Defining the Flood/post-Flood boundary in sedimentary rocks

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There are three main schools of thought in creationist circles on the location of the Flood/post-Flood boundary within the geological column. Because of controversy over the geological column, I have used Walker's biblical geological model[1] to develop diagnostic criteria for the boundary. Six qualitative diagnostic criteria typical of the Inundatory Stage and five criteria associated with the Recessive Stage of the Flood are developed. One paleoclimatic criterion is presented. Many examples of the use of the criteria are mentioned.

The placement of the Flood/post-Flood boundary in sedimentary rocks is important within Flood geology. The placement of the boundary affects our view of the Flood, such as its catastrophic extent, the detail of events, the amount and intensity of post-Flood geological events, etc. For instance, it makes a difference whether the boundary is in the late Cenozoic or at the Cretaceous/Tertiary boundary when it comes to the number and variety of animals that disperse after the Flood from ark representatives.[2,3] It may also affect burgeoning creationist research in baraminology. However, the location of the Flood/post-Flood boundary is quite controversial. With respect to the geological column, there have been three main schools of thought[4] (figure 1).

The first believes that the Flood/post-Flood boundary is generally in the late Paleozoic.[5–13] However, Robinson has recently moved the boundary from just below the Permian into the *Precambrian*.[14] Lowering the boundary within the geological column is a predictable progression since some of the criteria used to define a post-Flood environment in this school of thought, such as hardgrounds, are also found in the early Paleozoic.[15]

In the case of hardgrounds, why not, instead, question whether such features require a long period of time, and whether the unique catastrophic event of the one-year Flood could have developed them? A creationist needs to collect as much information as possible on hardgrounds, and then thoroughly analyze it before accepting uniformitarian conclusions. Even if such features are difficult to fit into a Flood chronology, it does not mean that the Flood could not form them. We still lack much knowledge of the Flood. Even a cursory look at the definition of hardgrounds shows it to be equivocal. There are indications of rapid formation, and enough uniformitarian 'mysteries' that leave room for alternative interpretations.[15–17]

The second school of thought believes the Flood/post-Flood boundary is near the Cretaceous/Tertiary (K/T) boundary.[18–22] Most, if not all, the Cenozoic strata would be post-Flood. Such a belief has spawned other creationist hypotheses, such as the dam-breach hypothesis for the origin of the Grand Canyon.[23] The Grand Canyon formed in 'late Cenozoic' time according to the uniformitarian geological column, and therefore must have been carved in post-Flood time, according to this school of thought.

Great tectonic uplift occurred during the Cenozoic; consequently, this school of thought automatically postulates that most mountain ranges arose in the post-Flood period without providing evidence. An example is the Sierra Nevada Mountains in California, USA.[24]

The third school of thought believes the Flood/post-Flood boundary is near the end of the Cenozoic.[25–31] In practice, this school of thought believes that practically all the lithified sedimentary rocks are from the Flood, and the boundary is near, or at the surface of these rocks.

The above schools of thought represent a considerable divergence of opinion, and as a result, contradictory concepts of the Flood have developed. All three schools of thought have used informal criteria. No set of criteria has been published against which the Flood/post-Flood boundary can be defined.

This article presents a set of diagnostic criteria with which to determine the Flood/post-Flood boundary, similar to the criteria developed by Walker[1] for distinguishing various stages and phases of the Flood. The list of criteria is not exhaustive, and there may be debate on the relevance of each criterion. The criteria are currently qualitative, but it is hoped that further research will enable quantification.

Biblical basis for defining the Flood/post-Flood boundary

Because of the controversy of how the geological column fits into a Flood model,[32] I will apply Walker's[1] biblical geological model for the Flood, which is similar to Froede's model.[33] Both models are based on Scripture and reasonable deductions of what is expected in a global Flood. Walker's model (figure 2) is preferred because it has diagnostic criteria. Klevberg modified the length of the Inundatory Stage to last 150 days, at which time the entire globe was finally covered by water. Then the Floodwaters retreat off the continents during the Recessive Stage that lasted 221 days. Walker divides each stage into phases. Following the Flood, there was an Ice Age of roughly 700 years duration.[33–35] Otherwise, general 'uniformitarian'

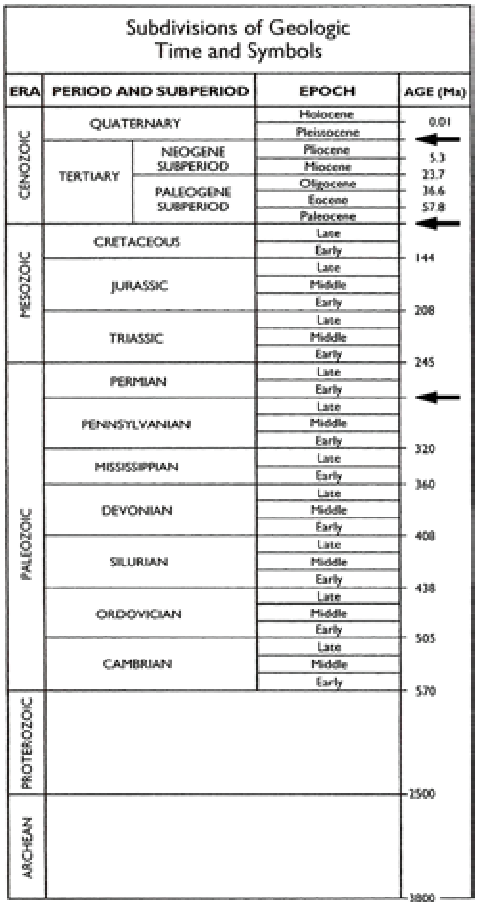

Figure 1. The uniformitarian geological column and time scale.[60] The three main locations that creationists have postulated for the Flood/post-Flood boundary are in the late Paleozoic, the Mesozoic/Cenozoic boundary, and in the late Cenozoic (shown in age column by arrows).

