Chapter 51

Does the Weathering Hypothesis Explain Planation Surfaces?

Like Davis's hypothesis, all the other hypotheses of landscape evolution that were developed over a period of more than 100 years, have been found wanting (see Appendix 19). Only one major hypothesis remains, the weathering hypothesis, also called *etchplanation*. It attempts to explain flat or nearly flat surfaces.

The Weathering Hypothesis

Weathering is defined as the in situ alteration and/or disintegration of rocks at or near the earth's surface.[1] Erosion is, "The general process or the group of processes whereby the materials of the Earth's crust are loosened, dissolved, or worn away, and simultaneously moved from one place to another…[2] Denudation is, "The sum of the processes that result in the wearing away or progressive lowering the Earth's surface by various natural agencies, which include weathering, erosion, mass wasting, and transportion…"[3] Denudation has a wider meaning than erosion and also includes the physical removal of the eroded or weathered material from the area and not just the movement of material a little.

The weathering hypothesis was first proposed by J.D. Falconer in 1911.[4] It was especially emphasized and developed by Wayland in the early 1930s and by Bailey Willis in his study of East African plateaus and rift valleys.[5] The hypothesis was advanced by Büdel during the third quarter of the twentieth century, primarily to account for tropical erosion and planation surfaces.[6] The weathering hypothesis seems to be the only one that is seriously considered by geomorphologists, but that of course does not mean it is correct. It is strongly advocated by several prominent geomorphologists, such as Thomas[7,8,9,10,11,12] and Twidale.[1,13,14,15,16]

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[1] Twidale, C.R., 1982. *Granite Landforms*, Elsevier Scientific Publishing Company, New York, NY, p. 58.
[2] Neuendorf, K.K.E., J.P. Mehl, Jr., and J.A. Jackson, 2005. *Glossary of Geology*, Fifth Edition. American Geological Institute, Alexandria, VA, p. 217.
[3] Neuendorf et al., Ref. 2, p. 171.
[4] Small, R.J., 1978. *The Study of Landforms: A Textbook of Geomorphology*, second edition, Cambridge University Press, London, U.K., p. 295.
[5] Willis, B., 1936. *East African Plateaus and Rift Valleys*, Carnegie Institution of Washington, Washington D.C.
[6] Ahnert, F., 1998. *Introduction to Geomorphology*, Arnold, London, U.K., p. 222.
[7] Thomas, M.F., 1965. Some aspects of the geomorphology of domes and tors in Nigeria. *Zeitschrift für Geomorpholgie* 9:63–81.
[8] Thomas, M.F., 1967. A bornhardt dome in the plains near Oyo, Western Nigeria. *Zeitschrift für Geomorpholgie N. F.* 11:239–261.
[9] Thomas, M.F., 1978. The study of inselbergs. *Zeitschrift für Geomorpholgie N. F.* 31:1–41.
[10] Thomas, M.F., 1989. The role of etch processes in landform development I. Etching concepts and their applications. *Zeitschrift für Geomorpholgie N. F.* 33 (2):129–142.
[11] Thomas, M.F., 1989. The role of etch processes in landform development II. Etching and the formation of relief. *Zeitschrift für Geomorpholgie N. F.* 33 (3):257–274.
[12] Thomas, M.F., 1994. *Geomorphology in the Tropics: A Study of Weathering and Denudation in Low Latitudes*, John Wiley & Sons, New York, NY.
[13] Twidale, C.R. 1982. The evolution of bornhardts. *American Scientist* 70:268–276.
[14] Twidale, C.R., 1986. Granite platforms and low domes: newly exposed compartments or degraded remnants? *Geografiska Annaler* 68A:399–411.
[15] Twidale, C.R., 1990. The origin and implications of some erosional landforms. *Journal of Geology* 98:343–364.

According to the hypotheses, erosion or planation surfaces form in two stages (Figure 51.1). First, a landscape chemically weathers from the surface downward with time (Figure 51.1a). The boundary between the weathered debris and unweathered rock is called the *weathering front*. Most of the weathering is accomplished by pervasive shallow groundwater.[17] Second, the weathered debris is removed by sheet wash, stream erosion, or other mechanisms, exposing the bedrock "erosion surface" (Figure 51.1b). Both stages can occur simultaneously. The mechanism is especially effective in the humid tropics where the weathering of rock is sometimes detected deeper than 330 feet (100 m). The resulting landform is called an etchplain if planar, and an etchsurface if not.

