts or depressed into broad basins. Where the Colorado River has eroded through the uplifts, as in Canyonlands National Park in Utah, deep canyons have formed. In northern Arizona, the river has chiseled its way down through the Kaibab-Coconino uplift to form the Grand Canyon.

In the walls of the Grand Canyon, approximately 4000 feet of superimposed horizontal strata are well exposed. Figure 3 summarizes the names of the formations that are exposed in the walls of this magnificent canyon. Also included are the approximate thicknesses of the formations, the standard geological periods assigned to these formations, and their approximate age in years as accepted by the professional geological community.⁵ The horizontal strata toward the bottom of the canyon rest on top of tilted rocks designated as the Unkar and Chuar Groups.⁴

These rocks in turn rest on highly deformed igneous and metamorphic rocks⁵—known as the Vishnu Schist and Zoroaster Granite. The spatial relationships among the Tapeats Sandstone, lowermost of the horizontal layers, the Unkar Group, and the Vishnu Schist and Zoroaster Granite are shown schematically in figure 3. As indicated by

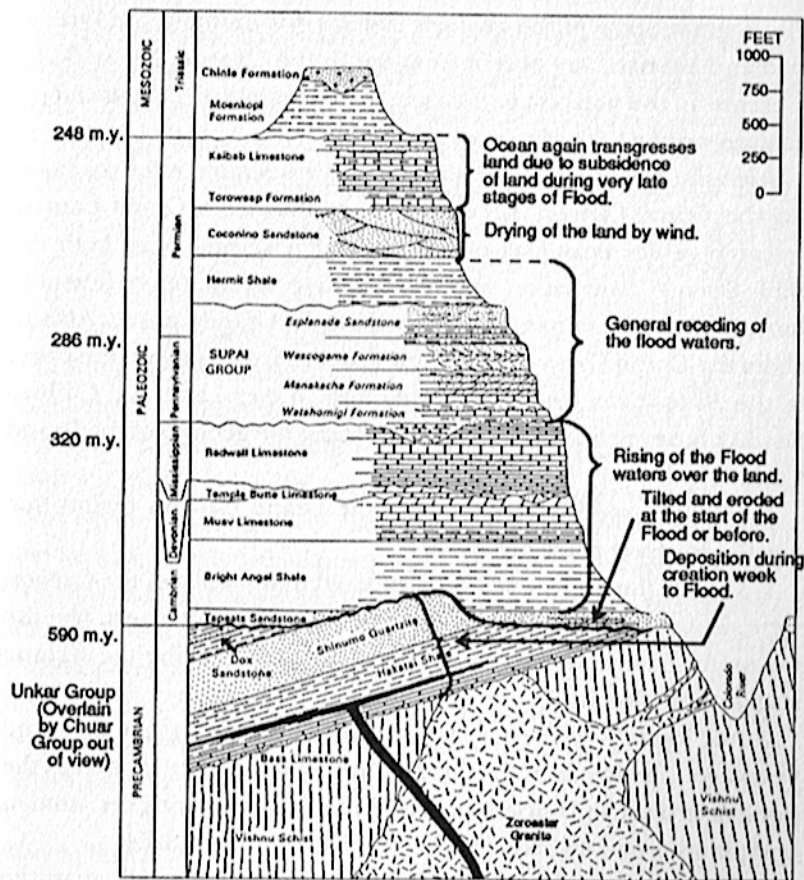


Figure 3. Schematic diagram of the stratigraphy of the Grand Canyon modified from McKee (1982). The ages in years of selected boundaries are those of Harland et al. (1982). Included for comparison is an interpretation of the geology in terms of a flood model.

the diagram, some of the geologic systems, for example, the Ordovician and Silurian,⁶ are absent from the Grand Canyon. Figure 3 also presents (in the notation to the right) the elements of a deluge model as suggested by scientific creationists.⁷

Scientific creationists have expended considerable effort in studying the Grand Canyon. Recently they established a Grand Canyon research center near Flagstaff, Arizona. For several years both the Bible-Science Association and the Institute for Creation Research have conducted seminars and field trips at the Grand Canyon. Articles about the Grand Canyon have been featured frequently on the pages of the *Bible-Science Newsletter*. Creationists Walter Lang and Clifford Burdick have each published booklets about the geology of the Grand Canyon.⁸

Among the specific claims about the Grand Canyon region that creationists have made are these:

1. Most of the horizontal layers exposed in the walls of the Canyon were deposited during Noah's flood.⁹ The uppermost layers, like the Coconino Sandstone, may have been deposited during the waning stages of the flood.

2. All "kinds"¹⁰ of life forms were created by God a few thousand years ago. The fossils in the Grand Canyon strata were formed as the flood destroyed and buried successive habitats containing the animals and plants originally created by God a few centuries earlier.

3. The Canyon itself was formed when huge cracks split apart the upward bulging Kaibab and Coconino Plateaus at the conclusion of the flood epoch. An enormous lake in the Colorado-Wyoming region, representing remnants of the great flood, drained catastrophically as a huge wall of water through the cracks, modifying and widening them as the draining waters eroded away the still soft, layered flood sediments now exposed in the walls of the Canyon.¹¹ Some creationists have postulated that the catastrophic faulting of the Kaibab uplift may have occurred about 100 years after the flood and that the layered sediments within the Canyon had already solidified.

4. The theory of evolution finds no support from the Grand Canyon because of the discovery of abundant conifer spores in several of the strata.¹² Evolutionary theory claims that conifers did not evolve until after the uppermost strata had already been deposited.

5. The usual uniformitarian explanations of the geology of the Grand Canyon are inadequate because several of the geological systems are missing from the Canyon.¹³ There is no physical evidence to indicate erosion of any missing systems. The physical evidence indicates that the layers were deposited continuously.

The list above represents only a small sample of the numerous claims made in scientific-creationist literature about the Grand Canyon. Space forbids considering all of them in detail, but each is severely lacking in scientific merit. In this case study, attention is focused on the "missing rock" claim (number 5 on the list) in order to demonstrate its utter inadequacy as a criticism of the results of professional geological investigation. This claim betrays a glaring lack of familiarity with the professional literature on Grand Canyon geology. Furthermore, the flood geology approach in which this claim is employed fails to display either internal coherence or consistency with other relevant bodies of knowledge, and it lacks the predictive accuracy expected of meaningful scientific theories.

Missing Strata

Creationists apparently think that the usual explanation of the stratigraphy of the Grand Canyon given by professional geologists is incorrect because geologists claim that there are "missing strata." They repeatedly assert that geologists (whom they persist in calling "evolutionists") have a severe problem with the Grand Canyon because only "five of twelve of the geological systems" are present.

For example, one article reviewing a creationist film about the Grand Canyon points out that the film stresses the problem of "missing rocks—the Grand Canyon is regarded as a prime example of the geologic column for in the canyon more strata of the column are

found than anywhere else in the world—yet more than one-half the strata are missing in the canyon. According to evolutionists, these missing rocks add up to a total of about one billion years.”¹⁴ These missing systems are thought by creationists to be devastating to the theory of evolution. The creationists claim that there are no missing strata. The Canyon walls are said to record evidence of essentially continuous sedimentation during the great flood and possibly just after it.

One representative treatment of the problem of missing strata has been provided by Gary Parker of the Institute for Creation Research. Parker says:

Again, evolutionists have coined a term to deal with the problem: *paraconformity*. A contact line between two rock strata is called a “conformity” if the physical evidence indicates smooth continuous deposition with no time break. “Disconformity” is used where the physical evidence indicates erosion has removed part of the rock sequence. Disconformities are often represented by wavy lines in geologic diagrams, and they often appear in the field as *real* “wavy lines” in which erosion channels and stream beds can be seen cutting into the eroded rock layer. But in the case of *paraconformity*, there is no evidence of erosion nor any other physical evidence of a break in time. The name even means that it looks like a conformity. In fact, the only way to recognize a *paraconformity* is by prior commitment to evolutionary theory. There is no physical evidence. But if you believe in evolution, then you must believe there was some gap in the sequence, or else the evolutionary chain would be broken.