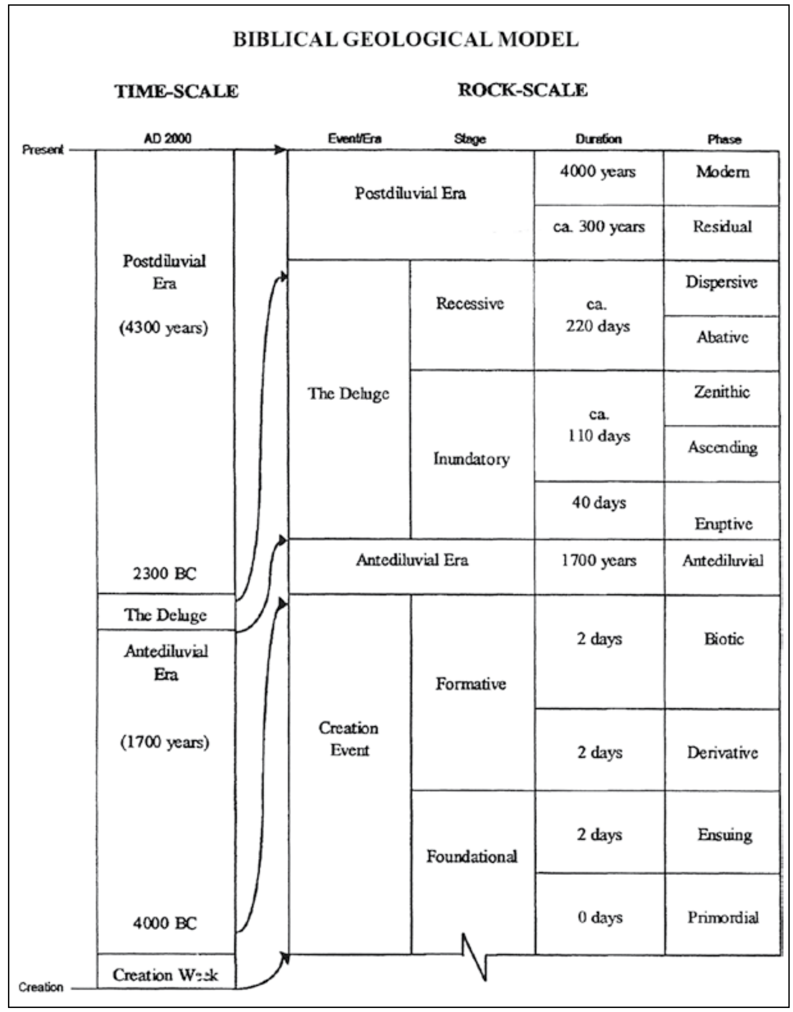

Figure 2. Walker's biblical geological model (permission from Tasman Walker with modification by Peter Klevberg for the length of the stages and phases).

conditions with no significant post-Flood catastrophism prevailed after the Flood.

The first two schools of thought would believe that a significant portion of the strata was laid down by 'post-Flood catastrophism.' Some 'catastrophes' did indeed occur, such as the Ice Age and giant Ice Age floods.[35,36] But the scale of the catastrophes in the post-Flood catastrophism view are much more immense, possibly on the scale of the Flood itself. There are reasons why such post-Flood catastrophism would threaten post-Flood life on Earth.[37] The dam-breach hypothesis for the origin of the Grand Canyon seems to be one of the few 'post-Flood catastrophic' hypotheses published in creationist literature.[23,38] However, to account for all the erosion, sedimentation and tectonics attributed to just the 'Cenozoic' would require much greater catastrophic action than postulated by the dam-breach hypothesis. Until further information is available on post-Flood catastrophism, Walker's biblical geological model, which is close to the ideas of Whitcomb and Morris,[25] will be applied.

Inundatory Stage diagnostic criteria

This section will develop criteria mainly caused by the Inundatory Stage of Walker's model.[1] The one following will present criteria for determining Flood strata mainly from the Recessive Stage of the Flood. Every criterion will have exceptions—nature is complex. That is why I will provide multiple criteria. The boundary will be determined easily in some areas, but it will be equivocal in other areas. Further refinement of the diagnostic criteria can potentially classify these equivocal areas into either the Flood or post-Flood period.

Thin, widespread sediments

Early in the Genesis Flood, regional or continental scale currents would be likely. These currents would spread sediments as a sheet over extensive areas. The sheets would be relatively thin vertically. Due to erosion, some of these widespread layers may have been dissected into remnants. However, these remnants should match lithologically across the eroded regions.

In areas with stacked sedimentary sheets, little evidence of erosion between layers would be observed, since the sediments were deposited rapidly.[39] Although the Flood could erode channels in depositional layers, channels should be rare. On the other hand, one would expect extensive erosion with many deep channels cutting practically all bedding planes if the sediments were laid down over millions of years. When we examine sedimentary rocks, we rarely observe channels at bedding planes or boundaries between layers, such as in the Grand Canyon (figure 3). The contacts between sedimentary formations are sometimes razor sharp over large areas (figure 4). Such a signature is a theme worldwide.[39] What better direct evidence is there for the Genesis Flood? The Flood boundary would be above these stacked sedimentary rock layers.

Post-Flood sedimentation would be local with a two-dimensional aspect, such as deposition along a flood plain, along the continental shelf as spread by long-shore currents, or as submarine slides perpendicular to the continental shelf. Horizontally extensive sheets of strata would be unexpected during the post-Flood period. River deltas are an example of three-dimensional deposition, but they are still small compared to sedimentary layers deposited during the Flood. Besides, river deltas have a more chaotic sedimentary fabric, unlike most Flood deposits. River deltas possess abundant cut and fill structures, slides and slumps, as observed on the Mississippi River delta.

