Flood processes into the late Cenozoic: part 5—geomorphological evidence

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Geomorphologic evidence suggests that the post-Flood boundary is best located in the late Cenozoic. Eight lines of reasoning support this conclusion: large-scale, rapid continental erosion; coastal erosional escarpments; planation surfaces; widespread transport and deposition of hard rocks at high elevations; deep valleys; pediments; water and wind gaps; and submarine canyons. Attempts to explain these features by post-Flood catastrophism are limited and, at present, insufficient.

Geology remains a major research need for creation science. Marvellous examples of design in the biological world abound that support the Bible, but this is not so apparent in the geological world. To counter the prevailing teaching that geology supports evolution and deep time, creation scientists need to develop hypotheses consistent with biblical earth history from which a comprehensive Flood model can eventually be created. In this endeavour, it is important to get the boundaries of the Flood correct.

Many evidences support the location of the Flood/post-Flood boundary in the late Cenozoic over most continental areas. These include seven factors within sedimentary rocks,[1] seven from organic remains,[2] five tectonic factors,[3] and others.[4] Very often the boundary is indicated in the very late Cenozoic, near the Pliocene/Pleistocene boundary. Locally, it may be in the Miocene, depending on the rocks present. Thus, we need to evaluate each area on its own merits within the biblical geological model.[5]

This paper will focus on eight lines of geomorphic evidence that suggest the Cenozoic is best explained by Flood runoff, rather than by post-Flood processes (table 1). Geomorphology is fairly straightforward, since it concerns the surface of the earth and mainly deals with the topography. It is a field that elicits evidence for the Flood runoff, and thus helps pinpoint the post-Flood boundary. Despite many Flood studies on the subject, few have been written supporting a Mesozoic/Cenozoic boundary. This paper will only summarize the geomorphological evidence for a late boundary and address arguments that the phenomena are post-Flood.

Enormous and rapid Cenozoic erosion of the continents

Continental rocks of all types have been strongly eroded.[6,7,8] The Colorado Plateau, including the Grand Staircase and the Roan and Book Cliffs, were produced after an average of 2,500–5,000 m of erosion.[9] Hundreds of metres of strata erosion has been documented in the basins and valleys of the Rocky Mountains.[10] The central Appalachian Mountains suggest up to 6,000 m of erosion.[11] Similar significant erosion can also be observed on many other continents.[12] This erosion was rapid and recent, as shown by several areas in the western United States, like Devils Tower, in northeast Wyoming,[13] and Navajo Mountain, at the Arizona/Utah border. Much of the erosion occurred in the Cenozoic, including the late Cenozoic. For instance, the massive erosion of the Colorado Plateau began after early Cenozoic strata were laid down,[9] including the Eocene Green River Formation.[14] The top strata of the Rocky Mountain basins and valleys are early to mid Cenozoic, indicating the erosion occurred during the mid to late Cenozoic.

In contrast, Whitmore has suggested that this erosion was due to the mass wasting of unlithified sediment *after* the Flood. He claimed this erosion was partly caused by abundant rainfall acting on unlithified sediments.[15] However, that hypothesis requires evidential support; no specifics or case studies have been offered in support of mass wasting. If we take the widespread and intense nature of the erosion into account, we see that it is much better explained by Flood runoff.

If mass wasting were responsible for the observed erosion, most of the resulting debris should have been redeposited nearby, on the continents. For instance, mass wasting of the ranges of the Rocky Mountains of the US would have largely moved debris into adjacent valleys and basins or out onto the high plains. But, in general, it appears that most of this eroded material was redeposited on the continental margins.[16] This is consistent with Flood runoff. If the Cenozoic valley fill sedimentary rocks and sediments show evidence of being mass wasting debris, Whitmore and colleagues should substantiate it.

Table 1. Summary of Cenozoic geomorphological evidences best explained by Flood processes. The strength is relative to arguments for a K/Pg (Cretaceous/Paleogene) post-Flood boundary.