Creationists don’t need the term *paraconformity*. Creationists can simply accept the physical evidence as it’s found: smooth, continuous deposition with no time break. . . . In parts of Grand Canyon, for instance, Mississippian rock rests *paraconformably* on Cambrian rock—a gap of 125 million years of hypothetical evolutionary time with no evidence of a time break at all. (At some

points, however, there is a disconformity between Devonian rock and Cambrian.)¹⁵

The same kinds of claims are found repeatedly in articles published in the *Bible-Science Newsletter*. For example, “The formation below the Mississippian, on both sides of the canyon, is the Muav. This poses a big problem for the evolutionist geologist. Here there are three layers missing: the Ordovician, the Silurian and most of the Devonian.”¹⁶

Such a claim calls for a careful scrutiny of both the data and their interpretation. Is there physical evidence, for example, to suggest that there are “missing rocks”? Specifically, is there physical evidence for the Cambrian-Mississippian *paraconformity*? Or have geologists simply invented the concept of “missing layers” in order to explain away a serious difficulty for the evolutionary theory to which they have a prior commitment?

In fact there is an abundance of physical evidence to indicate that layers of rock have been eroded away and are therefore now missing. This is so even in the specific case of the Mississippian-Cambrian *paraconformity* that Parker cites. Furthermore, the physical evidence exists independent of any paleontological evidence that might be adduced in support of biological evolution. *Regardless of whether or not the concept of biological evolution has any validity, the geological data clearly point to the former presence of “missing rock.”*

The Precambrian-Tapeats Unconformity

We consider first the buried erosional surface—known as an *unconformity*—between the Cambrian Tapeats Sandstone and the underlying Precambrian rocks. Concerning this erosional boundary, scientific creationists have claimed

the line which divides the lower rock from the first sedimentary rock, in this case the Cambrian, is very distinct. Creationists call this “The Great Unconformity” because, as signs along the path point out, 500 million years of the geological record is missing at this

point. If you examine the border between these two layers very carefully, you will see that, according to evolutionary time scales, the Cambrian rock was laid down directly upon the lower rock, for they fit together in a perfect fit. This would lead us to believe that if the evolutionary time scale for these rocks is correct, there was absolutely no erosion on the lower rock for 500 million years! Evolutionists do say there was erosion taking place here, but that all evidences of half billion years of weathering were swept completely away!¹⁷

Elsewhere it is said,

Then there are the Precambrian formations—Shinumo quartzite, Hakatai shale, and Bass limestone. These are dated from 500 million years to one billion years old according to the evolutionist geological column. One problem is that these formations are totally missing in certain areas of the canyon. As you hike up the Bright Angel trail, when you get within eight-tenths of a mile of Indian Gardens, you see the Tapeats immediately on top of the Vishnu schist which is Proterozoic and dated one billion years or older. At this point, then, there are 500 million years of rock missing, and this is very difficult to explain. How could something sit around for one-half billion years and show no signs of erosion, weathering or of catastrophic action?¹⁸

Geologists do indeed claim that there was erosion taking place at the boundary between the Tapeats Sandstone and the underlying Precambrian rocks before the Tapeats was deposited. On that point the creationists are correct. However, they are entirely incorrect in claiming that geologists say that “all evidences of half billion years of weathering were swept completely away!” Rather, *geologists have documented an abundance of physical evidence which indicates that the boundary is a severe erosional boundary.*

Scientific-creationist literature gives its readers the impression that the Tapeats-Precambrian boundary is a perfectly flat surface with no indication of what Parker called “wavy lines” in the rock. The assump-

tion is that a perfectly horizontal contact would imply virtually continuous deposition. On many individual exposures the contact between Tapeats and the underlying rocks is perfectly horizontal. However, at other exposures and on a *regional* scale the boundary is anything but perfectly horizontal. The complete surface is extremely irregular, indicating that prior to deposition of the Tapeats there was a distinctive, well-established hilly topography.

In some parts of the Grand Canyon, the Tapeats Sandstone overlies the truncated edges of the gently dipping Chuar and Unkar Groups. These groups form a succession of layered sedimentary rocks whose aggregate thickness is about 12,000 feet. Elsewhere the Tapeats directly overlies so-called Archean rocks, including the Vishnu Schist and Zoroaster Granite (figure 3).

The relief * on the unconformable surface beneath the Tapeats is very high. There are places where the uptilted strata of the Shinumo Quartzite penetrate several hundred feet above the general Tapeats-Precambrian surface. The physical evidence indicates that the Shinumo, composed of very tough quartzite, formed erosion-resistant ridges hundreds of feet higher than the plain on which the Tapeats Sandstone was originally deposited. In some locations the ridges of Shinumo are so high that the Bright Angel Shale and not the Tapeats was deposited on top of these Precambrian strata.

A striking example of one of these Precambrian hills can be viewed by tourists from Lipan Point on the south rim of the Canyon. Across the Canyon on its north wall toward the bottom, the angular unconformity between Tapeats and gently eastward tilting Precambrian strata can be plainly seen. The unconformity displays several irregularities and small hills (figure 4).

Besides the ridges of Shinumo, there are also hilly knobs of Archean

* *Relief* is a term that indicates the general ruggedness of a terrain. An area of high relief is generally rugged, and one of low relief is generally subdued topography. Specifically, relief is the difference between the point of highest elevation and the point of lowest elevation within the area of interest.

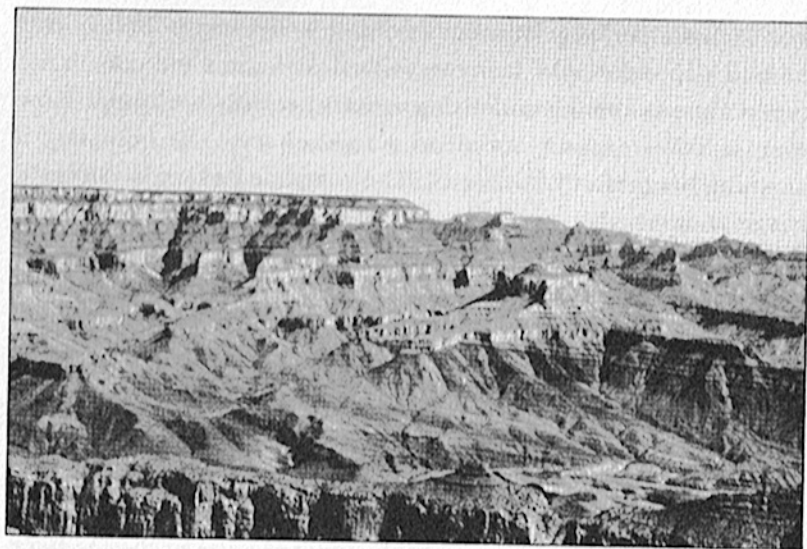


Figure 4. View of the north rim of the Grand Canyon from Lipan Point. The angular unconformity is exposed at the base of the lowest horizontal layer. The unconformity is an erosional surface on the underlying tilted rocks which was later covered by the horizontal layers of Tapeats Sandstone.

granite that penetrate several hundred feet upward into the overlying strata. Locally the Tapeats Sandstone can be seen thinning out against two hills of Archean granite.¹⁹ The relationships are sketched in figure 5. Robert Sharp summarizes the evidence:

The relief of the . . . surface is controlled by the nature of the underlying rocks, for the highest monadnocks [hills that stand above a surface of erosion] are composed of Shinumo quartzite and massive granite. . . . Hinds (1935, p. 27) reports a maximum relief of 250 feet in the Bright Angel and Vishnu quadrangles, and Noble (1914, p. 51) records a relief of 600 feet in Monadnock Amphitheater in the Shinumo quadrangle. A large monadnock on the north side of the Grand Canyon between Bright Angel and Ninetyone Mile creeks . . . is almost 800 feet high (Wheeler and Kerr, 1936, p. 5), and this is the highest known point on the . . . surface in the Grand Canyon, where more than 95 per cent of the

. . . surface has a relief of less than 150 feet and a large part is essentially flat.²⁰

Despite the fact that much of the surface is flat, no one can examine a surface with such extensive relief and justifiably claim that there is no physical evidence for erosion and removal of rock.

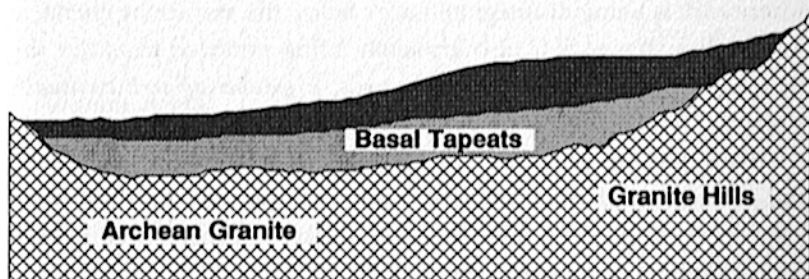


Figure 5. Schematic sketch of the local relationship between the Tapeats Sandstone and underlying Precambrian granite. Modified from Sharp (1941).

