Pediments formed by the Flood: evidence for the Flood/post-Flood boundary in the Late Cenozoic

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Contrary to the uniformitarian principle that 'the present is the key to the past', pediments are not observed to be forming today. The three main theories for the origin of pediments are fatally flawed. Only Crickmay's superflood hypothesis comes anywhere close to a solution, in that it postulates pediments formed by down-valley currents. Within a catastrophic Flood framework, a scientifically justifiable mechanism becomes obvious: pediments are erosional features caused by deep currents moving at high speed along a barrier, such as a submerged mountain range. Thus, pediments, found all over the world, were formed by fast currents during the Recessive Stage of the global Flood. Since the sedimentary rocks underneath the pediment are often dated as Cenozoic, this would place the Flood/post-Flood boundary in the late Cenozoic in many areas.

Geomorphology is the study of the surface features of the earth. These include large-scale landforms such as plains, mountains and continental shelves, as well as small-scale landforms such as valleys, plateaus, slopes, canyons, alluvial fans, submarine canyons, water gaps and pediments.

This article will focus on pediments, which are defined as: 'a broad sloping erosion surface or plain of low relief, typically developed by running water, in an arid or semi-arid region at the base of an abrupt and receding mountain front'.[1] 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'.[2] If the surface is very smooth, an erosion surface may be called a planation surface. Running water is involved in both definitions because rounded rocks cover many of these landforms.

The definition of a pediment is quite broad and has been subject to disagreement over terms.[3,4] I will refer to pediments as planation surfaces since many pediments are quite smooth.

Pediments are most evident in dry climates, which, as in the definition above, has led to many ascribing them to a dry climate mechanism. However, this may only be a selection artifact in that deserts often preserve features better and have greater rock exposure.[5] Yet, pediments are not restricted to dry areas and may be observed in any climate, cold or warm, wet or dry.[6] For instance, pediments are common in the Yukon Territory of north-west Canada.[7] The geomorphologist Lester King states:

> 'They [pediments] are, however, not absent from the landscapes of humid regions, and current research indicates that pediments are, indeed, the most widespread and possibly the most important of all land-forms.'[8]

The geologist Grove Karl Gilbert first recognized and described pediments in 1877 and there is now an extensive literature on the subject.[6,9,10] There are hundreds of pediments in the south-west United States. Figure 1 is just one example of a pediment along a mountain ridge, 10 km south-east of Hoover Dam, Nevada. Pediments are common in south-west Montana (figure 2). Although pediments have been widely studied, no mainstream explanation for their origin has been found to be satisfactory. However, from a creationist point of view, the evidence, as discussed here, indicates that pediments are relic features left over from the Recessive Stage of the Flood.

Pediment characteristics

Pediments are often remarkably flat on the broad scale when the whole pediment is viewed.[11–13] However, channels and rills leading from the mountains are often incized upon the surfaces of pediments (figure 3). In fact, most pediments are dissected.[14] Dohrenwend states:

> 'Certainly one of the most remarkable physical

Figure 1. *Pediment from the south-west US, 10 km south-east of Hoover Dam, Nevada (photo by Ray Strom)*

Figure 2. *Pediment along the western slope of the Tabacco Root Mountains, north-east of Twin Bridges, south-west Montana. The pediment is 18 km long parallel to the mountain front, 5 km wide perpendicular to the front, and about 300 m higher than the adjacent river.*

> attributes of any pediment is the generally planar and featureless character of most (or at least part of) its surface … Although, many large pediments are generally smooth and regular with less than a few metres of local relief, a more complex morphology occurs where shallow drainageways locally incise the pediment surface into irregular patchworks of dissected and undissected topography.'[15]

Generally, the remarkable smoothness is enhanced and protected by the deposition of a veneer of coarse gravel, which may include cobbles and boulders.[16,17] Boulders up to 1 m diameter are seen on pediments along the Kaibab Monocline in north-east Arizona,[18] and I have personally observed subrounded basalt boulders larger than 1 m in diameter on pediments in the John Day Country of north-central Oregon (figures 4 and 5). Although the surface of a pediment is smoothed due to the veneer of gravel, the relief below the gravel is also generally quite low and can be described as a planation or erosion surface.[19] In addition, some smooth pediments exist without a veneer of coarse gravel. Thus, the flatness of the pediment is *mostly a result of the smooth rock floor*, whether it has a capping of coarse gravel or not. The coarse-gravel veneer smooths the pediment even more. The gravel veneer normally thickens away from the mountains and sometimes blends into the accumulation surface of relatively thick gravel on the lower piedmont (surface from the mountain front to the centre of the valley).

The coarse gravel capping of a pediment is generally rounded, indicating that *water was involved in depositing the veneer and likely shaping the pediment*. The coarse gravel would act like sandpaper in a current while the pediment was forming.[16,20] Figure 8 shows the generally rounded and subrounded veneer of coarse gravel on the pediment shown in figure 7. Figure 9 shows a dissected pediment cut along the near-vertical eastern limb of an anticline near the Sheep Mountain water gap in the eastern Bighorn Basin, Wyoming. Figure 10 shows the gravel veneer on the pediment remnants. This pediment was cut evenly across strata at a considerable angle. Angular gravel is also sometimes found on pediments, especially near the mountains. For instance, angular limestone clasts are found on a pediment just east of the Little Rocky Mountains of north-central Montana, the likely source of this material since much limestone is draped over the granitoid core of the Little Rocky Mountains.