Geomorphological evidences	Strength
1. Enormous and rapid erosion of the continents	Strong
2. Erosional escarpments	Moderate
3. Planation surfaces	Strong
4. Long-distance transport of hard rocks	Strong
5. Deep canyons and valleys	Strong
6. Pediments	Strong
7. Water and wind gaps	Strong
8. Submarine canyons	Weak

Erosional escarpments

In addition to volume and extent, the character of the erosion also indicates Flood erosion. For instance, *coastal great escarpment*s (CGEs) are high cliffs or steep slopes found along Atlantic-type or passive continental margins. CGEs are often over 1,000 m high.[17] They tend to run parallel to the coast, but rather than being the result of faulting, they have likely been *eroded inland* from the coast over distances up to 200 km. CGEs separate a high plateau (itself an erosional or planation surface of low relief with erosional remnants) from a coastal plain of moderate relief. Some of the largest changes in topography on earth are CGEs.[18]

The best examples of CGEs are found in southern Africa, eastern Australia, eastern Brazil, and western India.[19] The CGE around southern Africa is over 3,500 km long (figure 1). The elevated plateau above the escarpment is part of a planation surface that covers much of Africa.[20,21] The escarpment is more than 100 km inland along the coast in Namibia and over 200 km inland in southeast Africa. The Drakensberg Great Escarpment of southeast Africa is 3,000 m high. The CGE in eastern Australia is 2,400 km long and is 200–1,000 m high (figure 2). These features are problematic for uniformitarianism, but seem to be readily explained by Flood runoff.[6,7]

These features are also problematic for a post-Flood boundary below the upper Cenozoic. Similar widespread mass-wasting events could have caused large blocks of high-altitude coastal sediments to slide into the oceans. However, if so, large masses of landslide debris on coastal plains, continental shelves, slopes, and rises oceanward of the Great Escarpments would be expected. Until seismic and drilling data indicate that these sedimentary wedges are the result of mass wasting, that hypothesis remains weak.

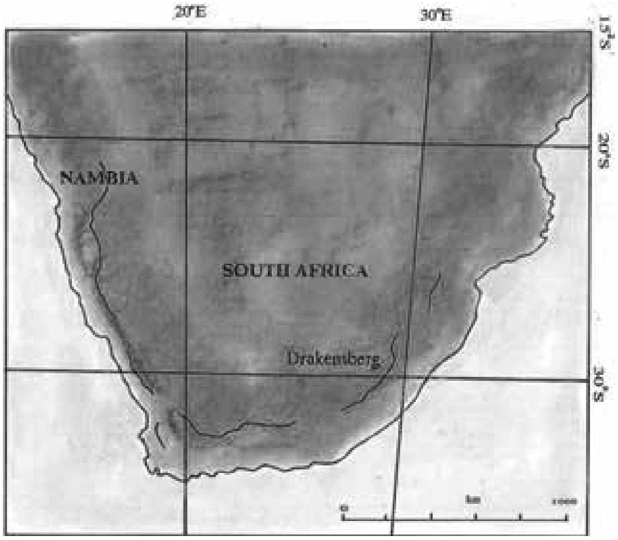

Figure 1. Great Escarpment that parallels most of the coast of Southern Africa (drawn by Melanie Richard)

Figure 2. Australian Great Escarpment in the Grose Valley, west of Sydney, Australia, from Govetts Leap (courtesy of Tas Walker)

Planation surfaces

Planation surfaces are generally flat erosion surfaces, seen in many areas of the world.[22] Some of these surfaces have been exhumed. By comparison, planation surfaces that form when rivers overflow their banks and erode rocks along the bank (today's analogue) are very small.[23] Uniformitarians try to link the physical and temporal scales and extrapolate that such processes can create continent-scale planation surfaces, but field data are not consistent with this idea. Present processes do not form planation surfaces of any *significant size*.

Large planation surfaces are found worldwide. Most of Africa is a planation surface that has been warped and faulted.[18,19] The Tibetan Plateau is another vast, dissected planation surface, which covers about 700,000 km^2. One Chinese scientist described it as a "vast planation surface".[24] Much of Australia is a planation surface, including the Tableland of eastern Australia, which has numerous erosional

Figure 3. Near-vertical sedimentary rocks have been bevelled to form the New England Tableland, Australia, a planation surface. Later, more channelized erosion carved the gorge, now home to the Wollomombi Falls.

Figure 4. Lake on the Piedmont, west of the Blue Ridge Mountains, US, near Parkersville, South Carolina, showing general flatness of the terrain

remnants called inselbergs (figure 3). The Piedmont province, east of the Blue Ridge Mountains of the US (figure 4), represents a planation surface eroded across variably deformed rocks of various lithologies.