In addition to this pronounced irregularity of the surface (what Parker refers to as “wavy lines”), the presence of very thorough weathering of the rock immediately beneath the boundary provides another strong indication that the unconformity represents a previously existing erosional surface along which material was being removed by weathering and erosion. The rocks that are below the unconformity “show extensive weathering to a depth of 10 to 12 feet and in some places are noticeably weathered 50 feet below the surface.”²¹

The effects of weathering include chemical breakdown of many of the minerals in the granites and schists beneath the unconformity. In some places there is evidence of a soil zone. Sharp notes that “in places the . . . surface is mantled by a foot or two of structureless, extensively weathered detritus [loose fragments from disintegrating rocks] which passes gradationally upward into the overlying Tapeats and downward into less weathered Archean rock. This layer is considered to be a residual regolith formed by subaerial weathering on

the . . . surface."²²

In still other places the weathered zone is characterized by relatively unweathered residual granite pebbles and boulders derived from the underlying unweathered material embedded in finer, more thoroughly weathered and disintegrated rock. All these features are commonplace in zones of active chemical weathering. And generally where rock is being disintegrated at or below the surface by chemical weathering, that rock is also gradually being removed from the site by erosional processes. In other words, *a weathering rock eventually becomes a "missing" rock.*

Finally, geologists find that much of the reworked weathered material from the soil zone was eventually incorporated into the basal Tapeats Sandstone. "In many localities the basal Tapeats is composed almost entirely of reworked regolith."²³

Scientific creationists, on the other hand, assert that there is no physical evidence for erosional removal of rock. They are also puzzled that the layered sedimentary rocks of the Chuar and Unkar Groups do not underlie the Tapeats Sandstone everywhere. That the Tapeats Sandstone does not directly overlie the layered rocks everywhere is no problem for geologists. Instead, it is precisely this geometrical arrangement of the rocks that provides one of the premier evidences for an enormous amount of erosion.

Figure 6, which shows the general relationships between the Tapeats and the various Precambrian rocks, indicates just how much rock must have been eroded away. Suppose that the Chuar and Unkar Groups have an average dip of 20 degrees and that their cumulative thickness is about 12,000 feet. The diagram shows that the Chuar and Unkar Groups must have experienced some kind of tilting episode after deposition. Since they are mostly sedimentary rocks, we can assume that they were originally deposited essentially horizontally on the Archean rocks.²⁴

But the tilting episode must have occurred prior to deposition of the Tapeats, or the Tapeats would also be tilted. If the Tapeats were

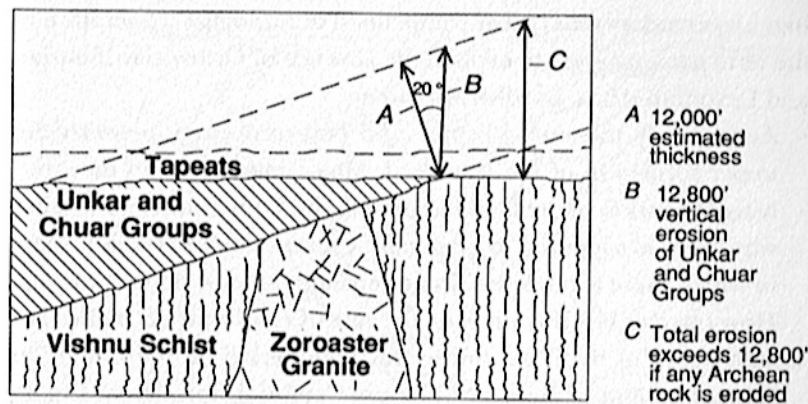


Figure 6. Schematic diagram of the relationship between the Tapeats Sandstone and underlying rocks indicating the amount of erosion that must have taken place prior to the deposition of the Tapeats.

deposited on *both* the Chuar and Unkar Groups *and* the underlying Archean rocks, then a simple trigonometric calculation shows that about 12,800 feet of layered Precambrian sedimentary rocks had to be removed in order for the underlying Archean rocks to be exposed as a land surface and to be covered by the Tapeats.

Moreover, the diagram also shows that some of the Archean also had to be removed. Sharp claims that "the total thickness of rock eroded during the Ep-Algonkian interval is close to 15,000 feet. This is a conservative calculation, and in many places the thicknesses were probably considerably greater."²⁵

Clearly there is ample physical evidence pointing to active removal of great thicknesses of rock along the great unconformity. The creationist claim that there is no such evidence is a false assertion made either in ignorance or defiance of a wealth of information available in the professional geological literature.

The Muav-Redwall Contact

A second example of a "missing rock problem" is the boundary between Cambrian and Mississippian strata of the Canyon. It is concern-

ing this boundary that Parker complained of geologists' application of the term *paraconformity* to explain the absence of Ordovician, Silurian and Devonian strata. Burdick also notes:

As we study the unconformity and paraconformity between the upper formation of the Cambrian Muav limestone and the overlying formation of the Mississippian Redwall limestone, we wonder why there is supposed to be a gap of some hundred million years in which there is no deposition or erosion. At least none shows up. How can this be? If at present, the rate of erosion is 6.5 inches per 1000 years, at that rate during this time period all the Cambrian formation, and perhaps also the pre-Cambrian formation, should have been eroded. Instead, we find no evidence whatsoever of erosion.²⁶

Burdick's claim of "no evidence whatsoever of erosion" is incorrect. Mississippian strata of the canyon are designated as Redwall Limestone, owing to the red stain that washes down from the overlying Supai Group over the major cliff about halfway up the canyon. In the Grand Canyon the Redwall is about 500-600 feet thick; south and east of the Canyon the Redwall thins. At Cameron, Arizona, the Redwall is 300 feet thick; near Flagstaff, Arizona, it is about 200 feet thick; and at Holbrook, Arizona, the Redwall has thinned to a negligible thickness (figure 7).²⁷

In the eastern end of the Grand Canyon, the Redwall Limestone generally rests on top of the Cambrian Muav Limestone, a more thinly-layered, slope-forming unit. In the western end of the Grand Canyon, the Redwall lies above the Devonian Temple Butte Limestone which in turn overlies the Muav. Southeast of the Grand Canyon, the Redwall generally rests on the Devonian Martin Limestone.²⁸ Because there is ample evidence of Devonian strata beneath the Redwall, the need is not to account for a Mississippian-Cambrian gap, as claimed by creationists, but to explain the nature of the Mississippian-Devonian boundary. In either case there is ample evidence for erosion of material.

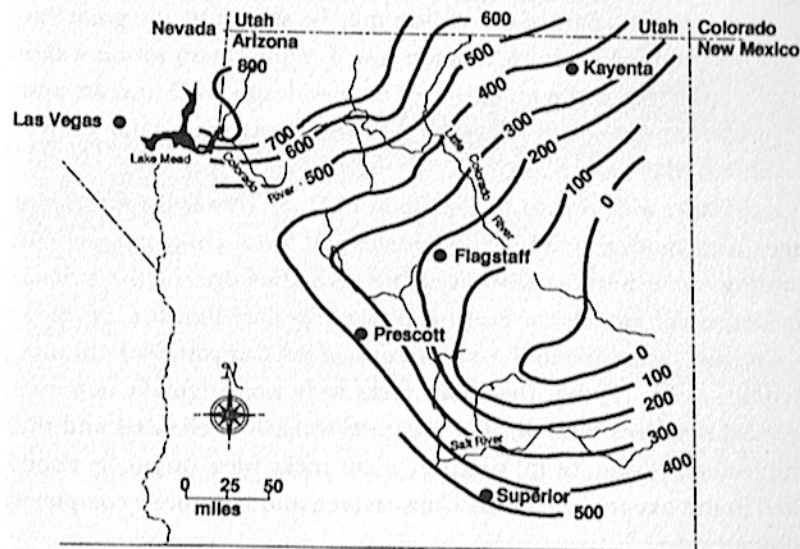


Figure 7. Variations in the total thickness (in feet) of the Redwall Limestone in Arizona. Modified from McKee and Gutschick (1969).