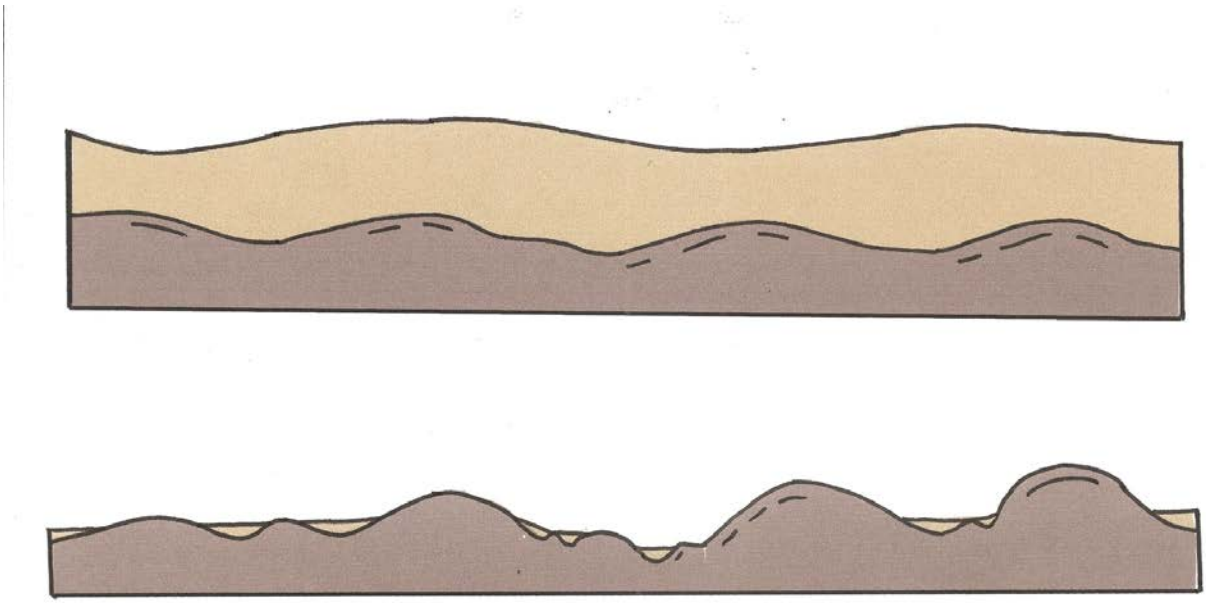

Figure 51.1. Schematic of the weathering hypothesis in forming an erosion surface (etchsurface) (after Thomas, 1994, p. 291, and redrawn by Mrs. Melanie Richard).
a) First, the land weathers deeply with the boundary between the weathered (light brown) and unweathered bedrock (dark brown) called the weathering front.
b) Second, the weathered material is almost totally eroded to form the etchsurface.

Weathering Does Not Form Planation Surfaces

There are many problems with this hypothesis. The first and probably most serious is that weathering does not form a planation surface. For a planation surface to result after the weathering of the surface, it is necessary to begin with a planation surface: "One problem with the process as a 'planation' process is that it starts off with a plain."[18] So, the weathering hypothesis cannot be an explanation for planation surfaces.

Moreover, weathering should roughen a previously formed planation surface. The many

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[16] Twidale, C.R., 2002. The two-stage concept of landform and landscape development involving etching: origin, development and implications of an idea. *Earth-Science Reviews* 57:37–74.
[17] Baker, V.R. and C.R. Twidale, 1991. The reenchantment of geomorphology. *Geomorphology* 4:81.
[18] Ollier, C. and C. Pain, 2000. *The Origin of Mountains* Routledge, London, U,K., p. 232.