Huge volume

Sedimentation today is very slow, except locally in a landslide, volcanic eruption, or in glaciated areas. Average sediment accumulation should be nil in approximately 5,000 years since the Flood. Even landslide accumulation has a small volume. The largest surficial landslides on the continents are only about 25 km^3 in volume.[40]

When we examine some of the formations across the earth, the volumes of many formations are huge. Ager made a point that some formations extend significantly farther than most geologists realized.[41] For example, the Coconino sandstone in the Grand Canyon (the white layer at the top of figure 3) and its equivalents outside the canyon represent a volume of 41,000 km^3.[42] The Coconino sandstone and the many other large volume sedimentary layers would be laid down during the Flood.

Lithified sediments

Sediments are converted into sedimentary rock by a combination of compaction and the precipitation of cement around sediment grains.[43] In order for the cement to work its way into the sediments, groundwater must readily flow through the pore spaces. Calcite and silica are the main cementing agents; iron oxides, other carbonate minerals, and clay minerals are minor agents. Thus, dissolved ions of mainly calcite and silica must flow through the pore spaces and precipitate in the voids between the grains. The grains themselves can be disintegrated in the lithification process by solution and then be redeposited as cement.

Flood deposition would rapidly deposit thick sediments, which would compact rapidly. The floodwaters would have contained dissolved substances in high concentrations, calcite and silica likely being common minerals in solution. When first deposited, sediments would be saturated with

Figure 3. Grand Canyon (view north from Mather Point, South Rim).

Figure 4. Knife-sharp contact between the Coconino Sandstone (light) and Hermit Shale (dark lower) of the Grand Canyon (view southwest from viewpoint just east of North Rim Lodge). Note the flat upper contact with the Toroweap Formation. These contact relationships exist throughout the Grand Canyon. The Coconino Sandstone is suppose to be a wind-blown desert deposit, but what desert deposit today possesses such a flat lower contact over such a large area, and if covered by more sediments, would form a flat upper contact? It is unlikely the Coconino Sandstone is aeolian.

ion-charged water. The weight of the rapidly deposited sediments would force the water out of the sediments with increasing hydraulic pressure. As the water is forced through the sediments, rapid flow of water would result in rapid lithification. It is of course expected that lithification would be incomplete in some sediments due to either a lack of compaction or insufficient cementing agents.

In the post-Flood environment, both compaction and cementing agents would be lacking. Few, if any, post-Flood environments would collect thick sediments for significant compaction. Groundwater moving through the sediments likely would lack cementing agents. Thus, lithification would be expected to be local at best after the Flood.

Therefore, lithified sedimentary rocks would be a good criterion for distinguishing between Flood and post-Flood deposits. The Flood/post-Flood boundary would be *above* the lithified sediments. I emphasize *above* because some of the unconsolidated sediments above the lithified sediments may be from the Flood.

The cementing of sediments is actually a uniformitarian problem today. Pettijohn states that in the lithification of a 100-m thick layer of sand, 25–30 m of cement must be deposited within the pore spaces (assuming little compaction).[44] But the origin of this cement, and how and when the sediment is cemented, is unresolved:

> 'Cementation, moreover, is the last step in the formation of the sandstone, and our knowledge is incomplete and unsatisfactory unless the origin and manner of emplacement of the cement are fully understood ... The problems of how and when sands become cemented and the source of the cementing material are still unresolved.'[45]

The same problem of lithification of sandstone, as well as other sediments (except possibly carbonates) would also occur in the post-Flood environment.

Permineralized fossils

An organism must first be buried rapidly to become a fossil. Otherwise predators, scavengers and the many biological and mechanical processes will destroy the remains.[46] Even the shells of marine organisms degrade rapidly, since the shell is made up calcium carbonate held together by a network of *organic* tissue. Once the organic tissue is degraded, the shell falls apart. Raup and Stanley noted:

> 'As soon as an oyster or other mollusc dies, its shell is subject to deterioration resulting from attack by a great variety of boring organisms, including worms, sponges, other molluscs, and algae. Most sea bottoms on which living shelled organisms are abundant have surprisingly few intact, empty shells.'[47]

Even if an organism is buried rapidly, it is not guaranteed to become a fossil. Biological and chemical degradation, even of hard parts, continues *within* the sediment.

Even if an organism is buried and protected from biological and chemical decomposition, it still must be fossilized. Organic matter must be replaced, or the spaces between organic matter must be filled by inorganic chemicals. This process is called permineralization (the rarer fossilization mechanisms, like carbonization, will not be discussed). Calcium carbonate and silica are the most common chemicals that cause permineralization.[48] They are also the most common cementing agents for sediments. The replacement process must act quickly, or else even the bones and shells decay. In the world today, modern ground water is too low in silica;[49] as a result, permineralization, as well as lithification of sediments, is rare.

On the other hand, organisms can become fossilized rapidly during the Genesis Flood. Similar to the lithification of sediments, rapid deposition of water-saturated sediment would cause chemically charged water to pass through the sediment pores under high pressure. These chemicals would cause rapid permineralization and explain the billions of fossils, the beautiful state of preservation of some fossils and the fossilization of huge graveyards of organisms, such as dinosaurs[50] and fish[51] over many thousands of square kilometres. Most dinosaur remains are permineralized, so most dinosaurs were very likely buried in the Flood. Exceptions can occur, possibly due to a lack of cementing chemicals. An interesting example is a generally unpermineralized *T. rex* unearthed from northeast Montana.[52,53]

Therefore, the Flood could cause rapid fossilization, while the conditions would be rare in the post-Flood period. Raup and Stanley conclude:

> 'The more we investigate the difficulties of fossil preservation, the more surprised we become that the fossil record is as good as it is ... it has been suggested in this chapter that geologically unusual or even catastrophic conditions contribute to the preservation of fossils. But to what degree? We do not have enough information yet to answer this question.'[54]

We can thus use the vastly different fossilization potentials of the Flood and post-Flood period to define the boundary separating the two. A permineralized fossil is likely from the Flood, while one that is surficial and not permineralized likely would be from post-Flood time.

