Brandberg, Messum and Spitzkoppe 10

Abstract
Several early Cretaceous igneous complexes have produced very distinctive landscapes in central Namibia and in this chapter three are discussed: Brandberg, Messum and the Spitzkoppe group. Brandberg is composed of a circular mass of granite that was intruded at depth and has now been exposed by erosion. Messum, which was originally the centre of a caldera, is a ring complex composed of such rocks as gabbro, rhyolite and syenite. The Spitzkoppe group consists of a series of granitic inselbergs, on which are found striking landforms such as weathering pits, natural arches and rock shelters.

10.1 Brandberg

Three major igneous complexes of early Cretaceous age give some of the most splendid landscapes in Namibia: the Brandberg, Messum and the Spitzkoppe group. Their geology is described in detail by Miller (2008, Chap. 18).

The first of these, the Brandberg, 'the burnt mountain' in German, is called thus because of the colour of its weathered granites (Kirk-Spriggs and Marais 2000). The Damaran name Dâures or Daureb has the same meaning. It is the highest point in Namibia (its Konigstein peak attains almost 2,579 m in altitude). It rises spectacularly above the Late Precambrian schists of the Namib plain (Fig. 10.1) which has a mean elevation of around 700 m above sea level. Located just south of the Ugab River, it has an area of c 420–450 km^2. This makes it is one of the largest sub-volcanic complexes in northwest Namibia. Its nearly circular stock of granite, over 20 km in diameter, and so plainly displayed on satellite images, is surrounded by a collar or skirt of Permo-Triassic Karoo sediments and remnants of basalt and quartz latite of the Etendeka Group. To the north of Brandberg, across the Ugab River, is an area of modest sand dunes.

Brandberg was a volcano at least 25 km in diameter and 2 km high that was active immediately after eruption of the Etendeka volcanic rocks (Miller 2000). Following cauldron subsidence on a ring fracture 25 km in diameter, a sequence of rings and plugs of granite were emplaced into the volcano (Fig. 10.2). This emplacement occurred about 130 million years ago. The thermally metamorphosed Karoo strata generally dip towards the complex, having been dragged downward by subsidence of the granite along the peripheral ring-fault.

The great dome (Fig. 10.3), created by the intrusion of the plutonic material, has since been altered in shape as a result of the erosion of the great bulk of the overlying cover of Karoo rocks (Dauteuil et al. 2013). Apatite fission track analysis (Raab et al. 2005) suggests that there may have been as much as 5 km of denudation in the Brandberg region since the Late Cretaceous. Much of this took place in the Late Cretaceous itself, with rates of 200 m per million years, declining to an average of <20 m per million years in the Tertiary. This tends to confirm the lower rates of current denudation implied by some studies based on long term dating by cosmogenic nuclides (see Chap. 1 for further details).

Brandberg is not only notable for its geomorphology, with its deep gorges cut into masses of granite and granite boulders, but it is also the location of a rich array of archaeological sites, of which the so-called White Lady rock painting in the Tsisab Gorge, is the most famous.