Scientific creationists have stated that where the contact between Redwall and Muav or Temple Butte is exposed there is no obvious evidence of erosion. According to geologists McKee and Gutschick, "At 11 of 21 localities examined, including most of those in eastern Grand Canyon, no evidence of an erosion surface could be detected at the contact: the surface appeared even and flat."²⁹

At the other ten localities, however, McKee and Gutschick found evidence for erosion—namely, the presence of shallow channels with minor relief excavated into the upper surface of the Muav or Temple Butte. The channels are typically filled, at least in part, by conglomerate containing angular fragments of chert, limestone or dolomite derived from the underlying Temple Butte or Muav Limestones. McKee and Gutschick concluded that

removal by beveling of a considerable thickness of Devonian strata

in the eastern part of the region may be shown by the great eastward thinning of this formation (the Temple Butte) within a short distance and by the remnants of once-widespread Devonian strata preserved in isolated erosion pockets in eastern Grand Canyon and in Marble Canyon.³⁰

Specifically, with regard to the Redwall-Muav contact, a number of sites display local relief at the contact and basal conglomerate containing some pebbles of underlying rock. But one of the primary evidences of significant erosion is the very fact that the Devonian units thin to nothing in the eastern end of the Canyon. Such thinning implies either (1) that Devonian rocks were not originally deposited toward that area because that area was somewhat elevated and thus subject to erosion, or (2) that Devonian rocks were originally deposited in the eastern end of the Canyon area and have been completely eroded away.

McKee and Gutschick also traced the Redwall Limestone southeast of the Grand Canyon and examined its contact with underlying rocks. They concluded that the boundary between the Redwall and underlying rocks is an erosional surface on the basis of several lines of evidence: (1) several exposures indicate local surfaces of relief as much as eight feet, (2) the basal Redwall consists of conglomerate containing fragments of underlying units, (3) in some exposures the underlying Devonian rocks (Martin Formation) show tilting beneath the horizontal Redwall, and (4) in some places the Devonian is completely missing and the Redwall directly overlies the Precambrian Mazatzal quartzite and contains angular fragments of that quartzite in its basal layers (figure 8).

McKee and Gutschick concluded: "A summary of available data . . . on the Redwall-Martin (Mississippian-Devonian) contact in the area south of the Grand Canyon gives abundant evidence of a broad regional disconformity."³¹ The Redwall was clearly deposited on top of an older eroded land surface with broad, gentle topographic irregularities.

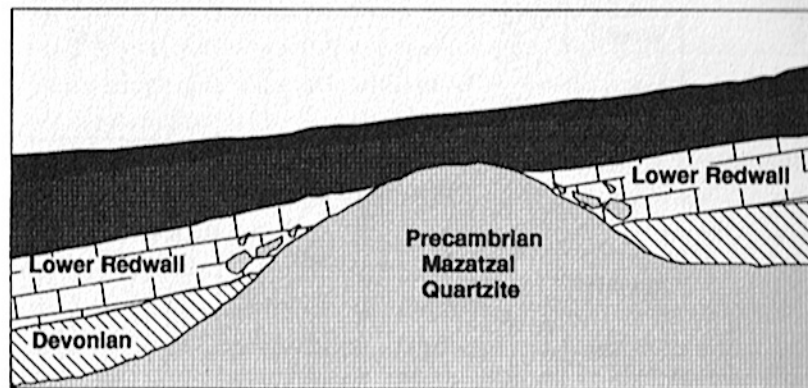


Figure 8. Locally the Redwall Limestone directly overlies Precambrian Mazatzal Quartzite and contains eroded pebbles of the Mazatzal. The quartzite existed as hills throughout early Paleozoic time until deposition of the Redwall around its upper reaches.

Although Ordovician rocks are completely missing from the Grand Canyon, they begin to appear in extreme southeastern Nevada.³² Moreover, post-Muav Cambrian rocks are found in southeastern Nevada and extreme northwestern Arizona. In other words, the Cambrian, Ordovician and Devonian units thinned drastically eastward toward the Grand Canyon. The Ordovician and Devonian units thinned out completely (figure 9). There are solid grounds for concluding that there are "missing rocks" between the Redwall and Muav, for there are physical evidences of erosion beneath the Redwall, the Devonian units thicken away from the eastern end of the Grand Canyon, and west of the Grand Canyon both Ordovician and Silurian rocks do appear between the Muav and the Devonian Temple Butte.

The Redwall Limestone itself has been subdivided into four distinctive "members," each of which progressively thins toward the southeast. Between each of the members there is also a well-documented erosional surface. Hence there is also "missing rock" within the Mississippian.

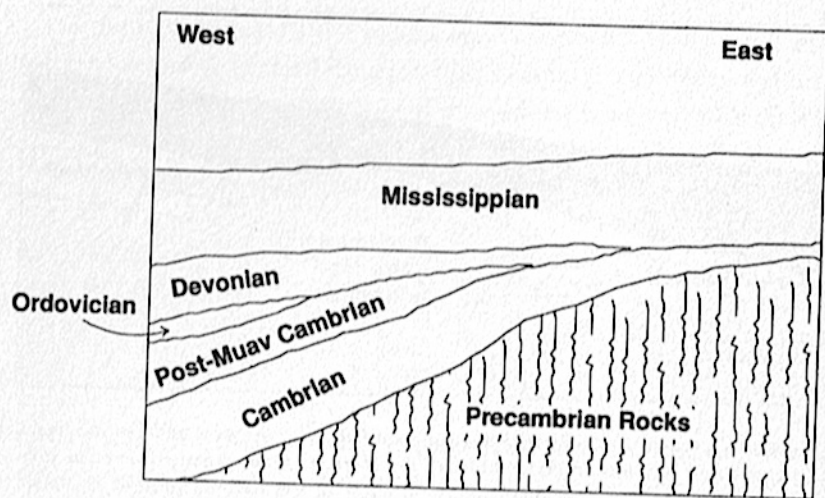


Figure 9. Schematic diagram illustrating the drastic thinning of Lower Paleozoic rocks from west to east in the Grand Canyon area. Note particularly that west of the Grand Canyon, probable Ordovician rocks are present as well as considerable thicknesses of post-Muav Cambrian rocks.

Lastly, Burdick argued that "if six inches per 1000 years erosion is projected, there should be about 50,000 feet of erosion, wiping out all the rocks down to the basement complex. There is no evidence of this."³³ Or, as he put it in a previous quotation, ". . . at that rate during this time period all the Cambrian formation, and perhaps also the pre-Cambrian formation, should have been eroded." Now Burdick has correctly reported the current average rate of erosion within the Colorado Plateau,³⁴ he has correctly calculated that there should be approximately 50,000 feet of erosion within 100,000,000 years *if* the rate of erosion remained at 6.5 inches per 1000 years, and he has correctly observed that all the Cambrian rocks should have been eroded away at this rate.

But Burdick's overall argument is fallacious because there is no warrant for extrapolating the present high rate of erosion into the past. Certainly no appeal to a principle of uniformity carries with it

the requirement that such a rate be extrapolated indefinitely into the past. The plateau is currently at a much higher overall elevation than it was during most of its past, and therefore overall erosion rates are now much higher than they would have been when the plateau was much closer to sea level. The fact that the channels excavated into the Muav are relatively small ones is an indication that the Muav-Temple Butte land surface was not very far above sea level and would therefore not be subject to a high erosion rate.

Furthermore, much of the current high rate of erosion of the plateau is due to the rapid removal of the very soft, easily erodible shales of Cretaceous age (for example, Mancos Shale) that are exposed at the surface. But the limestones of the plateau erode far more slowly than do shales, as indicated by their general tendency to form cliffs and far steeper slopes than the shales. As a result, erosion of the Muav Limestone surface would be expected to be far slower than erosion of soft shales. There is no reason to expect that the erosion rate before deposition of the Redwall was 6.5 inches per 1000 years. There is therefore no reason to expect that 50,000 feet of rock had to be eroded away as Burdick suggests. On the contrary, there is strong reason to expect that erosion rates just prior to Redwall deposition were considerably lower than they are at present, so that no very great thickness of rock had to be eroded away.

The Redwall-Supai Contact

According to scientific creationists, there is also a "problem" of supposedly "missing rock" between the Redwall Limestone and the overlying Supai Group.

Now begins the "missing rock" problem—if we follow the geologic column of the evolutionist. The Pennsylvanian formation, which ought to consume about 50 million years, is missing between the Supai and Mississippian formations. Much of the Mississippian is also missing. Generally the explanation given by evolutionists is that a mountain stood above water for a long time and, thus, there

are no deposits of Pennsylvanian. In that case there ought to be signs of erosion. Nothing can just stand still for 50 million years and show no evidence. And we do find the Pennsylvanian in the Colorado plateau country and in the San Juan area of southeast Utah. From an evolutionist viewpoint it is difficult to explain the absence of the Pennsylvanian and of much of the Mississippian.³⁵ But once again, the mystery of the "missing rock" is no more than an artifact of misinformation and misleading argumentation.

