On naturally sculptured granites in Zimbabwe

Address to the Geological Society of Zimbabwe AGM 2013

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Introduction

The greatest part of the Zimbabwe craton comprises granitic rocks broadly divided into the vast areas of older granitic gneisses (>2 800 Ma) and younger granitoids (approx. 2 500 to 2 750 Ma). Weathering and erosion over millennia have sculptured the granitoids into the most spectacular artistic landscapes such as bornhardts, castle kopjes, and balancing rocks. Marvellous minor weathering forms are also ubiquitous in granite areas.

While the Epworth balancing rocks, the Matobo hills castle kopjes, and the Domboshava batholiths may be the first images that come into mind when pondering about beautiful granite landscapes, the truth is that there is an abundance of impressive granite features occurring in other parts of the country. Many of these may pass unnoticed as they occur outside areas that have been officially designated leisure parks. However many have aesthetic attributes that can easily attract multitudes of admirers if promoted. This report is meant to raise an awareness of the existence magnificent granite topographical features in areas including those outside the traditional tourist resorts. The intention is to excite interest in the value of these picturesque features and to promote their preservation for scientific, educational and recreational purposes.

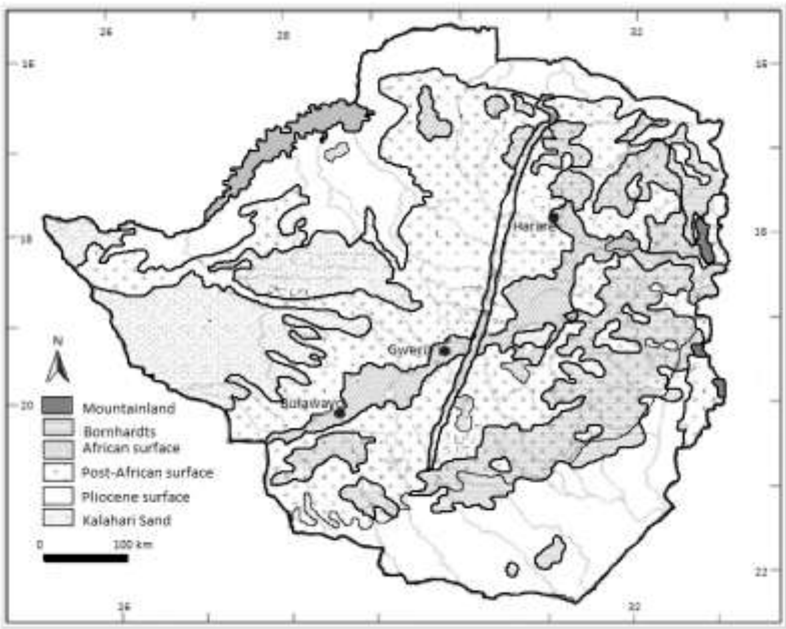

Figure 1. Distribution of areas with typical granite landscape (after Moore et al 2009).

Distribution of areas of interesting granite landscape

Granite topography is typically well developed in many parts of Zimbabwe, especially in younger granitoids, notably the area stretching from Rushinga in the north through Mutoko, Murehwa, Nyanga, Makoni, Buhera, Gutu, Ndanga, Chivi, Matobo to Umzingwane (see Figure 1).

Factors affecting landscape development

Weathering, structure and composition of rocks are the most important factors in the development of landscape. Highly fractured rocks are more susceptible to weathering than those in which the fractures are absent or widely spaced. Where rectangular jointing dominates as is the case in many younger granite outcrops, characteristic landforms are developed. Some granite landscape features are also created as part of the granite intrusion process. Thus intrusive activities, structure, and weathering have combined to create various landforms evident in granite areas.

Physical and chemical weathering and erosion are the most important factors in the sculpturing of rocks. In physical weathering, rocks breakdown without changing chemical composition whereas chemical weathering involves chemical alteration or decomposition of rocks and minerals. Mechanical breakdown of rocks is mainly caused by temperature changes, pressure release, and plant action whereas the main agent responsible for chemical weathering is water and weak acids formed in water.

Weathering and erosion features in granite are varied, occurring both as major and minor structures that present natural artistic displays adorning the countryside.

Major granite landscape structures

Batholiths

Some of the most curious features dominating the Zimbabwe granite landscape are batholiths. These are large masses of more than $100km^2$ of surface exposure. Batholiths crystallised at depth as plutons, and were subsequently exposed to the surface by the process of erosion.

There origin of batholiths is controversial. On observing the relationships between the granites and surrounding greenstone belt rocks where deformation fabric in the latter appears to have been effected by the granites, Macgregor (1951) proposed that the batholiths were emplaced by diapiric or ballooning processes, and coined the phrase `gregarious batholiths'. Ramsay (1989), and Dirks and Jelsma (1998) provided further evidence for diapirism and ballooning for the Chinamhora batholith north of Harare.