Planation surfaces are readily explained by Flood runoff during the Sheet Flow Phase.[25] Only widespread currents flowing at great velocities could create such surfaces. The existence of such currents is reinforced by the veneer of rounded large rocks deposited as a lag on many such surfaces. Instead of being formed today, they are actually being destroyed or reduced by weathering and erosion.

Whitmore and Garner stated that planation or erosion surfaces were formed both by Flood runoff and by post-Flood precipitation:

> “Very widespread erosion surfaces would also be expected to have formed in association with the recession of the ocean waters from the continents at the end of the Flood and with the intense precipitation predicted by models of the early post-Flood climate (Vardiman, 2003).”[26]

Wise also believes that heavy post-Flood precipitation caused sheet erosion, which in turn formed the planation surfaces:

> “If the water came down fast enough, it would not channel itself into streams but rather flow in sheets over the earth’s surface. In some areas this would erode sediments and rocks in a planar fashion. This might provide an explanation for the widespread planing off of rocks evidenced in Tertiary sediments. In other areas the water would slow down enough to begin dropping out the sediments it was carrying. This sheet deposition may provide an explanation for the extensive, nearly-flat wedges found in Tertiary sediments.”[27]

However, there is no evidence to support this idea. No matter how much rain falls, it tends to cut channels, especially in rough terrain. The heavier the rain, the faster the channels form. C.H. Crickmay writes that no modern processes can flatten the land:

> “Flat, near-horizontal land cannot be seen to have been made at the heights at which most of it is now seen. Such landscape [sic] as flat-topped hills or high plateaux shows *no* process in action that might favour or maintain its flatness. Consequently, one cannot say that any geological work *now observable* has made it as flat and level as it is. The completion of its flattening appears to have been in the past. … The very existence of much flat, near-level ground at all elevations demonstrates not only its extensive forming, but also its long survival [emphasis added].”[28]

One hypothesis for the origin of pediments proposes sheet flooding from intense thunderstorms.[29,30] Shallow sheet flooding has indeed been observed during thunderstorms in dry environments.[31] Can these sheetfloods cause planar erosion? No, because the flat surface must *first* exist. This is a fatal flaw in the hypothesis. Oberlander stated:

> “Early proposals that erosive sheetfloods could form pediments are defeated by the fact that sheetfloods require planar surfaces and are a consequence rather than a cause of planation.”[32]

Besides, one can produce only so much rain in a cloud volume. Even hypothetical ‘hypercanes’ could not generate enough precipitation to plane large areas.

Long-distance transport of durable detritus

During Flood-scale erosion, rocks of all hardness were eroded. Soft rocks, like shale, were quickly pulverized. Harder rocks, such as quartzite, were transported long distances, rounded, and then deposited as the currents slowed. For instance, we observe thick-bedded quartzite outcrops in the western Rocky Mountains of northern and central Idaho and extreme western Montana. These quartzite rocks are mostly from the Precambrian Belt Supergroup. These were eroded, and the detritus, ranging up to boulder size, was rounded and carried across the region.[6,7] West of the continental divide, these rounded quartzite rocks were found all the way to the Pacific Ocean, 600 km away. East of the continental divide, they were carried onto the plains of southern Canada, up to 1,300 km. Well-rounded quartzites accumulated in deep basins in thicknesses up to 4,575 m. Close examination of the individual rocks shows the presence of percussion marks—semicircular, shallow cracks indicative of high-velocity impacts during transport.[33] Such marks have not been observed to have formed in modern settings.

Durable rocks also accumulate in thick deposits close to the edge of rising mountain ranges, like the Himalaya, Tian Shan, and Zagros ranges in Asia, as well as the Tibetan Plateau.[34] The resulting conglomerates reach over 1,800 m in thickness, and form sheets up to thousands of km across, along the edge of the mountains. One such deposit, adjacent to the western Himalaya Mountains, is 3,400 m thick.[35] The gravel thins away from the mountains, towards the centre of the surrounding basins.

Almost all of this occurred in the Cenozoic, mostly the mid to late Cenozoic. It is more difficult to explain such deposition of cobbles and boulders by uniformitarian processes than by late Flood runoff.

The only post-Flood explanation for the widespread distribution of quartzite rocks in the northwest United States and Canada I currently know of was offered in the review of a paper Peter Klevberg and I submitted to the 1998 International Conference on Creationism. An anonymous reviewer suggested that hyperconcentrated mass flows in a post-Flood subaerial environment could have transported and deposited the quartzites in the region.

