Part XI

The Dilemma of Inselbergs

I discussed erosional remnants in Chapter 9, but these were mostly of a different type of rock than the surroundings. And many of these are not associated with planation surfaces. For instance, Devils Tower is a basalt-like rock that is very likely the remnant of the conduit of a volcano left over after erosion of the surrounding High Plains. In this part, I will explore erosional remnants associated with planation surfaces or pediments, and that are of the *same* composition as the surrounding rock. The general term for these erosional remnants is an inselberg. A typical example of an inselberg is a granite tower above a planation surface on granite. Inselbergs are another one of the many mysteries of geomorphology.

Chapter 53

Inselbergs

Inselbergs rise above many planation surfaces as hills or mountains that for some reason failed to erode during the planing process.[1] Any erosional mechanism proposed to plane the land must *also* account for erosional remnants. An inselberg is defined by the *Glossary of Geology* as, “A prominent isolated residual knob, hill, or small mountain…, usually smoothed and rounded that rises abruptly from an extensive lowland erosion surface in a hot, dry region (as in the desert of southern Africa and Arabia)…”[2] Twidale also included mountain ranges and ridges in his definition.[3] The word *inselberg* is a German word meaning a hill or an island jutting up from a flat sea, or more simply an “island mountain.”[4] The hill or island represents the inselberg while the flat sea represents the planation surface. Their origin is another unsolved mystery for uniformitarian geomorphology.[5]

Different Types of Inselbergs

Inselberg is a general term; more specific names have been given for those that have unique shapes. Some are associated with a particular erosional hypothesis. A *bornhardt* is defined as a large inselberg by Neuendorf *et al*. in the *Glossary of Geology*.[6] Twidale[7] and Summerfield[8] define a bornhardt as a steep-sided, dome-topped, and bare inselberg. This seems to be the common usage among geomorphologists.[9,10]

The term *monadnock* was coined for an inselberg that rises above a “peneplain.” This term is specific to Davis’ “cycle of erosion” hypothesis (see Chapter 50), and was derived from Mount Monadnock in New Hampshire. Monadnocks are the humid temperate equivalent of bornhardts, which are usually described in tropical climates.[11] The two terms are not usually synonymous. Bornhardts rise more abruptly from their surrounding plains than most monadnocks.

Smaller knobs or hills (technically inselbergs) have been called tors, castle koppies, domes, turrets, etc. A *tor* is probably the most common example of a small erosional remnant. It is defined as, “A high, isolated crag, pinnacle, or rocky peak; or a pile of rocks, much jointed and usually granitic...”[12] Tors are often found in granitic terrain. Figures 53.1and 53.2 show tors from

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[1] Small, R.J., 1978. *The Study of Landforms: A Textbook of Geomorphology*, second edition, Cambridge University Press, London, U.K., p. 291.
[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. 328.
[3] Twidale, C.R., 1982. *Granite Landforms*, Elsevier Scientific Publishing Company, New York, NY, p. 124.
[4] Faniran, I.A., 1974. Nearest-neighbour analysis of inter-inselberg distance: a case study of the inselbergs of South-Western Nigeria. *Zeitschrift für Geomorpholgie N. F.* 20:151.
[5] Twidale, C.R. 1982. The evolution of bornhardts. *American Scientist* 70:268-276.
[6] Neuendorf *et al*., Ref. 2, p. ???.
[7] Twidale, Ref. 3, p. 8.
[8] Summerfield, M.A. 1991. *Global Geomorphology*, Longman Scientific & Technical, New York, NY, p. 348.
[9] Twidale, C.R., 1968. *Geomorphology with Special Reference to Australia*, Thomas Nelson LTD, Melbourne, Australia, p. 105.
[10] Römer, W., 2005. The distribution of inselbergs and their relationship to geomorphological, structural and lithological controls in Southern Zimbabwe. *Geomorphology* 72:156-176.
[11] Twidale, Ref. 9, p. 109.
[12] Neuendorf *et al*., Ref. 2, p. 676.

a granitic terrain on the Tableland of eastern Australia. The most well-known tors are on the granite terrain of southwest England.[13,14] Tors are interesting, but this chapter will mainly focus on large, more difficult to explain inselbergs and the paradox of their existence.