The Redwall Limestone is overlain by the Supai Group, formerly designated the Supai Formation. The Supai Group, recently so designated by McKee, consists of four formations, the three lowest of which are Pennsylvanian in age, and the uppermost of which, the Esplanade Sandstone, is Permian.³⁶ Thus to claim that the Pennsylvanian System is missing from the Grand Canyon is incorrect. Some Pennsylvanian material is undoubtedly missing, but this cannot be said of the entire Pennsylvanian System. It can further be shown that some of the lower Supai formations are approximately correlative with the Pennsylvanian strata of southeastern Utah.

Scientific creationists have implied that there are no signs of erosion between the Redwall and the Supai: "Nothing can just stand still for 50 million years and show no evidence." At first glance it might appear to the casual observer that there are no signs of erosion. McKee and Gutschick stated: "Despite the magnitude of the stratigraphic break represented, the contact between the Redwall Limestone and the Supai Formation as viewed *from a distance* (emphasis ours) appears remarkably even and in most places gives little suggestion of the presence of any important unconformity. Strata of the two formations are nearly everywhere similar in attitude, and in most places rapid weathering of weak beds immediately above the Redwall Limestone has caused its upper contact to be concealed by talus."³⁷ *But despite this initial superficial appearance of a lack of erosion, there is a wealth of evidence along the Redwall-Supai boundary to indicate that intense erosion and weathering have taken place.*

The lowermost formation of the Supai Group is called the Watahomigi Formation. McKee has documented numerous large scours and channels that were excavated into the upper surface of the Redwall, subsequently filled in by pre-Watahomigi sediments, and then completely covered by Watahomigi sediments.³⁸ McKee's monumental publication on the Supai Group even includes an entire chapter on "Pre-Supai Buried Valleys." According to McKee

these valleys average about 1000 feet in width and 280 feet in depth with a maximum depth of 401 feet. . . . Apparently the valleys are parts of an extensive drainage system formed after Redwall deposition had ceased; they were completely filled with sediment, partly marine and partly continental by the close of Late Mississippian (Chesterian) time.³⁹

McKee's monograph includes several excellent photographs of these buried valleys. McKee concluded, on the basis of the existence of these valleys, that "the area must have been uplifted more than 400 ft above sea level . . . to have permitted dissection to that depth."⁴⁰ Because streams are not capable of eroding significantly below sea level, running water could not have scoured a 400-foot-deep channel into the Redwall surface unless the land had been elevated at least 400 feet above sea level.

Evidence for erosion is indicated not only by these deep channels but also by conglomerate deposits at the base of the Watahomigi Formation and in the bottom of the channel fills. The pebbles in the basal conglomerates of the Watahomigi are generally composed of chert (a hard, dense, compact rock, commonly layered, that is composed of very fine, crystalline silica), but other rock types may be present. Nearly all pebbles are of very resistant rock types. McKee comments,

Evidence that the basal Watahomigi conglomerates were derived from a relatively close source is the comparatively small amount of rounding on most pebbles. Surfaces characteristic of strong attrition through rolling by wave action are absent on most specimens;

the dominantly chert composition may be attributed to derivation from the underlying Redwall Limestone of Mississippian age.⁴¹ The Redwall does contain thin layers and nodules of chert, and during the weathering of the underlying Redwall, the relatively chemically resistant chert would survive the weathering process much more easily than the more readily destructible limestone.

But there is more. The upper part of the Redwall is also characterized by many cavities and depressions that are commonly filled with limestone breccia (rock composed of large angular fragments of limestone cemented together) or with distorted fine-grained red sediments that have clearly been derived from the overlying Supai. These features are indicative of the development of karst topography on the upper surface of the Redwall prior to Supai deposition.

Karst, an area of eroded limestone, is a characteristic topography in locations that are underlain by limestone layers, as found in large parts of Florida, Illinois or Kentucky. In such regions the limestone dissolves in circulating ground water, thus forming large crevices and even caverns. The roof rock may collapse into the caves or crevices so that the cavities become filled with fragmented limestone blocks or loose sediments that may have overlain the limestone. Sinkholes, that is, circular surface depressions, may develop if the effects of collapse reach the surface.

Now, the upper surface of the Redwall Limestone displays these characteristic karst features. This evidence further points to an extended period of weathering and erosion on an exposed Redwall land surface prior to deposition of the Supai. After resubmergence of the weathered and eroded Redwall surface, the Supai (Watahomigi) was deposited and its red muds were washed down into the cavities in the underlying Redwall.

Thus to claim that there is no physical evidence for an erosional break between the Mississippian and the Supai is to fly in the face of a wealth of fully documented geological data. The scientific-creationist claim for a lack of erosion can be made only if one is willing to

ignore the total regional relationships between superposed units. The claim can be made only on the bases of examinations from a long distance across the Canyon where there is a superficial appearance of conformity and of close inspection of some exposures where there is local conformity. As soon as one considers the regional picture and all available exposures of the boundary, it becomes clear that there is abundant evidence of erosion between the Redwall and the Supai.

The scientific creationists have also neglected to mention that there are similar compelling evidences of erosional episodes recorded by several unconformities within the Supai Group. There is, for example, a prominent erosional surface between each of the four formations of the Supai Group. Still further, there is also an important erosional surface within the Watahomigi Formation. For more detail on these thoroughly documented erosional surfaces, the reader is invited to consult the chapter, "Erosion Surfaces," in McKee's professional paper.⁴²

Mesozoic and Cenozoic Rocks

Scientific creationists have also claimed that there is a problem with standard geology because of the suggestion that the entire Mesozoic and Cenozoic sections are "missing" from the Grand Canyon. It is not clear why the absence of these rocks should pose a problem for geologists. In this case, even scientific creationists must admit the "missing rock" once existed. There is no need to establish its former existence by pointing out evidences of previous erosion along unconformities as with, say, the Redwall-Supai boundary. One simply cannot claim that geologists have invented the idea of "missing rock" in this case. The reason is, as even scientific creationists have recognized, that thick Mesozoic and Cenozoic layers are present all over the Colorado Plateau. A thick Mesozoic section exists immediately to the north and east of the Canyon toward Vermilion and Echo Cliffs. It is evident to any thoughtful observer that the Mesozoic rocks, exposed all around the base of the Kaibab-Coconino uplift through which the

Canyon has been excavated, have been eroded from the top of this uplift.

Much of the Colorado Plateau northeast of the Grand Canyon contains spectacular exposures of Triassic, Jurassic, Cretaceous and Tertiary layers that are unquestionably superimposed stratigraphically on top of the layers exposed at the Grand Canyon. For example, the Triassic Moenkopi, Chinle and Wingate Formations are beautifully displayed at Capitol Reef National Park in south-central Utah, as well as just north and east of the Grand Canyon. The Jurassic Navajo Sandstone is 2000 feet thick at Zion National Park in southwestern Utah, as well as at Vermilion Cliffs just north of the Canyon. An 800-foot thickness of the Jurassic Entrada Sandstone can be seen resting on top of the Navajo Sandstone at Arches National Park. The Jurassic Morrison Formation occurs at Dinosaur National Monument on the Colorado-Utah boundary, as well as 150 miles east of the Grand Canyon. The Cretaceous Mancos and Mesa Verde Formations that overlie the Morrison and Dakota Formations are easily seen in the Book Cliffs of northern Utah and at Mesa Verde National Park in southwestern Colorado. The Tertiary Wasatch and Green River Formations can be seen lying on top of the Mesa Verde in western Colorado and northern Utah. Yet all these great thicknesses of rock are missing in the Grand Canyon area, owing in large part to removal by erosion from above the layers of rock that are now present at the Canyon.

Evaluation of the Scientific-Creationist Argument

We have examined in some detail one of the major scientific-creationist assertions about the Grand Canyon, namely, that there is no evidence for any significant erosion of rock prior to deposition of the overlying layer. The claim is that there exists no basis for the geologists' talk about "missing layers of rock." It has been shown, however, that this scientific-creationist claim is without foundation and is discredited by a diverse array of abundant physical evidence found in the Grand Canyon region. Similarly, the other major claims made by

scientific creationists about the Grand Canyon can also be shown to be in error.

