11 Inselberg Landscape of the Bur Area in Southern Somalia

Borislav K. Kamenov, Paolo Billi, and Piotr Migoń

Abstract

A great number of spectacular inselbergs (burs in the Somali language) punctuates an otherwise flat landscape of a vast area in southern Somalia known as the Bur Area. These inselbergs are built mainly by granitoids, which represent two types: syn- to late kinematic and late-kinematic plutons. Their mineralogy, petrology and geochronological dating indicate that the youngest granitoids from the Bur Area belong to the final Pan-African magmatic event in the East African Orogen. Long-term surface lowering in the Mesozoic and Cenozoic, probably by a range of land-forming mechanisms, resulted in the formation of a vast plain dotted by inselbergs of various heights and shapes. Post-Miocene uplift of the Bur Area horst, elongated in a NE–SW direction, was moderate and did not trigger considerable incision of the plain. Inselbergs represent a range of types, from massive domes with smooth slopes of variable steepness through castellated forms to conical and crested hills. The contemporary morphology of the inselbergs reflects both structural control (joints, faults, sheeting) and the operation of various surface processes, mainly weathering and mass movements.

Keywords

Inselberg • Peneplanation • Block faulting • Granite weathering • Erosion cycles

B. K. Kamenov (✉)
Faculty of Geology and Geography, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria
e-mail: b.kamenov@gmail.com

P. Billi
International Platfrom for Dryland Research and Education, Tottori University, Tottori, Japan

P. Migoń
Institute of Geography and Regional Development, University of Wrocław, Wrocław, Poland

11.1 Introduction

A semi-arid area in southern Somalia is unusually rich in inselbergs, and it is known as the Bur Region. The physiographic features and petrologic research on the rock varieties of these inselbergs reveal that they are built up by a very hard and erosion-resisting lithology. The Bur Area is therefore an excellent example of residual relief forms, strongly influenced by the nature of the underlying rock.

This paper summarizes the geological and geomorphological background of the Bur Area. Unfortunately, the permanent state of civil war that has been distressing Somalia during the last two decades prevented researchers from continuing field work, thus not allowing one to upgrade the basic geological knowledge or to verify modern theoretical geomorphological models. Though the level of knowledge of the area is mainly based on data collected in the past, the landscape and landforms of the Bur Area are so peculiar that they deserve to be investigated and brought to the knowledge of the scientific community. Very few papers (e.g. Azzaroli and De Angelis 1965; Borsi 1965; Haider 1993; Ali Kassim et al. 2002; Kamenov and Lilov 2012), in fact, focus on this area, the geology and geomorphology of which are therefore poorly known. Given the limitations addressed above, this contribution is mainly descriptive and focused on data available at present. The main aim of this paper is therefore to provide data on the basic characteristics of the Bur inselbergs, to emphasize the causal connection between the lithological compositions of bedrock and the relief and indicate the role of inselbergs in human expansion in the region.

11.2 Physiographic Features of the Region

Somalia differs very much from other equatorial countries. The country is located in the equatorial and subequatorial climatic belts, but one cannot find here the humid climate,

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large discharge rivers, dense woodlands and high-grass savannas typical for such countries. The climate is semi-arid (see Chap. 2 of this publication or more details) and the landscape is monotonous, strewn with acacia and mimosa trees, thorny bush and blinding sand dunes (along the coast), whereas sunny days predominate. Except for the northernmost part of Somalia, flat land prevails for the most part of the country. Only the northern part of the plateau (Karkaar Mountains) is raised and cut by a fault-generated escarpment having the appearance of a mountainous range. The gradual lowering of the relief from north to south is also a typical landscape feature of the country (Fig. 11.1).

Southwestern Somalia is dominated by the country's only two permanent rivers, the Juba and the Wabe Shabelle (see Chap. 14 of this publication for more details on these rivers). With their sources in the Ethiopian highlands, these rivers flow in a generally southerly direction, cutting wide valleys in the Somali Plateau as it descends towards the sea; the plateau's elevation decreases rapidly in this area. The adjacent coastal zone, which includes the lower reaches of the rivers and extends to the Kenyan border, averages 180 m asl. Favourable rainfall and soil conditions make the entire riverine region a fertile agricultural area and the centre of the country's largest sedentary population.

The region between the Wabe Shabelle and Juba rivers, located in the southern part of the Central Plateau between the towns of Bur Acaba and Dinsoor, stands out from the lowlands with its outstanding morphological features. Isolated, steep-sided residual hills, rocky and usually bare rise conspicuously above the general level of the surrounding flat area, as either solitary hills or clusters of hills. These loaf-shaped small mountains reach elevations of up to 450 m asl, or some 200 m above the southern part of the plateau, although others are less than 100 m high. They are typical inselbergs, or "*burs*" in the Somali language, after which the whole region is named. The Bur Area lies some 180 km to the west of Mogadishu and occupies an area of about 25,000 km^2 (Fig. 11.1). The Bur Area is a flat erosional peneplain about 200 m asl, and occasional rocky domes and castellated hills are the only landmarks in the area.

Fig. 11.1 Main physiographic zones of Somalia and the location of Bur Area. B—Baydhabo, D—Dinsoor. *Source* of image: Landsat/Copernicus © 2020 Google

The Bur Area is an uplifted horst of Precambrian basement rocks (Stefanini 1918) with a southwest-northeast orientation, about 200 km long and 100 km wide (Fig. 11.2). About 200 burs have been observed on aerial photographs. These are scattered throughout the area, being most numerous in its southwestern portion. Two systems of faults cut across the horst and divide it into minor blocks. One system of normal faults has NW–SE to N–S trend, whereas the second one has a SW–NE to W–E trend.

The most striking inselbergs are mainly built of granitoids and, to a lesser extent, of quartzite. Amongst them, impressive examples are provided by Bur Acaba, Bur Degis, Banoda Boss, Safarnolei, Bur Gulo, Bur Galin, Bur Eibi, Alio Gheleh, Bur Geluai, Bur Dur and others.

11.3 Geological Background

The Somali territory is a transitional zone between the large Eastern African Arch and the deep sedimentary basin of the Indian Ocean. The Eastern African Arch (covering Ethiopia, Kenya, Uganda, Tanzania, Mozambique, Red Sea, Gulf of Aden and their neighbouring countries) is cut by deep penetrating faults of the Great Rift System. The biggest crustal structures were formed in the Precambrian and were influenced by different tectonic movements and igneous processes later on. Somalia is situated just within the eastern shoulder of the large Ethiopian Arch Uplift. Metamorphic and igneous complexes are exposed only in the uplifted blocks, which are, at the same time, the principal structural units:

- Northern Somali Zone, for which the largest gradients of vertical displacements are known.
- Bur Area, which pertains to the wide belt of Precambrian rocks, designated as the Mozambique Belt.
- Mesozoic-Cenozoic epiplatform sedimentary sequences that cover the rest of the country.