The size of pediments varies from less than 1 km^2 to quite large planation surfaces of hundreds of km^2.[21] Figure 2 shows a pediment, which is about 18 km long parallel to the mountain front and about 5 km wide perpendicular to the mountain front, representing 90 km^2 of generally smooth planed rock with a coarse gravel veneer. As an example, the city of Bozeman, Montana, sits atop a coarse-gravel-capped pediment that covers an area of over 200 km^2. The largest pediment in south-east Arizona covers an area of 615 km^2.[22]

Pediment shapes are generally similar with a slightly concave upward profile, steepening slightly towards the adjacent mountains.[23,24] The slope, within the first kilometre perpendicular to the mountain front generally ranges from 1° to 6°,[24,25] becoming quite flat further away from the mountains where it blends into the *lower piedmont* (figure 6).[26] Dohrenwend reports a slope up to 8.6° on a granitic pediment in the Mojave Desert. Where the pediment contacts the mountain front, it makes a significant angle (the *piedmont angle or junction*).[27] The origin of the piedmont angle, which is usually quite sharp, has been the cause of much speculation.[28] The slope of the pediment does not seem to be related to either the pediment length or the catch-

Figure 3. *Dissected pediment east of the Little Rocky Mountains, north-central Montana*

ment area in the mountains, nor the lithology.[24,29]

Figure 4. *Pediments on south side of John Day River Valley. Photo taken from pediment on north side of the Valley, north of Dayville, Oregon.*

An interesting feature of pediments is that they are sometimes observed at multiple elevations in a valley (figure 11). Twidale states that pediments in sedimentary terrains commonly occur in flights or steps.[16] More elevated pediments are occasionally detached or beheaded from the mountain front by a valley, leaving a pediment that represents an erosional remnant (figure 12).

Pediments have been found to have eroded all types of rocks,[24,30] most commonly in granitic terrains.[11,31–33] In sedimentary rocks the mechanism that formed the pediment is often found to have sheared or bevelled the layers.[34] Thus, pediments can cut evenly across rocks of varying resistance with no regard to whether the rock is hard or soft.[35–37] Figure 7 shows a pediment in the Ruby Valley, along the western slope of the Gravelly Mountains of south-west Montana. Note that the sedimentary layers tilt down to the right (east), while the surface of the pediment has been bevelled to the left (west). Pediments sometimes erode rock similar to that found at the mountain front,[10] while in south-west Montana, from personal observation, it appears that pediments mostly cut valley-fill sediments and not the rocks at the edge of the mountains.

Pediments vs alluvial fans

Some of the early geologists thought pediments were alluvial fans, or *bajadas* (coalesced alluvial fans), since they have a similar geomorphology.[14] But they were greatly surprised to discover that, in reality, the pediment surfaces were only thinly veneered over a hard rock floor, or sometimes there was no debris at all.[38] An alluvial fan is defined as:

> ‘An outspread, gently sloping mass of alluvium deposited by a stream, esp. in an arid or semiarid region where a stream issues from a narrow canyon onto a plain or valley floor. Viewed from above, it has the shape of an open fan, the apex being at the valley mouth.’[39]

While an alluvial fan or bajada is a *depositional* landform, a pediment is *planed rock* with a *veneer* of coarse gravel. Confusion between alluvial fans and pediments occasionally occurs when alluvial fan debris spreads from the mountain front or from a canyon on top of a pediment, disguising the pediment. This not only makes the recognition of a pediment difficult at times, but also causes confusion as to whether the capping debris originated during the formation of the pediment or was added later from the mountains.[40] Sometimes drilling and/or seismic investigations are necessary to distinguish the two landforms.

Recently, the question of whether a 3.5-km-long by 1-km-wide landform along the western Flinders Ranges in South Australia is a pediment or an alluvial fan was settled by seismic reflection in favour of a gravel- and cobble-covered pediment.[19] The rock making up the pediment surface was eroded with a relief of 25 to 30 cm in westerly dipping argillite and covered by coarse gravel with a uniform depth of 2 m. Thus, seismic investigations revealed that this geomorphological feature not only was a pediment, but also that it was planar both on the pediment surface and the dipping sediment rocks.

Pediments formed by some past process

Some geologists have written as if pediments continue to form today, especially those who believe in the weathering hypothesis,[41] which will be analyzed below. Without justification, it is simply assumed that pediments are continuing to form today as an application of the uniformitarian principle, which generally states that the present is the key to the past:

> ‘The assumption underlying such studies is that modern processes are responsible for the pediment. This may well be a case where the origin of the whole form is being confused with the process which is merely retouching the present surface. Modern process studies can tell us something about the mechanics of the modern processes and the sedimentary deposits they produce; their relevance to the overall origin of pediments is far more questionable.’[42]

According to the uniformitarian principle, there should be no reason why pediments are not forming today.

However, many geomorphologists state that pediments are *not* forming at the present time,[42–45] and they believe they are relics of the past. George Williams admits:

> '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.'[46]

Oberlander reinforces this observation:

> 'Until recently, these planar surfaces were assumed to be actively expanding in deserts. The processes creating such surfaces have long remained a matter of speculation and controversy.'[47]

In fact, the only observation of change on pediments is that they are being *dissected and actively destroyed*.[11,48–54] Observations of running water in deserts indicate that water incizes or else deposits debris on a surface.[55] Crickmay comments:

> 'There is no reason to suppose that any kind of wasting ever planes an area to flatness: decrepitation always roughens; rain-wash, even on ground already flat and smooth, tends to furrow it.'[56]