A number of important conclusions can be drawn about the scientific-creationist reasoning through this analysis of a claim that typifies the scientific-creationist approach to geology:

1. *Major distinctive scientific-creationist claims about geology betray a glaring lack of familiarity with relevant professional literature.* This lack of familiarity leads to a failure to engage in the critical discussion of data relevant to the claims being made, to misstatement of basic data and to misunderstanding of basic principles of geology. Regarding the specific claim that there is no evidence of erosion between layers in the Grand Canyon, the writings of Lang, Burdick and other scientific creationists are devoid of documentation which could have provided important geological data about the Canyon. In vain one looks for references to technical geological literature on the Canyon and its environs. Surely those anxious to propose the flood as an alternative theory for the geology ought to appeal to technical literature for relevant observations that would have to be accounted for more satisfactorily by a catastrophic flood.

Scientific creationists have as much right as anyone to construct a theory of the geological history of the Canyon. If, however, they expect their theory to receive serious consideration in the geological community, they must deal with the data that have already been collected by trained professionals. Scientific creationism will not be taken seriously as science if "flood geologists" are content to make sweeping generalizations based solely on a few disconnected observations. Scientific creationists must be prepared to explain in detail how their flood model accounts for channel fills, for pebbles within those channel fills, for karst features such as caverns and sinkholes, for weathering and fossil soil zones beneath unconformities, for the existence of angular discordance beneath some unconformities and for the presence of several unconformities within the Canyon and throughout the entire Colorado Plateau. If scientific creationists wish to have

their theories taken seriously, they must discontinue their current practice of ignoring the professional geological literature that discusses the observation of these critically important details.

The general lack of awareness of professional geological literature has resulted in repeated misstatement of fundamental information in scientific-creationist writings. For example, Burdick, Lang and other writers have built a case around the lack of Pennsylvanian rocks in the Grand Canyon while laboring under the mistaken impressions that the Supai is entirely Permian and that the Pennsylvanian System is completely missing from the Grand Canyon. Acquaintance with the technical literature could have prevented those mistakes. Much of the Supai in the Canyon is generally regarded by geologists as Pennsylvanian.

Another misstatement of fact is the assertion that geologists claim the Canyon to be "a prime example of the geologic column for in the Canyon more strata of the column are found than anywhere else in the world."⁴³ This misstatement then serves as the basis for an argument against standard geology for "more than one-half the strata are missing in the Canyon."⁴⁴

The first quotation is blatantly in error. No geologist would ever claim that the Canyon has more strata of the geologic column than anywhere else in the world for the simple reason that any geologist who knows the Grand Canyon knows that the Ordovician and Silurian are entirely missing and that significant portions of the Devonian and Mississippian are also lacking. Geologists also know that no Triassic, Jurassic, Cretaceous or Tertiary strata are present in the walls of the Canyon.

Any North American geologist would agree that the Appalachians provide a more complete representation of the column than does the Grand Canyon. In the Valley and Ridge province of the Appalachians in eastern Pennsylvania there are as much as 40,000 feet of Paleozoic rocks exposed, including Cambrian, Ordovician, Silurian, Devonian, Mississippian and Pennsylvanian, but no Permian rocks. There are

only about 4500 feet of Paleozoic rocks at the Grand Canyon. The Canyon provides an outstanding example of geology because the rocks are so well exposed and are relatively undeformed compared with the Appalachians, but the rock record in the Grand Canyon is much less complete.

Lack of familiarity with the literature has led also to a misunderstanding of basic geological concepts. Scientific creationists persistently misunderstand the principle of uniformity. There is among scientific creationists the impression that, on the basis of uniformity, geologists do or must extrapolate all presently measurable rates backward in time indefinitely. Hence Burdick bases an argument against missing rock on the mistaken assumption that the Colorado Plateau region has experienced a rate of erosion of 6.5 inches per 1000 years throughout its entire history. There seems to be no awareness by scientific creationists that geologists recognize that rates of many processes can vary drastically through time depending on material conditions and that such variation is not in conflict with a principle of uniformity.⁴⁵

Similarly, scientific creationists do not appear to understand the basic concept of the geologic column. They have created the impression that orthodox geology has severe difficulties with the Grand Canyon because of its acceptance of "the geologic column." Scientific creationists seem to think that geologists pretend that all the systems of the geologic column are, or should be, represented by actual rock in continuous successions of layers all over the world. Thus, if scientific creationists could show that real rock successions are lacking representatives of some of the geologic systems, the inference to be drawn is that the concept of the geologic column is severely deficient.

This view, however, completely misrepresents what geologists say about the column. The geologic column is an *idealized* composite constructed from real rock successions around the world on the basis of the principle of superposition.⁴⁶ Every geologist knows that some systems are going to be missing from any real rock succession for the

simple reason that sedimentation has not occurred and should not be expected to occur continuously through time at any one place on the face of the earth. There is no reason to expect that a sedimentary basin will remain a basin permanently. Geologists would, in fact, be very much surprised to find an area in which the geologic column was completely represented, for that would imply that the area had remained a basin of deposition throughout the whole of geologic time until extremely recently when it was uplifted, eroded and exposed to view.

Once a basin is uplifted, erosion will begin to remove sediment or rock that has already accumulated in the basin. No new sediment or rock will be deposited until the uplift has been worn down by erosion and is once more depressed to form a basin. For example, a basin that had accumulated sediments through Cambrian, Ordovician and Silurian time may be uplifted during Devonian time and may once again subside in Mississippian time. The result will be that during Devonian time, some and maybe all of the Silurian sediments will be eroded away. If all the Silurian layers are eroded away, then some and maybe all of the underlying Ordovician rocks will be eroded away. If all the Ordovician layers are eroded away, then some and maybe all of the underlying Cambrian rocks will be eroded away. And so on.

The amount of erosion that takes place will depend on many factors such as climate, severity of the uplift and composition of the rocks being eroded. The more severe the uplift, the more likely it is that a lot of rock will be eroded. Moreover, during Devonian time, since erosion is occurring, no Devonian sediments will be deposited. Once the basin forms again in Mississippian time, then Mississippian sediments will be deposited, but they will rest on top of either Silurian, Ordovician or Cambrian deposits, and there will be some kind of unconformity between the Mississippian and underlying rocks. This is exactly what we see in the Grand Canyon beneath the Redwall Limestone.

Many places on the continental land surfaces are not now receiving

any permanent accumulation of sediments. Thus the present time period will not be represented by rocks of the present in those places in the future. Therefore, it is no surprise whatsoever to a geologist that some systems are missing from the Grand Canyon area or anywhere else. During the development of the stratigraphy of the Grand Canyon there were times when the area was somewhat above sea level, thus not receiving sediments, and was experiencing mild erosion of previously deposited rocks. For example, at present, the area is well above sea level, is receiving little new sediment and is experiencing intense erosion. Rocks of the present will not be represented in the Grand Canyon of the future!

2. *The flood model entails a lack of external consistency with relevant bodies of knowledge.* This point could be developed at great length by considering the fact that the various scientific-creationist claims about the Grand Canyon are totally incompatible with the established results of radiometric dating and biogeography.⁴⁷ On these grounds alone the global flood theory is strongly suspect. This lack of external consistency is exemplified by the failure of scientific creationists to consider *regional* geology in their theorizing.

For example, scientific-creationist claims about a lack of erosion in the layers of the Grand Canyon are made on the basis of casual observations of rock exposures along the major hiking trails. A case is then built on a few isolated observations abstracted from the larger, regional context of the layers. One cannot argue from a few exposures of the Redwall-Supai boundary showing no evident signs of erosion that there is no erosion at the Redwall-Supai boundary. The geologist must consider that boundary on a regional scale, and that requires examination of dozens of exposures at widely separated areas as well as any available information from well drilling that would shed light on the regional relationships between rock units.

Similarly one cannot argue for continuous deposition of Redwall on top of Muav only on the basis of what can be seen in one part of the Grand Canyon. The geologist must also consider the regional

geology which indicates that west of the Grand Canyon several formations begin to wedge in between the Muav and the Redwall. Scientific creationists could have avoided mistakes about the Redwall Limestone if they had learned about its regional relationships and distribution, and had not been content to confine their studies to only a few isolated occurrences within the tourist part of the Canyon. It is small wonder that geologists will not take scientific-creationist theorizing seriously when it fails to reckon with basic, relevant bodies of information and seeks instead to develop theories that are inconsistent with that information.

