Chapter 56

Uniformitarian Hypothesis Fail

The origin of inselbergs and tower karst has generated considerable controversy for many years. Not only is there a problem accounting the height of these erosional remnants that tower over planation surfaces, but also inselbergs are claimed to be tens of millions to over 100 million years old. This seems impossible, as shown in the previous chapter, but uniformitarians have devised hypothesis to attempt to explain their existence.

Inselbergs Not Necessarily Harder with Fewer Cracks

Some aspects of structure and the hardness of the rock seems to control the development of inselbergs, but the relationship *appears weak*[1,2] King (1966) has observed that there does not seem to be any rock control on some inselbergs and their surrounding pediments. They developed from the same rock that was eroded away.

Some researchers have noticed a correlation between fracture patterns within some inselbergs and a contrasting pattern of the surrounding land. The inselbergs seem to be less fractured or jointed.[1,3] Still, there are many remaining questions.[2] Thomas stated:

> Enquiry into the origins and development of the prominent and generally isolated hills described as *inselbergs* continues to arouse controversy after many decades of research (emphasis his).[4]

Two Flawed Hypotheses

Since inselbergs are associated with planation surfaces, it is natural to assume their origin is associated with the origin of the planation surfaces themselves.[5] A number of hypotheses have been suggest over the years, but only two remain.[6,7,8,9] Unfortunately, both hypotheses are flawed—I believe fatally so.

King's Hypothesis

The first is King's planation hypothesis: inselbergs are residual hills left behind during the parallel retreat of slopes through "pediplanation"[8,10,11,12] (Figure 56.1) In this model, inselbergs represent the last remnants of the planed landscape (see Appendix 19 for an analysis of King's

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[1] Twidale, C.R. and J.A. Bourne, 1998. Origin and age of bornhardts, southwest Western Australia. *Australian Journal of Earth Sciences* 45:903-914.
[2] Römer, W., 2005. The distribution of inselbergs and their relationship to geomorphological, structural and lithological controls in Southern Zimbabwe. *Geomorphology* 72:156-176.
[3] Twidale, C.R., 1981. Granitic inselbergs: domed, block-strewn and castellated. *Geographic Journal* 147 (1):54-71.
[4] Thomas, M.F., 1978. The study of inselbergs. *Zeitschrift für Geomorpholgie N. F.* 31:3.
[5] Thomas, Ref. 4, p. 4.
[6] Thomas, M.F., 1978. The study of inselbergs. *Zeitschrift für Geomorpholgie N. F.* 31:1-41.
[7] Twidale, C.R., 1986. Granite platforms and low domes: newly exposed compartments or degraded remnants? *Geografiska Annaler* 68A:399-411.
[8] King, L., 1975. Bornhardt landforms and what they teach. *Zeitschrift für Geomorpholgie N. F.* 19:299-318.
[9] Brook, G.A., 1978. A new approach to the study of inselberg landscapes. *Zeitschrift für Geomorpholgie N. F.* 31:138-160.
[10] King, L., 1948. A theory of bornhardts. *The Geographical Journal* 112:83-87.
[11] King, L., 1966. The origin of bornhardts. *Zeitschrift für Geomorpholgie N. F.* 10(1):97-98.
[12] King, L., 1977. What bornhardts teach. *Zeitschrift für Geomorpholgie N. F.* 21:366-367.

pediplanation hypothesis). King thought the presence of pediments surrounding most bornhardts was positive evidence for his hypothesis. Inselbergs rising from little-weathered pediments are today offered as support for his hypothesis.[13]

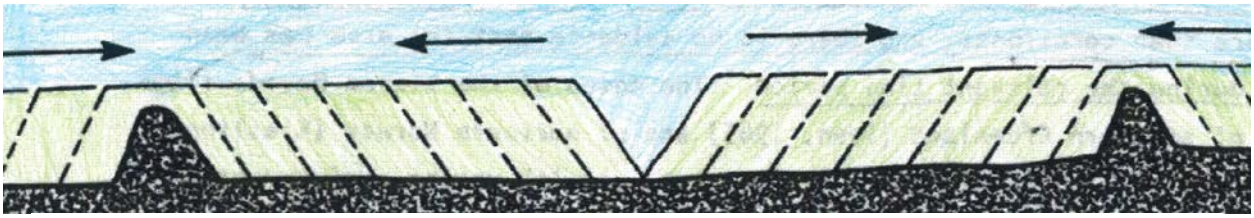

Figure 56.1. The formation of inselbergs as remnants of long-distance scarp retreat in the pediplanation hypothesis of Lester King (from Twidale, 1982b, p. 138). A V-shaped valley erodes, while keeping the same angle of slope, until just erosional remnants are left.