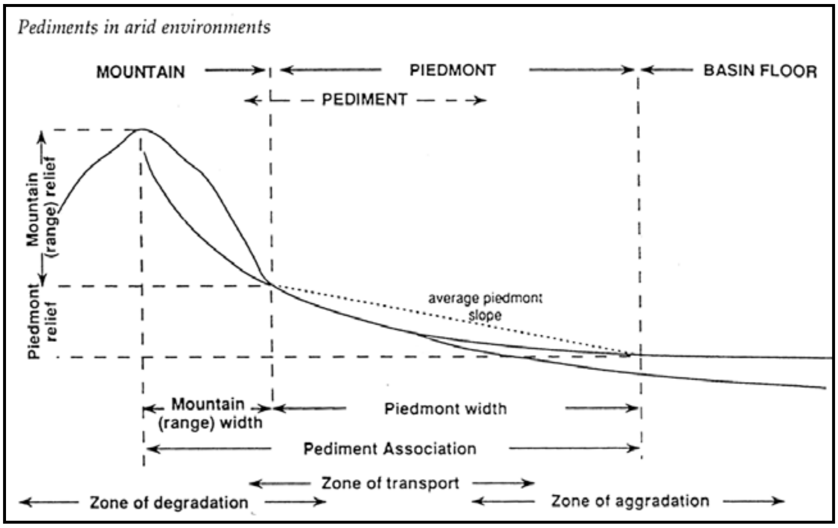


Figure 6. *The relationship between the pediment, piedmont and basin floor with inferred uniformi-tarian processes of gravel denudation and aggradation (after Dohrenwend, ref. 4., p. 324).*

Figure 3 shows a pediment being dissected by streams issuing from the Little Rocky Mountains.

Some workers claim that although pediments in a particular area are not forming today and hence are relict, they formed in a different climate in the past. For instance, Oberlander blames the deeply weathered granite in the Mojave Desert on a pre-Quaternary climate change to a wetter climate, since the weathering is not occurring today in the dry climate.[43,57] However, the big picture belies this simple explanation. Pediments, as well as planation surfaces in general, are observed in diverse areas which should cover *all* types of climates in the past. Yet, we do not see pediments forming in any climate today.[58,59] So, how can a past climate change help? Then there is the problem that researchers really do not understand how climate affects landforms.[60–62] Michael Thomas relates how either a wet or dry climate change is applied to the origin of pediment formation in the opposite environment:

> 'Thus within arguments about climate change, pediments occupy an interesting position, being widely regarded as markers of more humid conditions when found in the arid zones (Busche, 1976; Oberlander, 1974, 1989) and as indicators of drier conditions, where they occur within the humid tropics (Thomas & Thorp, 1985).'[63]

Figure 5. *Close-up of the very coarse subrounded basalt gravel about 100 m thick on top of pediment in figure 4 on the north side of John Day River Valley.*

Three fataly flawed uniformitarian hypotheses for forming pediments

As already indicated above, pediments are not forming today. However, this has not stopped mainstream geologists from forming a number of hypotheses, which have generated much controversy since the time of Gilbert. Oberlander writes:

> 'The form that has stimulated a century of argument is the *rock pediment* composed of the same material as the diverse relief rising about it—most commonly a plutonic rock: granite, granodiorite, or quartz monzonite.'[64]

Although there are many minor hypotheses for the formation of pediments, there have been mainly three hypothesis considered by a large number of geomorphologists (table 1). One hypothesis is that the pediment was laterally planed by streams flowing perpendicular to the mountain front and that have meandered back and forth countless times, smoothing the surface. This hypothesis was widely believed by many early geomorphologists, including Eliot Blackwelder[40] and Douglas Johnson.[11,36] It is still believed by some geomorphologists today:

> 'The smoothness of the pediment is due to the planation of the local bedrock, but more specifically to the deposition of coarse alluvium by the streams which, on debouching from the uplands to the east, adopted a distributary habit. These *laterally migrating streams* simultaneously planed off the bedrock and laid down point bar deposits (for lenses of especially coarse debris can be distinguished in the cover deposits), forming a veneer of coarse debris' [emphasis added].[65]

Figure 7. *Pediment in the Ruby Valley along the western slope of the Gravelly Range of south-west Montana. Note that the sedimentary beds of the valley-fill sediments dip right (east), while the surface of the pediment dips left (west) and shears the sedimentary layers evenly.*

However, streams flowing out of the mountains are rare to nonexistent in deserts, so unless the climate was different in the past, lack of water is one constraint on this hypothesis.[66] It is possible that thunderstorms, which can cause much erosion in a short time, may overcome the difficulty of a dry climate, but the water is practically always observed to channel. (An exception is sheetflooding „discussed next.) Streams flowing out from the mountains are observed to either form alluvial fans or damage pre-existing pediments.[67] We do not observe streams flowing out of the mountains and planing rough foothills.

Another major difficulty with the lateral planation hypothesis is that pediments from the opposite sides of a mountain range sometimes *merge with each other at the top of the range*![12,68] The area of merging is called a pediment pass, and the top of the pediment on one side of the mountain range can be higher than the one on the other side! In this situation, how can a lateral stream flowing away from the mountain ridge begin to develop near the top of the pediment in order to supposedly plane the pediment by horizontal meandering? How can lateral planation occur from a stream migrating widely at the *divide*? There is also the problem that many granite massifs surrounded by pediments lack valleys altogether, and hence no stream could have flowed from the massif to cut the pediment.[69]

A second major hypothesis is the sheetflooding hypothesis. Here sheetfloods from heavy thunderstorms spread perpendicular from the mountain front and erode a smooth surface over time. This hypothesis was also favoured by a number of the early geologists,[48,70] and a few modern geologists have invoked it as either the main mechanism or in combination with other mechanisms.[71] It has been observed that floods sometimes occur in shallow wide sheets during thunderstorms.[72] So, it seems logical that these sheetfloods could cause planar erosion. However, sheetfloods are rather rare; linear streamflows are much more common.[73] And if a flow starts as a sheetflood, it soon changes into a streamflow