Figure 53.1 Granite tors on the Tableland (an erosion surface) in eastern Australia.

Impressive Inselbergs

The most impressive inselbergs are found in Africa and the Middle East. Bailey Willis described inselbergs as rising up to about 2,600 feet (800 m) above the plains of east Africa.[15] The tallest is probably the mountain called Spitzkoppe[16] (see Figure 55.1) at about 3,600 feet (1,100 m) above the Namib Desert, a gravel-capped planation surface in the country of Namibia, west of the Great Escarpment in southern Africa (see Chapter 11). Sandstone inselbergs about 2,625 feet (800 m) are also found in southwest Jordan.[17] Inselbergs possess flared slopes and tafoni, usually at the base, which is somewhat of a puzzle, as discussed in Appendix 20.

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[13] Linton, D.L., 1955. The problem of tors. *The Geographical Journal* 121:470-487.
[14] Ehlen, J., 1991. Significant geomorphic and petrographic relations with joint space in the Dartmoor Granite, Southwest England. *Zeitschrift für Geomorpholgie N. F.* 35 (4):425-438.
[15] Willis, B., 1936. *East African Plateaus and Rift Valleys*, Carnegie Institution of Washington, Washington D.C.
[16] Selby, M.J., 1985. *Earth's Changing Surface: An Introduction to Geomorphology*, Clarendon Press, Oxford, U.K., p. 169.
[17] Osborn, G., 1985. Evolution of the Late Cenozoic inselberg landscape of southwestern Jordan. *Palaeogeography, Palaeoclimatology, Palaeoecology* 49:1-23.

Figure 53.2. A granite tor (right) on the Tableland (an erosion surface) in eastern Australia.

Bornhardts are the most common type of inselberg and can be found in groups or in isolation.[18] They range from relatively small, about 150 feet (45 m) high,[19] to enormous rock monoliths commonly between 1,000 and 1,600 feet (300 to 500 m).[20] A few bornhardts are as high as 2,000 feet (600 m),[21] such as those in east Africa. King claims that a 2,600- foot (800 m) high landform in Antarctica is a bornhardt, although the picture in the article shows a rough top. It would not fit the classical definition[22] and would be better described as an inselberg. But it may not even be an inselberg, since Thomas questioned King's deduction.[23] In some cases, bornhardts, as well as inselbergs, are not clearly defined.

How bornhardts can remain standing while the rest of the land eroded into a plain has exercised the imagination of uniformitarian geologists for over 100 years (see Chapter 56).

Bornhardts, like many inselbergs, *commonly* develop in granitic rock;[5,24,25] They almost

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[18] Twidale, Ref. 7, p. 124.

[19] Thomas, M.F., 1967. A bornhardt dome in the plains near Oyo, Western Nigeria. *Zeitschrift für Geomorpholgie N. F.* 11:239-261.

[20] King, L., 1966. The origin of bornhardts. *Zeitschrift für Geomorpholgie N. F.* 10(1):97-98.

[21] Brook, G.A., 1978. A new approach to the study of inselberg landscapes. *Zeitschrift für Geomorpholgie N. F.* 31:138-160.

[22] King, L., 1975. Bornhardt landforms and what they teach. *Zeitschrift für Geomorpholgie N. F.* 19:299-318.

[23] Thomas, M.F., 1978. The study of inselbergs. *Zeitschrift für Geomorpholgie N. F.* 31:35.

[24] Campbell, E.M. and C.R. Twidale, 1991. The evolution of bornhardts in silicic volcanic rocks in the Gawler Ranges. *Australian Journal of Earth Sciences* 38:79-93.

[25] 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.

always consist of the *same rock type* as the plains around them.[26] They differ from igneous erosional remnants, like Devils Tower, which consists of a different rock type than the surrounding sedimentary rocks. Such erosional remnants (see Chapter 9) are generally not considered inselbergs, but the same erosional principles would apply. Both Devils Tower and bornhardts indicate substantial erosion occurred during the planning of the land.

Figure 53.3. Sugarloaf Mountain, the tallest of several inselbergs situated in the Rio De Janeiro harbor, Brazil (Wikipedia). It is 1,300 feet (396m) high.

