# Where Is the Pre-Flood/Flood Boundary?

**Michael Oard and Carl Froede, Jr.***


## Abstract

Five discontinuity criteria have been proposed as tools in an effort to locate the pre-Flood/Flood boundary. On the basis of these criteria, a boundary has been proposed high in the Precambrian section for the eastern Grand Canyon and about midway in the Precambrian section of the eastern Mojave Desert. Examination of these criteria, based on certain assumptions of the pre-Flood world, suggests that changes should be considered for both the criteria and previously proposed boundaries. In general, the pre-Flood/Flood boundary is likely to occur lower in the strata—probably close to the top of the igneous/metamorphic basement.


## Introduction

Identifying the pre-Flood/Flood boundary affects both the identification of pre-Flood strata and any interpretation of early Flood catastrophism. Traditionally, this boundary has been placed at the Precambrian/Cambrian (Pc/C) contact (Austin, 1994), an assignment that assumes the chronostratigraphic validity of the uniformitarian geological column. Baumgardner (2005) stated, "Included in the list are a number of samples from the Precambrian, that is, what we consider non-organic pre-Flood settings" (p. 594).

There are several reasons for adopting the Pc/C contact, primarily because of the substantial increase in the number and complexity of Cambrian fossils. This sudden appearance of organic lifeforms is called the "Cambrian Explosion" (Meyer et al., 2003) and marks the sudden stratigraphic appearance of complex multicellular organisms. Snelling (2005, p. 125) writes:

> There is a widespread consensus that the evidence for the commencement of the Flood in the geologic record is where the strata containing fossilized multi-cellular organisms begin, and that is confirmed by the associated evidence of catastrophic deposition of those and other sedimentary strata.

Snelling (1991) formerly believed that most Precambrian sedimentary rocks were from the Flood, but he has since changed his mind (Wise and Snelling, 2005).

However, complex animals, such as the multicellular Ediacaran fossils, are increasingly found in the late Precambrian. Even embryos, likely of multicellular organisms, are found in late Precambrian rocks (Hagadorn et al., 2006). This has caused Wise (1992; 2003) to lower his pre-Flood/Flood boundary to the upper Precambrian.

But what if such a paleontological discontinuity was caused by depositional conditions within the Flood? If so, the pre-Flood/Flood boundary could be significantly lower in the geological column (Froede and Oard, 2007).

## The Discontinuity Criteria

Austin and Wise (1994) and Wise and Snelling (2005) proposed a pre-Flood/Flood boundary in the eastern Grand Canyon (Figure 1) at a stratigraphic level a little below the Pc/C contact, based on five "discontinuity" criteria. Since any one of these criteria is usually equivocal, multiple confirmatory criteria would be preferred. Wise and Snelling (2005) placed the boundary just below the late Precambrian Sixtymile Formation,

* Michael Oard, M.S. Atmospheric Science, 34 W Clara Ct., Bozeman, Montana 59718, mikeoard@bridgeband.com

Carl Froede, Jr., B.S. Geology, 2895 Emerson Lake Drive, Snellville, Georgia 30078

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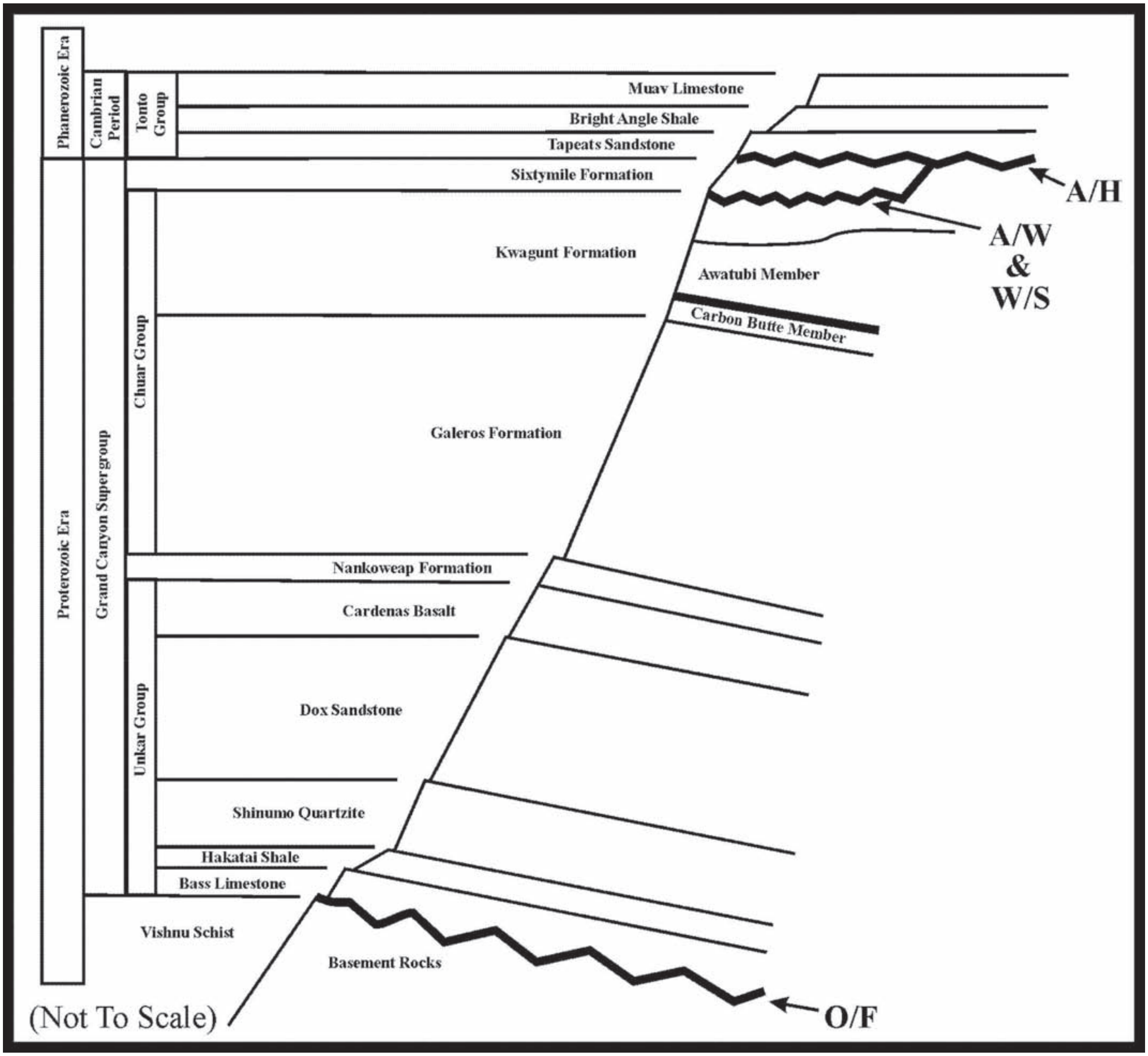