However, Twidale, Ollier, Thomas, and many other geomorphologists believe that King's hypothesis is *fatally* flawed, and I would agree. The origin of inselbergs is tied to that hypothesis' problems regarding the formation of a pediplain (see Table A19.2). Thomas noted that King's hypothesis cannot account for bornhardts 1,000 to 2,000 feet (300-600 m) tall.[14] That is a reasonable deduction.

These geomorphologists also note that inselbergs are not necessarily located where King expected them. They should be found only at the *tops* of ridges or the highest land in a planed region if King's hypthosis were correct, but they are not.[15,16,17,18] Twidale stated:

> The scarp retreat hypothesis implies that inselbergs are confined to major divides. It assumes long-distance scarp retreat—the recession of scarps over scores, even hundreds of kilometers. If the hypothesis were correct there ought to be massifs in all stages of areal reduction from extensive granitic plateaux, to mesas and inselbergs.[19]

Inselbergs are even located along valley sides.[20]

These observations refute King's parallel retreat of slopes hypothesis and his hypothesis on the origin of inselbergs. Hence, most geomorphologists today have rejected King's hypothesis and have been *forced* to accept the weathering hypothesis,[21] because there is no other choice. Table 56.1 summarizes these problems with the pediplanation hypothesis for the origin of inselbergs.

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[13] Chorley, R.J., S.A. Schumm, and D.E. Sugden, 1984. *Geomorphology*, Methuen, London, U.K., p. 492.
[14] Thomas, Ref. 4, p. 25.
[1515] Jeje, L.K., 1973. Inselberg's evolution in a humid tropical environment: the example of South Western Nigeria. *Zeitschrift für Geomorpholgie N. F.* 17:194-225.
[16] Thomas, M.F., 1965. Some aspects of the geomorphology of domes and tors in Nigeria. *Zeitschrift für Geomorpholgie* 9:63-81.
[17] Twidale, C.R. 1982. The evolution of bornhardts. *American Scientist* 70:268-276.
[18] Twidale, C.R., 1982. *Granite Landforms*, Elsevier Scientific Publishing Company, New York, NY, p. 139.
[19] Twidale, C.R., 1988. Granite landscapes. In, Moon, B.P. and G.F. Dardis (editors), *The Geomorphology of Southern Africa*, Southern Book Publishers, Johannesburg, South Africa, pp. 211-212.
[20] Twidale, Ref. 17, p. 268.
[21] 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.

1. Many problems associated with the pediplanation hypothesis (see table 19.2)
2. Cannot account for bornhardts 1,000 to 2,000 feet (300-600 m) tall
3. Inselbergs not found exclusively on ridge tops
4. Inselbergs also occur along valley sides

Table 56.1. Problems associated with King's pediplanation hypothesis for the origin of inselbergs.