Basement exposures occur only in the first two zones, which are referred to the East African Orogen, resulting from the continental collision between East Gondwana and West

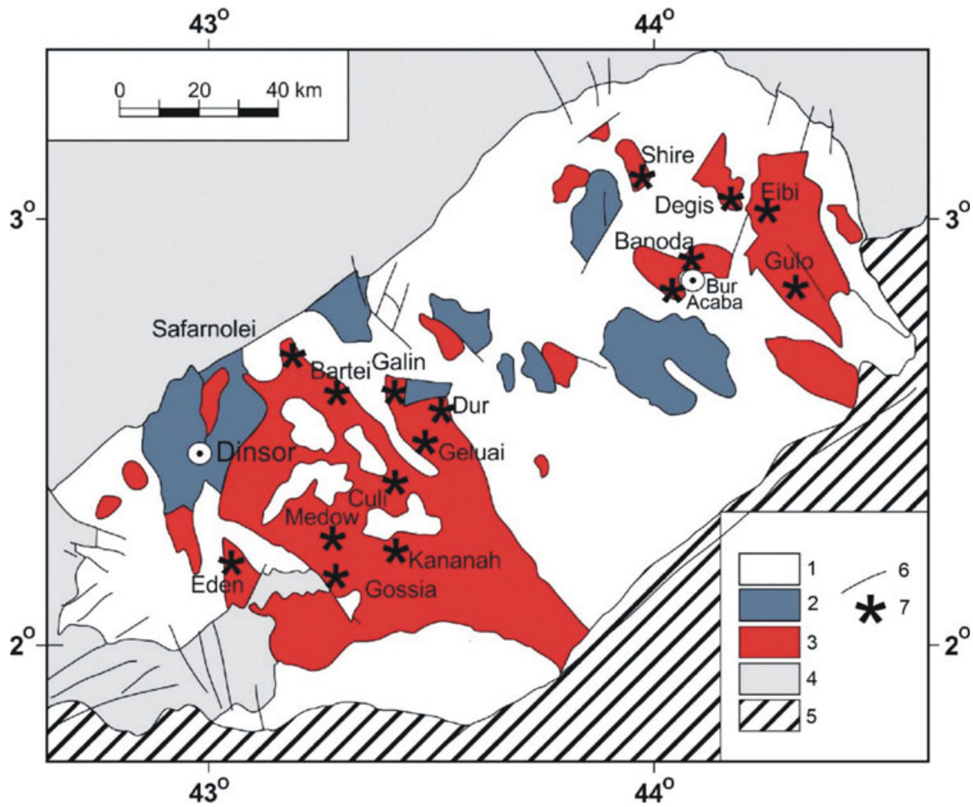

Fig. 11.2 Simplified geological map of Bur Area (after Kamenov and Lilov 2012). 1—Lower Olontaleh series of Precambrian metamorphic rocks, 2—upper Dinsor series of Precambrian metamorphic rocks, 3—granitoids, 4—Jurassic sedimentary rocks, 5—Pleistocene to recent deposits, 6—faults, 7—selected inselbergs (burs)

Gondwana at about 870–550 Ma. The southern part of the East African Orogen is a distinctive geotectonic unit called the Mozambique Belt, overprinted on the Eastern African Arch. The north-eastern branch of the Mozambique Belt in Somalia includes the Northern Somali crystalline basement and the Bur Area. Several major deformational phases were recognized, the last one being termed the Pan-African Orogeny. It is interpreted as the final tectonic-thermal event, culminating at 650–500 Ma ago. The granitoids making up the inselbergs of the Bur Area are products of these Pan-African magmatic events (Kamenov and Lilov 2012).

In the study area, the basement rocks are divided into two series: Lower (Olontaleh) and Upper (Dinsor) Series (Warden and Hörkel 1984) (Fig. 11.2). These series were metamorphosed simultaneously, and both were involved in a process of generation of silicic magma in situ or emplaced at close distance from the melting point. Basement rocks occur also outside the Bur Area, but they are traced by drillings or presumed to be present on the basis of geophysical investigations. It is generally accepted that they can be found at depths deeper than 5000 m. A number of block uplift movements complicate this area, and in places, the gradients of the tectonic displacements reach up to 1:5 (over 10 km). This is the reason why next to the contemporary erosion surface depressions thick sedimentary sequences in the order of over 10 km are found. The vertical movements brought the Precambrian Basement to the surface.

The Lower Olontaleh Series includes schists, gneisses, amphibolites and granulite-like rocks. The total thickness in its eastern part is estimated to be as much as about 3000 m. The metamorphic rocks are strongly migmatized in certain localities. The Upper Dinsor Series consists of several units of silicate rocks (gneisses, amphibolites and quartzites), calc-silicate rocks and marbles. The presence of beds of ferruginous quartzites is a characteristic peculiarity for its top part. The total thickness of the series is estimated as 2500 m.

The Mesozoic-Cenozoic epiplatform sedimentary sequences are mainly Jurassic and, in some places, Cretaceous in age, covering the western, northern and eastern parts of the Bur Area. The rocks are sandstones, argillaceous marls and limestones, dipping gently to the southeast. Along the northern and the western boundary of the Bur uplift zone basaltic dykes was intruded, tentatively dated as Miocene in age. Quaternary and recent deposits occur as marine, colluvial and alluvial sediments.

The igneous rocks in the Bur Area vary from leucocratic granites to gabbro. The prevailing rock types are granitoids and granite-gneisses, cutting the iron-bearing quartzites and assimilating them to a certain degree.

11.4 Granitoid Petrology

The granitoid bodies outcropping in the Bur Area can be grouped into two different types on the basis of their geology, mineralogy, petrology and dating (UNDP 1968, 1972, 1973; D'Amico et al. 1981; Kűster et al. 1994; Lenoir et al. 1994; Kamenov and Lilov 2012): the *Thin conformed intrusions* and the *Great discordant plutonic bodies*.

The *Thin conformed intrusions* are emplaced between the schists and gneisses and have variable thickness. Commonly, the granite plutons have a gneissic appearance, with inherited schistosity and banding and are encircled by migmatites (from nebulites to typical anatectites). Usually all gradations between isotropic granites and banded orthogneisses can be observed. The contacts between these intrusions and the surrounding migmatized gneisses are in most cases concordant, diffusive and gradual. The internal deformation is penetrative foliation. It indicates a syn- to late kinematic setting (Lenoir et al. 1994). Inclusions of the basement rocks are abundant. Usually, they are spread within the marginal parts of the plutons. The rather small granitoid inselbergs consist of leucocratic fine-grained monzogranite and syenogranite, rimmed by migmatites and gneisses. It seems that in the southwestern sector of the Bur Area mainly this type of granite is outcropping, supporting Bur Muun, Bur Daxale, Bur Kananah, Bur Gossia, Bur Geel Way and Bur Galin elevations. Quartz, microcline and plagioclase are the principal rock-forming minerals. Green amphibole is the minor constituent. Clinopyroxene and garnet are rare, but they are typical for this type of granitoids. Biotite flakes are found only in the pegmatite dykes. Cataclastic to low-grade metamorphic overprints are typical in some intrusions.

The *Great discordant plutonic bodies* are relatively homogeneous and often characterized by melanosoma inclusions. These granitoids were discordantly emplaced into the high-grade basement rocks, probably at a shallower level than the first group. Lenoir et al. (1994) referred the group to the post-kinematic type. Locally, weak foliation of magmatic origin is manifested by discontinuous layers of biotite or amphibole grains. These sections gradually pass into clear isotropic fabric in granite within short distances, of several metres only. Typical intrusive homogeneous textures are more frequent in the north-eastern sector of the Bur Area. The modal relationships of the principal rock-forming minerals in the sampled burs (Bur Gulo, Bur Eibi, Bur Acaba, Bur Banoda, Bur Degis, Bur Shire) confirm their assignment mainly to the monzogranites, but some samples fall also in the fields of quartz monzonite, granodiorite and quartz monzodiorite (Fig. 11.3). A characteristic feature of these rocks is the scarcity of femic minerals, and some of the samples could be classified as leucogranite (e.g. Bur Acaba).