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Fig. 10.1 Brandberg

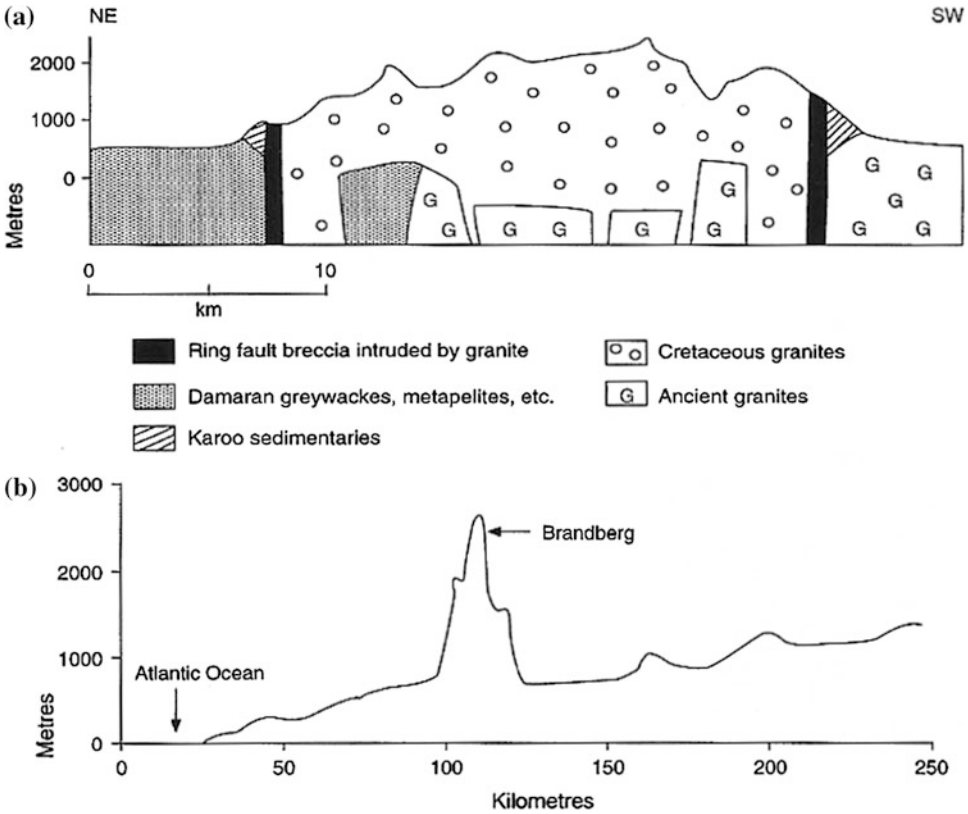

Fig. 10.2 Brandberg. **a** Geological cross-section modified from the Geological Map of Namibia, 1:250,000 series, sheet 2114, Omaruru (from Goudie and Eckardt 1999, Fig. 8), **b** Relief transect across Brandberg

10.2 Messum

The nature of the Messum ring complex (Fig. 10.4), named after sea captain and explorer William Messum, was unravelled by two great German geologists, Hermann Korn and Henno Martin in the 1930s. It lies to the southwest of Brandberg, covers approximately 400 km^2, has a diameter of approximately 18 km, and is bounded by ring-faults (Milner and Ewart 1989; Ewart et al. 2002). The geomorphology of the complex is striking and heavily influenced by the complex geology (Fig. 10.5), with the whole concentric structure recalling "petrified waves in a mud puddle into whose middle a stone has been dropped" (Korn and Martin 1954, p. 87). It consists of concentric hills and flats joined by radial gaps, with the outer rings being dominated by the black hues

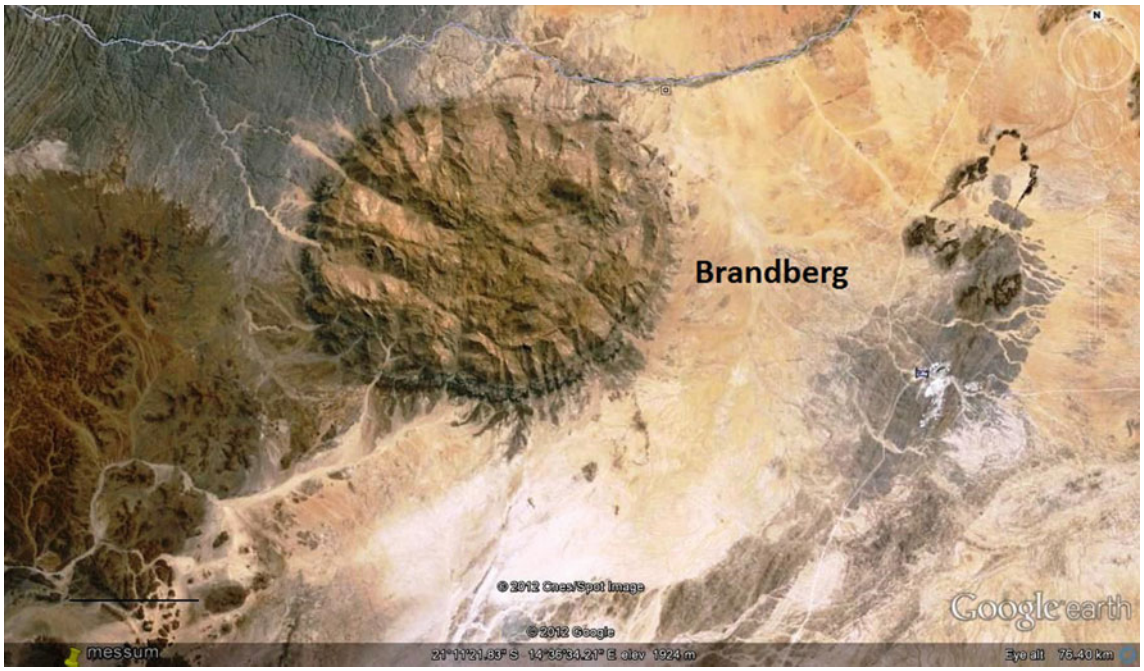

Fig. 10.3 Google Earth image of Brandberg. Scale bar is 10 km (© 2012 CNES/Spot Image, Google)