For many years bornhardts were thought to be products of only tropical erosion since they were first noted in many African countries, including Uganda,[27] Nigeria,[28,29,30] Sudan,[28] Kenya,[31] Libya,[32] the Kalahari Desert,[31] South Africa,[33] and Zimbabwe.[34,35] They were

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[26] Twidale, Ref. 3, p. 130.
[27] Ollier, C.D., 1960. The inselbergs of Uganda. *Zeitschrift für Geomorpholgie* 4:43-52.
[28] Bain, A.D.N., 1923. The formation of inselberge. *Geological Magazine* 40(3):97-101.
[29] Jeje, L. ., 1973. Inselberg's evolution in a humid tropical environment: the example of South Western Nigeria. *Zeitschrift für Geomorpholgie N. F.* 17:194-225.
[30] Faniran, I.A., 1974. Nearest-neighbour analysis of inter-inselberg distance: a case study of the inselbergs of South-Western Nigeria. *Zeitschrift für Geomorpholgie N. F.* 20:150-167.
[31] Ojany, F.F., 1969. The inselbergs of eastern Kenya with special reference to the Ukambani area. *Zeitschrift für Geomorpholgie* 13:196-206.
[32] Peel, R.F., 1941. Denudational landforms of the Central Libyan Desert. *Journal of Geomorphology* 4:3-23.

discovered by Wilhelm Bornhardt in tropical east Africa around 1900. Willis[15] studied the east African planation surfaces and rift valleys and named these bald, steep-sided towers in honor of Bornhardt:

> They [bornhardts] take their name from a German explorer and geologist, Wilhelm Bornhardt, who late in the last [nineteenth] century ascended from the Indian Ocean to the high plains of the interior or East Africa. He was astonished by the landscapes he saw. ... Africa looms large in any discussion of bornhardts, for it is in the deserts and savannas of that continent that these domical hills are especially well developed and preserved. The classical inselberg landscapes of Africa are particularly dramatic, for there, more clearly than in most other places, the residuals can be seen to rise abruptly from otherwise monotonously flat, seemingly endless plains untrammeled by dunes or by forests.[36]

Figures 53.4. Monadnock on the Inner Piedmont, east of the Blue Ridge Mountains close to Caesar's Head State Park, South Carolina.

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[33] Le Roux, J.S., 1991. Is the pediplanation cycle a useful model? evaluation in the Orange Free State (and elsewhere) in South Africa. *Zeitschrift für Geomorpholgie N. F.* 35 (2):175-185.
[34] 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. 198-230.
[35] Römer, W., 2005. The distribution of inselbergs and their relationship to geomorphological, structural and lithological controls in Southern Zimbabwe. *Geomorphology* 72:156-176.
[36] Twidale, Ref. 5, p. 268.

Bornhardts are not restricted to the tropics, however. They are found in *all* types of climates and environments,[5,30] possibly even in Antarctica.[22] Bornhardts are common in some areas, yet strangely absent from large areas of the continents. The famous Sugarloaf Mountain, 1,300 feet (396 m) tall, and other granite residuals bordering the Rio de Janeiro harbor of Brazil are bornhardts[37] (Figure 53.3). There are inselbergs or bornhardts in the Southwest United States, although they are not as well developed as those in Africa. Bornhardts are also found in Idaho, as will be discussed in the next section.