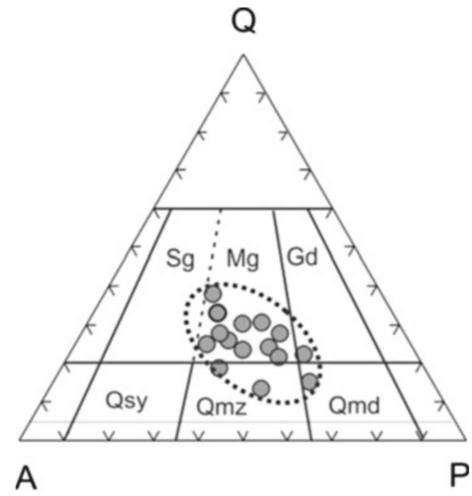

Fig. 11.3 APQ classification diagram of the analysed granitoids in the Bur Area (after Kamenov and Lilov 2012). A—percentage (mode) of alkali feldspar, P—percentage of plagioclase feldspar, Q—percentage of quartz; Sg—syenogranite, Mg—monzogranite, Gd—granodiorite, Qsy—quartz syenite, Qmz—quartz monzonite, Qmd—quartz monzodiorite

The post-magmatic process of "albitization" over the microcline is widespread. It is most intensively developed in the sector close to Alio Geleh. Here, the metasomatic alteration of granites reaches its maximum to the real "albitites" and "alkaline syenites", which include rare-metal economic mineralization of thorium specialization. The weathered granitic crust contains kaolin occurrences around the burs.

Almost all granitoid inselbergs are quite similar in terms of texture and structure, mineral and chemical composition, structural and erosional level of emplacement. Different generations of dykes can be distinguished as well.

The bigger granitoid bodies from the first diffusive group occur exceptionally within the Lower Olontaleh Series, whereas the typical discordant intrusions with sharp contacts can be found in both basement series. The above-described granitoid suites, i.e. "diffusive" and "discordant", were assumed also by Dal Piaz and Sassi (1986) and by Küster et al. (1994).

The earlier foliated suite indicates the presence of ~2.5 Ga crust in the region, with anatexis occurring at 536 ± 18 Ma (Küster et al. 1994). Younger massive granites contain zircon that indicates post-tectonic emplacement at 474 ± 9 Ma (Küster et al. 1994; Lenoir et al. 1994). The implemented discriminations (Lenoir et al. 1994) show that the syn- to late kinematic granitoids are referred mainly to Within-Plate Group and less probably to the Syn-Collisional Granites, while the post-kinematic samples fall in the field of Volcanic Arc Granite. Newly published K–Ar data (Kamenov and Lilov 2012) confirmed the age of the younger granitoid magmatism (ranging 440–490 Ma), whereas pegmatites from northern Somalia turned out to be affiliated to the syn- to late-kinematic magmatic event (500–560 Ma, Kamenov and Lilov 2012). Granitoid magmatism and high-grade metamorphism in Southern Somalia are probably both related to post-collisional lithospheric thinning, magmatic underplating and crustal relaxation.

11.5 Landforms and Geomorphological Processes

Morphologically the inselbergs are mainly rounded hills (domes) standing out of the plain (Fig. 11.4). In some areas, larger domes are surrounded by smaller ones and the landscape is like a flat ocean surface with scattered islands, ideally consistent with the original German term coined at the turn of the twentieth century (Fig. 11.5). Sharp pointed peaks are not observed, although crested hills are present. The Bur Area landscape is monotonous as it consists of a flat land covered with sparse bushes not higher than 2–3 m. The average monthly maximum temperature recorded at Bur Acaba is over 30 °C in 10 months a year, and the maximum monthly temperatures peak between 40 and 45 °C in eight months a year (Fig. 11.6). The soil is predominantly reddish-brown, but in some places, dark grey-brownish soils are found. Vegetation is developed only on the quartzite burs, whereas the granitoid burs are bare.

The Bur Area is crossed by a number of drainage lines, but water flow is ephemeral and discharge is present only in response to high-intensity rainstorms. These stream channels are incised into alluvial deposits or basement weathering products (Ferrari et al. 1985). The flat land between the inselbergs consists of past alluvium deposited by several fluvial cycles, modern alluvium and endorheic depressions (Ferrari et al. 1985). The older alluvial deposits are terraced and make a transition to the modern alluvial material and/or to the clayey facies of the present plain (Ferrari et al. 1985). A general scheme of this geomorphological setting, based on the situation of Bur Acaba, is illustrated in Fig. 11.7.

The granites are mainly fine-grained and seldom show a porphyritic structure (Azzaroli and De Angelis 1965). The exposed parts of the burs are considerably jointed. Well-expressed parallel-piped cleavage along three orthogonal joints systems favours rock splitting into large blocks. Layers rich in biotite and poor in quartz and feldspars typically alternate with those including more quartz. Late thin pegmatite veins cut the rocks. In places, next to these veins, metasomatic processes formed aureoles of epimagmatic microclinization.

Foliation is common in all inselbergs, but it does not coincide with the elongated shapes of contemporary exposures. In the Bur Area, fault dislocations are usually oriented along two main systems with the Red Sea one (NNW) prevailing over the Cameroon Line (NE) (Fig. 11.2). The shape of many inselbergs is elongated for it is controlled by these fault line systems. For example, the shape of some burs of Kananah inselberg group is controlled by faults parallel to the Red Sea, while other granite burs such as Bur Finini, Warabe, Banoda, Wagelle and Eibi are strongly influenced by faults almost perpendicular to the former. Another group of granitoid hills shows foliation oblique or, in some places, even transversal to the general elongation of the outcrops. The best examples of this peculiarity can be observed in the group of granitic hills named Bur Gossia.

A typical weathering product of the granite is kaolin. Preliminary investigations and boreholes indicate that the kaolin deposits are located at a distance of not more than 150–200 m from the inselberg/plain junction. Their form and position are genetically related to the fault tectonics in the Bur Area. The kaolin occurrences are usually elongated and oriented along the two fault systems mentioned above. Representative examples of kaolin occurrences parallel to the two fault systems can be seen at Bur Galan, Bur Siabo, Bur Dur and Bur Gosei, respectively. The kaolin

Fig. 11.4 Google Earth transverse view of Bur Acaba, with Bur Eibi in the background