factors determining weathering rate are spatially variable.[19,20] Erosion is often greater in one area than another. Lithology and drainage patterns are especially relevant to the weathering rate.[21] Therefore, the weathering front below the surface should be *rough and not planar* (Figure 51.2). Twidale stated: "Weaknesses in the country rock are exploited by moisture and the weathering front is frequently irregular in detail: a topography is developed."[22] Ollier and Pain write:

> Other writers (including Ollier, 1959) believe the weathering front (the surface between fresh rock and saprolite) is very irregular and not parallel to the ground surface. Soil surveys have shown that some planation surfaces cut indiscriminately across both fresh and weathered rock…[23]

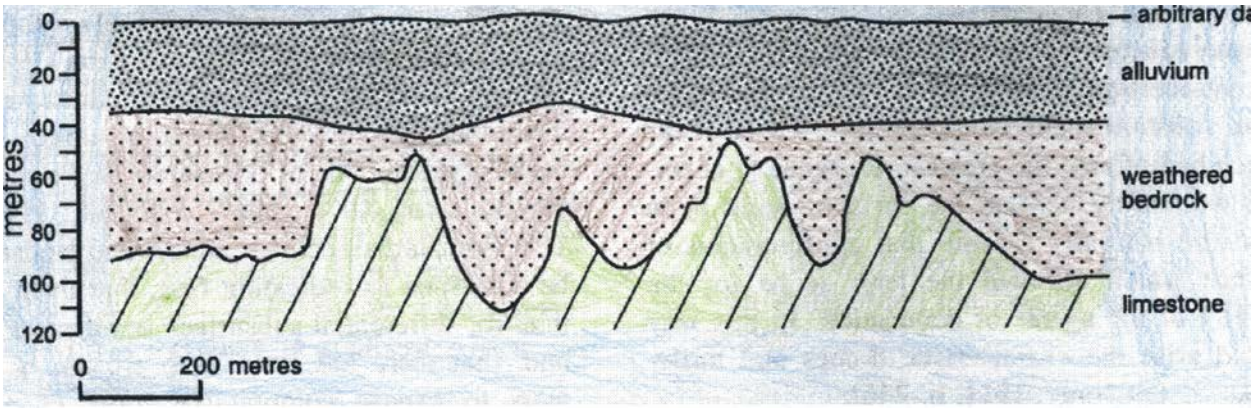

Figure 51.2. Profile showing the weathered material above rough bedrock (from Twidale, 2002, p. 46).

How could an exceptionally flat surface over a large area form by irregular weathering? The fact that some planation surfaces bevel both weathered and unweathered rock indicates weathering has little or nothing to do with the formation of the planation surface. It also indicates some "weathering" occurred before planing.

Migoń contends the planation surface in the mountains of southwest Poland (see Chapter 47) was caused by weathering over millions of years.[24] However, he admits that the planation surfaces were probably not formed by weathering on the granite rocks of the area, suggesting some other planation process: "Moreover, some types of bedrock, such as granite, are unlikely to give rise to a planation surface if etching is the dominant geomorphic process."[25] As stated by Bishop, the geomorphologist Thornbury could not conceive of weathering forming regional planation surfaces.[26] In fact, weathering should roughen a planation surface as shown in Figure

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[19] Birkeland, P.W. 1984. *Soils and geomorphology*, Oxford University Press, New York, NY.
[20] Hall, K.J., 1988. Weathering. In, Moon B.P. and G.F. Dardis (editors), *The Geomorphology of Southern Africa*, Johannesburg, South Africa, pp. 12–29.
[21] Summerfield, M.A. 1991. *Global Geomorphology*, Longman Scientific & Technical, New York, NY, pp. 462–463.
[22] Twidale, C.R., 2004. River patterns and their meaning. *Earth-Science Reviews* 67:160.
[23] Ollier and Pain, Ref. 18, pp. 232–233.
[24] Migoń, P., 1999. Inherited landscapes of the Sudetic Foreland (SW Poland) and implications for reconstructing uplift and erosional histories of upland terrains in Central Europe. In, Smith, B.J., W.B. Whalley, and P.A. Warke (editors), *Uplift, Erosion and Stability: Perspectives on Long-Term Landscape Development*, Geological Society of London Special Publication No. 162, The Geological Society, London, U. K., pp. 93–107.
[25] Migoń, Ref. 24, p. 105.
[26] Bishop, W.W., 1966. Stratigraphical geomorphology: a review of some East African landforms. In, Dury, B.H. (editor), *Essays in Geomorphology*, Heinemann, London, U.K., pp. 142–143.