**Figure 1. A composite cross section of the lower section of Grand Canyon (modified from Elston, 1989, p. 261). The three different pre-Flood/Flood boundaries are indicated by the arrows: A/H – Austin (1994) and Hoesch (2007); A/W – Austin and Wise (1994); W/S – Wise and Snelling (2005); and O/F – Oard and Froede (this paper). The Great Unconformity was originally proposed as the pre-Flood/Flood boundary. Based on the five discontinuity criteria, the boundary is proposed to exist deeper within the Canyon—not at the base of the Cambrian, not at the Upper Precambrian Sixtymile Formation, but at the base of the Sixtymile Formation.**

which represents the top formation in a 4-km thick Precambrian sedimentary succession.

In the eastern Mojave Desert near Death Valley, the boundary is placed in the lower Kingston Peak Formation (Austin and Wise, 1994; Wise, 2003) about 4 km below the top of the Precambrian and approximately 2 km above the crystalline basement. The upper and middle Kingston Peak Formation consists mostly of diamictite, an unsorted or poorly sorted, sedimentary rock with a wide range of particle sizes. Uniformitarian geologists consider the diamictite an ancient ice-age deposit, while creationists consider it a massive submarine landslide formed during the Flood (Oard 1997; Sigler and Wingerden 1998; Wise, 1992). Wingerden (2003) has extended the pre-Flood/Flood boundary within the Kingston Peak Formation northward into Utah and Idaho just below Precambrian diamictites.

The five discontinuity criteria proposed by Austin and Wise (1994) and amplified by others represent a good starting point for further discussion. Each discontinuity criterion will be discussed in general and applied to the eastern Grand Canyon and Mojave Desert.

## What Do We Know about the Pre-Flood World?

Understanding how to use these criteria would be easier if we knew the type and scale of geological activity before the Flood. However, the geological evidence is uncertain since there is no clear stratigraphic demarcation of the pre-Flood world. We do know that the topography and the geography of the pre-Flood world were *unlike* today, because the Flood catastrophe destroyed the earth's surface (Gen. 6:13). Differential vertical tectonic movements measured in miles combined with the erosion, transport, and deposition of an average of 1.5 km of strata on the present continents occurred during the Flood. It is even possible that there were rapid, large-scale horizontal dislocations of lithosphere during the Flood (e.g., catastrophic plate tectonics, hydroplate), though the evidence presented to date is less than compelling (Reed, 2000a; Akridge et al., 2007). Thus, the Bible must provide clues about the early earth to constrain geological and paleontological evidence.

On Day 3 of the Creation week, God separated the dry land from the waters below (Gen. 1:9). Some creationists believe that this event was accompanied by great geological activity such as the deposition of thick sediments (Austin, 1994). However, since the creation was by definition a supernatural activity, the dry land could have appeared absent geological upheavals, and their subsequent erosion, transport, and deposition of sediments. For the sake of argument, we will assume the formation of some sedimentary sequences on Day 3.

Some creationists also assume that since the creation of bacteria is not mentioned in Genesis 1, they could have been created on Day 2 or 3 (Wise, 2002). The Bible is also not specific about the appearance of marine blue-green algae (cyanobacteria), but presumably they also could have been created at the same time as the bacteria. Thus, both bacteria and blue-green algae (unicellular, prokaryotic organisms) could have been created before the dry land appeared and thus *buried* if there was depositional activity on or after Day 3. Those rocks could potentially contain fossils of bacteria and algae, but nothing more since land plants were created following the emergence of land on Day 3 (Gen. 1:11) and the rest of the animals were created during Days 5 and 6. We would not expect any land plants or multicellular animals in Day 3 strata (if any).

However, there are differences of opinion about the timing of creation of bacteria and algae. Walker (1994) favored their creation on Day 5, along with the other ocean creatures, but he admits that they could have been created on Day 3 with the terrestrial vegetation. Whether created on Day 2, 3, or 5, Walker (1994) believes bacteria and algae were created *after* the dry land appeared. Thus, he would predict the total absence of microfossils of bacteria or blue-green algae in the Day 3 strata, if any were deposited. Due to the paucity of data, any opinion is speculative.

Though unexpected on the earth as created ("very good"), catastrophic natural disasters could have occurred following the Curse. Did the Curse per se result in natural disasters prior to the Flood, or would a relatively uniform climate, hydrology, tectonics, etc. have continued as created? Walker (1994) and Reed et al. (1996) suggest that the pre-Flood earth was rather placid geologically. Geological reasoning could be applied only if we knew the stratigraphic boundaries of Day 3 rocks (if any), the antediluvian world, and the Flood.

The Bible suggests that the early Flood was the most geologically intense phase; the fountains of the great deep were broken and the windows of heaven opened, all on a global scale. Although there is some divergence of opinion on the precise meaning of the fountains of the great deep, most creationists believe that the crust of the earth was broken up and the ocean water rose. The lead author leans toward the idea that the fountains of the great deep were caused by thousands of meteorite impacts. The windows of the heavens imply heavy rain for 40 days and nights, which in the view of the lead author would easily occur if meteorites hit the pre-Flood ocean, blasting water up into and above the atmosphere. The rain abated after 40 days, and it is reasonable to suggest that the initial tectonic upheavals also abated. Figure 2 shows a chart of the geological energy levels during the Flood (Reed et al., 1996; 2006).

Thus, the following discussions of the lower Flood boundary and the discontinuity criteria must be tempered by the historical uncertainty inherent in the problem. That aside, do the discontinuity criteria offer a definitive means of identifying this important boundary at Grand Canyon and the eastern Mohave Desert?