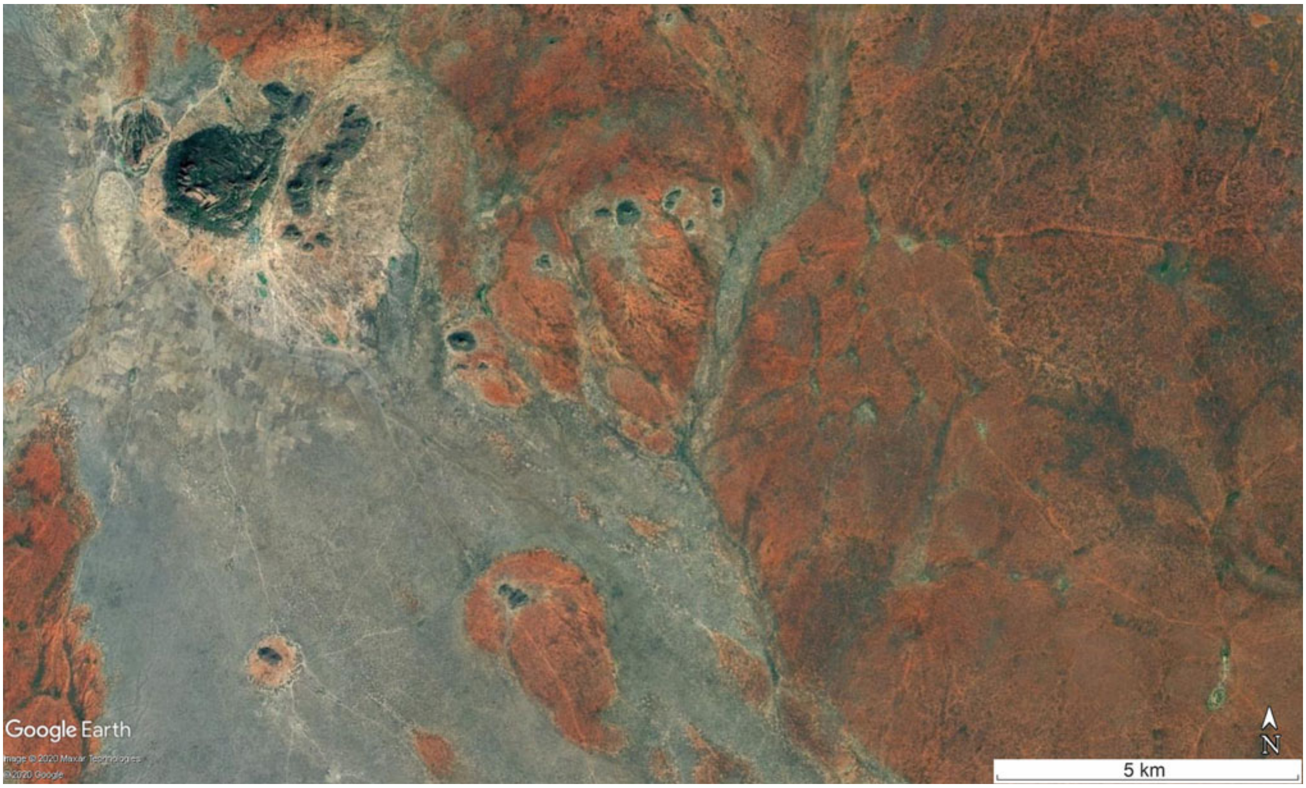

Fig. 11.5 Bur Eibi (upper left) is one of the largest inselbergs in the region, whereas several minor burs occur in the vicinity. *Note* the presence of SW–NE faults dividing Bur Eibi into three smaller elevations (Bur Eibi coordinates: 03° 00′ 01″ N; 44° 18′ 07″ E; for location, see Fig. 11.10). *Source* of image: © Google

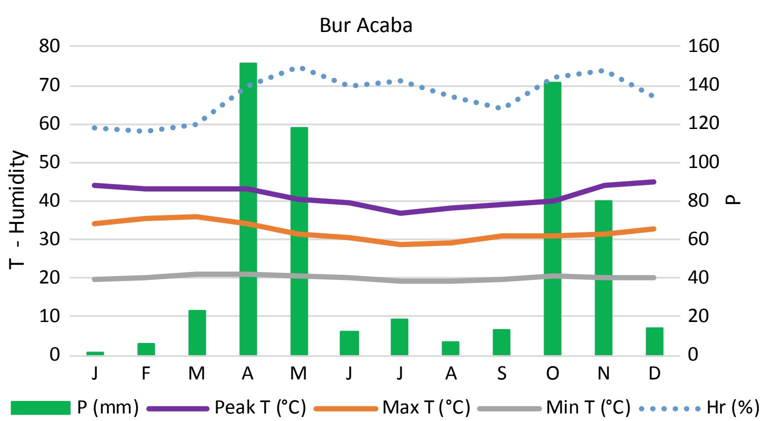

Fig. 11.6 Climograph of Bur Acaba. Observation interval 1961–1990. *Source* of data Deutscher Wetterdienst DWD (2016)

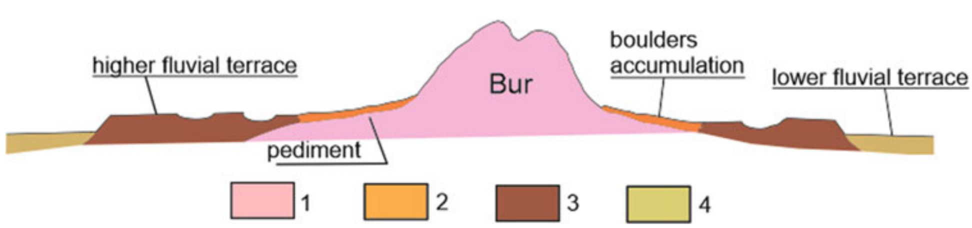

Fig. 11.7 Schematic geomorphological setting and alluvial–colluvial deposits based on the situation of Bur Acaba. 1—granite, 2—accumulation of boulders derived from physical weathering on the inselberg, 3—higher fluvial terrace (older alluvial deposits, consisting of coarse, rounded clasts), 4—lower fluvial terrace (modified from Ferrari et al. 1985)

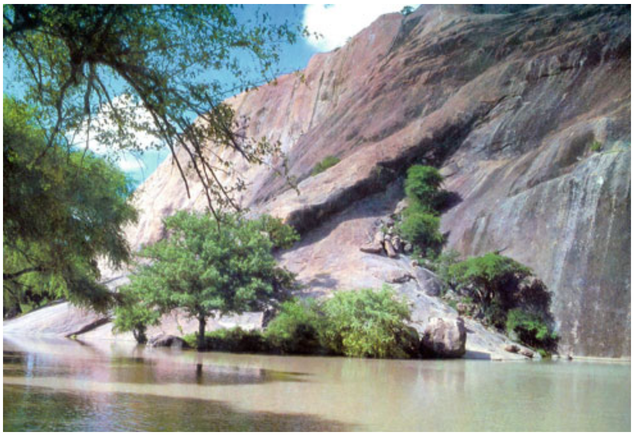

Fig. 11.8 Temporary water wells at the foot of Bur Banoda (photo by B. Kamenov)

Fig. 11.9 Hand-dug water ponds around Bur Degis. *Source* of image: © Google

occurrences are 50–350 m long, 20–110 m wide and 0.5–10 m thick and lie at a depth to 20 m. Although the hills have a limited surface, along with their footslopes underlain by kaolin materials, they have enough capacity to store a great deal of rainwater. Therefore, inselbergs provide most of water supply to the local communities and commonly the water wells encircle almost completely the slope/plain junction (Figs. 11.8 and 11.9).

11.6 Diversity of Inselberg Morphology

The generally good quality of Google Earth imagery allows one to examine inselberg morphology in more detail. The diversity of form amongst inselbergs in general has long been known, resulting in several attempts to produce a typology of these residual hills (Thomas 1978; Twidale 1981, 1982; Migoń 2006). Referring specifically to granite settings, Twidale (1981) distinguished domes (= bornhardts), block-strewn inselbergs (= nubbins) and castellated hills (= castle koppies), arguing that they are all genetically related in that the latter two are products of disintegration of primary domes. Domed inselbergs may assume different shapes: high, steep-sided cupolas, similar to "sugar loafs" as described from Rio de Janeiro and elsewhere in Brazil (e.g. Fernandes et al. 2010) or low shields (whalebacks, ruwares) with gentle slopes and flattened top surfaces. However, inselbergs may also be conical (Meyer 1967; Kesel 1977). It seems agreed that this diversity of form reflects the variable patterns of jointing and other fractures, bornhardts being formed in particularly massive bedrock compartments, experiencing significant compression.