Table 1. *The three main uniformitarian hypotheses for the formation of pediments and their problems*

		Lateral Plantation	*Sheet Flooding*	*Weathering*
Problems	1	Desert streams are rare	Sheet Flooding is rare	Does not form planar surfaces
	2	Streams destroy pediments	Quickly transforms into linear flow	Does not form rounded, coarse gravel vener
	3	Pediment passes	Pediment must pre-exist	Problem of debris removal
	4	Exotic coarse gravel	Exotic coarse gravel	Exotic coarse gravel
	5	Granite massifs with no valleys	—	Little weathered rock at top of pediment

Figure 8. *Coarse gravel veneer capping pediment shown in figure 7. Note that the clasts are rounded to subrounded.*

or a channel-like network.[74,75]

But, the most significant problem—a fatal flaw—with the hypothesis is that you need a pre-existing pediment *first* for a sheetflood to occur. This has been pointed out by many investigators.[73, 76–78] Oberlander states:

> '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.'[69]

Furthermore, sheetfloods normally *deposit* rather than erode material.[49,79]

The third and final hypothesis is that pediments are a result of downward weathering.[41,43,49] This process is similar to the weathering hypothesis for planation and erosion surfaces in general and has been believed by many geomorphologists for several decades.[80] Twidale (1981) believes that the slightly rough surface of a rock pediment below the coarse gravel veneer is evidence for the weathering hypothesis.[33] However, many pediments are still planar with no veneer, and some pediments are planed on *soft* rocks.[81–83] These observations do not seem to line up with the downward weathering hypothesis for pediments. I have observed planar pediments on the soft rocks of the John Day Country, north-central Oregon (figure 13). All the problems associated with forming planation surfaces from the weathering hypothesis are also common to the formation of pediments. Especially problematic is that weathering will not form a planar surface, neither in the veneer of coarse gravel nor in the subsurface weathering front. It is water that causes the weathering in the subsurface, but moisture tends to penetrate or attack joints or zones of textural and mineralogical weakness in a rock.[84] Once formed, such depressions in the weathering front hold more water and weather even faster. So, weathering roughens a surface. Dohrenwend admits:

> 'Although subsurface weathering processes have strongly influenced pediment development in many areas and profoundly modified pediment surfaces in many others, it would appear unlikely that these processes actually 'control' pediment development, at least in arid and semi-arid environments.'[85]

Thus, weathering processes are obviously acting on pediments today and have in the past, but the question really is whether such a weathering process on a steep mountain front or in the foothills bordering mountains could wear the relief down or back, forming a planar surface. If the weathering hypotheses were true and the mountain scarp retreated, one should also see disintegrated rock accumulating, especially at the foot of the scarp, but this is not observed.[86] And it is unlikely that water would have removed all the debris from the upper portion to the lower portion of the pediment.

One of the problems with all hypotheses for the origin of pediments, except for Crickmay's 'outrageous hypothesis', as some have called it (discussed below), is that a minor proportion of the coarse gravel capping some pediment is *exotic* (foreign) to the mountains adjacent to the pediment.[87] I have observed rounded quartzite cobbles on the impressive pediments north-west of Grand Mesa, Colorado. The closest quartzite outcrop upstream from Grand Junction in the Colorado River Valley is many tens of kilometres upstream.[88] There is no possibility this quartzite could have been weathered from the sedimentary rock below the pediment or have been transported from off Grand Mesa above, since this mesa is a basalt capping sedimentary rocks. The dissected pediment on the eastern flank of the Sheep Mountain anticline (figures 9 and 10) contains quartzite cobbles with percussion marks.[89] Percussion marks indicate strong, turbulent flow,

Figure 9. *Dissected pediment on the near-vertical eastern limb of an anticline at the Sheep Mountain water gap, eastern Bighorn Basin, Wyoming*

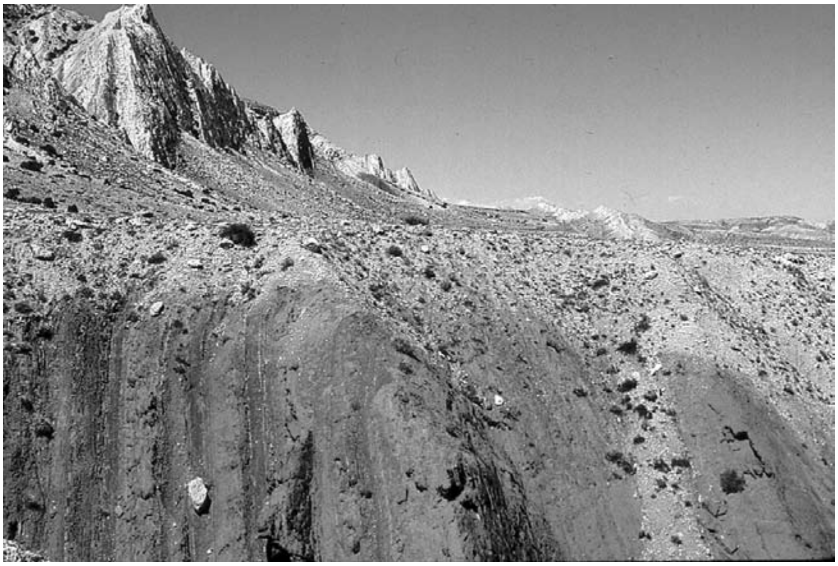


Figure 10. *Coarse gravel veneer capping the pediment shown in figure 9. A minor proportion of the clasts on this dissected pediment were exotic quartzites, some with percussion marks, from at least 500 km to the west.*

which would be consistent with the mechanism proposed below.[90] The nearest 'upstream' outcrops of quartzite are at least *500 km to the west in central Idaho*![91–95] For south-west Montana, north-west Wyoming and adjacent Idaho, Love determined that the quartzites could not have come from the local mountain ranges because the textures of the quartzites do not match.[96] They are similar to the Belt quartzites that outcrop in central and northern Idaho.[96] The quartzites in the eastern Bighorn Basin are similar to those farther west in north-west Wyoming. I consider exotic clasts on pediments a fatal flaw for all three hypotheses.