### Paleontological Discontinuity

The first criterion is a paleontological discontinuity—traditionally considered the most significant in determining the boundary. It is based on a transition from unicellular to multicellular fossils. In eastern Grand Canyon and the eastern

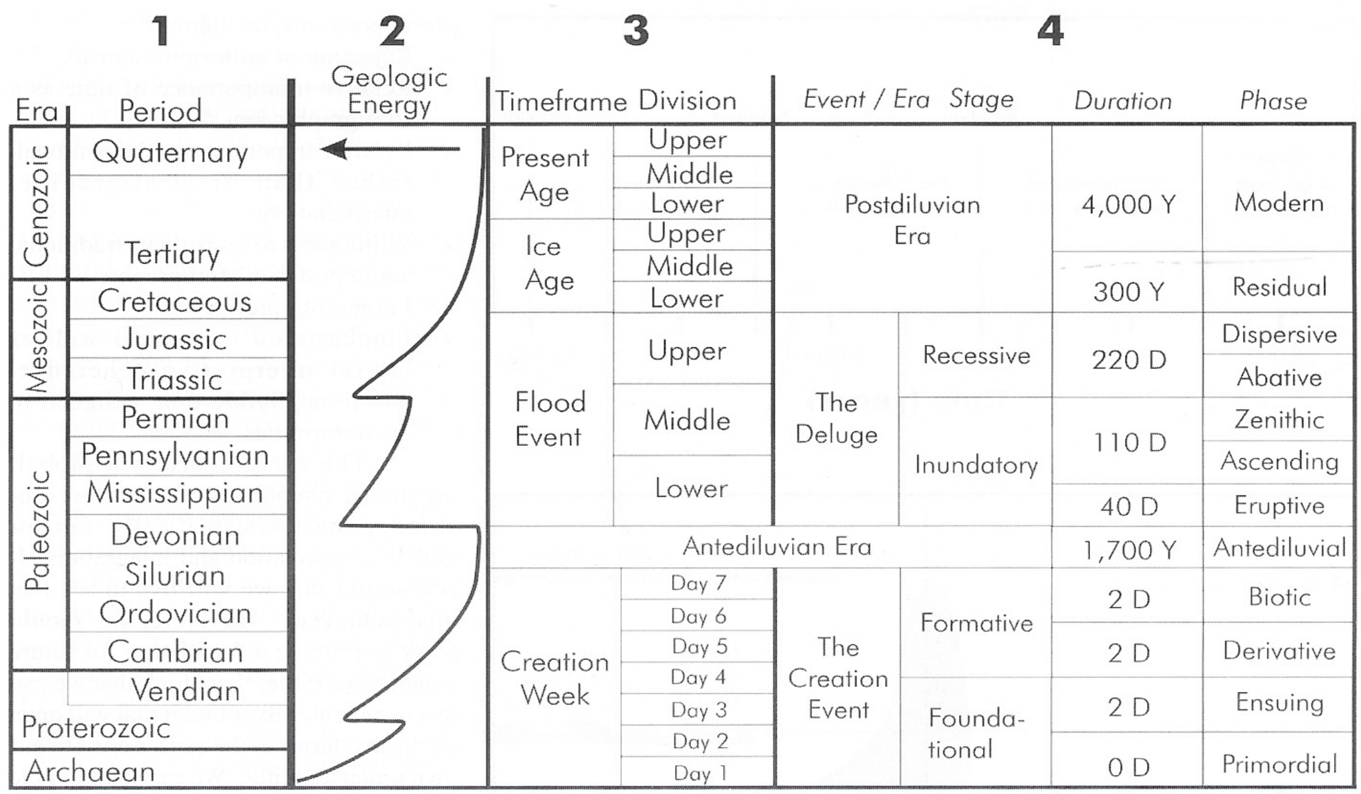


**Figure 2. Comparison of stratigraphic interpretive frameworks between (1) the uniformitarian stratigraphic column, (2) geological energy versus time (Reed et al., 1996), (3) Froede's (1995) classification, and (4) Walker's (1994) classification (from Reed et al, 2006, p. 138).**

Mojave Desert, "stromatolites" and microfossils are found in the Precambrian sedimentary rocks both above and below the proposed pre-Flood/Flood boundaries of Austin and Wise (1994) and Wise and Snelling (2005). The Sixtymile Formation is unfossiliferous (Wise and Snelling, 2005), while the Paleozoic formations above the Sixtymile Formation contain multicellular organisms. Therefore, the pre-Flood/Flood boundary would have been better placed at the top of the Sixtymile Formation based strictly on the paleontological discontinuity.

The paleontological discontinuity hinges on the status of the stromatolites and microfossils in the Precambrian below the boundary, and interpretations of the events of Day 3 and the nature of the pre-Flood world influence where the boundary is placed.

## 1. "Stromatolites" Below the Pre-Flood/Flood Boundary

"Stromatolites" are reported in Precambrian formations below the currently proposed pre-Flood/Flood boundary in eastern Grand Canyon and eastern Mojave Desert. They are found as deep as the first formation above the igneous/metamorphic basement rocks, the Bass Limestone. They are also found in the Dox and Kwagunt formations (Hendricks and Stevenson, 1990). Wise and Snelling (2005) proposed that stromatolites in the Kwagunt Formation, 635 m below the base of the Sixtymile Formation, help define the pre-Flood/Flood boundary because they supposedly developed over a relatively long period of time before the Flood.

In the eastern Mojave Desert, stromatolites are found in the Beck Springs Dolomite, the second formation above the basement and just below the proposed boundary (Tucker, 1983).

There are at least nine reasons why creationists need to be cautious in assuming these stromatolites are biogenic and thus could not have been rapidly formed (see Appendix 1).

## 2. Microfossils Below the Pre-Flood/Flood Boundary

The paleontological discontinuity also rests on the stratigraphic position of microfossils relative to the proposed boundaries. Microfossils are found in the eastern Grand Canyon and the eastern Mojave Desert in the Precambrian formations below the proposed boundary of Wise and Snelling (2005). For instance, more advanced eukaryote fossils are found in the Beck Springs

Dolomite in the eastern Mojave Desert (Wise, 2003). The Kwagunt Formation just below the Sixtymile Formation also contains fossils of cyanobacteria.

More and more microfossils are being found worldwide in Precambrian sedimentary rocks, even in those considered early Precambrian. The presence of microorganisms was a major factor in Snelling's (1991) early belief that some Precambrian sedimentary rocks were deposited by the Flood. Although microfossils can often be confused with abiogenic structures, research is progressing, and presumably the ability to recognize microfossils is improving. Schopf (2006) reported 40 microfossil localities in Archean (older than 2.5 billion years) sedimentary rocks. Even eukaryote fossils are found in rocks dated at 2.7 billion years (Oard, 2001). The Proterozoic (2.5 to 0.5 billion years) includes many sediments containing microfossils.

The significance of "Precambrian" microfossils is uncertain. They are found in thick, widespread Precambrian sedimentary rocks that strongly suggest regional catastrophic deposition. There are two compelling reasons to think that these may be Flood deposits. First, the strata in question are thick accumulations of sediment, consistent with deposition in the Flood (see Appendix 1). Second, if the microfossils represent pre-Flood fossilization, it is reasonable to ask why there are *no* fossils of multicellular organisms associated with the microfossils. It seems more reasonable to assume that "Precambrian" microorganisms were fossilized in the Flood. In many locales, this would push the pre-Flood/Flood boundary to the contact between Precambrian sedimentary rocks and the crystalline basement rocks.