3. *The flood model lacks internal coherence.* Scientific creationists have claimed that between layers of rock in the Grand Canyon there is no evidence for erosion at all and that the layers were deposited successively and continuously by great flood waves passing back and forth across the face of the earth. But if the flood model is correct, then there should be abundant signs of erosion between layers, especially if those layers were still soft and unconsolidated as most flood geologists believe! Indeed, flood geologists repeatedly talk of the tremendous erosive capabilities of the flood.

Suppose that a thick layer of soft mud, just deposited from a great flood wave passing to the east, is briefly exposed to the air. Another gigantic wave comes surging back from the opposite direction. The wave is charged with suspended sediment eroded from highlands to the east. That such a turbulent wave loaded with sediment should pass over the soft mud without in the least disturbing its upper surface is not even remotely credible. There would unquestionably be severe scouring and churning of the mud. The supposed absence of erosion between layers to which scientific creationists appeal would be a strong argument *against* a global flood that consisted of a succession of waves!

4. *The flood model lacks predictive accuracy.* Scientific creationists claim that the Tapeats-Precambrian boundary represents the onset of the flood and that the other layer boundaries are not erosional but rep-

resent essentially continuous sedimentation from sweeping flood waves. If the preflood land surface is identified with the great unconformity at the base of the Tapeats Sandstone, then this land surface should have had vegetation growing all over it. Moreover, that land surface should have had a variety of animals living on it, animals originally created by God only a few thousands of years earlier. That land surface should have had turtles, snakes, small mammals in burrows like gophers and ground hogs, crocodiles, freshwater fish living in streams. Once the flood came, all of these life forms should have been overwhelmed and suddenly buried in the mass of sediment that became the Tapeats Sandstone. The flood model should predict the occurrence of a wide variety of fossils in the Tapeats, but they are not there. Where are the fossil turtles, snakes, trees, bushes, grasses, mice, ground hogs, lizards and sloths in the Tapeats? They have never been found.

If the formations above the Tapeats were deposited virtually continuously by successive flood waves, then we should expect to find certain kinds of fossil organisms. If a flood wave that deposited the Redwall Limestone had swept into the area from an adjacent land mass, then we would have expected to find a host of vegetation and land animals. Instead we find only marine fossils. But if the flood wave swept out of the ocean, why is the Redwall *totally* lacking in such marine forms as whales, seals, walruses, dolphins, sea birds, ichthyosaurs, all kinds of fish and sea snakes? Moreover, if these animals were buried rapidly, we should expect to find whole skeletons. We don't even find individual vertebrae.

If a flood wave that deposited the Supai swept into the area from a continental highland nearby, then why, as with the Tapeats, do we find absolutely no signs of trees or shrubs, shrews, frogs and a host of other land animals that could not possibly escape to higher ground? The Supai contains only a limited selection of fossil amphibians and reptiles. Why are there no mammals, trees or shrubs? The flood model utterly fails to predict the observed paleontology of the

Grand Canyon formations with even the slightest degree of accuracy.

Conclusion

If space permitted, analysis of the other claims of scientific creationists about the Grand Canyon would repeatedly indicate their lack of familiarity with the relevant literature. By its failure to deal with a wealth of relevant data, the recent creation-global flood model is unable to display the appropriate characteristics of a credible scientific theory such as external consistency, internal coherence, predictive ability and ability to account for a wide diversity of geological phenomena. Scientific creationists cannot expect geologists to take flood theories seriously until such theories demonstrate the appropriate characteristics. And that will not happen unless scientific creationists become sufficiently familiar with geological observations that have been made by trained professionals and demonstrate that they can treat those observations competently and with professional integrity.

SCIENCE HELD HOSTAGE BY NATURALISM PART III

Earlier in this book we carefully delineated the domain of natural science. By agreeing to limit its attention to an empirically based study of the intelligibility of the physical world, natural science has chosen to maintain a respectful silence on questions regarding the relationship of the physical universe to transcendent beings or powers. In this way persons representing a broad diversity of religious perspectives can fruitfully work together within the scientific community.

However, perhaps because of the respect and credibility that the sciences have rightfully gained, many persons have been tempted to exploit the good name of science by speaking as if their particular religious or ideological perspective were derivable solely from the established results of scientific investigation.

In this final part we call attention to the way in which the ideology of naturalism has failed to honor the limitations of natural science and has sought instead to hold science hostage to support the tenets of its own form of religious faith.

¹⁶*Continents Adrift*, a collection of *Scientific American* reprints (San Francisco: Freeman Books, 1972).

¹⁷J. P. Riley and R. Chester, eds., *Chemical Oceanography*, 2nd ed. (New York: Academic Press, 1975). See especially chapter 33, "The Mineralogy and Chemistry of Near-Shore Sediments," by S. E. Calvert, and chapter 34, "The Geochemistry of Deep-Sea Sediments," by R. Chester and S. R. Astron.

¹⁸James I. Drever, *The Geochemistry of Natural Waters* (Englewood Cliffs, N.J.: Prentice-Hall, 1982).

¹⁹Keith Stowe, *Ocean Science* (New York: John Wiley and Sons, 1983).

²⁰Ferren MacIntyre, "Why the Sea Is Salt," *Scientific American* 223 (November 1970):104-15.

²¹Robert J. Strutt (Lord Rayleigh), "On the Radioactive Minerals," *Proceedings of the Royal Society of London*, A 76 (Feb. 28, 1905):88-101; Bertram B. Boltwood, "On the Ultimate Disintegration of the Radioactive Elements; Part II, The Disintegration Products of Uranium," *American Journal of Science* 23 (Feb., 1907):77-88; Arthur Holmes, "The Association of Lead with Uranium in Rock Minerals, and Its Application to the Measurement of Geological Time," *Proceedings of the Royal Society of London* 85 (Mar. 20, 1911):248-56.

Chapter 6: Making Mysteries out of Missing Rock

¹Walter Lang, *Geological Study Course on Grand Canyon Arizona*, p. 31. Available from the Bible-Science Association, 2911 E. 42nd St., Minneapolis, Minn.

²For a summary paper with an extensive list of references on the geology of the Canyon, see Edwin D. McKee, "Stratified Rocks of the Grand Canyon," U.S. Geological Survey Professional Paper 669-B, 1969, pp. 23-58.

³The names of formations of layered rocks are generally derived from localities where those particular formations are especially well exposed. For example, the Moenkopi Formation is named after Moenkopi, Arizona. Some of the names of formations in the Grand Canyon are derived from prominent features within the Canyon; for example, Vishnu Schist after the Vishnu Temple.

The standard geological periods have been named after localities (Pennsylvanian, Devonian), tribes of people (Silurian and Ordovician after ancient Welsh tribes), characteristic rock type (Cretaceous from creta, Latin for chalk) and relative position (Tertiary). Rocks are assigned to the appropriate geological period on the bases of characteristic fossil remains, by which they can ordinarily be identified, and their position relative to rocks belonging to other periods. The criterion of relative position succeeds because in stacks of undisturbed layered rocks around the world, rocks of younger age are invariably found overlying rocks of older age. For example, Triassic rocks always overlie Permian or older rocks, and Mississippian rocks always underlie Permian or younger rocks unless a great disturbance has overturned the rocks.

The dating of geological-period boundaries is a matter of constant discussion among geologists, and not all geologists are likely to agree on the exact same set of values. The ages used in figure 3 have been taken from one of the most recent evaluations of the geologic time scale, namely, W. B. Harland, *A Geologic Time Scale* (Cambridge: Cambridge University Press, 1982), p. 4-5.

⁴Some geologists have also suggested the designation Nankowep Group for some of

the layered rocks between the Unkar and Chuar Groups.

⁵Igneous rocks are those that have solidified either underground or on the earth's surface from previously molten rock. Metamorphic rocks are those that have been recrystallized well below the earth's surface under the influence of extremely high pressures and temperatures. Before metamorphism, such rocks may have been igneous, metamorphic or some kind of sedimentary rock such as shale, limestone or sandstone.

⁶The Ordovician and Silurian periods follow the Cambrian and come before the Devonian (see figure 3).

⁷A summary diagram of a creationist flood model can be seen in *Bible-Science Newsletter*, 15 (1977):5.

⁸Lang, *Geological Study Course*, and Clifford L. Burdick, *The Canyon of Canyons* (Minneapolis: Bible-Science Association, 1974).