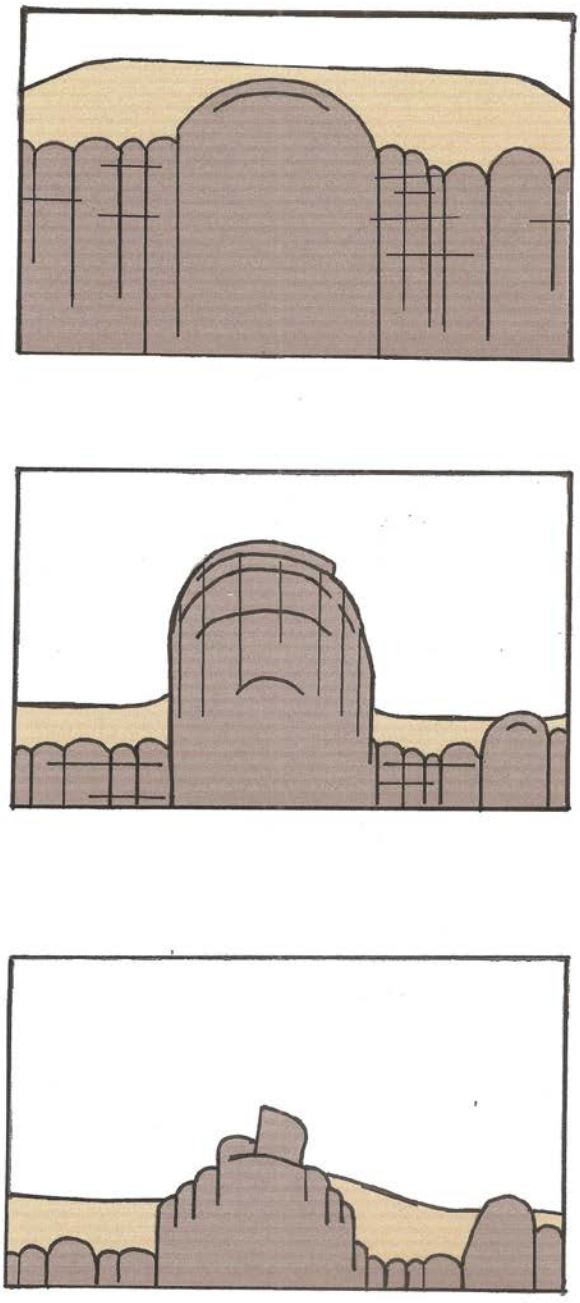

Figure 56.2. A schematic diagram to show the origin and decay of a bornhardt in the weathering hypothesis (from Chorley et al., 1984, p. 492 and redrawn by Mrs. Melanie Richard).

The Weathering Hypothesis

The second hypothesis was discussed in Chapter 51. The weathering hypothesis posits inselbergs formed by the uneven weathering of granite. As granite weathers, some portions are thought to weather less rapidly. Next, the weathered material is washed away, presumably by rivers and streams,[7,17] leaving the un-weathered granite as a dome. Figure 56.2 is a schematic showing the life cycle of a bornhardt within the weathering hypothesis. In figure 56.2a, the bornhardt is born by surficial weathering and denudation of the weathered material. The bornhardt is a resistant area that became more exposed as the area around eroded downward (Figure 56.2b). Eventually, it too is erodes away (Figure 56.2c).

There are a number of problems associated with the weathering hypothesis (see Table 51.1). King pointed to the great height of some bornhardts and argued that there is *little weathering around many bornhardts today*.[11] He questioned whether deep weathering in the past could have produced such tall features, which I believe is a reasonable question:

> The height of bornhardts, sometimes 1000-1500 feet [300-460 meters] consonant with the measure of relief between the earlier and current base-levels, surpasses any known depth of weathering in such rock types. ... The reduction of bornhardts, individually and en masse is seen to take place wholly in rock that shows no deep pre-weathering at all ... it [the weathering hypothesis] fails utterly to account for the great bornhardt fields of Africa or South America with their many hundreds of feet of relief.[22]

King argued elsewhere: "Many bornhardt regions are indeed remarkable for the extent of bare rock pediments, as hard as the bornhardts they surround, and for the thinness and poor quality of their soils."[23]

The great height of some bornhardts, over 1,000 feet (300 m), is a severe problem for the weathering hypothesis, since even the weathering of 330 feet (100 m) of granite can hardly produce a relief over 165 feet (50 m).[24]

Many other authors have noted the current lack of weathered debris around inselbergs. There is no trace of former deep weathering in Natal where many inselbergs exist and where King lived and wrote.[25] The central Namib Desert especially shows no weathered material or even localized patches of weathered material, despite extensive drilling and excavation for mining exploration.[26,27,28,29] The tallest inselberg in the world exists in this desert (see Figure 55.1). The lack of weathering debris and the height of inselbergs is seen as fatal evidence against the weathering hypothesis, and I agree.