Thick, pure coal seams

Coal is not expected to form after the Flood in any significant quantities.[55] Thick and widespread coal seams of nearly pure, low ash coal seem impossible to form under uniformitarian or post-Flood conditions.[30,56] There are many coal layers in the 'early Cenozoic'; e.g. in the Powder River Basin of northeast Wyoming and southeast Montana (figure 5). Some of these nearly pure coal seams extend about 100 km north-south, 25 km east-west, and range up to 75 m thick in the Powder River Basin! 75 m of coal represents about 500 m of almost pure peat, if the ratio of peat to coal thickness is 7 to 1. How could such a thick layer of peat develop, subside slowly and be protected from all the vicissitudes of weather, stream deposition and other factors that would impinge on such a peat bed over millions of years, or in the post-Flood period?

It is uncertain how such huge coal beds formed during the Flood, but large-scale Flood catastrophism at least has *the scale and potential* to explain such unique deposits. Uniformitarianism seems hopeless; modern analogs are woefully inadequate. Thus, coal seams, especially if they are pure and of large volume, would be a good criterion for Flood deposition. The Powder River coal seams also imply that the Flood/post-Flood boundary is at least above the 'early Cenozoic' of the geological column in this area.

Widespread and/or thick 'evaporites'

Evaporites form slowly today and cover small areas. So, one would not expect to see evaporites of significant volume formed in the post-Flood period. Some of the 'evaporites' in the rock record are huge, covering tens of thousands of km^2 and are over 1 km thick. Such deposits are likely *precipitates* from the Flood. For instance, an 'evaporite' layer found in and around the Mediterranean Sea covers *2.5 million km^2 up to 1.8 km deep*.[57] Such a deposit is attributed to the 'Messinian salinity crisis' in which the Mediterranean Sea supposedly dried out numerous times. Some now question whether the Mediterranean Sea dried out at all.[58] Regardless, it is very difficult to conceive of the Mediterranean Sea drying in the post-Flood period, or that any widespread, thick 'evaporite' was deposited after the Flood. The Flood/post-Flood boundary must be stratigraphically above the 'late Miocene' date of this deposit in the Mediterranean Sea area. This would put the boundary near the upper part of the 'late Cenozoic'.

Another very thick 'evaporite' of only about 200 km^2 in area occupies the Hualapai basin of northwestern Arizona, just west of the Grand Wash Cliffs southeast of Lake Meade.[59] This deposit is 'nonmarine' halite or salt that is 2.5 km thick! It is dated as Miocene, but it defies common sense to place this thick 'evaporite' in the post-Flood period. The Flood/post-Flood boundary must be above this 'evaporite' in this area. Assuming the geological column, the boundary would be in the upper part of the 'late Cenozoic'.

Table 1 presents the above six criteria generally defining the Inundatory Stage of the Flood.

Table 1. List of Inundatory Stage criteria.

Thin, horizontally widespread sediments or sedimentary rocks
Large volume of sediment or sedimentary rocks
Lithified sediments
Permineralized fossils
Coal
Large volume of 'evaporites'

Figure 5. Part of Wyodak coal seam just east of Gillette, Wyoming, in the Powder River Basin.

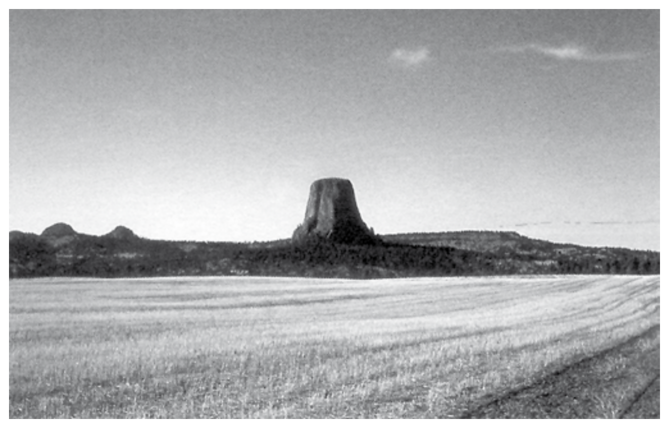

Figure 6. Devils Tower, northeast Wyoming, stands 245 m above the surrounding plains and 400 m above the rivers of the region. This well-jointed igneous rock, the throat of a volcano, was once covered by sedimentary rocks. The Tower could not have remained standing for the tens of millions of years the plains were eroding all around. It is more indicative of rapid sheet erosion of the plains that left behind a few harder remnants. (From Oard,[36] p. 75).

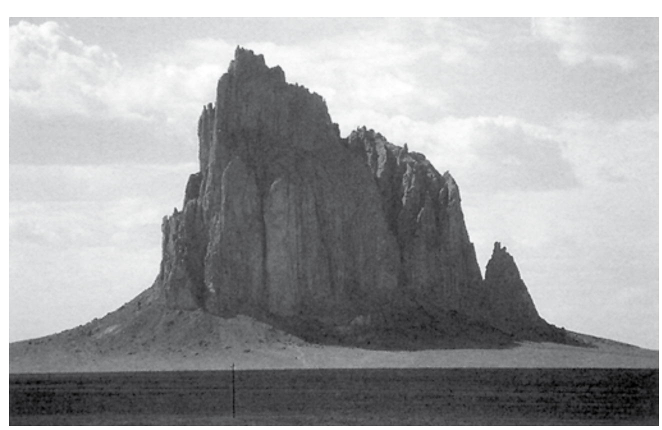

Figure 7. Ship Rock, northwest New Mexico, stands 520 m above a wide valley. It too is an igneous erosional remnant that is the throat of a volcano, like Devils Tower. (From Oard,[36] p. 75).