An overview of inselberg morphology of the Bur Area shows that all morphological types are present, clearly indicating the variety of structural controls and the different pathways of degradation of these landforms. Figure 11.10 shows the location of representative examples of inselbergs, which will be briefly described. Bur Dur is an example of a massive dome, elongated in a N–S direction, c. 1.4 km long and up to 0.6 km wide (Fig. 11.11). Its peak is at 483 m asl, which is more than 200 m higher than the level of the adjacent plain. The dome is cut by one prominent discontinuity in the south that forks into two in the northern part. Vertical cliffs have developed along these structures, whereas the benches below are apparently covered by enough regolith to allow vegetation growth in specific places. The southern perimeter of the dome is punctuated by two large recesses (alcoves), more than 100 m across. Large boulders at their foot suggest the role of rock slope collapses in their origin. Otherwise, talus is scarce around Bur Dur, indicating the limited role of catastrophic slope failures in the evolution of slopes. By contrast, light-tone aprons around the perimeter, partly overgrown, are probably accumulations of products of granular disintegration of granite. Structural control is even more evident at Bur Acaba (Fig. 11.12)—a prominent complex dome in the middle of Bur Acaba town, 1.1 km long and 0.5 km wide. This one is N–S elongated too, rising to nearly 290 m asl, more than 100 m above the plain. Several master fractures trending N345W are exposed within the hill, which therefore consists of a few elongated, upward-convex ridges. Slope inclinations vary between vertical to gently inclined, whereas the summit parts are flattish. Intersections of vertical fractures with sheet joints give rise to minor benches and, locally, overhangs. Talus at the slope/plain junction is scarce, although does occur
(e.g. at the southern end). Shallow channels modelled by sporadic runoff can be recognized, especially on the less steep, eastern side.

Durdur inselberg (Fig. 11.13) has smaller dimensions than the two described above, but provides a good example

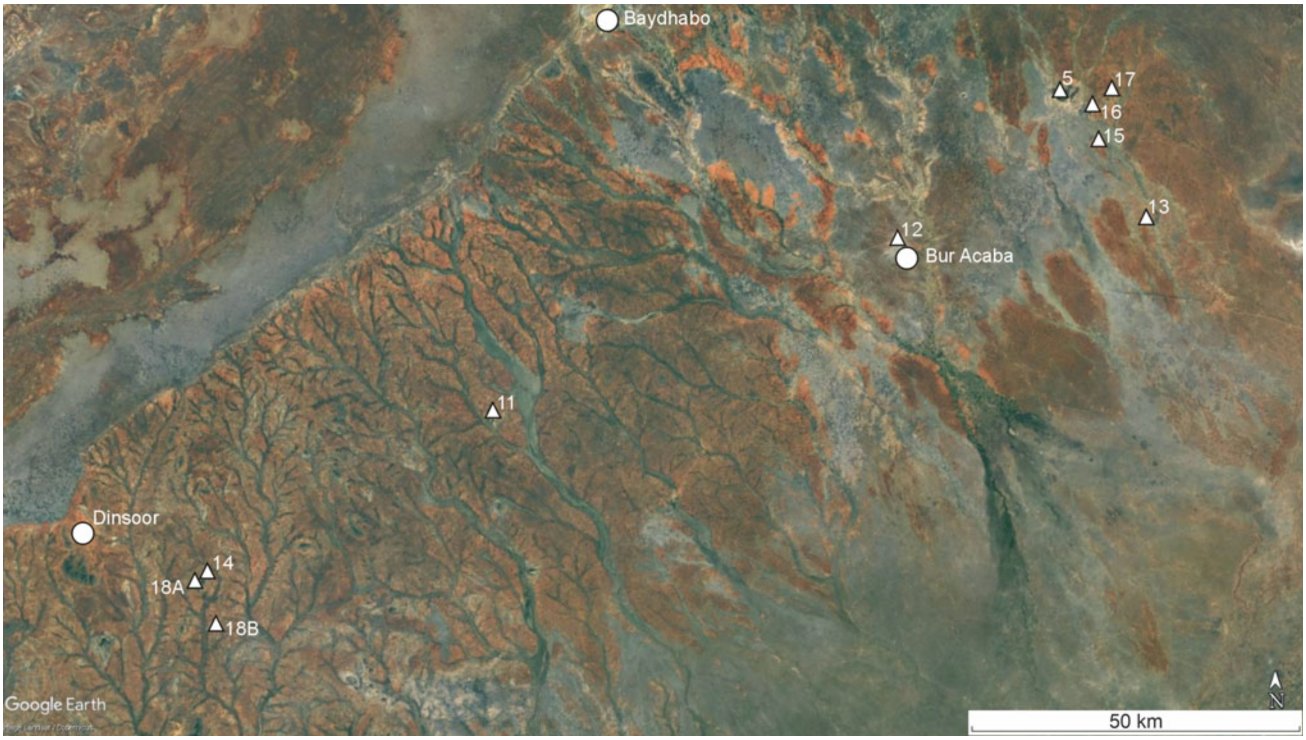

Fig. 11.10 Location of inselbergs described in more detail. Numbers next to triangles refer to figure numbering in this chapter. *Source* of image: © Google