The ballooning theory emphasises vertical movements, yet the relationship of batholiths to surrounding greenstone belts in some areas suggest the importance of horizontal movements. To this effect, Wilson (1990) proposed a situation where horizontal movements caused pervasive deformation in greenstone belts being buttressed by blocks of granitic batholiths that jostled around, the so-called billiard ball tectonics, forming some of the features observed in the relationships between the granitoids and greenstone belts (see also Treloar et al 1992). However Snowden and Bickle (1976) and Snowden (1984) emphasize the importance of multiple phases of deformation in producing the batholiths such as the Chinamhora.

Also in contrast to diapiric models of intrusion for granitic batholiths in Zimbabwe, Snowden (1976) and Becker et al. (2000) suggested that the latest phases of the Chinamhora and Murehwa batholiths were tabular, which is consistent with a growing body of evidence that granites commonly intrude as tabular bodies. For instance, a recent study shows that the Murehwa batholith has a tabular geometry (Blenkinsop and Treloar 2001).

Thus although they may appear uniform, batholiths are structures with complex histories and compositions. The batholiths have been subjected to tectonics and weather conditions, and these combined with varied textural and mineralogical composition of the granite, has produced a plethora of topographical features some of which are described below.

Bornhardts

Bornhardts are the basic forms of granite landscape, and are found throughout the country's granite areas. They form large domes of massive rocks with faces ranging from gently inclined slopes to almost vertical slopes (Figure 2).

Bornhardts appear to have developed on resistant portions of batholiths with few open fractures surrounded by highly fractured rock (see Pye et al 1984). The domical profile is caused by exfoliation.

Bornhardts are also considered to be the surviving remnants of scarp retreat (Lister 1990). However if this is a valid explanation, bornhardts would be restricted to major drainage divides but this is not always the case (see Twidale 1980 and Campbell 1997). The profusion of bornhardts on the post-African erosion surface (see Fig. 1) tends to suggest that they are residual hills that became exhumed by weathering and erosion of cover of the African erosion surface (Moore et al 2009).

Castle kopjes and balancing rocks

Castle kopjes are an assemblage of boulders contiguous with pockets of soil and vegetation. They are formed as a result of the disintegration of bornhardts into boulders especially where rectangular jointing dominates. Occasionally rocks balanced precariously on top of other rocks can be observed in areas of castle kopjes. The most popular of these are the Epworth and Matobo hills rocks.

Figure 2. Ngomakurira bornhardt, Chinamhora.

Evidence from quarry exposures and road cuttings suggest that the process of development of castle kopjes and balancing rocks is initiated in the subsurface and continues after exposure. Prolonged erosion removes the soil, leaving piles of boulders resting on and against each other (see Fig.3).

Figure 3. A road cutting showing stages of development of castle kopjes and balancing rocks, Kuwadzana Harare-Bulawayo Road. Weathering along vertical and horizontal joints isolate boulders that will eventually support each other as soil between the boulders is removed by erosion.

Although outcrops of large balancing boulders are expected to be abundant in Zimbabwe given the vast granite areas, they are in fact not so common. They appear to be restricted to granitic rocks that are massive and cut by widely spaced vertical and horizontal joints, coarsely crystalline or porphyritic, and with mineral assemblages that make the rocks resistant to decomposition. Foliated and highly fractured granitoids favour development of castle instead of balancing rocks (Romer 2007).

Where it outcrops, the Harare Granite (Baldock et al 1991) has produced outcrops with unique features of balancing rocks of various forms. The area stretching from Mabvuku through Epworth and Chitungwiza, to Lion and Cheater Park, is a paradise of balancing rocks. Vast areas in Chitungwiza and Mabvuku are strewn with fantastic outcrops that have varieties that could easily surpass the infamous Epworth outcrops in diversity and attractiveness (Fig. 4).

Minor weathering features

Weathering of granitic rocks occasionally produces fascinating minor structures. The following are some of the minor weathering forms found in granitic rocks (see also Campbell and Twidale, 1995).

<u>Polygonal cracks</u>
Some boulders of coarse grained granite display interesting polygonal structures that resemble mud cracks (Fig. 5). The cracks affect the superficial shell of the rock, extending to no more than a few centimetres beneath the surface of boulders. The polygonal plates are usually more represented on steeper faces of boulders than on horizontal faces and pavements. This is clearly the result of differential weathering where plates on horizontal surfaces are quickly destroyed by chemical and biological weathering as water and plants settle in the cracks.

Figure 4. Examples of balancing rock topography associated with the Harare Granite; a. view of part of the Chitungwiza rocks; b. view of part of Mabvuku rocks; c-g examples from Chitungwiza; h. a balancing rock from Mabvuku.

Whereas desiccation cracks in mud are easily explained by shrinkage as the mud dries, polygonal cracks in such solid crystalline rocks are assumed to have a different origin. However as these only affect the thin surface crust of the rock exposed to weathering, it can be assumed that they are the result of temperature changes where the differential rates of expansion and contraction causes fracturing due to tensile stresses parallel to the face of the rock.

a. b.

c. d.