Recessive Stage diagnostic criteria

The last major event of the Flood on the continents was the Recessive Stage of the Flood.[1] This stage began as the Sheet Flow (Abative) Phase and slowly transformed over 221 days into the Channelized Flow (Dispersive) Phase (figure 2). During this stage, the Floodwater rushed off the continents into the ocean basins as the land uplifted and became more exposed.[30,60] Such catastrophically flowing water would have shaped the earth's surface into unique landforms.

Has denudation since the Flood erased these landforms? Summerfield provides a summary of current average denudation rates versus various climates and reliefs (table 2).[61] Erosion rates vary from 1.5–10 mm/1000 years for a low relief, tropical climate to 95–740 mm/1000 years for mountainous areas with high precipitation. Since the Flood ended about 4500 years ago, denudation would have been slight. Of course, there are local and regional areas of much higher erosion, such as badlands, but badlands cover small areas. Denudation is expected to be greater during the Ice Age, but such denudation should not be significant.[62] Thus, landforms created during the Recessive Stage of the Flood—the last major event, besides the Ice Age, to impact the surface of the earth—should be *evident*. Since the landforms were carved by a catastrophic flow of water, one would expect that uniformitarian or post-Flood processes would be inadequate to explain the landforms, although many uniformitarian hypotheses are in the literature. In fact, these unique Flood-derived landforms could be used to test whether significant post-Flood catastrophism has occurred.

Table 2. Average denudation rate in millimetres over 5,000 years with respect to climate and relief.[61]

	Mountainous	Rough	Smooth
High Precipitation	2,100	370	90
Low Precipitation	1,040	370	90
Tropical			30
Subarctic			60

Abundant evidence exists for the Recessive Stage of the Flood.[30,63,64] There is a long history of failed uniformitarian hypotheses to explain many types of landforms, such as tall erosional remnants, planation surfaces, water gaps, inselbergs, pediments, submarine canyons, continental shelves and slopes, and other features of the earth's surface.[30,60,64–66] There are no post-Flood hypotheses for the formation of these features, except for the Grand Canyon water gap. I will briefly discuss some of these features in relation to the Flood/post-Flood boundary.

Tall erosional remnants demonstrate rapid continental erosion

Great denudation of the western United States has occurred. More than 300 m of sedimentary rock has been stripped from the High Plains of Montana and Wyoming. A few kilometres of strata likely were removed from southern Arizona.[31] Erosional remnants of this great denudation were sometimes left behind.

One of the best indicators of rapid erosion is Devils Tower, northeast Wyoming (figure 6). All the plains strata surrounding the tower were eroded during more than 40 million years of geological time. But the tower continues to stand, almost untouched by erosion! I would expect Devils Tower to be a pile of boulders in less than 100,000 years, especially in view of freeze-thaw weathering. Notice in figure 6 that the igneous rocks of Devils Tower are well jointed. Water would lodge in the cracks, freeze, and break up the well-joined monument in a relatively short time. Devils Tower is better explained by a wide current of water associated with the Flood rapidly eroding the plains sedimentary rocks, but leaving behind more resistant rocks.[64]

There are many other erosional remnants in the western United States, such as Ship Rock in northwest New Mexico that is 520 m high (figure 7), Pumpkin Buttes in the center of the Power River Basin, Square Butte in central Montana, and the Cypress Hills in southeast Alberta and southwest Saskatchewan, Canada.

It then follows that the sedimentary rocks *left behind* after the great continental denudation are from the Flood. Therefore, the strata surrounding these remnants are from the Flood. Relative dating of all these erosional remnants would favor a general Flood/post-Flood boundary in the late Cenozoic of the geological time scale.

It was because of many thousands of metres of deposition of the Green River Formation and equivalent formations over a huge area in southwest Wyoming and northeast Utah, followed by *over 600 m of denudation in much of the area*, that especially persuaded me that these formations were laid down in the Flood.[67]

Planation surfaces and pediments

Planation or erosion surfaces are one of the strongest evidences demonstrating that the Flood really occurred.[60–66] A planation surface is a flat erosion surface. According to the *Dictionary of Geological Terms*, an erosion surface is defined as: 'A land surface shaped and subdued by the action of erosion, esp. by running water. The term is generally applied to a level or nearly level surface.'[68] Running water is involved because planation surfaces are often capped by rounded rocks. A pediment is a type of planation surface formed at the foot of a mountain or ridge. A pediment is officially defined as: 'A broad sloping erosion surface or plain of low relief, typically developed by running water, in an arid or semiarid region at the base of an abrupt and receding mountain front.'[69] Pediments are not restricted to just semiarid environments. As the Floodwaters rushed off the continents, planation surfaces would form over large areas (figure 8).

Figure 8. The flat surface on top of Cypress Hills at Upper Battle Creek. Surface has been partially dissected, likely from glacial meltwater rivers, since large crystalline boulders were found within the valley. (From Oard *et al.*,[73] p. 80).

Figure 9. Well-rounded quartzite rocks on top of the Teton Mountains transported from around 320 km to the northwest. (From Oard *et al.*,[73] p. 87).

Figure 10. Well-rounded quartzite rocks from on top of the Gravelly Range, southwest Montana. (From Oard *et al.*,[73] p. 85).

Figure 11. Well-rounded quartzite rock, weighing about 200 kg, from on top of the Wallowa Mountains, northeast Oregon (photo by Paul Kollas). (From Oard *et al.*,[74] p. 74).

Figure 12. Well-rounded quartzite cobbles from on top of Gold Hill, Blue Mountains, 45 km north of Burns, central Oregon. The mountain is called Gold Hill because gold is also found within the quartzite gravel (photo by John Hergenrather). (From Oard *et al.*,[74] p. 73).

