Appendix 21

Three Fatally Flawed Uniformitarian Hypotheses for Pediments

Since the time of Gilbert the fact that pediments are not forming today has not stopped mainstream geologists from proposing a number of hypotheses. Each has generated a great deal of controversy. Thomas Oberlander states:

> 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…[1]

Although there are many minor hypotheses for the formation of pediments, there are three main ones put forward by mainstream geomorphologists: (1) lateral planation hypothesis, (2) the sheetflooding hypothesis, and (3) the weathering hypothesis.

Lateral Planation

One of the most popular early hypotheses suggests meandering streams first ran perpendicular from the mountains and eroded the pediments as they swept side to side across the along the edge of the mountains or the foothills. Countless back and forth meandering supposedly changed the rough surface into a smooth surface. This hypothesis was widely believed by many early geomorphologists, including Eliot Blackwelder[2] and Douglas Johnson.[3,4] It is still believed by some today, Bourne and others write:

> 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 mine).[5]

Streams that flow out of the mountains are *rare to nonexistent* in deserts, so unless the climate was different in the past, a lack of water is one problem with this hypothesis.[6] It is possible thunderstorms, known to cause significant erosion in a short period of time, may overcome the lack of water in a dry climate. But, most of the time water from thunderstorms form channels and erode preexisting pediments or form alluvial fans.[7,8] We do not observe streams flowing out of the mountains planing rough foothills and mountains into pediments.

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[1] Oberlander, T.M. 1989. Slope and pediment systems. In, Thomas, D.S.G. (editor), *Arid zone Geomorphology*, Halsted Press, New York, NY, p. 57.
[2] Blackwelder, E., 1931. Desert plains. *Journal of Geology* 39:133-140.
[3] Johnson, D., 1931. Planes of lateral corrasion. *Science* 73:174-177.
[4] Johnson, D., 1932. Rock fans of arid regions. *American Journal of Science* 23(137), fifth series:389-416.
[5] Bourne, J.A., R. Hillis, M. Rutty, and C.R. Twidale, 2002. Fan, fill or covered pediment? Seismic investigation of alluvial cover thickness, Hayward 'pediment', Flinders Ranges, South Australia. *Zeitschrift für Geomorpholgie N. F.* 46(2):193-201.
[6] Selby, M.J., 1985. *Earth's Changing Surface: An Introduction to Geomorphology*, Clarendon Press, Oxford, U.K., p. 528.
[7] Crickmay, C.H., 1974. *The Work of the River: A Critical Study of the Central Aspects of Geomorphology*, American Elsevier Publishing Co., New York, NY, p.213.

Another problem with the lateral planation hypothesis is the streams flowing out of the mountains must also flow *parallel* to and along the edge of the ridge or mountains.[8] Normally streams flow downhill, but how can a stream fow parallel to the topographic contours?

When exposed bedrock is observed on a pediment, stream and river sculpting features are not detected.[8] Furthermore, many granite mountains that are surrounded by pediments lack valleys for emerging streams, as a result no stream could have flowed from the mountains to cut the pediment![9] Although once very popular, the hypothesis of lateral planation has been almost totally rejected because of these fatal flaws. Table A21.1 summarizes the problems of the lateral planation hypothesis.

1. Mountain streams are rare in dry environments
2. Heavy rain is observed to channel
3. Mountain streams are observed to form either alluvial fans or dissect pre-existing pediments
4. Stream must flow parallel to edge of mountains or ridge for awhile
5. Exposed bedrock shows no evidence of stream erosion features
6. No valleys in some granitic mountains for a stream to flow down to form a pediment

Table A21.1. Problems with the lateral planation hypothesis.

The Sheetflooding Hypothesis

The second major hypothesis is the sheetflooding hypothesis. In it, repeated sheetflooding from heavy thunderstorms spreads away at right angles from the mountain front. Over time the flooding erodes and smooths the surface. This hypothesis was also favored by a number of the early geologists.[10,11] A few modern geologists have invoked it as either the main mechanism or in combination with others.[12] Shallow sheetflooding has been observed during thunderstorms in dry environments.[13] So, it seems logical they could cause planar erosion. However, sheetfloods are rather rare, linear streams are much more common.[14] Also, it is observed that sheetfloods quickly transform into a channelized drainage network.[15,16]

But, the most significant problem—a fatal flaw—with the hypothesis is there must be a pre-existing flat pediment, first. Without a pediment, there would be no surface to carry the sheet-flood. Many investigators have pointed out this inconvenient fact.[14,17,18,19] Oberlander stated:

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[8] Strudley, M.W., A.B. Murray, and P.K. Haff., 2006. Emergence of pediments, tors, and piedmont junctions from a bedrock weathering—regolith thickness feedback. *Geology* 34:805-808.
[9] Oberlander, Ref.1, p. 72.
[10] Paige, S., 1912. Rock-cut surfaces in the desert ranges. *Journal of Geology* 20:442-450.
[11] Rich, J.L., 1935. Origin and evolution of rock fans and pediments. *GSA Bulletin* 46:999-1,024.
[12] Vincent, P. and A. Sadah, 1995. Downslope changes in the shape of pediment debris, Saudi Arabia. *Sedimentary Geology* 95:207-219.
[13] McGee, W.J., 1897. Sheetflood erosion, *GSA Bulletin* 8:87-112.
[14] Ritter, D.F., 1978. Pediments. In, *Process Geomorphology*, Wm. C. Brown, Dubuque, IA, p. 294.
[15] Davis, W.M., 1938. Sheetfloods and streamfloods. *GSA Bulletin* 49:1,337-1,416.
[16] Bloom, A.L., 1978. *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms*, Prentice-Hall, Englewood Cliffs, NJ, p. 199.
[17] Howard, A.D., 1942. Pediment passes and the pediment problem (Part II). *Journal of Geomorphology* 5(2):110.
[18] Crickmay, Ref. 7, p. 211.
[19] Dohrenwend, J.C., 1994. Pediments in arid environments. In, Abrahams, A.D. and A.J. Parsons (editors), *Geomorphology of Desert Environments*, Chapman & Hall, London, U.K., p. 342.