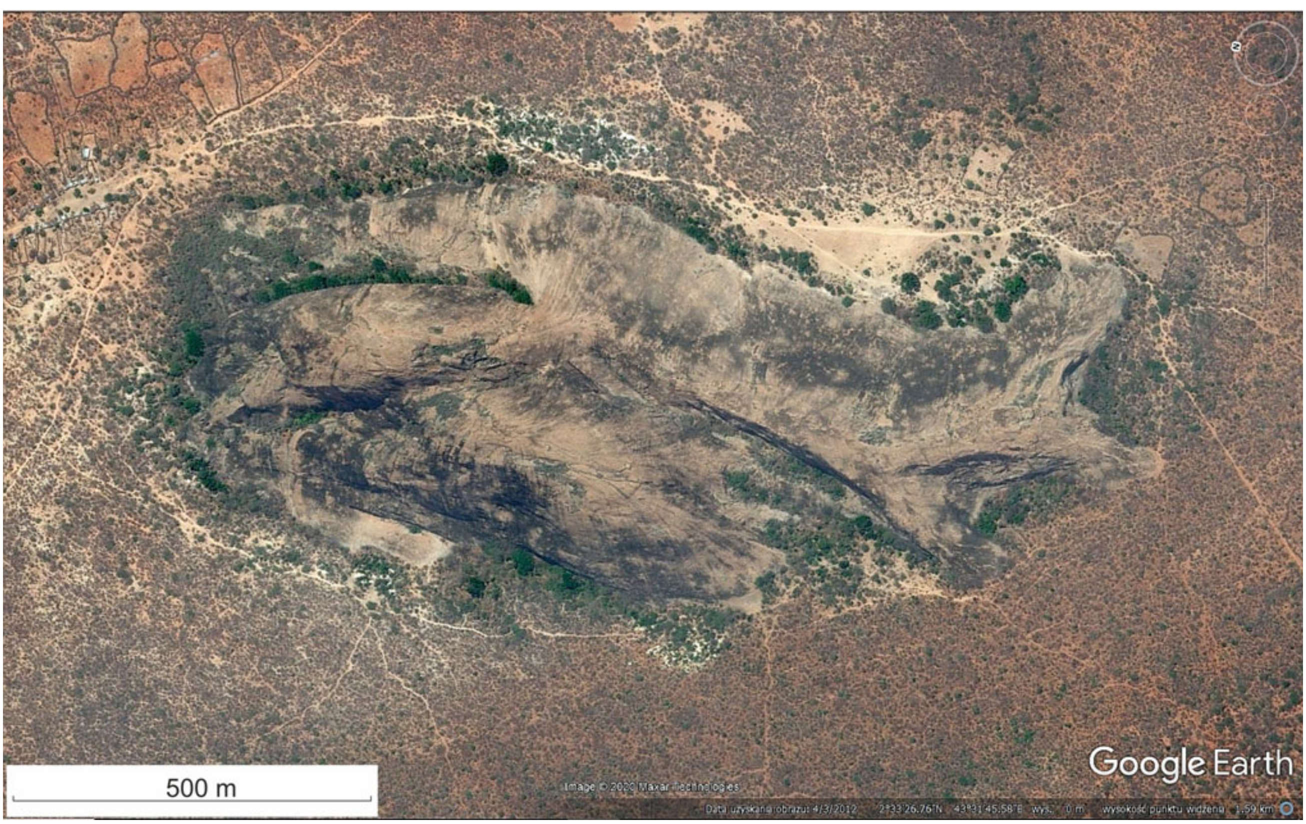

Fig. 11.11 Bur Dur—an example of tripartite massive dome (for location, see Fig. 11.10). *Source* of image: © Google

Fig. 11.12 Bur Acaba—an example of fracture control on dome morphology (for location, see Fig. 11.10). *Source* of image: © Google

Fig. 11.13 Complex morphology of Durdur inselberg, with elements of a dome, castle koppie and nubbin (for location, see Fig. 11.10). *Source* of image: © Google

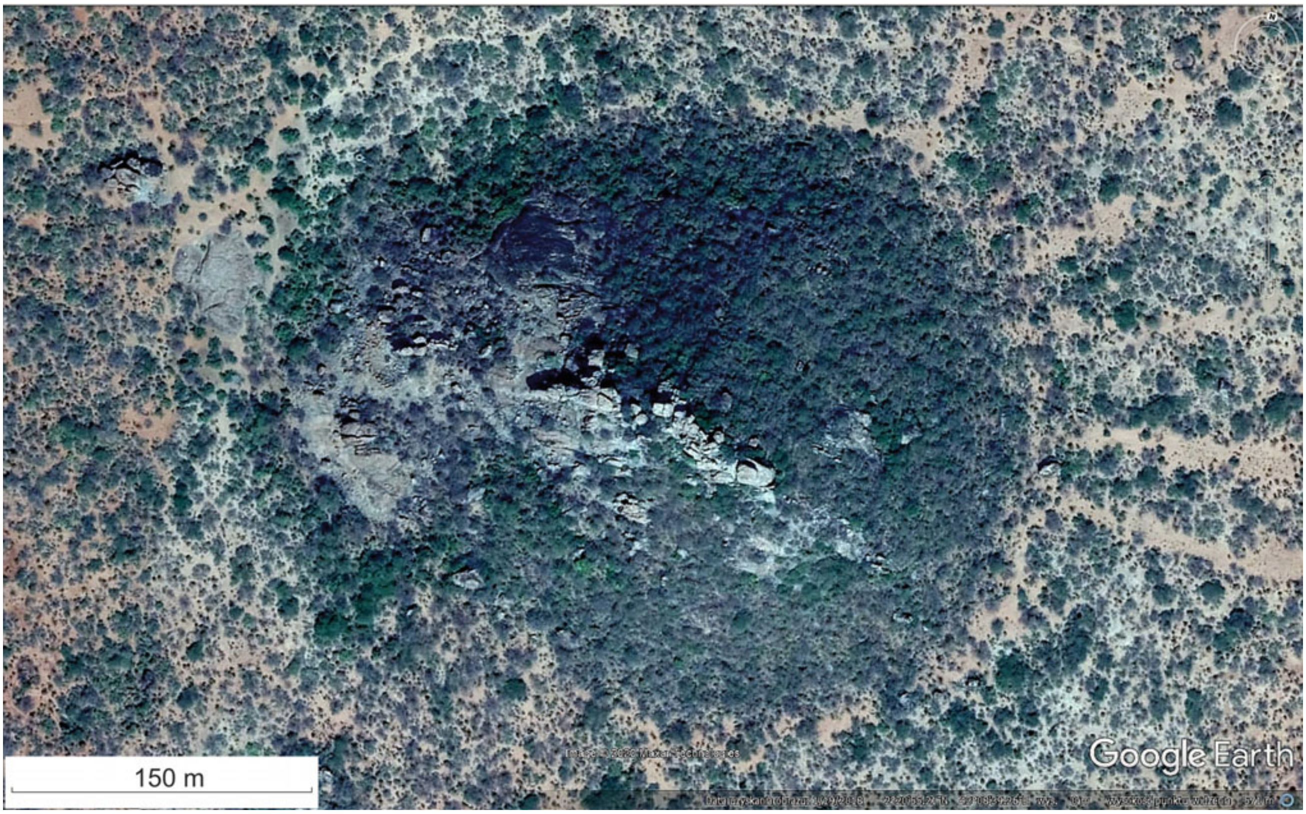

Fig. 11.14 Castellated inselbergs located 20 km to SE from Dinsoor (for location, see Fig. 11.10). *Source* of image: © Google

of a transitional form between a dome, a castle koppie and a nubbin. It is nearly circular, 300 m long and 250 m wide, reaching the height of 212 m asl (c. 50 m above the plain). Remnants of a dome form the peak of the hill, whereas numerous multidirectional joints separate massive blocky compartments, some more than 20 m long. A cluster of big boulders on the north-eastern side, just below the peak, is probably a talus from rock slope collapse, but otherwise big boulders appear to be in situ or moved only little. No boulders or shield-like bedrock outcrops are present in the vicinity of the inselberg. An unnamed inselberg some 20 km to the SE from the town of Dinsoor (Fig. 11.14) is castellated in the upper part, whereas moderately inclined convex rock surfaces are exposed below. W–E trending vertical joints outline remnant ridges and clusters of cuboid blocks, which give rise to a small rock city on the west-facing slope. The hill is 400 × 300 m and reaches c. 315 m asl, with a relative height in the order of 50 m. Another example of a castellated inselberg is provided on Fig. 11.15. The twin hill of Madhabey (229 m asl) is located c. 8 km to SE from Bur Eibe and consists of a larger southern hill (350 × 250 m) and smaller northern hill (200 × 170 m). NW–SE and NE–SW joint directions control the shape of bedrock outcrops, dividing these into mostly rectangular blocks which occur either in isolation or in clusters. The relative height of the hill is about 40 m. More advanced degradation can be recognized at Heudooliyow hill (283 m asl), 4 km to SE from Bur Eibe (Fig. 11.16). The core of the hill, which still rises some 60 m above the plain, is made of a remnant dome, which is 200 × 120 m. It is surrounded on all sides by a wide belt of displaced talus boulders, some more than 20 m long. Their occurrence strongly suggests frequent rock slope collapses. Reasons for this rather unusual pattern of degradation, standing in contrast with the fairly limited amount of talus elsewhere in the region, remain unclear, although another granite elevation located 3.5 km to the NW shows a very similar garland of talus too (Fig. 11.17).