The significant aspect of planation surfaces, as well as pediments, is that they are not forming today, except on a very small scale when a river erodes its banks. Rivers and streams are actively *destroying* planation surfaces, but planation surfaces are common and worldwide, indicating a *global* Flood. Some planation surfaces cover thousands of km^2. Thus, sedimentary rocks below planation surfaces and pediments would be Flood rocks. Since planation surfaces commonly formed in the middle to upper Cenozoic,[70] assuming the geological column, the Flood/post-Flood boundary must be in the late Cenozoic in many areas.

It is inconceivable that planation surfaces and pediments could be formed after the Flood. In fact, abundant planation surfaces and pediments are strong evidence against significant post-Flood catastrophism.

Long-transported cobbles and boulders

If resistant rocks from a known location are found much too far for modern transport processes, they likely would have been transported during Flood runoff. Peter Klevberg, John Hergenrather, and I have traced the location of well-rounded quartzite boulders for distances *greater than 1,000 km* from their known source in the Rocky Mountains.[71–77] Such long transported rocks are known from around other mountain ranges.[31,64]

The location of some of the cobbles and boulders further reinforces the Flood interpretation. For instance, some rounded cobbles are found on plateaus and at least four mountain ranges of the northwest states (figures 9–12). Not only are the coarse gravels from the Flood, but the rock below the gravel would also be from the Flood or before the Flood.

One must be careful with pediment gravel. The gravel on top of a pediment may be the veneer of cobbles and boulders left over from the time the pediment was cut by the Flood. On the other hand, the cobbles and boulders could be post-Flood from the surrounding mountains. Post-Flood deposits would be described as an alluvial fan or coalesced alluvial fans, called a bajada. However, the difference should be rather evident. The fabric and geomorphology of the deposit should determine how the pediment gravel was deposited. Alluvial fans are generally fan shaped extending out from a mountain valley. The fabric of the fan should be more chaotic with many angular rocks and fine-grained interbeds. Pediment gravel from the Flood likely would be more rounded and massive. Flood gravel may contain a proportion of exotic clasts from lithologies that do not outcrop in the mountains above the pediment.

Water and wind gaps

A water gap is: 'A deep pass in a mountain ridge, through which a stream flows; especially a narrow gorge or ravine cut through resistant rocks by an antecedent stream.'[78] An antecedent stream is one of three main uniformitarian hypotheses for the formation of water gaps. A wind gap is: 'A shallow notch in the crest or upper part of a mountain ridge, usually at a higher level than a water gap.'[79] The notch in a ridge usually has to be an erosional notch, not a notch caused by faulting or some other mechanism. In other words, the entire ridge was once at the same altitude, and some mechanism eroded a notch in the top of the ridge.

The existence of water and wind gaps is another one of those geomorphological features that are difficult to explain within the uniformitarian paradigm.[64] There are well over 1,000 water gaps over the Earth. Figure 13 shows the Shoshone water gap near Cody, Wyoming, that is 760 m deep through the Rattlesnake Mountains, east of Yellowstone National Park, USA. It appears that the river continued to flow straight east and somehow cut through the mountains, when the river could have easily passed around the mountain range to the south. Figure 14 shows Buffalo Bill Reservoir west of the water gap. A dam had to be built south of the reservoir to keep the water from flowing south.

Water and wind gaps could easily form during the Recessive Stage of the Flood, in particular the Channelized

Figure 13. Shoshone water gap, near Cody, Wyoming (view west). This gap is 760 m deep through the Rattlesnake Mountains, east of Yellowstone National Park, USA.

Figure 14. Buffalo Bill reservoir and view southeast from the other side of the water gap (arrow). A dam had to be built so the water from the reservoir would not spill southward.

Phase of the Flood when Flood currents flowed perpendicular to a ridge. Such flow can easily erode a notch in a short time that would become a wind or water gap after the Flood. An analog for the formation of water and wind gaps occurred during the Lake Missoula flood when water overtopped a ridge and excavated two vertical walled canyons 150 m deep.[64,80,81] Instead of flowing west into the Columbia River as before, the Palouse River at the end of the Lake Missoula flood took a left hand turn and now flows through one of the gaps into the Snake River. Devils Coulee, the other gap cut in the ridge, has an obstruction at its entrance and, therefore, is a wind gap.

Since water and wind gaps are typical Flood carved features, the Flood/post-Flood boundary would include any feature that can be relatively dated with respect to these geomorphic features. In other words, any strata that were deposited or eroded before the cutting of the water and wind gap would be from the Flood. For instance, there are 300 water gaps in the Zagros Mountains that are as deep as 2,500 m.[82] The formation of the mountains cut by these water gaps would have been during the Flood. The Zagros Mountains are dated as *Pliocene* or late Cenozoic, so the Flood/post-Flood boundary would be somewhere in the Pleistocene in this region.

Some creationists automatically assume the Pleistocene refers to the Ice Age and must be post-Flood. However, much Pleistocene strata is unrelated to the Ice Age or any obvious surficial post-Flood process. Pleistocene strata in many cases are just a continuation of Cenozoic strata that have been dated by certain index fossils. To determine whether Pleistocene strata are Flood or post-Flood, every case must be evaluated by diagnostic criteria. Based on careful analysis of many geological features, Holt concluded that the Flood/post-Flood boundary generally occurs in the mid Pleistocene and that practically all the sedimentary rocks are from the Flood:

> 'Evidences … place the Flood/post-Flood boundary during or after the mid-Pleistocene. It is not clear how the evidences presented could be interpreted in a different manner.
>
> 'The Flood/post-Flood boundary is near the surface of the Earth's sediments, independent of one's viewpoint of the geological column …'[83]

Continental margins

The debris eroded from the continents during sheet erosion has to go somewhere. This sediment would continue to move off the uplifting continents as a sheet, until the currents decreased upon reaching deeper water at the edge of the continents. The velocity drop would be similar to water moving through a narrow pipe and suddenly coming to a wide pipe. The areas of deeper water would be at the edge of the continents, called the continental margin, or in deep basins near the continental margin. Such deep basins would include rift basins along the continental margin[84] and possibly in such areas as the lower Mississippi River Valley where very thick sedimentary rocks occur.