Weathering advocates counter saying deep weathering up to 200 feet (60 m) is seen in some areas today where inselbergs exist.[9,16,30,31,32] This still does not account for all bornhardts, since

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[22] King, Ref. 11, pp. 97-98.
[23] King, Ref. 8, pp. 306-307.
[24] Small, R.J., 1978. *The Study of Landforms: A Textbook of Geomorphology*, second edition, Cambridge University Press, London, U.K., p. 295.
[25] King, Ref. 8, p. 300.
[26] Selby, M.J., 1977. Bornhardts of the Namib Desert. *Zeitschrift für Geomorphologie N. F.* 21:1-13.
[27] Selby, M.J., 1982. Form and origin of some bornhardts of the Namib Desert. *Zeitschrift für Geomorphologie N. F.* 26:1-15.
[28] Ollier, C.D., 1978. Inselbergs of the Namib Desert: processes and history. *Zeitschrift für Geomorpholgie N. F.* 31:161-176.
[29] Cockburn, H.A P., M.A. Seidl, and M.A. Summerfield, 1999. Quantifying denudation rates on inselbergs in the central Namib Desert using in situ-produced cosmogenic ^{10}Be and ^{26}Al. *Geology* 27:399-402.
[30] Ollier, C.D., 1960. The inselbergs of Uganda. *Zeitschrift für Geomorpholgie* 4:43-52.

many of them show little if any weathering products at their base and are very high.

Twidale conceded all bornhardts could not have formed from weathering.[33] If this is the case, then there is another unknown mechanism that geomorphologists have yet to identify. Maybe this unknown mechanism can account for all bornhardts.

Figure 56.3. A granite corestone within weathered granite, Sequoia National Park, California, USA. Note that the corestone is quite small, which is typical of corestones in weathered granite.

Those favoring the weathering hypothesis believe that unweathered corestones in weathered granite, we see today, are "seeds" for future inselbergs.[17,34] Corestones are the unweathered portion between granitic joints, where weathering is concentrated. The corestones become more spherical with time (Figure 56.3 and see Figure 32.4). Their size is related to joint spacing. Unfortunately for the weathering hypotheses, the weathering around corestones also takes place *underneath* them, and so they could not stand very high once they become exposed. Inselbergs, of course, are not weathered at the base (except possibly for tafoni and flared slopes), so that the

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[31] Ojany, F.F., 1969. The inselbergs of eastern Kenya with special reference to the Ukambani area. *Zeitschrift für Geomorpholgie* 13:196-206.

[32] Migoń, P., 1997. The geological control, origin and significance of inselbergs in the Sudetes, NE Bohemian Massif, Central Europe. *Zeitschrift für Geomorpholgie N. F.* 41:45-66.

[33] Twidale, C.R., 1981. Granitic inselbergs: domed, block-strewn and castellated. *Geographic Journal* 147 (1):57.

[34] Twidale, C.R., 1982. *Granite Landforms*, Elsevier Scientific Publishing Company, New York, NY.

analogy of corestones in granite does not fit: the continued weathering of corestones would result in a ball, not a domed rock spire, which is seen in some areas of granite weathering. Furthermore, observed spheroidal corestones in granitic weathering environments are *quite small* (Figure 56.3), unlike the tall bornhardts that are resistant to weathering:

> The [weathering] hypothesis extrapolates from small common features of the regolith [the weathered rock] such as spheroidal weathering to the mighty, toughened lithosphere of chemically stable, siliceous rock types such as are characteristics of bornhardt regions. However, there is not involved just a difference of scale, from small scale features to large, but a transition across a physical boundary from chemically susceptible to highly intractable substances.[35]

But, Twidale[36] and Thomas[37] showed that there are some unweathered domes within weathered granite that are larger than ordinary corestones. However, it is unknown whether these are ridges that will soon weather away. Granitic domes within weathered granite observed by Thomas weather rapidly upon being exhumed and are not expected to survive long enough to be classified as bornhardts.[38] The geomorphologist Small observed that the weathered debris in granitic terrains is rather granular and a residue of *mechanical* weathering. Weathering according to the weathering hypothesis should be *chemical*. At least some of the feldspar should have weathered to clay, if the weathering hypothesis were true.[39]

Even if these observations might lead to bornhardts, there is the problem of the *missing* debris around the bornhardt.[40] Weathering advocates believe streams and rivers carried away the weathered debris, but there is rarely any evidence of past streams or rivers around inselbergs.