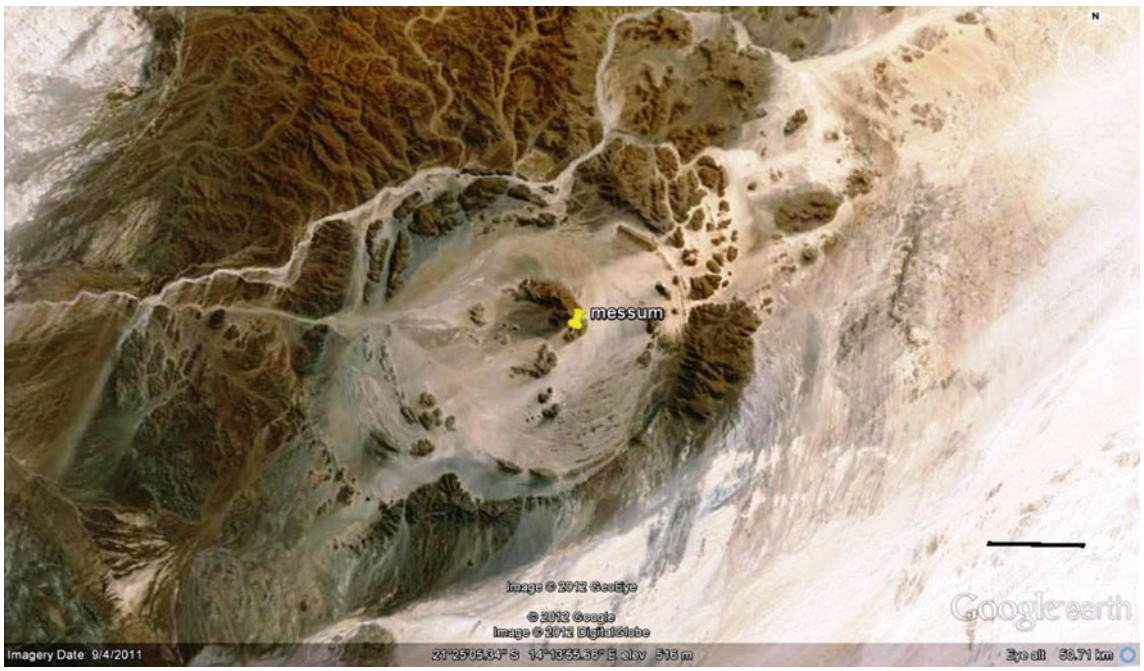

Fig. 10.4 Google Earth image of Messum. Scale bar is 5 km (© 2012 GeoEye, Google, Digital Globe)

of gabbros and the more central parts by the grey tones of granites and syenites. Dating back to 135–132 million years, it is of similar age to features such as Erongo and the Etendeka volcanic sequences (Bauer et al. 2003). It was originally the centre of a volcanic caldera, formed when a volcano collapses down into itself (Ewart et al. 2002).

10.3 Spitzkoppe

Gross and Klein Spitzkoppe and the Pondok Mountains in west-central Namibia are dramatically prominent inselberg groups that are visible for huge distances (Fig. 10.6).