Thus, the continental shelf, slope and rise would be deposits from the Sheet Flow Phase of the Recessive Stage of the Flood.[85] Submarine canyons, deep erosional channels perpendicular to the coast, likely were cut during the subsequent Channelized Phase of the Flood.[64] The continental margin sedimentary rocks are often quite thick. One of the deepest basins along the continental margin is the Baltimore canyon trough off the central East Coast of the United States, extending from Cape Hatteras to Long Island[86] This basin covers 200,000 km^2 with a maximum depth of 18 km of continental margin sedimentary rock! Another very deep basin is the 20 km deep Jeanne d'Arc Basin, offshore from Newfoundland, Canada.[87] Except for some surficial sediments, practically all the continental margin sedimentary rocks should be from the Flood.[64] A majority of the continental margin sediments are Cenozoic. It is doubtful that such a thick layer of sedimentary rock with the unique geomorphological profile of the shelf and slope could form after the Flood, ringing all the continents. Again, the continental margin points to a Flood/post-Flood boundary in the upper Cenozoic along the continental margin.

If a coastal sedimentary layer is part of the continental margin, the coastal strata likely are from the Flood. Some of the Cenozoic formations along the east coast of the United States extend into the continental margin. So, it is likely that these sedimentary rocks are from the Flood.

Table 3 lists the five criteria generally defining the Recessive Stage of the Flood.

Table 3. List of Recessive Stage criteria.

Tall erosional remnants
Planation surfaces and pediments
Long-transported cobbles and boulders
Water and wind gaps
Continental margins

A paleoclimatic criterion

If a fossil indicates that it mostly likely lived in a warm environment, and it is found in an area in which winter temperatures are much colder than the likely tolerance of that organism, the fossil was deposited in the Flood. Granted, some cases are equivocal, and in other cases, the tolerance of some organisms is broader than their current climatic preference. The Siberian tiger is one example of the latter. A few examples would be the finding of palm fossils or a crocodile at high latitudes or in the continental interior at mid latitudes. Post-Flood climates in those regions must have been cold during the winter, especially during the Ice Age that started immediately after the Flood. It is likely that some warm climate organisms lived close to the warm oceans immediately after the Flood, but further information should reveal that the environment was post-Flood.

Probably the most impressive example is the finding of Cretaceous to early Cenozoic flying lemurs, swamp cypress and other warm climate paleoflora, tortoises, alligators, and an extinct type of crocodile from Axel Heiberg and Ellesmere Island about 80°N in the Queen Elizabeth islands of northeast Canada[88,89] A few of these fossils were unpermineralized, but most of them were permineralized. Some of the 'Eocene' swamp cypress could be cut with an axe and burned. These fossils indicate a subtropical to tropical climate while the average temperature in the region is about –20°C with an average winter temperature of around –40°C. Wintertime extreme minimum temperatures are probably around –55°C. It seems obvious that such fossils are from the Flood, and that the Flood/post-Flood boundary in the area is above the Eocene.

Post-Flood diagnostic criteria

Post-Flood diagnostic criteria are based on features that would develop within the past 4,500 years, assuming a rapid post-Flood Ice Age of about 700 years and a 'uniformitarian' environment thereafter. Many features of the landscape are obviously post-Flood and the Flood/post-Flood boundary would lie below these features. Some of these features are surficial soils, surficial Ice Age debris, fluvial deposits from nearby rivers or streams, surficial landslide debris, alluvial fans, shoreline or beach features, lacustrine deposits, tarpits, surficial sand dunes, loess, peat bogs, talus and modern reefs.

There are supposed ancient counterparts for some of these features in the sedimentary rocks, but the surficial features are very likely post-Flood. For example, there are claimed ice age deposits going back to over two billion years in geological time. These deposits are questionable and better explained as gigantic submarine landslides during the Flood.[90] Ancient sand dunes and sand sheets are claimed in the southwest US, such as the Coconino and Navajo sandstones. These sandstones display cross-beds and are likely marine sand deposits.[91,92] They are also likely from the Flood. The sharpness of the contacts is unlike any present day sand deposits (see figure 4).

From these diagnostic criteria and the Flood diagnostic criteria, the approximate position of the Flood/post-Flood boundary can be established in many areas.