Inselbergs conical in cross section occur too (Fig. 11.18), as demonstrated by two examples located to the SE from Dinsoor, at a distance of c. 18 and 24 km from the town. They are 900 × 500 m and 850 × 250 m, respectively, with the higher one being more than 100 m high in respect to the plain. In both cases, a narrow rock fin forms the axial part. Degradation patterns appear to vary. On the northern hill (Fig. 11.18a), the north-facing slope is covered by many rectangular blocks—almost certainly products of rock slope collapses, whereas the south-facing ones lack boulders and seem to have mantling materials of smaller size. The southern hill seems to be a hogback ridge, with the form adjusted to the near-vertical position of discontinuities (Fig. 11.18b).

Fig. 11.15 Twin castellated inselberg of Madhabey (for location, see Fig. 11.10). *Source* of image: © Google

Fig. 11.16 Advanced disintegration of an inselberg—Heudooliyow hill (for location, see Fig. 11.10). *Source* of image: © Google

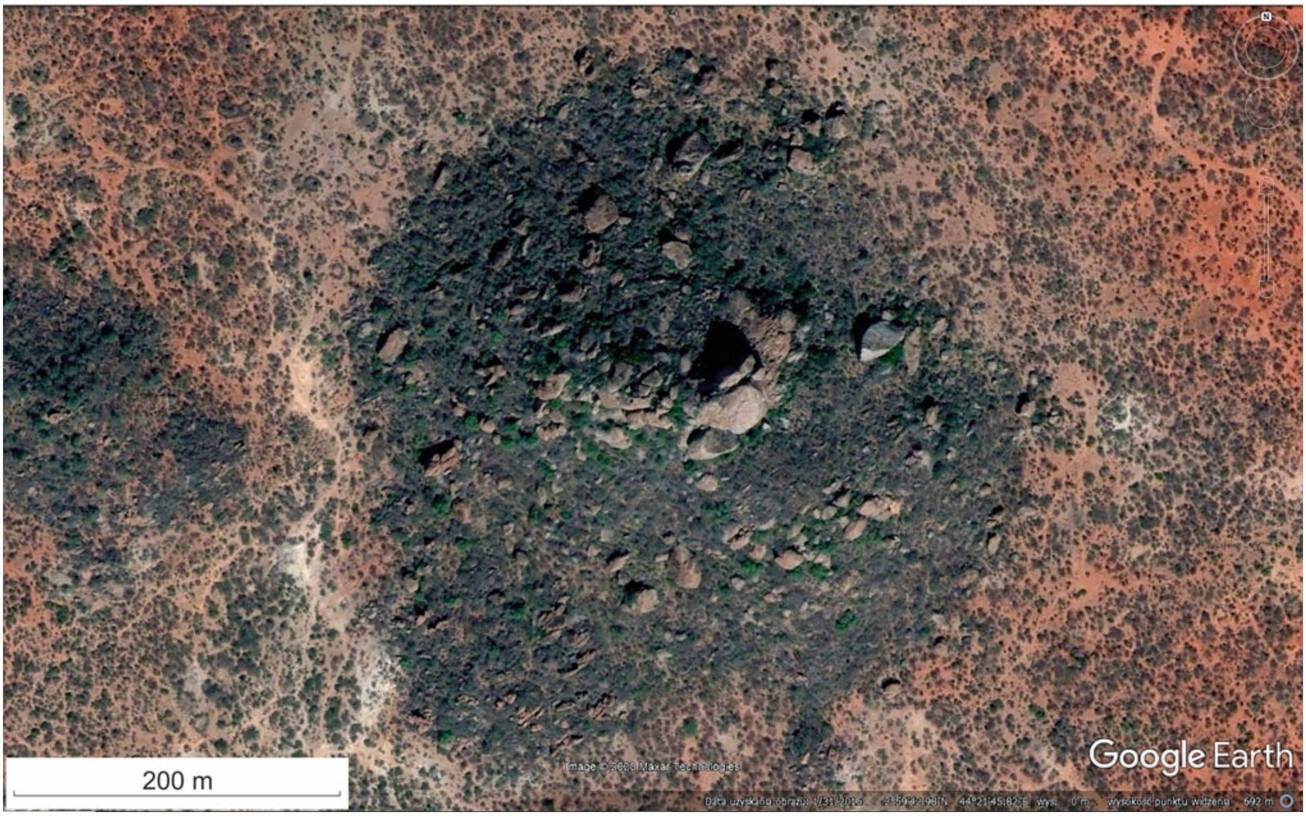

Fig. 11.17 Another example of considerable degradation of an inselberg, as attested by widespread talus blocks (for location, see Fig. 11.10). *Source* of image: © Google

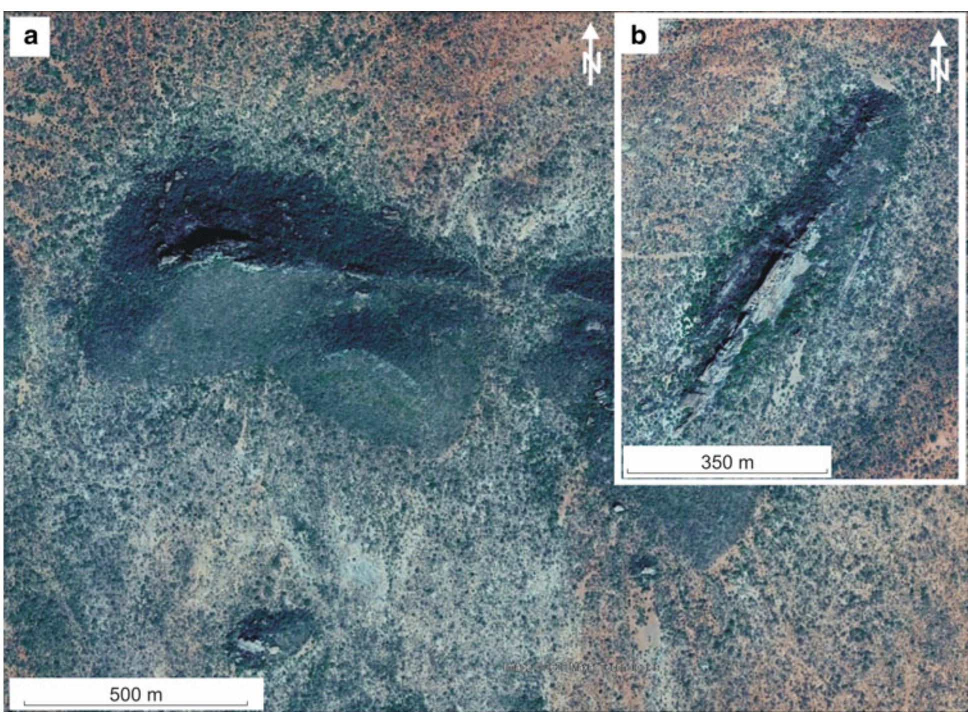

Fig. 11.18 Two examples of elongated inselbergs in the vicinity of Dinsoor, conical in cross section and probably built of quartzite (for location, see Fig. 11.10). *Source* of image: © Google