There is little, if any, observational support for any of the above speculative hypotheses,[97] as summarized in table 1. Dale Ritter concludes that the hypotheses are untested, with little observational data to support any of them:

> 'It is ironic that in spite of the singular attention devoted to pediments, a multitude of untested hypotheses exist concerning the processes of pedimentation, but an amazingly skimpy pool of reliable data to support them. After a century of study, there is still confusion and lingering disagreement about every aspect of pedimentation. Cooke and Warren (1973, p. 188) express this succinctly in their description of the topic as "a subject dominated by almost unbridled imagination".'[21]

As a result of the failure to observe pediments forming today and to explain all the other unique characteristics of pediments, it is admitted that their origin is really *unknown*.[44,98] Dohrenwend exclaims:

> 'Pediments have long been the subject of geomorphological scrutiny. Unfortunately, the net result of this long history of study is not altogether clear or cogent and has not produced a clear understanding of the processes responsible for pediment development.'[99]

This is called the 'pediment problem' by Oberlander.[100] It is truly amazing that after a century and a quarter of research on pediments, scientists seem to have little knowledge on how pediments formed. Could it be due to their underlying assumptions?

Crickmay's superflood hypothesis

One of the most insightful geo-morphologists, who is not afraid to follow the data and challenge mainstream theoires, is C.H. Crickmay. Most of his ideas are summarized in his book: *The Work of the River*.[45] Crickmay concludes that water not only shaped pediments but most of the scenery around the world. This is supported by the occurrence of rounded rocks associated with planation surfaces. Rocks are only rounded by water, except for the rounding of surficial boulders that occurs in the weathering of granitic terrains. Since exotic rocks are observed on some pediments, Crickmay deduced that pediments must have formed by water flowing *parallel* to the mountain front and not from out of the mountains and down the slope away from the mountains. Crickmay writes:

> 'Many pediments of this type [short but laterally extensive pediments] are carpeted with thin gravel deposits that include among their pebbles a greater variety of rock types than is represented in the bed-rock of the immediate vicinity. These facts, together with the peculiarly continuous, linear form of the pediplains [similar to a pediment], suggest that perhaps one should look in an entirely different direction for the mode of origin of the features. Rather than looking to the small streams (including,

Figure 11. *Three pediments along the John Day River Valley downstream from the Sheep Rock visitors' centre*

Figure 12. *Pediment remnant from the John Day Country, 7 km north of Twickenham*

> of course, their sheet-flood counterparts) that *now* run *down the slope* of the pediplain as the possible agent of its making, one should perhaps visualize a stream that formerly *ran* the *lateral length* of the pediplain—its greater dimension' [emphasis in original].[67]

Exotic clasts on pediments is a crucial observation that should have made geomorphologists reject their main hypotheses. The flood running parallel to the mountains in Crickmay's hypothesis is not an ordinary flood, but a superflood. He envisions this superflood as possibly as large as a one-in-a-900-year event. The edges of these large floods supposedly plane the sides of the valley or bounding mountains. With multiple superfloods over millions of years, a pediment results, according to Crickmay's hypothesis.

I believe Crickmay is close to the solution, in that he shifted from the idea of pediment origin by streams issuing from the mountains to mountain-parallel superfloods. How else can a geomorphologist account for exotic clasts on a pediment, than by water moving parallel to the mountain front? He formed his hypotheses according to almost all the observed data on pediments. Unfortunately, his hypothesis is not even considered of significance,[101] probably because his vision of a superflood also has a number of problems. First, no-one has ever observed such a superflood, as Crickmay admits. Secondly, it is doubtful such a flood could smoothly erode the edges of a mountain front. Third, multiple superfloods would likely both erode and deposit sediment as cut and fill structures and terraces on the side of a mountain.[102] But pediments are large-scale *smooth* structures.

Pediments formed in the Recessional Stage of the Genesis Flood

In summary, pediments are not forming in the present; *they formed by some past process involving water*. Thus, the uniformitarian principle fails to account for pediments. About the only option left is a catastrophic process from the past. The Genesis Flood would provide such a catastrophic mechanism. (I would be happy to consider post-Flood catastrophism if someone would suggest a model or even a catastrophic post-Flood event that could form pediments. Otherwise post-Flood catastrophism seems contrary to geological data,[103] and the great numbers of large pediments of worldwide extent, discussed in the next section, would seem to argue against post-Flood catastrophism.) Since pediments are surficial landforms showing little modification subsequent to the planation that formed them, it is reasonable to place the origin of pediments during the Recessive Stage of the Flood.[104,105]

In the Creation-Flood model, the last event to occur in the Flood was the runoff of the floodwaters from the future continents. This is called the Recessive Stage in Tas Walker's biblical geological model,[104] which will be used in this paper. As the Flood happened around 4,500 years ago, there has been relatively little subsequent erosion from most areas of the earth, as shown in table 2, taking into account climate and topographic relief.[106] Of course, denudation has been much faster in some glaciated areas, badlands, landslide areas and other such active areas. In the first several hundred years after the Flood, the Ice Age occurred,[107] and snowfall, rainfall, volcanism, flooding, etc. would have been much greater than today. So, the rates in table 2 would have been significantly higher than today in many areas. Regardless, denudation since the time of the Flood would not have been significant enough to erase landforms in many areas that were created during the Recessional Stage of the Flood, especially in dry areas. One would expect that such landforms created in such a unique

Figure 13. *Pediments on tilted soft rocks of the John Day Formation, Painted Hills, north-central Oregon.*

process as the Genesis Flood would not only be evident on the surface of the earth, but would also be difficult to explain by the Evolutionary-Uniformitarian model, which relies on present processes for hundreds of thousands to millions of years.