However, there are several problems with that mechanism. Hyperconcentrated mass flows have a texture between that of a turbidity current and a debris flow. We evaluated the possibility of this mechanism (along with several others) while studying the Cypress Hills gravels. The only mechanism that explained the field data was powerful late-Flood currents.[36] The quartzite rocks are well rounded. They were transported up to 1,300 km from central Idaho across the Continental Divide to Saskatchewan and Manitoba.[37] They form a layer that averages about 40 m thick over the Cypress Hills, an area of about 3,000 km^2 on a high plateau. Furthermore, post-Flood catastrophism would have to account for 750 m of erosion over an extensive area surrounding the Cypress Hills which occurred *after* the

Figure 5. Grand Coulee in north-central Washington, US. It formed quickly within days during the Lake Missoula flood. The walls are up to 275 m high and as much as 10 km wide.

Figure 6. Zion Canyon in Zion National Park, Utah, US

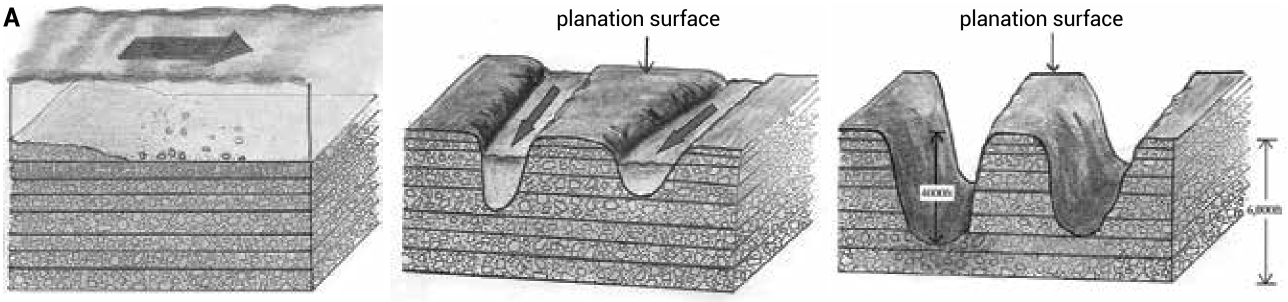

Figure 7. Schematic of sheet flow erosion that transforms into channelized flow erosion in the Absaroka Volcanics of northwest central Wyoming and south central Montana (drawn by Melanie Richard).
A. Deposition of the multiple volcanic landslides of Absaroka Volcanics, which is over 1,830 m thick and covers about 23,000 km^2.
B. Sheet deposition gave way to sheet erosion forming a planation surface, which transformed into channelized erosion.
C. Channelized erosion cuts canyons up to 1,220 m deep before the floodwater finally drains.

quartzite rocks were initially spread.[38] Finally, since quartzite rocks are abundant on multiple planation surfaces of the high plains, multiple hyperconcentrated flows over long distances would be required.

Since it is common to find well-rounded quartzites several mountain ranges away from their source, Whitmore wondered how they were transported over the ranges.[39] Since quartzites are also found on top of mountain ranges in the northwest United States, the mountains must have uplifted during or after the quartzite rocks were deposited. All these factors argue for late-Flood erosion and deposition.

Deep valleys and canyons

Valleys and canyons come in all sizes and shapes, but some are quite deep. The eruption of Mount St Helens showed that valleys and canyons with vertical walls, both in hard rock and unconsolidated sediment, can form quickly by catastrophic processes.[40] Near vertical-walled canyons are young features, becoming wider and more V-shaped with time.[41] Catastrophic flows of water carved the vertically walled Channeled Scabland of eastern Washington by the Lake Missoula flood at the peak of the Ice Age (figure 5).[42,43]

Deep valleys or canyons occur worldwide. Grand Canyon, 1,800 m deep, is the most well-known. Zion Canyon in southern Utah is nearly 600 m deep (figure 6). Copper Canyon in the Sierra Madre Occidental Mountains of the state of Chihuahua, northwest Mexico, is a magnificent example of a deep canyon that starts near a mountain divide.[44]

Some of the best examples of the rapid formation of deep canyons and valleys are found in the canyons of the Absaroka Volcanic Field of northwest Wyoming, which have peaks that exceed 3,660 m above sea level.[7] These volcanic rocks are up to 1,830 m thick and cover about 23,000 km^2 in the lower Cenozoic. After deposition, their top was eroded into a planation surface, strongly suggesting this all occurred during the Sheet Flow Phase of the Flood. As the water level decreased, channelized flow eroded canyons up to 1,200 m deep, dissecting much of the planation surface (figure 7).