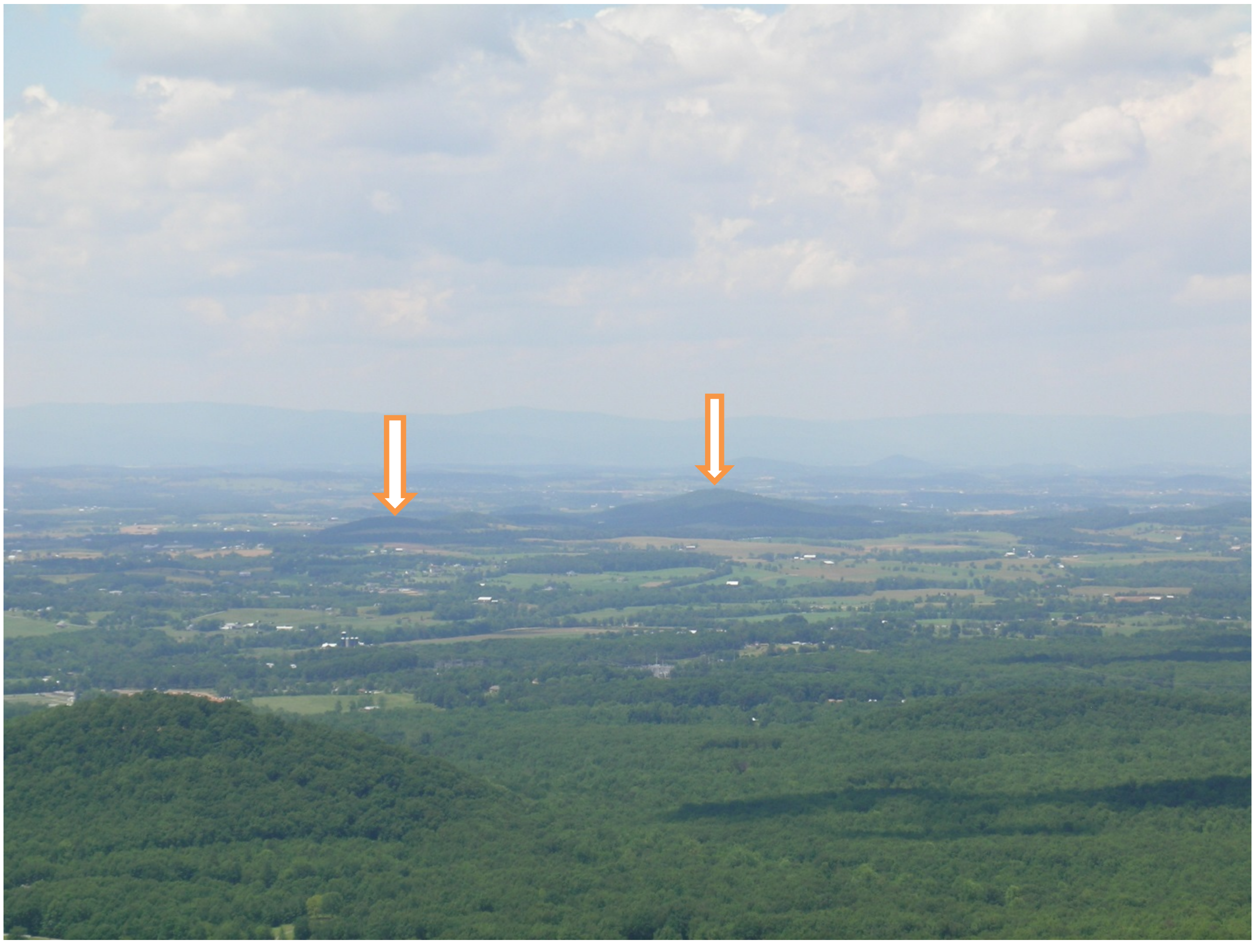

Figure 53.5. Monadnocks (arrows) above the flat floor of the Great Valley as seen to the northwest from Rocky Top Overlook, Shenandoah National park, Virginia.

Bornhardts, also called monadnocks, are associated with the Appalachian Mountains and the adjoining piedmont just east of the Appalachians of the eastern United States.[38,39,40] Figures 53.4 and 53.5 show two monadnocks in and near the Appalachian Mountains. Mount Monadnock, New Hampshire, is the classical mountain for the definition of a monadnock. The most famous

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[37] Twidale, Ref. 3, p. 13.
[38] Crickmay, G.W., 1935. Granite pedestal rocks in the southern Appalachian piedmont. *Journal of Geology* 43:745-758.
[39] White, W.A., 1945. Origin of granite domes in the southeastern piedmont. *Journal of Geology* 53:276-282.
[40] Whitney, J.A., L.M. Jones, and R.L. Walker, 1976. Age and origin of the Stone Mountain Granite, Lithonia district, Georgia. *GSA Bulletin* 87:1,067-1,077.

monadnock in the Appalachian Mountains is Stone Mountain, Georgia, on the southeast piedmont (see Figure 40.4). It is oriented west northwest-east southeast. Stone mountain is a lens-shaped dome about 785 feet (240 m) above the planed piedmont and is composed of a fine-grained granitic rock within schist and gneiss.[41,42]

Figure 53.6. Picture of Kata Tjuta (formerly called the Olgas) (courtesy of Tas Walker).