Figure 5. Polygonal cracks; a, b. well developed cracks on steep face of a boulder, Mabvuku; c. remnants of polygons being destroyed by weathering along joints on horizontal face of a boulder; d. the interior of polygons being weathered faster than the edges. The edges remain as raised structures being protected from weathering by a mat of grass that grows in the cracks, Domboshawa batholiths.

a. b. c.

Figure 6. Examples of tafoni in coarse grained granite, Gutu. The base of the boulder in c is almost completely eaten away by the process of tafoni development.

<u>Tafoni</u>

Differential weathering can produce curious cavernous structures termed tafoni on high angle faces of some coarsely granular granitic rocks. They occur in different forms and shapes ranging from single depressions to complex honey comb structures (see figure 6). It appears tafoni initiate in zones of natural depressions on a rock surface. The weathering across the surface can then be further enhanced by moisture especially at the base of the boulder. Once weathering initiates at a site, the rock will degrade at a faster rate than adjacent unweathered regions, forming a tafone. The tafone interior weathers at a faster rate than the walls.

Gnammas

These are circular, elliptical or irregular depressions in solid rock. They occur in varied shapes caused by the structure of the rock, the slope of the exposure and the depth of erosion. For instance, elliptical depressions occur in laminated rocks while circular pits occur in homogeneous granites (Fig. 7).

While gnammas are commonly the result of weathering of the host rock, some represent areas where xenoliths in the granite were etched out by weathering and erosion.

a. b.

Figure 7. Gnammas; a. elliptical gnamma in slightly foliated granitoid; b. a circular gnamma on a steep face of a boulder, Chitungwiza. The gnamma in (b) nucleated on a tension fracture.

a. b.

Figure 8. Drainage channels on the Domboshawa batholith; a. channels breaking into several branches in a wide valley; b. deep channel with raised rock levees.

Drainage channels

A striking feature of some granite batholiths is the occurrence of drainage channels eroded into solid rocks. The channels mirror the patterns of normal drainage basins. The Domboshawa batholith exhibits excellent examples of these microgeomophological features (see also Lister (1973). On flatter parts of the batholith, the channels exhibit the pattern of sluggish and swampy mature rivers breaking and meandering in wide valleys (Fig 8 a) whereas on steeper slopes, the channels show river patterns with deep and narrow trench-like structures bordered by rims of rock levees (Fig 8 b). The origin of these curious levee structures is debatable although there have been suggestions that they are the result of deposition of silica, or the areas remain standing as a result of protection from weathering by certain species of lichens that grow on the edges of the water channels (Whitlow and Shakesby 1988).

Pseudo ripple marks

Weathering along planes of closely spaced joints can produce features that resemble sedimentary ripple marks in granite (Figure 9).

a. b.

Figure 9. Pseudo ripple marks in granite, Gutu. In this case the ripple marks occur associated with a quartz-filled fault (see b.) over the granite pavement. Movement along the fault caused development of closely spaced tension fractures in the outer layer of the granite. Weathering along the fractures produced the ripple marks.

Etch marks

Some weathering etch marks in granite have always astonished observers as some of them resemble trace fossils. For instance, a weathering etch mark resembling foot marks on a granite dome in Epworth have given fame to this rock. The etch marks are erroneously believed to have been made by God's feet on the solid rock, hence the name Domboramwari 'God's Rock' given to this rock. Carl Mauch, perhaps the first person to give detailed accounts of geological information on parts of this country, was in February 1872, shown in the Ndanga area, several marks in granite that local people believed were footprints of birds' feet (Bernard and Bernard 1969).

Figure 10. Examples of balancing rock outcrops that have been taken over by church groups, Chitungwiza.

Concluding Remarks

Tectonics, volcanism, weathering and erosion have combined to sculpt granite areas in Zimbabwe into most fascinating landscapes. Given the vast areas covered by granites in this country, areas with attractive outcrops are boundless. Some of these areas, especially those close to urban areas, could be easily turned into leisure parks. An area that immediately comes into mind in this consideration is the one south of Chitungwiza. This area covering over 5km^2 of ground has numerous granite outcrops including astonishing balancing varieties (Fig. 4). Small wild animals such as squirrels, hares and rock rabbits that live among these rocks enhance the attractiveness of the area.

The Chitungwiza balancing rocks area is however under threat. Apostolic church groups have invaded the area to claim outcrops with religious graffiti for their shrines (see Fig. 10). Groups of youths have also invaded the area to extract gravel and crush rocks manually for aggregate to sell to neighbouring Chitungwiza. These activities are making some areas inaccessible by ordinary citizens. Much of the area has also been cleared of trees by urban farmers.

Such areas of rare natural beauty should not be allowed to be monopolised by few individuals, but should be preserved for everyone to enjoy. The Lion and Cheater Park, Mukuvisi Woodlands and Epworth Balancing Rocks concepts of preserving areas of natural beauty could be extended to areas such as the Chitugwiza granite outcrops. Rehabilitation of such areas could be achieved through commercial partnerships between private or public companies and landowners to establish leisure parks that protect the natural scenery as well as protecting flora and fauna.

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