I suggest that pediments formed by deep erosive currents flowing parallel to a barrier, such as a mountain range during the Genesis Flood (figure 14). This flow of water would be similar to Crickmay's superflood but on a much greater scale. The pediment likely represents the effects of the *last erosive current* in a particular location, and afterwards the water either drained from the pediment surface or was too slow to erode any further. For instance, if a current were moving at 30 m/sec down valley, it would erode the valley fill and the edge of the mountains. As the current slows to some threshold, for instance 15 m/sec, it would stop eroding, and the resistant rocks being carried along the bottom (the eroding tools) would deposit a veneer of coarse gravel on the pediment. (These velocity values are used for illustrative purposes only.)

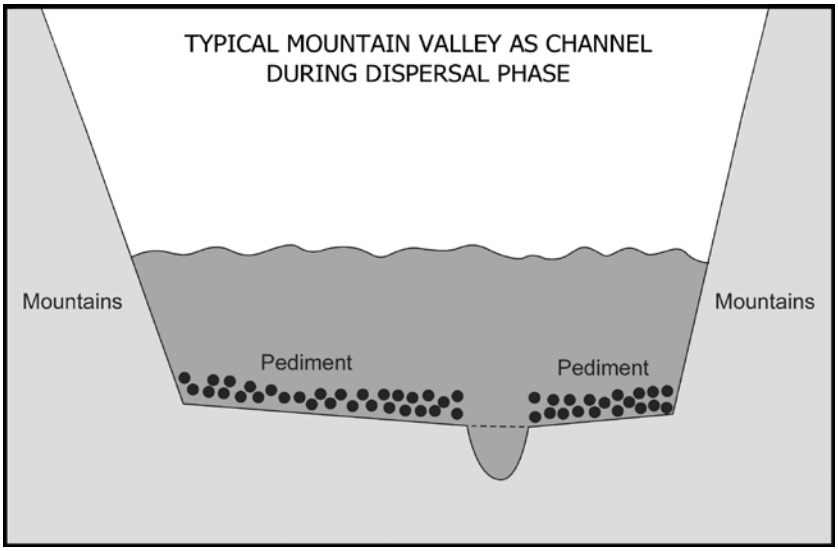


Figure 14. *Illustration of downvalley pediment formation. View is downvalley with spheres representing coarse gravel also moving downstream and smoothing the sides of the mountains. Area below dash line represents further erosion, either in the last stages of floodwater drainage or by post-Flood rivers.*

The above would be the general case. However, variable current speeds would complicate the general rule and explain some of the other observations of valley pediments. It is possible that the threshold current speed was variable across the valley, resulting in the pediment forming on one side of the valley with continuing erosion on the other side, as is commonly observed. If the valley meanders a bit, a favourable location for pediments would be the inside of a meander, as is shown in figure 2.

How would this hypothesis account for multiple pediments in a valley? I propose that variable current speeds, possibly caused by variable rates of tectonics, could result in multiple pediment levels. A decreasing current could form a pediment while an increasing current could mostly erode this pediment, leaving the pediment as an erosional remnant. As the current decreases again, another pediment could be formed at a lower level in the valley. Oscillating current speeds would result in variable pediment levels, with multiple pediments occurring mainly in sedimentary rocks because these rocks would usually erode faster than plutonic rocks.

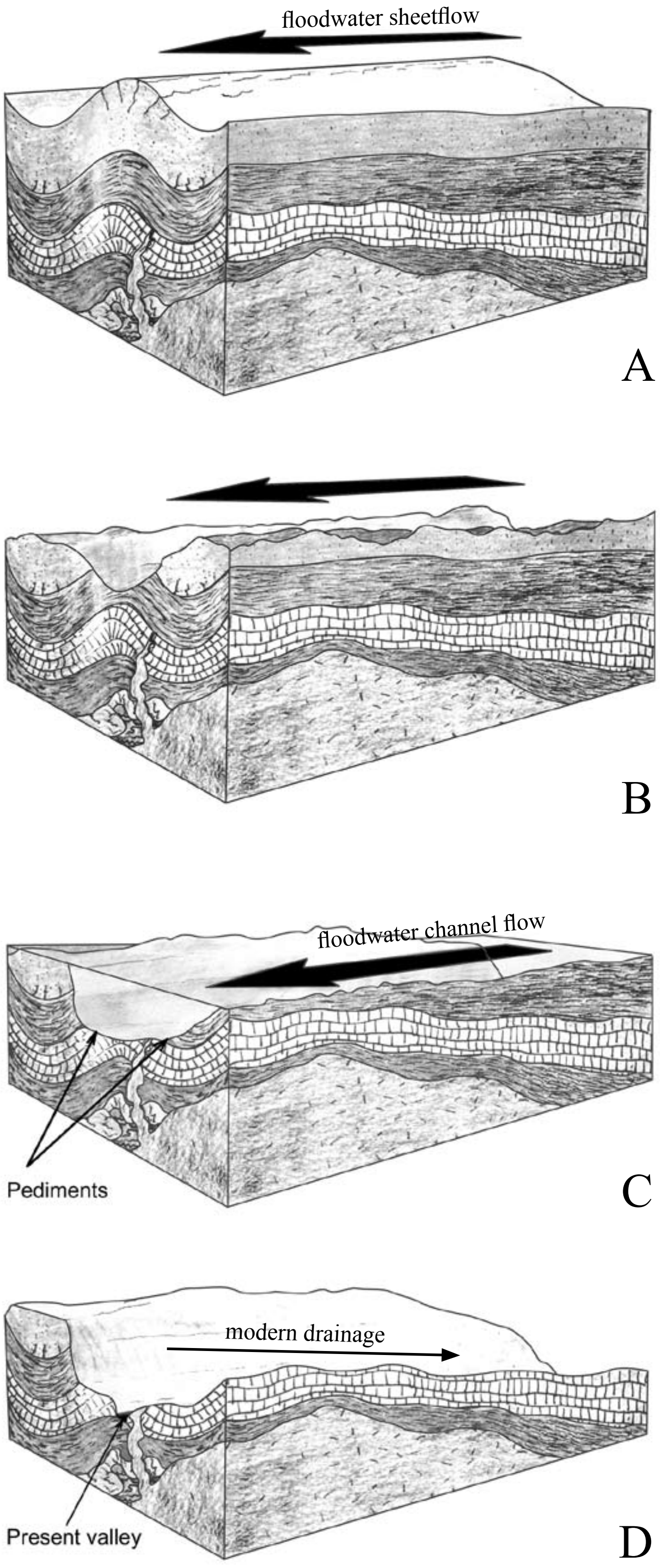
Variable current speeds across the valley, locally soft substrate, or the lack of a sufficient veneer of coarse gravel can explain other observations such as beheaded pediments, which could have formed by a local acceleration of flow along the edge of the valley.