Ayers Rock (Uluru) in central Australia is a famous non-granitic inselberg composed of vertically tilted beds of arkose sandstone.[43,44,45] It stands 1,150 feet (350 m) above the surrounding flat desert floor (see Figure 1.6). However, a buried pediment lies on its east and north edges. Ayers Rock is a surface erosional remnant of a huge sandstone body that continues into the subsurface that is 20,000 feet (6,100 m) thick. Since the sandstone of Ayers Rock is vertical, before erosion it must have formed a gigantic arch that was subsequently eroded to a flat

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[41] Brook, G.A., 1978. A new approach to the study of inselberg landscapes. *Zeitschrift für Geomorpholgie N. F.* 31:138-160.
[42] Froede, Jr., C.R., 1995b. Stone Mountain Georgia: a creation geologist's perspective. *Creation Research Society Quarterly* 31:214-224.
[43] Ollier, C.D. and W.G. Tuddenham, 1962. Inselbergs of Central Australia. *Zeitschrift für Geomorpholgie* 5:257-276.
[44] Twidale, C.R., 1978. On the origin of Ayers Rock, Central Australia. *Zeitschrift für Geomorpholgie N. F.* 31:177-206.
[45] Patrick, K., 2010. Geomorphology of Uluru, Australia. *Answers Research Journal* 3:107–118.

surface (see Figure 43.4). Ayers Rock has remarkably few joints and is probably the major reason why it was not eroded during the planation process. Joints are tension cracks or fractures that do not dislocate the rock. Ayers Rock also has flared slopes at its southeast margin[46] and other special features sometimes associated with inselbergs.[44] The flared slopes and tafoni will be discussed in Appendix 20. The origin of Ayers Rock (as well as other inselbergs) remains a mystery, since its survival was not due to its lithology[47]: "The early geomorphological history and the fundamental reasons for Ayers Rock remain obscure, though various possibilities have been suggested."[48]

Figure 53.7. Conglomerate from Kata Tjuta (courtesy of Tas Walker, who provides the scale).

Twenty miles (30 km) west of Ayers Rock, Kata Tjuta (formerly the Olgas) juts 1,790 feet (546 m) above the plain (Figure 53.6).[49] It is composed of a huge mound of conglomerate composed of cobbles and boulders (Figure 53.7). The boulders are rounded except for a few large angular ones that probably were eroded from the underlying sedimentary rocks. Similar to Ayers Rock, the conglomerate of Kata Tjuta continues many hundreds of feet underground.

Pediments (see Part XIV) have been cut in the rock surrounding the base of most

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[46] Twidale, Ref. 3, p. 247.
[47] Twidale, Ref. 44, p. 194.
[48] Twidale, Ref. 44, p. 203.
[49] Walker, T., 2006-2007. Kata Tjuta: an astonishing story. *Creation* 29(1):24-27.

bornhardts.[22,50,51] Surprisingly, little talus from the inselbergs has accumulated on these pediments.[22,52,53,54] Is this an indication the inselbergs and their surrounding pediments are young and most likely the result of a high energy erosional processes?

The tops of many bornhardts display numerous curved joints that are parallel to the surface giving the top of the bornhardt a domed appearance. The rounded shape and jointing are likely caused by exfoliation associated with the "unloading" of cover rocks that once overtopped the bornhardt.[55] Twidale pointed out compression and decompression tests show fractures parallel with the surface of the dome *cannot occur when erosion is slow*.[56] So, from the uniformitarian point of view the origin of the domed top of bornhardts is still uncertain, since they cannot conceive of a mechanism for fast erosion. However, it is perfectly consistent with the Flood approach, which would demand *rapid* erosion, exfoliation being one result.

Sometimes the tops of bornhardts are beveled, indicating their tops represent a small remnant of a high-level planation surface.[24,57,58]

Figure 53.8. The Twin Sisters bornhardt in the "Silent City of Rocks" in the Albion Mountains of south-central Idaho.