The absence of Precambrian multicellular fossils also presents a problem for the Flood model. Perhaps factors associated with the onset of the Flood, such as intense turbulence, heat, volcanism, or metamorphism (Hunter, 1992) precluded preservation of multicellular fossils. Perhaps the earliest phase of the Flood was so violent in certain locales such as rift basins, that multicellular organisms were pulverized. Or they could have been transported away by powerful currents or sediment gravity flows. Furthermore, just because a formation is unfossiliferous does not mean that the formation is not from the Flood. Even some Phanerozoic sedimentary rocks (younger than 0.5 billion years) are strangely unfossiliferous (Peters, 2007). There must be a source of organisms in addition to sediment to preserve fossils. In short, the paleontologic discontinuity is not definitive.

## Erosional Discontinuity

The second criterion cited is an erosional discontinuity—the presence of a widespread and significant erosional surface representing the early scouring action of floodwaters. It is a reasonable expectation for many areas because of highly energetic hydraulic flows expected with the initiation of the Flood. Large-scale erosion and deposition, especially combined with tectonics, would have created widespread unconformities.

But it is simplistic to attribute identical processes everywhere at the same time. Flat-lying pre-Flood strata, protected from the initial onslaught of the Flood (e.g., in a deep basin), could be conformable with early Flood sediments. Some sedimentary basins might show no signs of a significant erosional discontinuity. Clearly, none of the discontinuity criteria are absolute.

Wise and Snelling (2005) noted that the unconformity between igneous/metamorphic rocks and sedimentary rocks in the eastern Grand Canyon (Figure 3) is *the most significant unconformity* in the area. It is called the "Greatest Unconformity" and occurs deeper than the "Great Unconformity" below Precambrian sedimentary rocks. The Greatest Unconformity is an erosion surface capped in places by conglomerate or breccia. We believe this contact better fits the criteria for the pre-Flood/Flood boundary. It merges with the Great Unconformity at the base of the Tapeats Sandstone in the western and central Grand Canyon.

## Time Discontinuity

We reject the Austin and Wise (1994) "time discontinuity" as a *field* indicator of the pre-Flood boundary because it must be *interpreted*, not observed. Any "time discontinuity" will be subjective and potentially influenced by uniformitarian assumptions. Furthermore, tremendous tectonic forces and considerable erosion could have occurred anytime during the Flood. So, the duration of any proposed time discontinuity could be at any time during the Flood, depending on the local conditions. If forced to pick a time discontinuity, we would favor the *lowest*. In the eastern Grand Canyon and Mojave Desert, that would be at or near the top of the igneous and metamorphic basement.

Wise and Snelling (2005) stated that pre-Flood sediments had more time to lithify while Flood sediments experienced only limited lithification in the course of the yearlong Flood. So they would not expect erosion of early Flood sediments to generate significant conglomerates or breccias. Given that assumption, any thick conglomerate or breccia would suggest a time discontinuity between the deposits containing the clasts and the underlying source strata, and the pre-Flood/Flood boundary would then be defined immediately beneath the conglomerate or breccia. The large number and size of the clasts in conglomerates and breccias in the Sixtymile Formation in the eastern Grand Canyon and the Kingston Peak Formation in the eastern Mojave Desert have been cited as evidence for a significant time discontinuity. But if their assumption about lithification rates is incorrect, so is their interpretation of the boundary (see Appendix 2).

**Figure 3. Two unconformities in Grand Canyon (view north from Moran Point, South Rim). The Great Unconformity is the contact between the horizontal strata above and the eastward dipping Precambrian strata below (horizontal line). The Greatest Unconformity is the boundary between the Precambrian strata and the underlying igneous/metamorphic rocks (line slanting to the right).**

Even if the assumption regarding breccia and conglomerate clasts were true, the boundary should not be based on clast size, which is not a time indicator. The varying energy levels of the Flood at different locations could have produced any size clasts, even small clasts. Or energetic transport of eroded clasts, even over a short distance, could have deposited them higher in the sedimentary column in another location. For instance, a downfaulted basin could collect several kilometers of early Flood sedimentation (e.g., Grand Canyon Supergroup). Then a tectonic event nearby could spread breccia or conglomerate from pre-Flood rocks over those sediments. Variations in elevation, proximity to source areas, current velocity, etc. would ultimately control clast size and stratigraphic position. Clasts alone cannot serve as a deterministic indicator.

## Sedimentary Discontinuity

The base of a fining upward sedimentary sequence has also been suggested as a defining criterion for determining the pre-Flood/Flood boundary (Wise and Snelling, 2005). Since the base of the Sixtymile Formation (a conglomerate) is also the base of a fining upward sequence in Grand Canyon, they believe that it marks the pre-Flood boundary. The overlying Tonto Group consists of the basal Tapeats Sandstone, a coarse stone with layers of quartz pebbles (Figure 4), which in turn is overlain by the Bright Angel Shale and then the Muav limestone.

That is the problem. Fining upwards sequences are caused by hydraulic conditions that could have existed at any time during the Flood. Such a sequence can be formed when a current deceler-