It is likely that different current velocities on opposite sides of a mountain range would exist, and as a result pediments would form at different elevations on either side. The erosion could have been so strong along both sides of the mountain range that the range would be locally breached, forming a pediment pass. In such a case, the top of the pediments at the ridge crest could be at different elevations. Such pediment passes are observed in the Sacaton Mountains of Arizona.[12,68] If denudation continued to wear down the mountains themselves, possibly because the water was slow to drain in the area, it is also conceivable that the whole range could have been eroded down to a generally smooth, rounded mound, such as Cima Dome in the eastern Mohave Desert.[43,57,74,108,109]

The above scenarios would occur while the water was draining from off the land and the level of the water was falling relative to the valley sides. The last erosional event would likely occur just before the water completely drained from the valley, in which case the centre or lowest part of the valley likely would be eroded further. After the floodwaters had totally drained from the area, a river or stream would end up flowing down the lowest part, deepening the

Table 2. *Variable denudation from the continents in 5,000 years at the present rate, based on climate and relief (Summerfield, ref. 5, p. 396).*

	Mountainous	*Rough*	*Smooth*
High precipitation	2.1 m	0.4 m	0.1 m
Low precipitation	1.0 m	0.4 m	0.4 m
Tropical			0.03 m
Subarctic			0.06 m



Figures 15A–D. *Block diagrams showing the development of pediments along the sides of mountains during the downvalley drainage of floodwaters (drawn by Peter Klevberg)*

river channel in the valley. Hence, the notch in the valley where the river flows would have been cut by post-Flood erosion.

The draining of the floodwaters, while carving valleys and forming pediments, would also occur during the Dispersive or channelized Phase of the Recessional Stage of the Flood.[104] There are also pediments along isolated mountain ranges on the high plains of Montana, such as the pediments along the Little Rocky Mountains (figure 3). This erosion and pediment formation could have occurred during the Abative or Sheet Flow Phase of the Recessional Stage of the Flood. Regardless, pediments would be relics of the Recessional Stage of the Flood.

I am essentially describing a situation in which the valleys started off completely submerged and the water drained from the valleys during the Flood. Figure 15 shows a series of block diagrams of how I believe pediments were formed in a valley during the late Flood. In this situation, the veneer of coarse gravel that helps protect the pediment from further erosion likely originated from both the sides of the valleys (the mountains) and upstream, sometimes resulting in exotic clasts. This is what we observe on some pediments, such as the basalt and quartzite capping a pediment at the edge of the Grand Mesa in western Colorado.

Pediments point to the global Flood, not a local flood.

Pediments are not only found in the western United States, but they are also found over many other areas of the world. Figure 16 shows a world map of pediments as described in the literature from over 900 references up until the early 1970s,[6] showing an abundance of pediments in the low and mid latitudes. Many pediments in high latitudes may have been erased by erosion and the map does not include many other pediments not mentioned in the literature, for instance in the Yukon Territory of north-west Canada, and the many pediments in the John Day Country of north-central Oregon.

The fact that pediments are very common in some areas, and that they occur globally, means that the Flood was a global event and not a local occurrence!

Pediments indicate a late Cenozoic Flood/post-Flood boundary

Since pediments represent the last major erosional event in an area, it is reasonable to conclude that the sedimentary rocks underneath the pediment, as well as the sedimentary rocks estimated to have been eroded from the valley, were deposited earlier in the Flood. Hence, the sedimentary rocks under pediments, often the valley- or basin-fill sediments, and the pediments themselves are clearly from the Genesis Flood. The standard dates for the valley-fill sediments are often Cenozoic, including the late Cenozoic in some areas;[98]