To counter the argument that the weathering hypothesis cannot account for the great height of some inselbergs, its proponents have tacked on the subsidiary hypothesis of "multiple cycles of weathering and denudation."[16,41] That is, once a small dome forms, the water that was mostly responsible for the weathering quickly drains away from the dome causing the inselberg to weather slowly and remain essentially unaffected while the surrounding area continues to weather and be denuded by water during subsequent cycles, and eventually form a pediment. Twidale saw tafoni, flared slopes, and other minor features at the base and sometimes high on bornhardts as evidence of these multiple cycles.[17,34] King, however, believed none of those minor features are related to their origin.[12] He thought the exquisite flared slopes could have been formed by weathering in sand dunes that once flanked the lower slope of the bornhardt. Fairbridge saw no evidence for King's suggestion.[42] It does seem strange that inselbergs would weather so slowly while all the surrounding countryside is lowered, especially in view of how old many inselbergs are believe to be.

Taylor and Howard admitted that it is difficult to develop a viable weathering hypothesis:

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[35] King, Ref. 8, p. 306.
[36] Twidale, Ref. 34, pp. 142-144.
[37] Thomas, M.F., 1994. *Geomorphology in the Tropics: A Study of Weathering and Denudation in Low Latitudes*, John Wiley & Sons, New York, NY, p. 329.
[38] Thomas, Ref. 16, p. 73.
[39] Small, Ref. 24, p. 133.
[40] King, Ref. 8, p. 309.
[41] Twidale, C.R. and J.A. Bourne, 1977. Bornhardts—An alternative view. *Zeitschrift für Geomorpholgie N. F.* 21:363-365.
[42] Fairbridge, R.W., 1977. Note on bornhardt formation—the King-Twidale exchange. *Zeitschrift für Geomorpholgie N. F.* 21:368.

Reconciling the development of landforms, such as inselbergs and duricrusts by cycles of deep weathering and stripping with a viable model of landscape evolution, has historically proved difficult.[43]

Figure 56.4. A duricrust cap on an inselberg in Africa (Wikipedia).

A duricrust is a general term for a hard crust on the surface.[44] Duricrusts commonly cap planatin surfaces, but they also cam some inselbergs (Figure 56.4). The subject of duricrusts will be explored in Chapter 57. It is interesting that the weathering hypothesis attempts to account for both the flat planation surfaces as well as the formation of tall inselbergs on the planation surfaces.[45,46,47] Table 56.2 summarizes the evidence against the weathering hypothesis for the origin of inselbergs.

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[43] Taylor and Howard, Ref. 21, p. 174.
[44] Neuendorf, K.K.E., J.P. Mehl, Jr., and J.A. Jackson, 2005. *Glossary of Geology*, Fifth Edition. American Geological Institute, Alexandria, VA, p. 197.
[45] 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.
[46] Twidale, C.R., 1990. The origin and implications of some erosional landforms. *Journal of Geology* 98:343-364.
[47] 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.

1. Many problems associated with weathering hypothesis (see Table 51.1)
2. Cannot account for bornhardts 1,000 to 2,000 feet (300-600 m) tall
3. Lack of weathered debris surrounding many bornhardts today
4. Weathering not deep enough
5. Twidale concedes that there must be another mechanism, besides weathering
6. Corestones in granite weathering debris are too small
7. Weathering also occurs underneath corestones
8. Corestones weather rapidly after exposure
9. Mechanical, not chemical, weathering debris is mostly observed in granitic terrains

Table 56.2. Problems with the weathering hypothesis for the origin of inselbergs.

I agree that *both* hypotheses are fatally flawed and cannot account for the impressive height of inselbergs. Both hypotheses are highly speculative and have little observational (empirical) backing:

> The numerous approaches to the study of inselbergs (reviewed by Thomas (1978)) have generally tended to be static and theoretical in nature, attempting to explain inselberg form and distribution with reference to factors such as climate, lithology and tectonic uplift history with little regard to or empirical backing for the details of the processes involved.[48]

So, there does not appear to be any uniformitarian options left. We will now move on to the only reasonable possibility that explains both planation surfaces and their residual inselbergs: runoff from the Genesis Flood.

[48] Campbell, M.D., R.A. Shakesby, and R.P.D. Walsh, 1987. In, Gardiner, V. (editor), *International Geomorphology 1986*, Proceedings of the 1st International Conference on Geomorphology, Part II, p. 1249.