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[50] Selby, M.J., 1977. Bornhardts of the Namib Desert. *Zeitschrift für Geomorphologie N. F.* 21:1-13.
[51] Selby, M.J., 1982. Form and origin of some bornhardts of the Namib Desert. *Zeitschrift für Geomorphologie N. F.* 26:1-15.
[52] Thomas, M.F., 1965. Some aspects of the geomorphology of domes and tors in Nigeria. *Zeitschrift für Geomorpholgie* 9:63-81.
[53] Twidale, Ref. 5, p. 273.
[54] Selby, Ref. 50, p. 5.
[55] King, L., 1948. A theory of bornhardts. *The Geographical Journal* 112:83-87.
[56] Twidale, Ref. 3, pp. 150-158.
[57] King, Ref. 55, p. 87.
[58] Twidale, Ref. 3, pp. 147-148.

The City of Rocks South-Central Idaho

Some bornhardts are not associated with planation surfaces. Multiple bornhardts, called the "Silent City of Rocks," are found in the Albion Mountains of south-central Idaho.[59,60] They are erosional remnants of a highly-eroded core of a granite uplift, and are *atypical* since they do not rise above a planation surface. The Twin Sisters, one of the bornhardts, rises 600 feet (180 m) and has a saddle near the top (Figure 53.8). It is unusual in that the northern knob of the Twin Sisters is composed of granite, while the southern knob consists of gneiss. To the north of the Silent City of Rocks is another group of bornhardts, represented by Castle Rock, about 400 feet (120 m) high (Figure 53.9) and other smaller bornhardts. They possess flared slopes and tafoni, which appear to be a post-Flood weathering phenomenon (see Appendix 20). Cunningham noted a lack of talus, considering their supposed great age (Figure 53.10). [61]

Figure 53.9. Castle Rock in the Albion Mountains, just north of the "Silent City of Rocks."

Another "city of rocks" is in the Bennett Hills about 60 miles (90 km) southeast of Boise, Idaho. They are pinnacles composed of ignimbrite, a welded volcanic ash flow or tuff that

[59] Cunningham, F.F., 1971. The silent City of Rocks, a bornhardt landscape in the Cotterrel Range, South Idaho, USA. *Zeitschrift für Geomorpholgie N. F.* 15:404-429.
[60] Pogue, K R., A.S. Hacker, and J.W. Laucks, 2003. The landscape evolution in Castle Rocks State Park, Albion Range, Southern Idaho. *GSA Abstracts with Programs* 35(6):543.
[61] Cunningham, Ref. 59, p. 426.

quickly becomes very hard.[62] The pinnacles rise up to 120 feet (40 m) and form in small south flowing drainages (Figure 53.11).

Figure 53.10. Bornhardt in the "Silent City of Rocks" with a lack of talus for its supposed age.

Another "city of rocks" is in southwest New Mexico.[63] It is a rather unusual concentration of small bornhardts also composed of ignimbrite. There also are many inselbergs in south-central[64] and southwest Arizona.[65] These were left behind after pediments formed around the many mountain ranges of the area.

Bornhardts are found in other places in western United States, as those 30 miles (50 km) south of the "Silent City of Rocks."[60] A 1,000-foot (300 m) high inselberg of non-welded volcanic rock is reported from west central Utah.[66]

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[62] Neuendorf *et al*. Ref. 2, p. 321.

[63] Mueller, J.E., 1988. Geomorphic development of City of Rocks, Grant County, New Mexico. *New Mexico Geology* 10(4):73-79.

[64] Kesel, R.H., 1977. Some aspects of the geomorphology of inselbergs in central Arizona, USA. *Zeitschrift für Geomorpholgie N. F.* 21:119-146.

[65] Rahn, P.H., 1966. Inselbergs and nickpoints in Southwestern Arizona. *Zeitschrift für Geomorpholgie N. F.* 10:217-225.

[66] McBride, E.F. and M.D. Picard, 2000. Origin and development of tafoni in Tunnel Spring Tuff, Crystal Peak, Utah, USA. *Earth Surface Processes and Landforms* 25:869-879.

Figure 53.11. Pinnacles of welded tuff in the City of Rocks, southeast of Boise, Idaho. Boise creation geologist Brent Carter for scale at base of pinnacle to the left of center.