Wise stated that all canyons on the earth's surface were formed by catastrophic floods during the first millennium after the Flood.[45] The Lake Missoula flood surely is his analogue.[38,39] Though few detailed studies have followed this proposal, it is a reasonable idea. The main difficulty is trying to explain the source of the water to carve canyons after the

Figure 8. Pediment in the Ruby River Valley along the western slope of the Gravelly Range of southwest Montana, US. Note that the sedimentary beds of the valley fill sediments dip right (east), while the pediment surface dips left (west) and shears the sedimentary layers evenly at a low angle.

Flood. Grand Canyon illustrates the problem. Its post-Flood formation, suggested by Wise and others, requires large lakes to supply the floodwaters, east of Grand Canyon. However, there is little geological evidence for the gigantic lakes or the dam-breach hypothesis.[46,47] A late Flood origin, using the two-phase model of sheet flow followed by channelized flow, is a much simpler and more reasonable theory.[48]

Pediments

A pediment is a planation surface at the foot of a mountain, ridge, or plateau. Pediments occur globally and number in the thousands. Hundreds are found in the western United States alone (figure 8). Although a few geomorphologists have tried to make the case that pediments are still forming today, active pediment formation has not been documented. Thus, pediments also conflict with the uniformitarian principle.[49] They were apparently formed by water, since most are capped by rocks rounded by water. Williams acknowledged:

> "A major obstacle to agreement on the origin of modern hard-rock pediments and their relationship to adjacent alluvial deposits is that the mountain front and flanking pediment appear frozen at the present instant of time."[50]

In fact, the only modern processes observed on pediments is their *dissection and destruction*.[51,52] Almost all pediments appear to have formed in the mid to late Cenozoic based on the rocks they are formed across. The best explanation for the field data is that they were formed by fast channelized currents during Flood runoff.[6,7,53]

Whitmore has addressed their origin several times.[35,54] As far as I know, he has offered *no* hypothesis for their origin. Rather, he has objected to the late-Flood theory, pointing out that pediments can be mistaken for depositional surfaces and there should be pediments associated with the Lake Missoula flood.

However, even a cursory examination can readily distinguish a pediment from a depositional surface. Pediments are predominantly *eroded* into hard rock, leaving a thin veneer of mostly rounded rocks. In contrast, mass wasting debris flow surfaces exhibit thick alluvium. For example, the Madison River Valley of southwest Montana possesses outwash terraces, alluvial fans, and pediments. The tops of the outwash terraces are flat with angular boulders transported by icebergs. In contrast, pediments gradually slope up to the mountain. An alluvial fan is a fan-shaped formation found at the mouth of a mountain valley, and when alluvial fans combine forming a bajada, there is still a low area between fans.

Whitmore believes that pediments in enclosed basins, such as the Great Basin, including Death Valley and Cache Valley, require post-Flood processes.[55] But even in these settings,

Figure 9. Two pediments about 30 km west of Wells, Nevada, US (view southeast). Highway altitude about 1,650 m and upper pediment at the foot of the mountain ranges is estimated at about 2,100 m.

Figure 10. A pediment in Cash Valley, Utah (view east southeast)

Figure 11. A pediment in Marsh Valley along Interstate 15 about 30 km southeast of Pocatello, Idaho (view southwest)

a Flood origin is possible. They could have been carved when the water was deeper or the terrain higher. Subsequent tectonic movement could have caused the basin to sink, as is likely for the Great Basin. The pediments in the Great Basin are generally high above the valleys (figure 9). This would favour formation during deeper channelized flow or when the valley fill was thicker. Whitmore pointed to Cache Valley, near Logan, Utah, in the northwest part of the Great Basin, as containing post-Flood pediments. The pediments in this valley are generally at moderate altitudes above the bottom of the valley (figure 10). However, Cache Valley is separated from Marsh Valley, southeast Idaho, by a low, wide pass. Cache Valley connects with the steeper Marsh Valley to the north in extreme southeast Idaho. There are pediments all along this segment (figure 11), showing that channelized flow during Flood runoff, starting in southern Cache Valley and flowing north-northwest, carved the pediments. Other individual examples require further field work, but experience has shown that the late-Flood model is feasible and preferred in most well-studied examples.