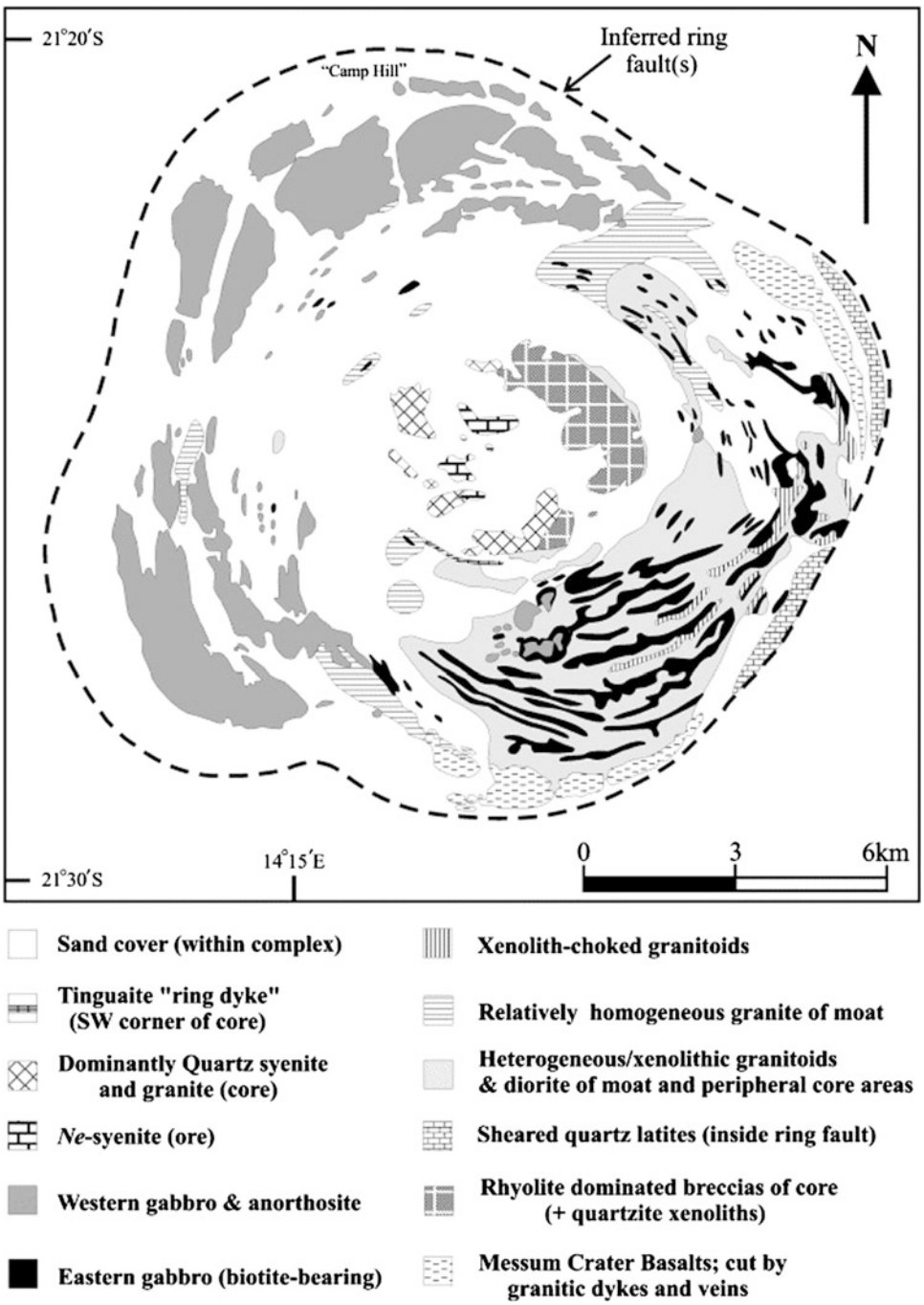

Fig. 10.5 The Geology of Messum Crater (from Ewart et al. 2002, Fig. 3)

Inselbergs, one of the iconic landforms of Africa, are isolated hills that stand above a flat or gently rolling topography. The topographic boundary between the hill and the plain is fairly abrupt. They are residual landforms made of strong and resistant rock, often granite, which have been developed as a result of the relative wearing down or back of the surrounding terrain. Spitzkoppe is one of the tallest, if not *the* tallest inselbergs on Earth (Migoń 2010) and is often referred to as the "Matterhorn of Africa". The gently sloping surfaces around the hills are called pediments. These are cut into rock and typically slope at less than 2°.