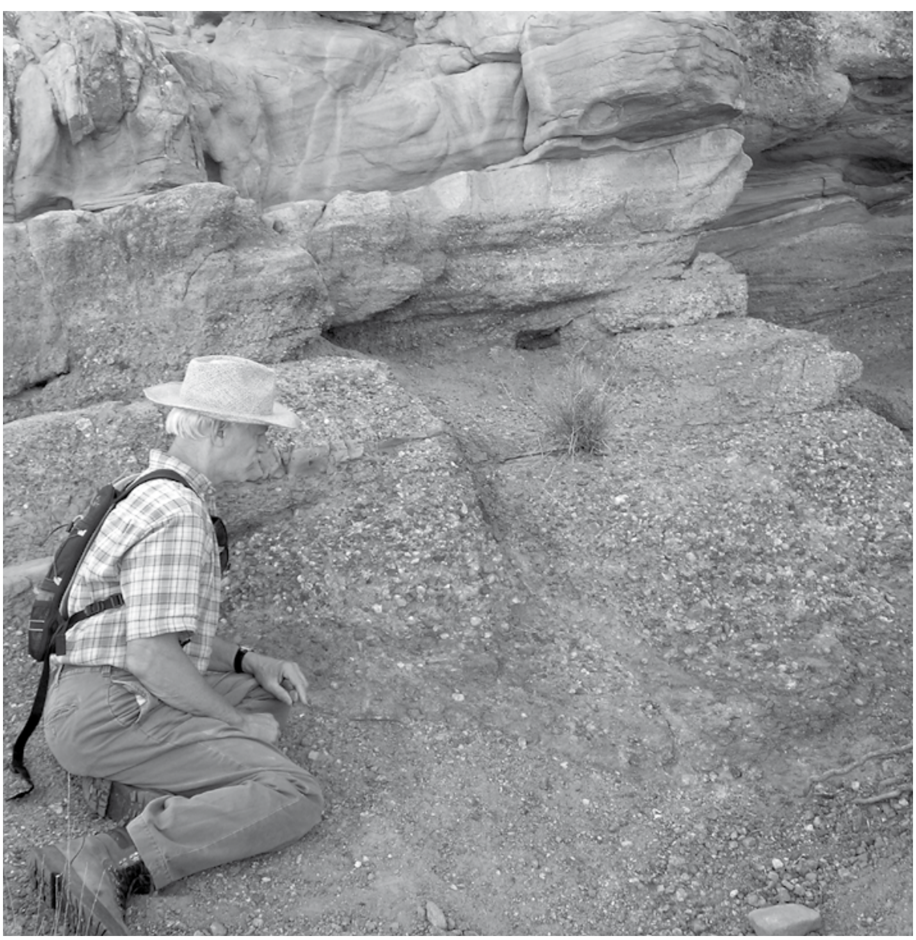

Figure 15. Shinarump conglomerate at Canyon d'Chelly, northeast Arizona.

Figure 16. Vertical petrified tree from Yellowstone National Park, protruding about 4.5 m out of the ground. It was likely exposed during the Recessive Stage of the Flood, as per criterion 1 in table 3.

Examples of locating the Flood/post-Flood boundary

I have already provided examples utilizing one or more criteria for locating the Flood/post-Flood boundary. Several more will be presented.

The Shinarump Conglomerate outcrops over 260,000 km^2 on the Colorado Plateau and is only about 15 m thick.[93] The formation consists of sand and rounded pebbles (figure 15). It is also lithified. Thus, from the first three criteria presented in tables 1 and 3, the deposit is likely from the Flood. It is dated as Mesozoic in the geological column.

Based on the criteria from Tables 1 and 3, the lithified strata below the thin surficial soils on the plains of Montana are likely from the Flood. This designation is based on the first five criteria in table 1 and the first three criteria in table 3. The plains strata of Montana are dated as Cretaceous and early Cenozoic.

The extensive fossil 'forests' of Yellowstone National Park are found in volcanic lahars over an extensive area in eastern and northern Yellowstone Park.[94] The layers are stacked one on top of another for many hundreds of metres. The deposits are lithified, and petrified trees (figure 16) are found at many levels in various areas, with little if any evidence for soils. After the deposit was laid down, channelized erosion took out over 1,000 m of the deposit in some areas. Based on criteria one to four of table 1 and criteria one of table 3, the lahars and fossil 'forests' are likely from the Flood. The layers containing the fossil forests are dated as early Cenozoic.

Woolly mammoth fossils are found by the millions in Siberia, Alaska, the Yukon, and the shallow continental shelves.[35,95] These mammoth bones and tusks are *not* permineralized. They are buried mostly in surficial loess and reworked loess, called 'muck' in Alaska. Based on Flood criterion 1 and 2 in table 1, they could be from the Flood. However, criterion 3 and 4 would say post-Flood. The woolly mammoth is mostly unearthed from surficial wind-blown silt—a typical post-Flood deposit. So, these woolly mammoths likely lived in the post-Flood period, which is dated as late Pleistocene in the geological column

Summary

The three main schools of thought for the location for the Flood/post-Flood boundary, assuming the geological column, were briefly mentioned: (1) the late Paleozoic, (2) the Cretaceous/Tertiary and (3) the late Cenozoic. Because of controversy and confusion over the use of the geological column within Flood geology,[32] I used Walker's biblical geological model[1] and made comparisons to the geological column.

Six Flood diagnostic criteria, mainly from the Inundatory Stage, were laid out: (1) thin, horizontally widespread sedimentary rocks, (2) a large volume of sedimentary rock, (3) lithified sediments, (4) permineralized fossils, (5) coal seams and (6) a large volume of 'evaporites.' Five criteria from the Recessive Stage of the Flood were presented: (1) tall erosional remnants, (2) planation surfaces and pediments, (3) long distance transported cobbles and boulders, (4) water and wind gaps, (5) and continental margin sediments. One paleoclimatic criterion was developed in which organisms from a radically different climate from today would indicate Flood deposition of that fossil. The list is not exhaustive.

There are many surficial post-Flood criteria. These were not developed, since their post-Flood nature should be obvious in most cases. Examples of Flood sediments were presented, such as the Coconino Sandstone, strata containing dinosaur fossils, the coal seams of the Powder River Basin, the Messinian evaporites in the Mediterranean Sea region, the Zagros Mountains, the Shinarump conglomerate, the plains strata of Montana, the lahars containing the Yellowstone fossil 'forests,' and the warm-climate fossils on Axel Heiberg Island. The Flood/post-Flood boundary would be above these features. The surficial woolly mammoth fossils found in loess in Siberia, Alaska and the Yukon are likely post-Flood.

As it turns out, there are many areas of the world where the Flood/post-Flood boundary is in the late Cenozoic. I agree with Holt's view that the boundary is near the surface of the sediments or sedimentary rocks at the earth's surface in most areas.

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