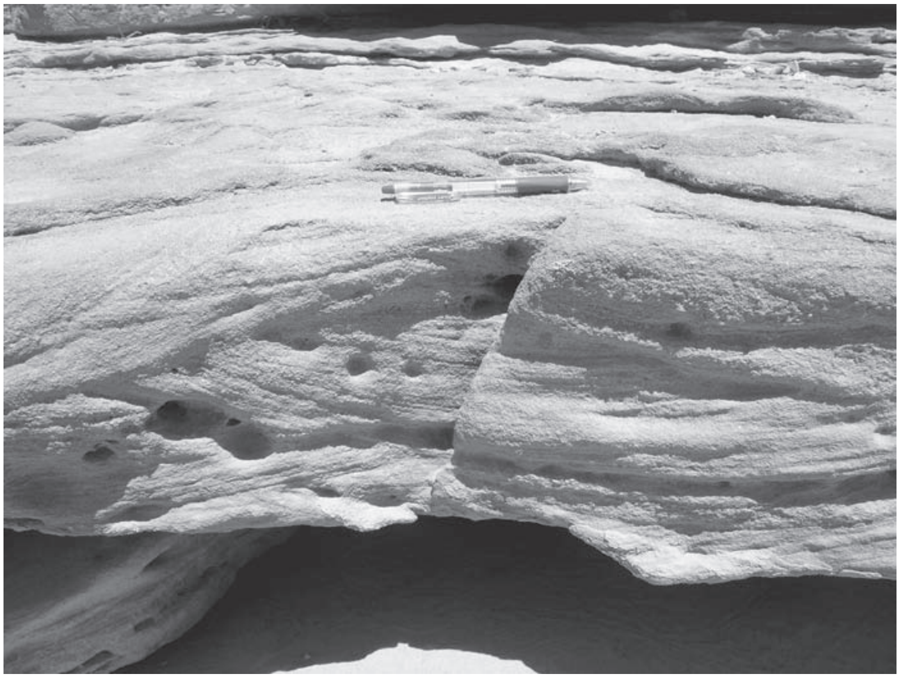

**Figure 4. The coarse Tapeats Sandstone with pebbles at the mouth of the Little Colorado River.**

ates or when sufficient sediment is added to a current, forcing deposition. The latter case is similar to a fining upward turbidity current, but on a large scale.

Since the initial stages of the Flood would very likely have been the most violent (see Figure 2), fining upward sequences would likely have been less common. One location where fine-grained sediments might have occurred very early in the Flood is in deep basins. Strong currents could have spread sediments into the basin from above, where the sediments settled into an area of weak currents within the basin or rift zone. The rapidly subsiding basins of the eastern Mojave Desert and the eastern Grand Canyon might well have generated a *coarsening* upwards sequence that would define the basal Flood boundary.

The fining-upward Tonto Group in Grand Canyon areas likely represent a subcontinental-wide sedimentation event and not a localized deep basin deposit (Morris, 2000). Such a laterally extensive sedimentation event would probably not represent the onset of the Flood, since the first widespread sedimentation across North America would have followed sedimentation in deep rift basins formed at the very outset of the Flood. Such a widespread layer would likely represent a time when the mechanism of the Flood waned. Thus, it is *difficult to be specific* as to what would be a reasonable sedimentary discontinuity criterion for the boundary.

### Tectonic Discontinuity

The earliest stage of the Flood probably included significant tectonic activity, but it might not have occurred everywhere at the same time. Moreover, tectonic activity apparently continued throughout the Flood. Thus, more than one tectonic discontinuity would be expected within the same region.

If the onset of the Flood was marked by rifting of basement igneous and metamorphic rocks (Reed, 2000b), and since the Precambrian sedimentary rocks in the eastern Grand Canyon were deposited in a north-south rift (Karlstrom et al., 2000), then they could have been part of this early Flood rifting.

However, in most places, the initial stages of the Flood would have deposited sediments above an eroded granitic basement absent any sign of tectonism or strong currents. Later tectonism could have deformed those deposits. In that case, the pre-Flood/Flood boundary could be well below the first evidence of a tectonic episode. This illustrates again that none of these criteria are absolute. If anything, the tectonic discontinuity marking the basal Flood surface should be the lowest in the section. This would suggest that the most appropriate place to locate a pre-Flood/Flood "tectonic discontinuity" is at or near the contact between the clastic sediments and underlying basement igneous/metamorphic rocks.

## Is the Boundary Located below Diamictite?

In the eastern Mojave Desert, the diamictite of the Kingston Peak Formation represents a tectonic, erosional, and sedimentological discontinuity (Austin and Wise, 1994; Sigler and Wingerden, 1998). Similar Precambrian diamictites are found in the western United States.

The Kingston Peak Formation, which lies above fine-grained sediments, may not be the basal Flood deposit. Earlier Flood fine-grained sediment could have been deposited prior to the diamictite. Moreover, there are other diamictites stratigraphically older elsewhere (Oard, 1997). Some diamictites are dated older than 2 billion years within the uniformitarian geological timescale. There are also younger diamictites—in the Ordovician and late Paleozoic, well above the pre-Flood/Flood boundary. Uniformitarian geologists interpret all these diamictites as glaciogenic, although they are better interpreted as large submarine mass flows (Oard, 1997). Therefore, the mere presence of diamictite is not diagnostic. The pre-Flood/Flood boundary could undoubtedly be well below the lowest diamictite, which would place the boundary into the Archean in areas where lower Proterozoic "tillites" are located. This all assumes the reliability of the chronostratigraphic aspects of the geologic column.

Table I presents a proposed modification of the Austin and Wise (1994) discontinuity criteria that makes them better suited to help determine the pre-Flood/Flood boundary. Based on these revised criteria, we would favor the placement of the boundary near or at the contact between the igneous and metamorphic basement rocks and the overlying sedimentary rocks, whether Precambrian or Phanerozoic. These criteria may also be relevant for areas outside the southwest United States, but we recommend careful local studies rather than the careless application of these criteria. Note that this boundary negates our earlier assumption (used for sake of argument) that there were thick sedimentary rocks formed on Day 3. It is possible that most, if not all, Precambrian sedimentary rocks were deposited in the Flood.

**Table I. Pre-Flood/Flood boundary criteria and proposed boundary location.**

| Boundary Criterion | Boundary Location |
|---|---|
| Paleontological Discontinuity | Between rocks with no fossils and unicellular fossils, but nevertheless equivocal |
| Erosional Discontinuity | The lowest unconformity or nonconformity at the contact with crystalline basement |
| Time Discontinuity | Equivocal, but probably lowest discontinuity |
| Sedimentary Discontinuity | Between igneous/metamorphic basement and sedimentary rocks. Can include some melted basement or possibly even metasedimentary strata |
| Tectonic Discontinuity | At the lowest discontinuity |

**Table II. Nine reasons why fossil stromatolites may be inorganic.**

| |
|---|
| 1) Definition problems |
| 2) Unsupported bias toward biological origin |
| 3) Not rare in Phanerozoic rocks considered from the Flood |
| 4) Unlike stromatolites from Bermuda and western Australia |
| 5) Very little organic matter or organic structures |
| 6) Practically always consist of carbonate laminations |
| 7) Exist in extensive layers in fossil record unlike local occurrences today |
| 8) There are chemical mechanisms for abiotic formation |
| 9) Huge volume of Precambrian sedimentary rocks not likely between Day 3 and Flood |

## Conclusion

Application of the revised five discontinuity criteria to selected sites in the southwestern United States suggests that the pre-Flood/Flood boundary is located lower in section than some creationists have suggested, perhaps as low as the contact between sedimentary/metasedimentary strata and underlying igneous/metamorphic basement rocks. It is also possible that some of the basement may have melted (i.e., anatexis) and recrystallized during the Flood. Additionally, the placement of the boundary at this contact, although tentative and open to further research, suggests that there may not be any Day 3 sedimentary rocks in Grand Canyon or the eastern Mojave Desert and that most, if not all, Precambrian sedimentary rocks were laid down in the Flood. The inclusion of thick sections of Precambrian rock as Flood strata may also have interesting consequences for the chronostratigraphic validity of the uniformitarian geologic column.