⁹Lang, *Geological Study Course*, p. 6; Burdick, *Canyon of Canyons*, pp. 60-61.

¹⁰Here the term *kinds* is used in the sense of the "kinds" of Genesis 1 as translated from the Hebrew word *min*.

¹¹Burdick, *Canyon of Canyons*, pp. 27, 59-60.

¹²*Ibid.*, pp. 65-74.

¹³*Ibid.*, pp. 41-51; Lang, *Geological Study Course*, pp. 4-5.

¹⁴"Grand Canyon 'Creation' Story," *Bible-Science Newsletter*, 14 (1976):1.

¹⁵Gary E. Parker, *Creation: the Facts of Life* (San Diego: CLP, 1980), pp. 123-4.

¹⁶"Grand Canyon Presents Problems for Long Ages," in *Bible-Science Newsletter* (an insert under the heading, "Five Minutes with the Bible & Science") 18 (1980):4.

¹⁷"A New Look at Arizona's Grand Canyon," in *Bible-Science Newsletter* (an insert under the heading, "Five Minutes with the Bible & Science") 20 (1982):1.

¹⁸"Grand Canyon Presents Problems for Long Ages," p. 8.

¹⁹Robert P. Sharp, "Ep-Archean and Ep-Algonkian Erosion Surfaces, Grand Canyon, Arizona," *Geological Society of America Bulletin*, 51 (1940):1235-70. See specifically a photograph on plate 4, figure 1, facing p. 1244 in Sharp's paper.

²⁰*Ibid.*, p. 1244.

²¹*Ibid.*, p. 1245.

²²*Ibid.*, p. 1248.

²³*Ibid.*, p. 1252.

²⁴*Archean* is a term that refers to the earth's very oldest rocks. These are typically, though not exclusively, igneous and metamorphic rocks that can ultimately be found beneath the layered sedimentary rocks that characterize most of the earth's surface.

²⁵Sharp, "Ep-Archean and Ep-Algonkian Erosion Surfaces," p. 1261.

²⁶Burdick, *Canyon of Canyons*, p. 3.

²⁷E. D. McKee and R. C. Gutschick, *History of the Redwall Limestone of Northern Arizona* (Boulder: Geological Society of America, 1969).

²⁸*Ibid.*, pp. 22-23.

²⁹*Ibid.*, p. 16.

³⁰*Ibid.*, p. 18.

³¹*Ibid.*, p. 21.

³²Andrew H. McNair, "Paleozoic Stratigraphy of Part of Northwestern Arizona," *American Association of Petroleum Geologists Bulletin*, 35 (1951): 503-41. McNair measured 216

feet of predominantly limestone in the Virgin Mountains of easternmost Nevada and tentatively assigned the rocks to the Pogonip Limestone of probably Ordovician age. McNair also measured in the Virgin Mountains 651 feet of Cambrian Limestone that overlies the Peasley Limestone, the western lateral equivalent of the Muav. As indicated from sections measured east of the Virgin Mountains, these post-Muav Cambrian Limestones thinned eastward.

³³Burdick, *Canyon of Canyons*, p. 77.

³⁴Charles B. Hunt, "Geologic History of the Colorado River," U.S. Geological Survey Professional Paper 669-C, 1969, p. 65.

³⁵"Grand Canyon Presents Problems for Long Ages," p. 4.

³⁶Edwin D. McKee, "The Supai Group of Grand Canyon," U.S. Geological Survey Professional Paper 1173, 1982, p. 4.

³⁷McKee and Gutschick, *History of the Redwall Limestone*, p. 74. Talus refers to the pile of rocks at the base of a cliff. The rocks were dislodged from the cliff and fell to the base.

³⁸See G. H. Billingsley and E. D. McKee, "Pre-Supai Buried Valleys" in McKee, "Supai Group," pp. 137-47.

³⁹*Ibid.*, p. 139.

⁴⁰*Ibid.*

⁴¹*Ibid.*, p. 190.

⁴²*Ibid.*, pp. 155-76.

⁴³"Grand Canyon 'Creation' Story," *Bible-Science Newsletter*, v. 14, 1976, p. 1.

⁴⁴*Ibid.*

⁴⁵The principle of uniformity is one of the most widely discussed and misunderstood principles in geology. Those who wish to understand the term would do well to read Martin J. S. Rudwick, "Uniformity and Progression: Reflections on the Structure of Geological Theory in the Age of Lyell," in D. H. D. Roller, *Perspectives in the History of Science and Technology* (Norman, Okla.: University of Oklahoma, 1971), and also Stephen Jay Gould, "Toward the Vindication of Punctuational Change," in *Catastrophes and Earth History* (Princeton: Princeton University Press, 1984).

⁴⁶The principle of superposition is a fundamental principle of geology in which it is stated simply that in any succession of layered rocks that has not been overturned or injected by parallel sheets of igneous rock, the layer at the bottom of the succession was deposited first and succeeding layers were deposited sequentially.

⁴⁷For example, radiometric dating of a variety of rocks and minerals using several well-established techniques repeatedly discloses that earth materials typically have ages measurable in terms of a few million to a few billion years in age. Indeed, one lava flow in the western end of the Grand Canyon that clearly erupted after all the layered sedimentary rocks were deposited has been dated by Potassium-argon dating as about 1.2 million years old. Clearly the theory of a global flood that occurred only a few thousand years ago is incompatible with such an age for the lava flow. Moreover, all the layered rocks, since they underlie the lava flow, must be older than 1.2 million years.

Biogeography concerns the distribution of plants and animals over the face of the earth. That distribution is totally at odds with the theory of a global flood and the preservation of animals on Noah's ark. As one example, consider the fact that all

fossil sloths occur in the rocks of the Americas. During a global flood all sloths would inevitably be drowned and therefore would become extinct. Sloths are extremely slow movers and could never be expected to flee to high ground during a flood. If they were to be preserved by having them board Noah's ark, then several sloths would have to migrate to the Middle East.

That, of course, is rather unlikely since sloths, as arboreal animals, don't like to move more than a few feet to find water or get from one tree to another. Also, three-toed sloths eat nothing but Cecropia tree leaves, a treat they would be unlikely to find all the way to Noah's ark. Then the problem is compounded by the need to have the sloths migrate all the way back to South America at the conclusion of the flood since that is the only place they live today. The problem could be multiplied a thousandfold by considering the improbabilities of the migration of Australian marsupials to the ark, or the difficulties of preserving river dolphins, freshwater fish, snakes and turtles and so on.

Chapter 7: Popular Portraits of Science: Focused or Fuzzy?

¹In spite of the fact that many within the scientific-creationist movement who are actively involved in writing in defense of scientific creationism have Ph.D. degrees in science, it is very difficult to regard these people as professional, practicing scientists. They do not demonstrate the marks of integrity that are so important in professional science (see, for example, the case studies of part two), and most of them are not actively practicing in a field of science by conducting legitimate research following the accepted canons of scientific practice.

²For P. W. Atkins, see our chapter eight. Carl Sagan's *Cosmos* begins with the overtly naturalistic statement, "The cosmos is all that is or ever was or ever will be." One wonders how Sagan can know that.

³These works do, however, criticize specific religious tenets when they masquerade as science. For example, the scientific-creationist claim that scientific evidence supports the notion of special creation of organisms is attacked by these evolutionists because it is a scientific claim as well as a religious one.

⁴Niles Eldredge, *The Monkey Business* (New York: Washington Square, 1982); Norman D. Newell, *Creation and Evolution* (New York: Columbia University Press, 1982); Philip Kitcher, *Abusing Science* (Cambridge, Mass.: MIT Press, 1982); and Michael Ruse, *Darwinism Defended* (Reading, Mass.: Addison-Wesley, 1982).

⁵Eldredge, *The Monkey Business*, p. 18.

⁶*Ibid.*

⁷Michael Ruse, for example, has an entire chapter devoted to evolution and ethics in his *Darwinism Defended*. In that chapter he takes great pains to dismiss evolutionary ethics and social Darwinism.

⁸Kitcher, *Abusing Science*, p. 200.

⁹Isaac Asimov, *In the Beginning* (New York: Crown, 1981).

¹⁰Douglas J. Futuyma, *Science on Trial* (New York: Pantheon, 1983).

¹¹See our chapter one for a brief discussion of the term *scientism*.

¹²According to Asimov, his book "merely considers the verse of the Bible, line by line and, indeed, word by word, discusses the content and meaning and compares them with the scientific view that pertains to the passage" (p. 2).