A key to the origin of pediments is their veneer of rounded rocks, which strongly suggests deposition by water. This is especially true for the *exotic rocks* on pediments, which were transported hundreds of kilometres. This would require currents flowing parallel to the mountain range or ridge. If pediments were formed by mass wasting, the debris would have come from the adjacent mountains.

Figure 12. The Shoshone water gap through the Rattlesnake Mountains west of Cody, Wyoming, US. The Shoshone River flows east toward the viewer.

Figure 13. The Cumberland wind gap in the Appalachian Mountains along the Virginia/Kentucky border near Middlesboro, Kentucky, US (view northwest from highway 58). This notch has been eroded down about 300 m, as measured on the northeast side.

Water and wind gaps

A water gap is an erosional gap cut through a mountain range, ridge, or other structural barrier, with a river or stream at its base. Figure 12 shows the Shoshone water gap, a 760-m-deep canyon, cut through the Rattlesnake Mountains, just west of Cody, Wyoming. The gap defies uniformitarian explanation because the Shoshone River could have migrated around the mountain range to the south through a low area.

A wind gap is similar to a water gap but lacks the river or stream. Many were probably once water gaps or incipient water gaps before uplift of the ridge, particularly if the ridge is a fault block. Figure 13 shows the famous Cumberland wind gap between Virginia and Kentucky, US.There are thousands of water and wind gaps. For instance, 653 water gaps have been identified in the Susquehanna watershed of the northern Appalachian Mountains that range from 23 to 539 m deep.[56] The deepest water gap in North America is Hells Canyon, between Idaho and Oregon, that is 2,440 m deep on the Idaho side.

Water and wind gaps are problems for uniformitarian geology. Crickmay noted that rivers seem to cut water gaps as if there were no mountain barrier:

> "Admittedly a fascinating picture, a river runs over low, open plains directly towards seemingly impassable mountains but, undiverted by their presence, passes through them by way of a narrow defile, or water gap, to a lower region beyond."[57]

Water and wind gaps, again dated as Cenozoic, are easily explained by the two-stage late-Flood flow across, and then through, barriers. However, Whitmore suggests that the thousands of water and wind gaps across mountains, ridges, and plateaus over the earth are explained by faults and joints: "In some cases these features might help explain how rivers cut through mountains and topographic highs, or have cut exceptionally deep canyons in short periods of time."[58] But water and wind gaps are hardly ever connected with faults,[59] leaving the origin of water and wind gaps a major problem for Flood geologists proposing a K/Pg Flood/post-Flood boundary.[60] The best-known water gap, Grand Canyon, illustrates these problems, given the issues with the dam-breach theory.[42,43,48]

Submarine canyons

Large submarine canyons are also fascinating geomorphological features. They dissect the continental shelf, often oriented perpendicular to the coast. Because submarine canyons formed *after* practically all the continental shelf sediments were laid down, their origin must also account for the sediments. Some are immediately offshore and can quickly exceed Grand Canyon in depth. The deepest is Capbreton Canyon off northern Spain, over 3,000 m deep.[61] The longest is the Bering Canyon, which includes a 95-km fan valley, giving a total length of 495 km—longer than Grand Canyon.[62,63]

Uniformitarian scientists can explain submarine canyons better than any other geomorphological feature discussed so far. They believe shelf-indenting canyons formed by mass wasting near the shelf edge, and that the canyon eroded shoreward over millions of years. This is a plausible hypothesis given deep time but has one major question. How does continental erosional debris become concentrated at *one* location along the shelf edge so that many mass flow events over a long time carve a canyon in *one* location?

Since submarine canyons are believed to have been eroded in the Cenozoic, it seems that late-Flood channelized flow[64] may offer a better explanation for their existence than post-Flood mass flow processes.

This subject remains sparsely discussed in creation science literature in terms of a post-Flood origin, but it would be plausible that such models would be similar to uniformitarian ones, but with a compressed timescale. However, post-Flood mass wasting events would need to have been continually depositing sediment at the *same* location at the top of the canyons on the continental shelf to have gradually carved the canyons.

Conclusion

Many geomorphological features are difficult, if not impossible, to explain by uniformitarianism. Likewise, models of post-Flood catastrophism, such as heavy precipitation or mass wasting, also seem inadequate. In contrast, the simple two-stage process of sheet flow followed by channelized flow in retreating floodwaters can explain the terrain features we see today. Since most geomorphological features formed in the Cenozoic, the post-Flood boundary is best placed late in the geological column.

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