## Appendix 1. Stromatolites and the Pre-Flood/Flood Boundary

There are at least nine reasons (Table II) why creationists should be cautious in accepting stromatolites as biogenic and thus diagnostic of pre-Flood sedimentation.

(1) It is difficult to unambiguously identify stromatolites (Riding, 2000; Schopf, 2006), especially since some non-biogenetic structures look like stromatolites (Schopf, 2006). Awramik (2006, p. 700) stated:

> Confidence in the interpretation of stromatolites as biogenic structures was dealt a serious blow with the proposal that stromatolite structure could theoretically result from abiotic processes in sediment accumulation. To make matters more bewildering, the very definition of stromatolite is contentious.

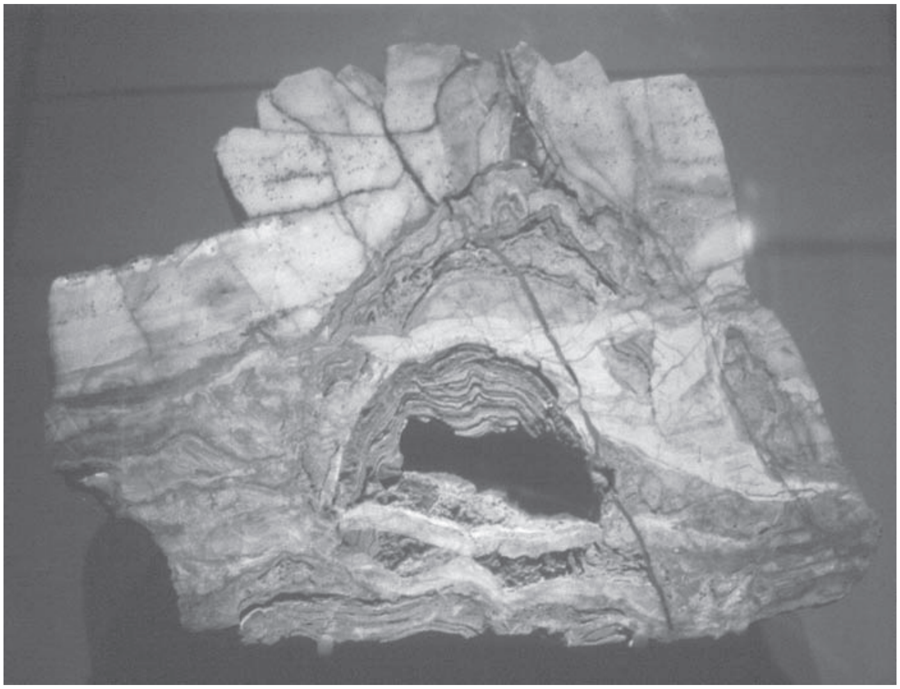

**Figure 5. A fossilized stromatolite collected from Western Australia and purported to be one of the oldest evidences of life on Earth at 3.5 billion years old. On exhibit at the National Museum of Natural History (Smithsonian). Approximately 30 cm in height.**

Some researchers simply define stromatolites as biological structures, while others prefer a more descriptive definition (clearly a more scientific approach). Most think of stromatolites as upside down dish-like structures (Figure 5). However, modern research has shown that there are a number of stromatolite-like laminations, and the variety has caused confusion in terminology and cast doubt on any biogenic origin. For instance, some horizontal laminations are interpreted as microbial mats, which are then defined as stromatolites.

So what is a stromatolite? Since the present is supposed to be the key to the past, biologists have studied a complex variety of microbial mats and stromatolites in various fresh and saltwater environments (Riding, 2000; Visscher and Stolz, 2005). These are then extrapolated to the rock record. For the sake of simplicity, we will assume that the typical inverted, stacked dish structures are the stromatolites under discussion in regard to the pre-Flood/Flood boundary (Figure 5).

(2) Researchers have been *biased* toward the biogenic interpretation of these fossil structures.

> But in the past, we have tended to rely too much upon evidence that is 'consistent with' microbial processes, without falsifying or rejecting (*sensu* Popper 1959) other possible non-biological scenarios that may likewise be consistent. We have tended to ask 'what do these structures remind us of' rather than 'what are these structures?' (Brasier et al., 2006, p. 889).

This bias has steered paleontologists away from abiotic mechanisms, stifling research.

(3) These structures are found in strata that were clearly deposited by the Flood. Although stromatolites are best known in Precambrian strata between 2.8 and 1.0 billion years (Flügel, 2004), and even as far back as 3.4 billion years in Western Australia (Allwood et al., 2006; Awramik, 2006), they are also present in Phanerozoic strata (Bertrand-Sarfati and Monty, 1994; Flügel, 2004; Gebelein, 1969; Monty, 1981; Riding, 2000). (Some uniformitarians dispute the biogenic origin of the very oldest features [Brasier et al., 2006; Lowe, 1994].) Most creationists would consider most Phanerozoic sedimentary rocks as Flood deposits. Thus, a Flood mechanism for the development of "stromatolites" is required unless they are all pre-Flood structures that were transported and redeposited intact. In that case, the most likely mechanism would be abiogenic, since the Flood year does not provide sufficient time for slowly accumulating stacked microbial mats. And if Flood stromatolites might be inorganic, then why not "older" stromatolites?

(4) Fossil stromatolites are typically *unlike* modern examples observed in such classical environments as Bermuda and Shark Bay, Western Australia (Ginsburg, 1991). The stromatolites in Shark Bay show coarse rock particles and crude banding and are isolated mounds (Pope et al., 2000; Riding, 2000; see Figure 6). "Ancient" stromatolites are commonly evenly layered, fine-grained laminations and are interconnected. All of these features are dissimilar from today's upside down, stacked-dish stromatolites. Hence, there really is no clear modern analog for fossil stromatolites, and the uniformitarian principle fails yet again! Riding (2000, p. 204) summarized: "If this is correct, the question arises whether and where modern analogues for Precambrian stromatolites actually exist."