> 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.[20]

Furthermore, sheetfloods normally *deposit* rather than erode debris.[21,22] Table A21.2 sums up the serious problems with this hypothesis.

1. Sheetflooding rare
2. Sheetflooding changes quickly to a channelized streamflow network
3. Sheetflooding normally deposits debris
4. Requires a pre-existing pediment

Table A21.2. Problems with the sheetflood hypothesis.

The Weathering Hypothesis

The third major hypothesis for the origin of pediments is the weathering hypothesis.[22,23,24,25] It is identical to the weathering hypothesis that attempts to explain the planation and erosion surfaces described in Chapter 51. Most geomorphologists lean toward this hypothesis.[26,27]

A major problem with this hypothesis is weathering will not form a planar surface, neither on top of the gravel veneer nor in the subsurface since the weathering front migrates downward. Water causes weathering in the subsurface, moisture tends to penetrate or attack joints and zones of textural and mineralogical weakness in a rock.[28] Once formed, depressions in the weathering front hold more water and weather even faster. So, weathering roughens a preexisting surface. It does *not* create a planar surface. Furthermore, the surface gravels on a large pediment should not be as uniform as they are if the weathering hypothesis were true.[8]

Although Twidale stated that the slightly rough surface of the rock pediment below the coarse gravel veneer is evidence for the weathering hypothesis,[29] the relief on the hard rock below the gravel veneer is generally *low* and, some pediments are planed on soft rocks.[30,31,32] Weathering should rapidly roughen soft rocks. Planar pediments on the soft rocks of the John

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[20] Oberlander, Ref.1, p. 72.
[21] Howard, Ref. 17, p. 106.
[22] Mabbutt, J.A., 1966. Mantle-controlled planation of pediments. *American Journal of Science* 264:78-91.
[23] Oberlander, T.M., 1974. Landscape inheritance and the pediment problem in the Mojave Desert of Southern California. *American Journal of Science* 274:849-875.
[24] Tuan, Y.-F., 1959. Pediments of Southeastern Arizona, *University of California Publications in Geography 13*, University of California Press, Berkeley, CA.
[25] Twidale, C.R., 1978. On the origin of pediments in different structural settings. *American Journal of Science* 278:1,138-1,176.
[26] Hadley, R.F., 1967. Pediments and pediment-forming processes. *Journal of Geological Education* 15:89.
[27] Twidale, C.R. and Bourne, J.A., 2013. Pediments as etch forms: implications for landscape evolution. *The Journal of Geology* 121:607–622.
[28] Twidale, C.R., 1978. Granite platforms and the pediment problem. In, Davies, J.L. and M.A.J. Williams (editors), *Landform Evolution in Australia*, Australian National University Press, Canberra, Australia, p. 299.
[29] Twidale, C.R., 1981. Origins and environments of pediments. *Journal of the Geological Society of Australia* 28:423-434.
[30] Sinnock, S., 1981. Glacial moraines, terraces and pediments of Grand Valley, western Colorado. *New Mexico Geological Society Guidebook, 32nd Field Conference, Western slope Colorado*, pp. 113-120
[31] Cole, R.D., and J.L. Sexton, 1981. Pleistocene surficial deposits of the Grand Mesa area, Colorado. *New Mexico Geological Society Guidebook, 32nd Field Conference, Western Slope Colorado*, pp. 121-126.
[32] Chorley, RJ., S A. Schumm, and D.E. Sugden, 1984. *Geomorphology*, Methuen, London, U.K., p. 489.

Day Country, northeast Oregon (see Figure 32.10) are much smoother than they should be if the weathering hypothesis were true. This is instead an indication that these are young formations.

Weathering processes are obviously acting on pediments today, but the question is really whether such a weathering process on a steep mountain front or in the foothills bordering mountains could wear the relief down or back into the mountain and form a planar surface. Dohrenwend admitted:

> 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 (emphasis his).[33]

If weathering were the cause of pediments and the mountain scarp retreat, we should see mounds of disintegrated rock, especially at the foot of the scarp, but this is not observed.[34] It is unlikely that the limited flow of water seen in the present would have removed all this debris from the upper portion to the lower portion of the pediment.

Several of the other problems associated with the first two hypotheses also apply to the weathering hypothesis. Table A21.3 is a summary of the problems with the weathering hypothesis.

1. Surface of rock and gravel veneer too planar
2. Gravel above bedrock of pediment is too uniform
3. Some pediments planed in soft rocks
4. The weathering debris often missing
5. Several of the problems associated with the other hypotheses also apply to this hypothesis

Table A21.3. Problems for the weathering hypothesis.

[33] Dohrenwend, Ref. 19, p. 343.
[34] Small, R.J., 1978. *The Study of Landforms: A Textbook of Geomorphology*, second edition, Cambridge University Press, London, U.K., p. 324.