51.3. The surface below weathered rock is rarely flat, so Bishop believed the term “etchplain” should be excised from the vocabulary of geomorphology: “Similar value cannot be claimed for the term *etchplain*, which seems of doubtful value in the already overburdened vocabulary of geomorphology.”[27]

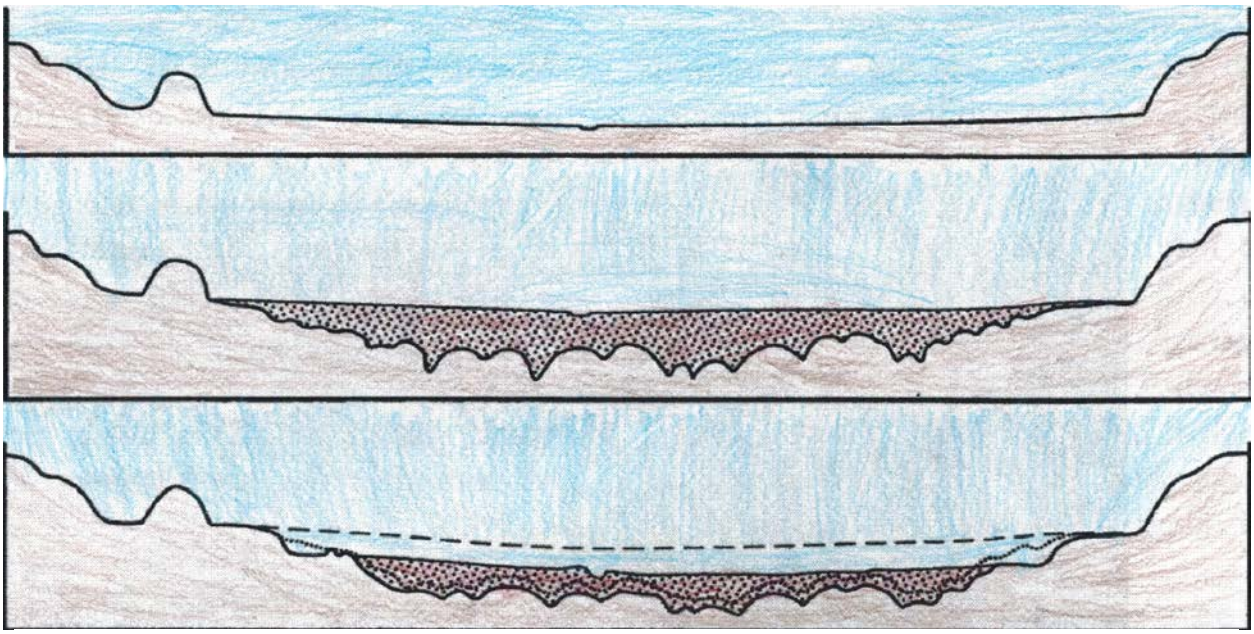

Figure 51.3. Diagram showing the weathering of a planation surface. Sometimes the debris on the top of the weathered surface is flat, but the weathering roughens the bedrock below (from Twidale, 2002, p. 50).

Thomas admitted that the weathering hypothesis merely *fills a theoretical void* rather than standing on its own merits, and he also adds weathering normally does not form a flat planation surface:

> The application of etchplanation to the formation of landsurfaces of extreme planation has tended to be the primary emphasis given to the theory, *perhaps because the explanation of extensive plains has always been elusive*, and the continued operation of weathering with the gradual removal of the fine-grained or solutional products, proves a logical mechanism for the destruction of relief. However, the basal weathering surface (weathering front) which may become exposed …, is *generally quite irregular*, and most instances are better described as etchsurfaces rather than as etchplains…(emphasis mine).[28]

A second, but related problem is weathering would most likely destroy an already existing planation surface. Hall admitted:

> It is far from simple to determine what weathering process acted to cause the formation of any given landform. The type of weathering *currently* active may be in the process of destroying, rather than forming, that landform (emphasis his).[29]

Although Hall was thinking about landforms in general, planation surfaces would fall under his generalization.