(5) There is very little organic matter or organic structures found in fossil stromatolites (Grotzinger and Rothman, 1996; Hofmann, 1969; Riding, 2000; Schopf, 2006; Seong-Joo et al., 1999). Awramik (2006, p. 700) admitted,

> Only rarely are microfossils found in ancient examples, but many researchers consider stromatolites to

**Figure 6. Stromatolites from Shark Bay, Western Australia, showing the coarse particles and crude banding of the isolated mounds (display from the Museum of the Rockies, Bozeman, Montana). The layers are formed as cyanobacteria emit slime, which captures rock particles. As the particles create a layer, the colony secretes more slime and other layers form, eventually creating the stromatolite.**

> be the products of microbe-sediment interaction, and so to be fossils.

The organic matter and structures that are sometimes claimed are equivocal and can occur by chance. Schopf (2006, p. 873) stated,

> Unfortunately, even this criterion [preserved microfossils or trace fossils] falls short, since the mere presence of fossilized micro-organisms within an ancient stromatolite-like structure cannot demonstrate that the structure accreted as a direct result of microbial mat-building activities.

This criterion is doubtful too, because of the presence of Precambrian carbonaceous matter and microfossils (Snelling, 1991; Tice and Lowe, 2006). Brasier et al. (2006, p. 888) stated, "Carbonaceous matter is found remarkably widely across Archaean cratons." Carbon isotope ratios indicate that this carbon is biogenic, but abiotic processes can also produce carbon ratios that appear biogenic (Brasier et al., 2006; Tice and Lowe, 2006). If organic matter and microfossils, even the more complex eukaryotes (Oard, 2001), are preserved in the rocks, then why would organic matter be almost nonexistent in stromatolites if they really were formed biologically? Although the rarity of organic matter and structures directly associated with stromatolites could be caused by diagenesis, it could also indicate an abiogenic origin.

(6) Practically all fossil stromatolites occur in carbonates (Schieber, 1998). Schopf (2006) stated, "Almost all known ancient stromatolites are or were originally of calcareous composition" (p. 873). But modern stromatolites are found in a variety of sedimentary environments and bind all types of sediments (Schieber, 1998). Those in Grand Canyon are associated with carbonates, even those in the Kwagunt Formation used to place the pre-Flood/Flood boundary at the base of the Sixtymile Formation (Austin and Wise, 1994). Given the complexity of carbonate depositional and diagenetic processes, it is certainly possible that stromatolites may be an artifact of inorganic carbonate processes.

(7) Fossil stromatolites can be widespread over tens of kilometers while those today are found over a much smaller area (Ginsburg, 1991).

(8) Non-biological mechanisms have been shown to produce structures very similar to stromatolites (Brasier et al., 2006; Perri and Tucker, 2007; Pope et al., 2000).

> But when computer models suggested that simple chemical reactions and physical forces can mimic stromatolites, those fossils too were cast in doubt. Martin Brasier of Oxford University is less sanguine, arguing that the structures [presumed stromatolites from 3.4 billion-year rocks from Western Australia] are more likely chemical precipitates. He also objects to the reasoning in the Nature paper. "You can't use the argument that complexity is the signature for life," he says. "The extreme variability is what we would expect from a physical mechanism" (Stokstad, 2006, p. 1,457).

As a result, some evolutionists have expressed doubt over the biological origin of at least some of the stromatolites found in the sedimentary rocks (Brasier et al., 2006; Grotzinger and Rothman, 1996; Hoffman, 1973; Lowe, 1994; Schieber, 1998; Stokstad, 2006; Walter, 1996). Perri and Tucker (2007, p. 207) admitted, "Proving a biogenic microbial origin for ancient stromatolites can be very difficult." Brasier et al., (2006, p. 894) stated,

> We agree with Schopf (2006), that "it is perhaps impossible 'to prove beyond question' that the vast majority of reported stromatolites…are assuredly biogenic."

(9) Precambrian sedimentary and metasedimentary strata occur in great thicknesses in the western United States, as well as many other areas of the world. These strata are 4 km thick in the eastern Grand Canyon and 6 km thick in the eastern Mohave Desert. The Precambrian Belt Supergroup in western Montana is up to 20 km thick and covers an area over 200,000 $km^2$ (Horodyski, 1993; Ross and Villeneuve, 2003). Furthermore, the Belt metasedimentary rocks show fairly uniform grain sizes of coarse silt and fine sand over a wide area, and there is very little tectonic movement indicated by the strata. Uniformitarian scientists must accept that Belt sediments were deposited in stable, shallow-water environments that somehow produced 20 km of strata *before* uplift and tilting.

It is unlikely that such thick, widespread Precambrian strata could accumulate in the pre-Flood world. They are too thick, often too widespread, and show little if any erosion between layers (like Phanerozoic sedimentary rocks). These all imply large-scale erosional/depositional processes acting in conjunction with large-scale tectonic movements. It seems more reasonable to associate those processes with significant catastrophism. That means that these thick Precambrian sediments are either relicts of Day 3 or the Flood. In either case, stromatolites would not have formed by uniformitarian mechanisms. The inorganic origin of stromatolites is an area ripe for diluvial research.

If the stromatolites below the proposed pre-Flood/Flood boundary are inorganic, then there probably is no paleontological discontinuity at the base of the Sixtymile Formation. Wise and Snelling (2005) astutely left open the possibility that the stromatolites are inorganic. However, they also believe that it would make no difference to their proposed boundary, because a nonbiological origin would still require the passage of sufficient time to rule out the Flood, making the structures pre-Flood. But that requires a leap of faith; if these stromatolites are inorganic, only further research can determine the timing of their formation.

## Appendix 2. Rates of Lithification

Wise and Snelling (2005) assumed the pre-Flood strata would have more time

**Figure 7. Red Conglomerate Peaks along the Montana/Idaho border about 25 miles west of Interstate 15 (mountain just right of center in background). Peaks consist of erosional remnants of a thick sheet of breccia.**

**Figure 8. Rounded and angular clasts from breccia of the Red Conglomerate Peaks. Most clasts are limestone with fossils, but some are sandstone. These clasts are eroded Flood rocks with the clasts in the breccia dated as Paleozoic within the geological column.**

to lithify, while Flood strata would not have enough time to harden completely until after the Flood. But they presented no evidence to support these assumptions. There has been little if any published creationist research on this subject, and quantifying lithification rates in the numerous physical and chemical environments of the Flood is a massive problem. However, there are several points worth making at present.