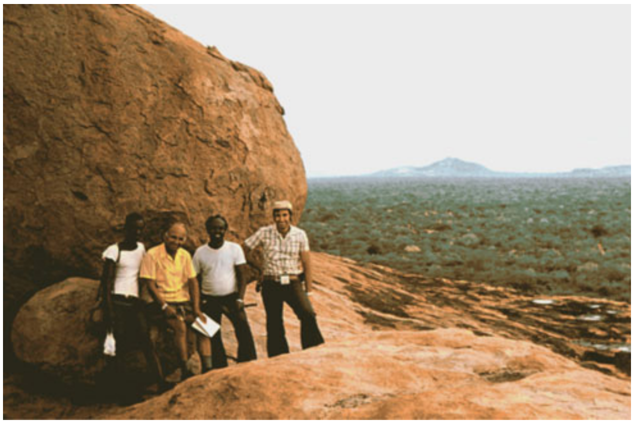

Fig. 11.19 Rounded top with evidence of exfoliation of Bur Eibi. Notice Bur Acaba in the background and the flat bush land in between (photo B. Kamenov)

Limited ground observations revealed the presence of "onion skin" spheroidal weathering leading to exfoliation (Fig. 11.19), which is probably attributable to diurnal temperature ranges. Large boulders litter the perimeter of inselbergs (Fig. 11.20) and locally extend over the surrounding pediment. The burs also show various large to small-scale weathering forms that typically characterize inselbergs in the crystalline rocks (Twidale and Vidal Romani 2005; Migoń 2006). They include large tafoni (a very big one can be seen in Bur Acaba), alveolar weathering and pitting (examples of different size can be seen on Bur Eibi), exfoliation slabs and balanced rocks (Bur Eibi and Bur Gulo), rounded top and spheroidal blocks, flutings (Bur Acaba and Bur Gulo), plinths (Bur Acaba) and flared slopes.

11.7 Inselbergs and Geoarchaeology

Limited geoarchaeological work undertaken in the region before the onset of civil war and following unrest suggests that inselbergs in the Bur Area played a significant role in the life of prehistoric human populations and may have been catalysts of permanent settlement (Clark 1954; Brandt 1986, 1988; Jones et al. 2018). Archaeological excavations were performed in rockshelters at Bur Eibe (Brandt 1988) and Bur Acaba (Jones et al. 2018), yielding human skeletons, artefacts and animal bones which allowed one to reconstruct hunting patterns during the transition period from hunter–gatherer to more sedentary subsistence and settlement patterns. The record covers the period from more than 20 ka to the Mid-Holocene, when significant environmental changes occurred. Faunal assemblages show that during the Last Glacial Maximum the rockshelters were occupied by mobile groups who hunted big game over very arid grasslands. Climate amelioration allowed a change in strategy since reliable water resources on and around inselbergs continued to attract animals, so that human groups focused mainly on dwarf antelopes. The beginning of a lifestyle probably induced ever-increasing emotional ties with inselbergs, as evidenced by burials and rock art. It is noticeable in this context that relatively large settlements are located at the foot of the largest inselbergs, Bur Acaba and Bur Eibi being particularly good examples (see Fig. 11.12).

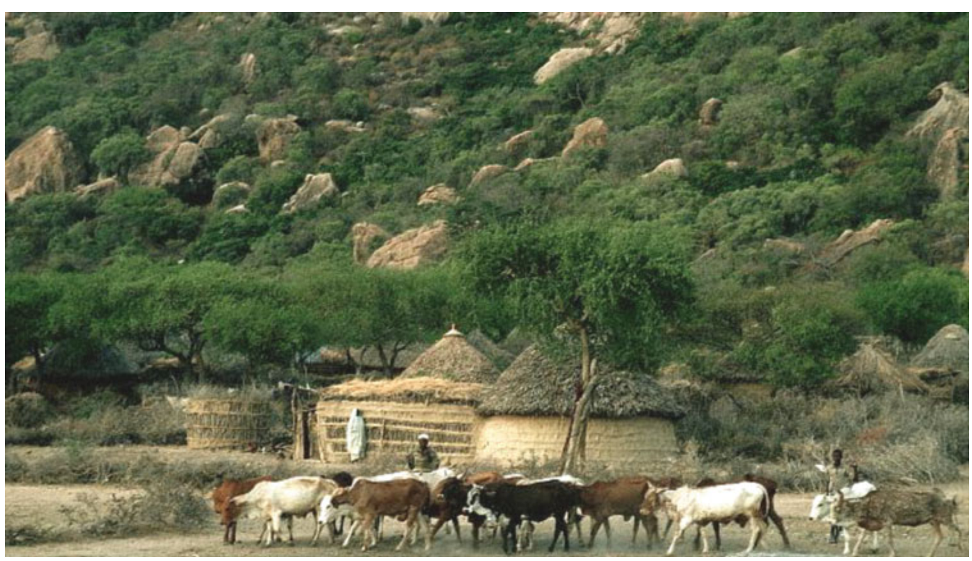

Fig. 11.20 Talus of big boulders accumulated at the base of Bur Acaba

Table 11.1 Hypothetical sequence of geologic and geomorphic events that led to the formation of inselbergs in Bur Area

Phase	Events	Time interval
11	Reworking of weathering products from inselbergs by slope and fluvial processes, boulder accumulation, formation of pediments and depositional surfaces around the inselbergs	Quaternary
10	Uplift associated with the East Africa doming and the formation of the Rift Valley Differential weathering and further growth of inselbergs, shaping of their form in detail	Post-Miocene
9	Long period of stability, with the formation of an etchplain as witnessed by laterites and fluvial deposits with rounded pebbles	Cretaceous to Miocene
8	Transgression and deposition of predominantly carbonaceous sediments over a peneplain with isolated inselbergs. Complete submergence probably accomplished by the end of the Jurassic	Jurassic
7	Uplift followed by a new period of peneplanation	Triassic—early Jurassic
6	Subaerial denudation and peneplanation	Palaeozoic
5	Intrusions of post-kinematic granitoids of metaluminous composition	490–440 Ma
4	Large syn- to late kinematic intrusions of granitic masses into the Olontole rocks. Magmatism probably related to both post-collisional lithospheric thinning, magmatic underplating and crustal relaxation	Approx. 550–600 Ma
3	Folding and metamorphosis of the Olontole and Dinsor series towards amphibolite grade rocks. This orogenic event was accompanied by large-scale anatexis and migmatization	Approx. 600 Ma
2	Deposition of arenaceous, argillaceous and calcareous rocks of the Dinsor Series with their interbedded spilite flows	Early Proterozoic
1	Deposition of sediments to form the Olontole series. This deposition may have been multi-cyclic and represented a long time span, possibly including early Proterozoic time	Archean, possibly including early Proterozoic

11.8 Conclusions

The Bur Area is flat land (though very small-scale undulations are present as well) punctuated by a few tens of isolated hills protruding to a height from a few metres to more than 200 m above the surrounding plain. These hills are typical examples of inselbergs, made up by crystalline basement rocks. The majority of these inselbergs occur as individual outcrops and are spaced several kilometres from each other. In places, they occur in groups, including 4–5 hills of different size. Their petrological composition is typically granitic or gneissic, though some variations in the mineralogical composition emerged from the petrographic analysis of a number of samples. The mineralogical and petrographic data and some field observation allowed the reconstruction of the geological history of the inselberg landscape of the Bur Area and its morphological evolution (Table 11.1).

Unfortunately, the state of war that has been devastating Somalia for a long time has prevented scientists (and ourselves as well) from refining their studies and results. The Bur Area is a very interesting and, in some instances, a unique place in the world to investigate the interactions of geological, geomorphological and pedogenic processes. We do hope that peace will be eventually restored in the country and that international scholars will have again the possibility to do field work all over Somalia in collaboration with their Somali colleagues and with the support of what has always been a friendly population.

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