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[27] Bishop, Ref. 26, p. 149.
[28] Thomas, Ref. 12, pp. 303–304.
[29] Hall, Ref. 20, p. 12.

Many More Difficulties

A third problems with the weathering hypothesis is the stripping of weathering products from the surface.[27] Many planation surfaces are bare rock. King questioned how deep weathering products could be removed from a flat surface, often leaving no weathered material behind.[30] Taylor and Howard claim that tectonics causes the removal of weathering products that collect during a stillstand.[31] But, how would uplifting a planation surface erode the weathered material to bare rock? Uplift would cause dissection of the planation surfaces, so removal would also destroy the surface.

Fourth, it has also been observed that planation surfaces sometimes cut across *both* weathered and unweathered surfaces, as was already mentioned, indicating planation is *independent* of weathering.[27] Pugh stated: "The perfection of plains cut without distinction across weathered and unweathered material implies considerable efficiency of erosional processes."[32] It also indicates the denuding mechanism ignored the degree of weathering.

The fifth question is, how can the weathering hypothesis account for the rounded rocks that cap many planation surfaces? It is not able to account for their transportation from long distances or the abundant percussion marks found on the gravels that top the Cypress Hills and Flaxville surfaces, and other planation surfaces.

Because of all these difficulties, the weathering hypothesis is generally unsupported. Weathering advocate, Thomas acknowledged the speculative nature of the hypothesis:

> However, there is an important difference between studies concerned principally with the description of a sequence of periods of deep weathering followed by stripping, possibly repeated through geologic time …, and the provision of a *convincing account* of the processes involved and their geomorphological consequences. Some principles for the formation of etchplains have been adduced above, but *many questions remain that require further study* (emphasis mine).[33]

Furthermore, Watchman and Twidale confessed that the weathering hypothesis cannot account for all planation surfaces; some must have formed by another mechanism associated with water.[34]

As if to marshal a consensus, Summerfield and Thomas stated that "overwhelming opinion" favors landscape lowering by the removal of deep weathering profiles.[35] However, it is questionable whether a majority of geomorphologists really accept this hypothesis. Ollier counters the claim of widespread belief in the hypothesis:

> I do not know of any basis for the 'overwhelming opinion' [favoring the weathering hypothesis], but my own view is that etchplanation is understood and thought widespread by only a minority of geomorphologists at present.[36]

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[30] King, L., 1975. Bornhardt landforms and what they teach. *Zeitschrift für Geomorpholgie N. F.* 19:309.

[31] Taylor, R.G. and K.W.F. Howard, 1998. Post-Palaeozoic evolution of weathered landsurfaces in Uganda by tectonically controlled deep weathering and stripping. *Geomorphology* 25:173–192.

[32] Pugh, J.C., 1966. The landforms of low latitudes. In, Dury, B.H. (editor), *Essays in Geomorphology*, Heinemann, London, U.K., p. 125.

[33] Thomas, Ref. 12, p. 301.

[34] Watchman, A.L. and C.R. Twidale, 2002. Relative and 'absolute' dating of land surfaces. *Earth-Science Reviews* 58:1.

[35] Summerfield, M.A. and M.F. Thomas, 1987. Long-term landform development: editorial introduction. In, Gardiner, V. (editor), *International Geomorphology 1986*, Proceedings of the 1st International Conference on Geomorphology, Part II, pp. 928.

[36] Ollier, C., 1991. *Ancient Landforms*, Belhaven Press, New York, NY, p. 205.

Although developers of the weathering hypothesis strongly believe their hypothesis is correct, there are many who reject it. Table 51.1 lists the difficulties with the weathering hypothesis.

1. Weathering causes a rough surface, not a planation surface
2. Weathering will destroy an already existing planation surface
3. Weathered debris must be stripped from the area
4. Planation surfaces cut across both unweathered and weathered rock
5. Cannot account for exotic, rounded rocks with percussion marks

Table 51.1. Problems with the weathering hypothesis for the formation of planation surfaces.