Wise and Snelling (2005) assumed time was the major factor in lithification. But it is only one factor. Sediments are converted into sedimentary rock by a combination of compaction and precipitation of cement around sediment grains (Plummer and McGeary, 1996), but there are many other variables (Bjørlykke and Egeberg, 1993; Haddad et al., 2006; McBride, 1989; Molenaar et al., 2007; Pettijohn et al., 1987). In order for the cement to work its way into the sediments, great volumes of fluids must readily flow through the pore spaces, but as more and more cement is deposited the porosity drops substantially. Cements include calcite, silica, iron oxides, and various clay minerals. To further complicate the problem, framework grains can dissolve and be redeposited as interstitial cement, depending on the chemical environment. Diagenesis is complex and greatly complicates the rock history. Because Flood processes may well have been unique, we do not understand diagenetic processes in Flood sediments. Thus we have no way of knowing how quickly they might or might not lithify.

There are many indirect evidences for rapid lithification during the Flood. Breccias in southwest Montana and adjacent Idaho that were indisputably produced in the Flood (Figures 7 and 8) must have lithified rapidly, since both sandstone and carbonate clasts within the breccia were rock prior to their erosion and subsequent redeposition by late Flood catastrophic processes (Oard et al., 2005).

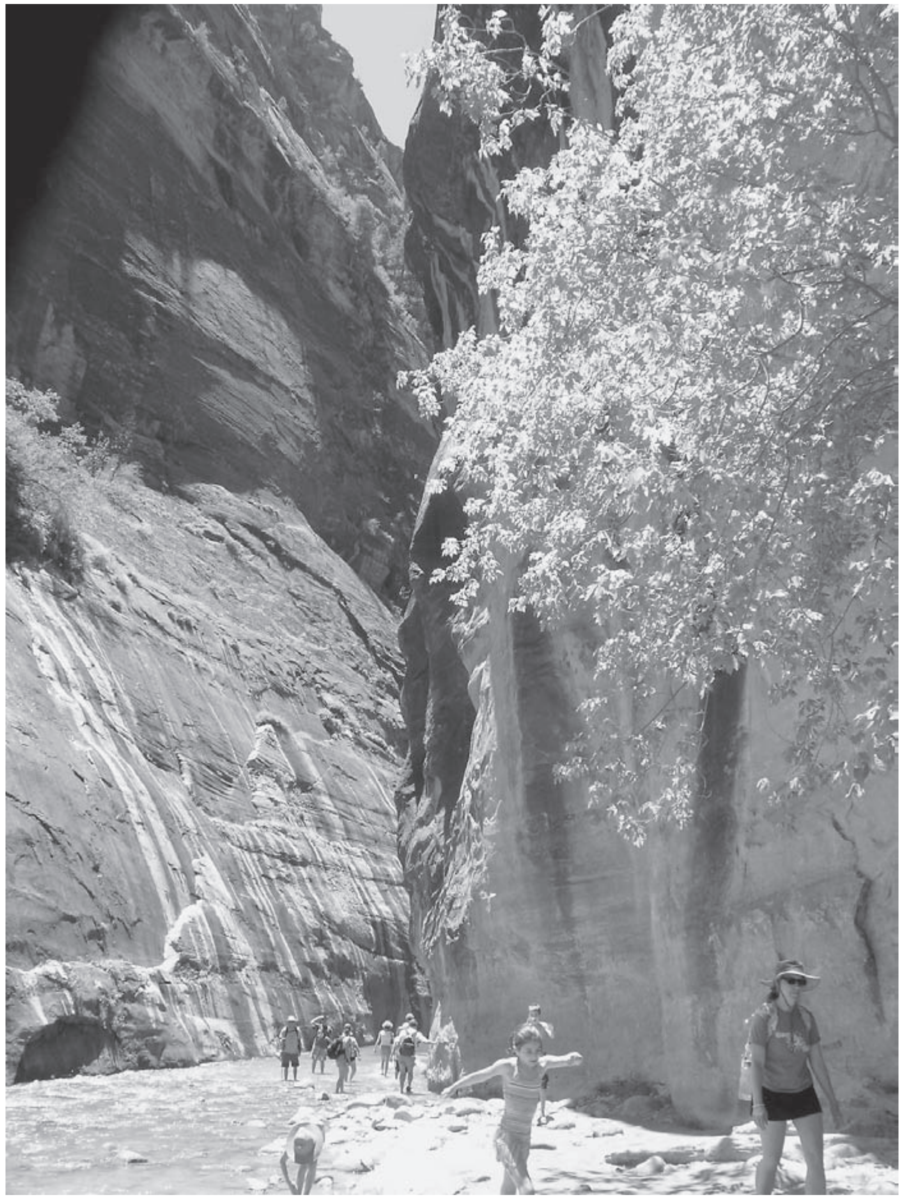

**Figure 9. The Narrows, a 600-meter-deep slot canyon at the upper end of Zion Canyon, Zion National Park.**

Another evidence of rapid lithification is the vertical cliffs of cross-bedded sandstone at such places as Zion National Park. These cliffs are over 600 m high (Figure 9) and were hard prior to erosion. The same can be said of any other deep, vertically-walled canyon carved into sedimentary rocks, such as the Grand Canyon. Since the scale of erosion implies late Flood runoff (Walker, 1994), lithification must have occurred between deposition and canyon cutting—at most a matter of months.

Another example of Flood-lithified sediments is their erosion into planation surfaces, and these are ubiquitous (Figures 10 and 11). Since they most likely formed late in the Flood, the underlying sediments must have been already lithified (Oard, 2004; 2007; 2008). Pediments are planation surfaces at the foot of mountains or a ridge. Such surfaces are often cut across granite and

**Figure 10. Flat-topped granitic mountains, northwest Wind River Mountains, Wyoming.**

**Figure 11. Flat-topped Gypsum Mountain, northwest Wind River Mountains, Wyoming. This mountain is composed of limestone dipping about 40° to the west (right). Gypsum Mountain is located just west of the granitic mountains shown in figure 10, indicating planation sheared both igneous and sedimentary rocks in the Wind River Mountains.**

tilted layers of sandstone and shale of all uniformitarian ages (Figures 12 and 13). The fact that most planation surfaces and pediments are capped by rounded rocks is further evidence for late Flood erosion. These surfaces would appear much different if the rocks below had been soft sediment or molten granite when they were eroded. Like rapidly formed Flood clasts and canyons carved into hard sedimentary rock, these planation surfaces and pediments are evidence for the development of lithified sediments during the Flood. If it must be possible that lithification can occur rapidly, then only empirical field research can determine which rocks lithified at what time.

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**Figure 12. Pediment in the Ruby Valley along the western slope of the Gravelly Range, Southwest Montana. Note that the valley-fill sedimentary rocks dip right (east), while the surface of the pediment dips left (west) and truncates the sedimentary layers evenly at a low angle.**

**Figure 13. Coarse gravel veneer capping the pediment shown in Figure 12. Note that the clasts are rounded to subrounded, indicating that water truncated the pediment.**

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