There have over the years been a range of hypotheses evoked to explain inselberg formation. One widely accepted view is that inselbergs are products of a two-stage development involving differential deep weathering in the first phase and stripping of the weathered mantle in the second one, which leaves an unweathered rock mass (the inselberg) at the surface. The unevenness in the depth of weathering results from differences in the degree of jointing in the bedrock. Another hypothesis, championed in southern Africa by Lester King (King 1949), invokes scarp retreat across unweathered, but possibly differentially jointed bedrock,

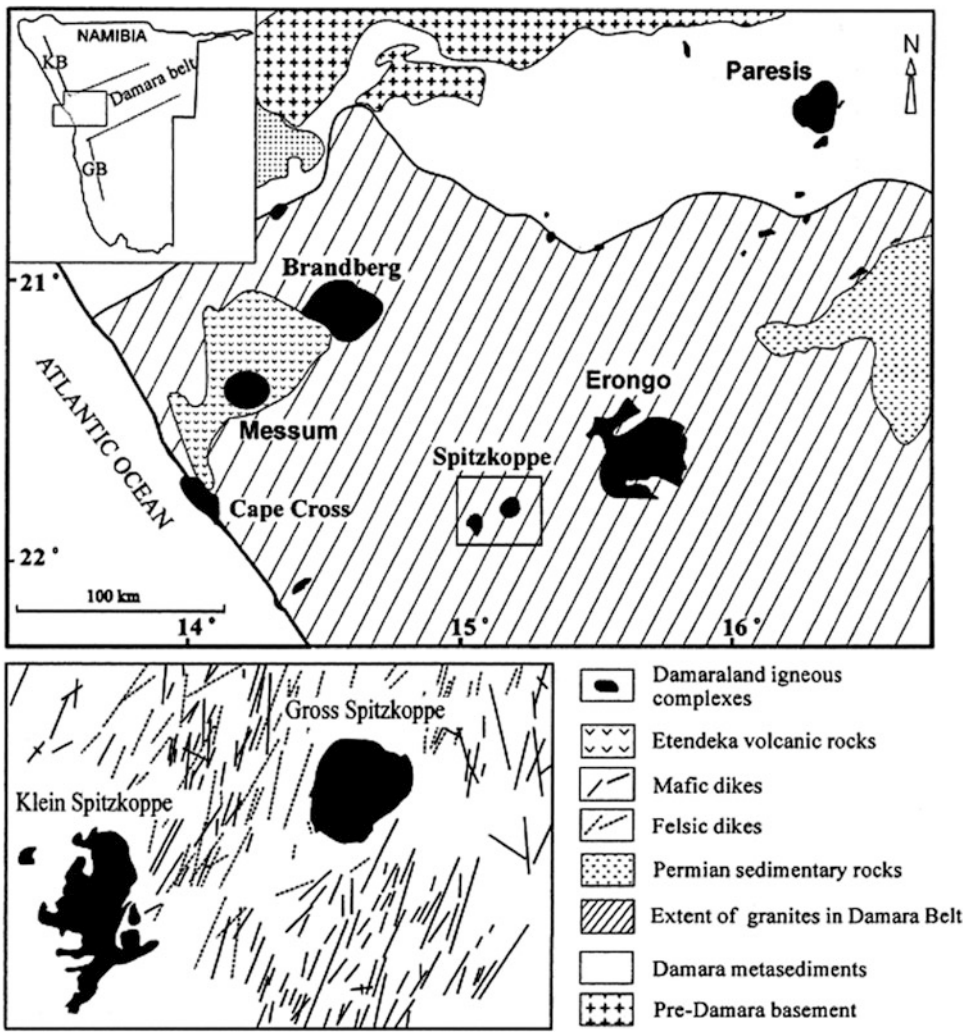

Fig. 10.6 Spitzkoppe and neighbours (after Frindt et al. 2004, Fig. 1)

leading to the creation of outliers at a varying distance from major escarpments. A third hypothesis, which seems widely applicable in Namibia, is that the inselbergs are the result of long continued differential erosion, with massively jointed rocks made of resistant minerals standing proud as the land around them is lowered (e.g. Selby 1982). In this respect, Spitzkoppe is composed of potassium-rich granite which is relatively resistant to chemical attack, mechanically strong, poorly jointed and with widely spaced fractures.

Recently, cosmogenic nuclides have been used to assess the rate at which the Spitzkoppe granites are eroding (Matmon et al. 2013). These suggest that the inselbergs are being lowered very slowly—at about 1–2 mm per thousand years, but that cliff retreat is taking place at a faster rate—c 8 mm per thousand years.

Gross and Klein Spitzkoppe rise abruptly and spectacularly from the partially calcreted planation surface developed across basement rocks, of which the Salem Granite and Damara mica schists and gneisses are the most important. Gross Spitzkoppe (Fig. 10.7) reaches an altitude of 1,728 m, Klein Spitzkoppe of 1,584 m and the Pondoks of 1,628 m, while the surrounding plains have an altitude of 1,000–1,100 m.