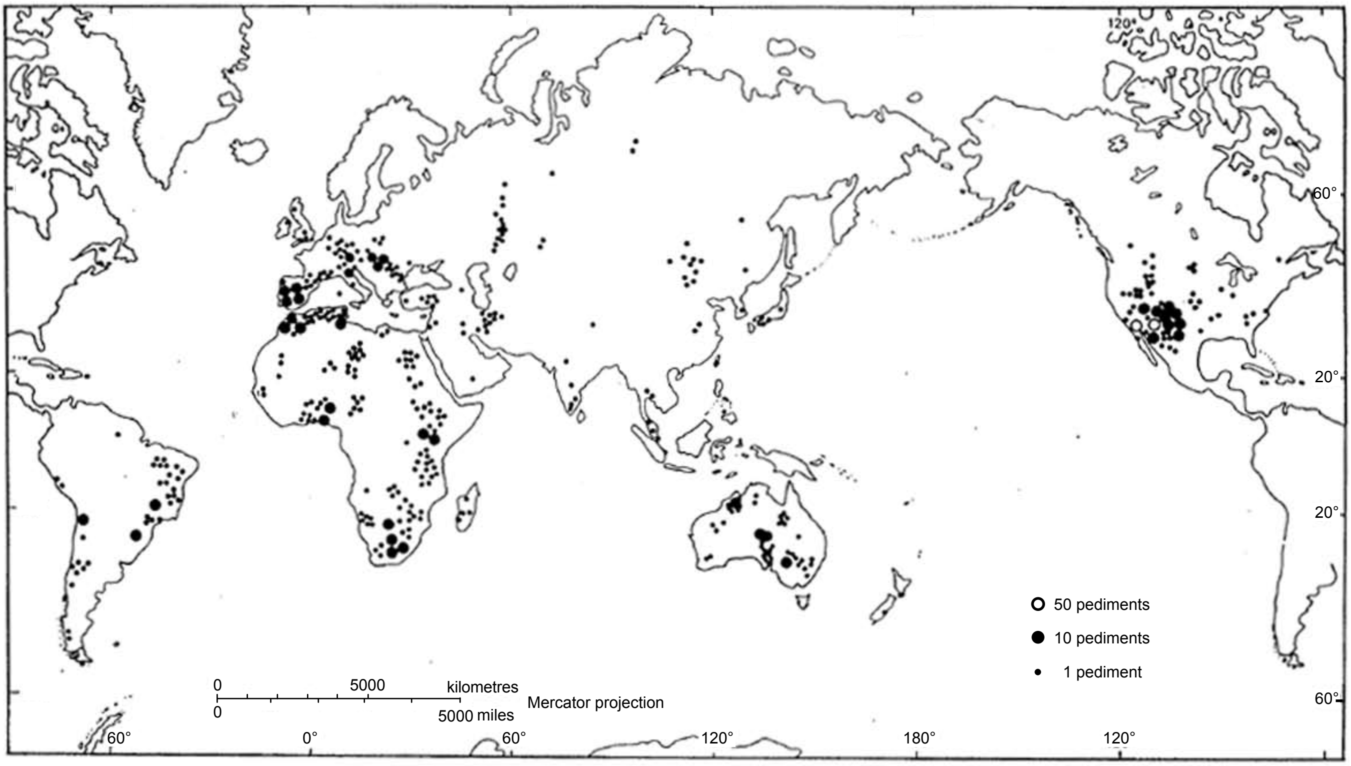


Figure 16. World map of pediments as described in the literature from over 900 references (from Whitaker).[6] Note that the map does not include all known pediments, for instance in the Yukon Territory of north-west Canada.

and the pediments themselves are sometimes even dated as late Cenozoic. Therefore, pediments in the western US valleys indicate a Flood/post-Flood boundary in the late Cenozoic, assuming the geological column is an absolute, but temporally compressed, Flood sequence. (There is evidence that the geological column is a general sequence with many exceptions and that the Cenozoic especially is not an absolute Flood sequence.[110]) I suspect that a similar time for the boundary can be surmised for other areas of the world where pediments have been formed.

Summary and Conclusion

Pediments are planar geomorphological surfaces at the foot of a mountain or mountain range, which are remarkably flat on the broad scale. Pediments can sometimes cover several hundred km^2 and they have similar concave-up shapes, with the steepest angles usually between 1° and 6° at the mountain front. Pediments are found on both plutonic and sedimentary rock, with multiple levels sometimes observed on sedimentary rocks. Additional downcutting sometimes leaves pediments as erosional remnants or beheaded from the edge of the mountains. A veneer of rounded to subrounded coarse gravel, usually of similar lithology to the surrounding mountains but with a minor proportion of exotic clasts on some pediments, is often noted overlying the rock planation surface, increasing in thickness away from the mountains.

The most significant aspect of pediments is that they are not observed forming today but are being dissected by modern streams and rivers, indicating that they were formed by some past process. Scientists have three main hypotheses for the formation of pediments, all of which have fatal flaws. These hypotheses are: 1) lateral planation from streams flowing out of the mountains, 2) sheetflooding at the edge of the mountains and 3) weathering. Only C.H. Crickmay's superflooding hypothesis, not considered significant by mainstream geologists, comes anywhere close to a solution, in that it postulates pediments are the result of large downvalley water flows.

I propose that pediments formed during the Recessional Stage of the Genesis Flood, since pediments are surficial landforms, which formed after the last major erosional event of the area. For pediments located in valleys, I suggest that pediments were formed during the Dispersive or channelized Phase—the last phase—of the Recessional Stage. In particular, pediments were formed by the last fast flow that smoothed the surface and left a veneer of mostly rounded coarse gravel on top. The various subsidiary observations of valley pediments, such as multiple pediments and eroded pediments, can be explained by changes in downvalley current speeds.

Two deductions from the Flood origin of pediments can be made. First, the Genesis Flood was a global flood and not a local flood, because pediments are observed worldwide. Second, pediments indicate a Flood/post-Flood boundary in the late Cenozoic, assuming the geological column is a temporally compressed Flood sequence. The reason for this deduction is that pediments sometimes are cut on late Cenozoic sedimentary rocks and are themselves sometimes dated as late Cenozoic.

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