On the Spitzkoppe inselbergs a wide range of smaller landforms are present, largely produced by weathering processes. For example, weathering pits are extensively developed and unusually large (Goudie and Migoń 1997) as are rock shelters (as at Bushman's Paradise), and natural arches (e.g. The Bridge) (Fig. 10.8). The southwestern face of Gross Spitzkoppe also shows the effects of large-scale rock slides, with a chaos of enormous boulders, some as much as 30 m long, lying beneath an area from which a great slab, which was at least 50 m thick, has evidently been dislodged (Migoń 2006, p. 175). The Spitzkoppe granites are similar to those of Erongo and details of their composition are given by Mathias (1962), Frindt et al. (2004) and Haapala et al. (2007). They are of early Cretaceous age. The granites were emplaced at depths of several km below the ground surface that existed at the time, indicating substantial amounts of erosion since then. As indicated by the piles of boulders and rock debris surrounding the plains, massive rock falls have taken place.

Fig. 10.7 Gross Spitzkoppe

Fig. 10.8 Natural arch developed in granite at Spitzkoppe

References

Bauer K, Trumbull RB, Vietor T (2003) Geophysical images and a crustal model of intrusive structures beneath the Messum ring complex, Namibia. Earth Plan Sci Letters 216:65–80

Dauteuil O, Deschamps F, Bourgeois O, Mocquet A, Guillocheau F (2013) Post-breakup evolution and palaeotopography of the North Namibian Margin during the Meso-Cenozoic. Tectonophysics 589:103–115

Ewart A, Milner SC, Duncan AR, Bailey M (2002) The Cretaceous Messum igneous complex, S.W.Etendeka Namibia: reinterpretation in terms of a downsag-cauldron subsidence model. J Volcanol Geotherm Res 114:251–273

Frindt S, Trumbull RB, Romer RL (2004) Petrogenesis of the Gross Spitzkoppe topaz granite, central Namibia: a geochemical and Nd-Sr-Pb isotope study. Chem Geol 206:43–71

Goudie AS, Eckardt F (1999) The evolution of the morphological framework of the Central Namib Desert, Namibia, since the early Cretaceous. Geogr Ann 81A:443–458

Goudie AS, Migoń P (1997) Weathering pits in the Spitzkoppe area, Central Namib Desert. Z Geomorph 41:417–444

Haapala I, Frindt S, Kandara J (2007) Cretaceous Gross Spitzkoppe and Klein Spitzkoppe stocks in Namibia: Topaz-bearing A-type

granites related to continental rifting and mantle plume. Lithos 97:174–192
King LC (1949) A theory of bornhardts. Geogr J 113:83–87
Kirk-Spriggs AH, Marais E (2000) Dâures—biodiversity of the Brandberg Massif, Namibia. Cimbebasia Memoir 9, National Museum of Namibia, Windhoek
Korn H, Martin H (1954) The Messum igneous complex in south west Africa. Trans Geol Soc S Afr 57:83–122
Mathias M (1962) A disharmonious granite: the Spitzkop granite, south west Africa. Trans Geol Soc S Afr 65:281–292
Matmon A, Mushkin A, Enzel Y, Grodek T, ASTER Team (2013) Erosion of a granite inselberg, Gross Spitzkoppe, Namib Desert. Geomorphology 201:52–59
Migoń P (2006) Granite landscapes of the world. Oxford University Press, Oxford
Migoń P (2010) Spitzkoppe: the world of granite landforms. In: Migoń P (ed) Geomorphological landscapes of the world. Springer, Dordrecht, pp 155–162
Miller RMG (2000) Geology of the Brandberg Massif, Namibia and its environs. Cimbebasia Memoir 9:17–38
Miller RMG (2008) The geology of Namibia, vol 3. Geological Survey of Namibia, Windhoek
Milner SC, Ewart A (1989) The geology of the Goboboseb mountain volcanics and their relationship to the Messum Complex, Namibia. Comm Geol Surv Namibia 5:31–40
Raab MJ, Brown RW, Gallagher K, Weber K, Gleadow AJW (2005) Denudational and thermal history of the early Cretaceous Brandberg and Okenyenya igneous complexes on Namibia's Atlantic passive margin. Tectonics 24: TC 3006
Selby MJ (1982) Rock mass strength and the form of some inselbergs in the central Namib Desert. Earth Surf Proc Landf 7:489–497