Geological Society of Zimbabwe

SUMMER SYMPOSIUM

FIELD GUIDE

HILLSIDE SYENITE

DIANA'S POOL ORBICULAR GRANITE

2 NOVEMBER 2024

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Geology of the Bulawayo Greenstone Belt

The Bulawayo Greenstone Belt was first mapped by Amm (1940) and again by Garson (1995).

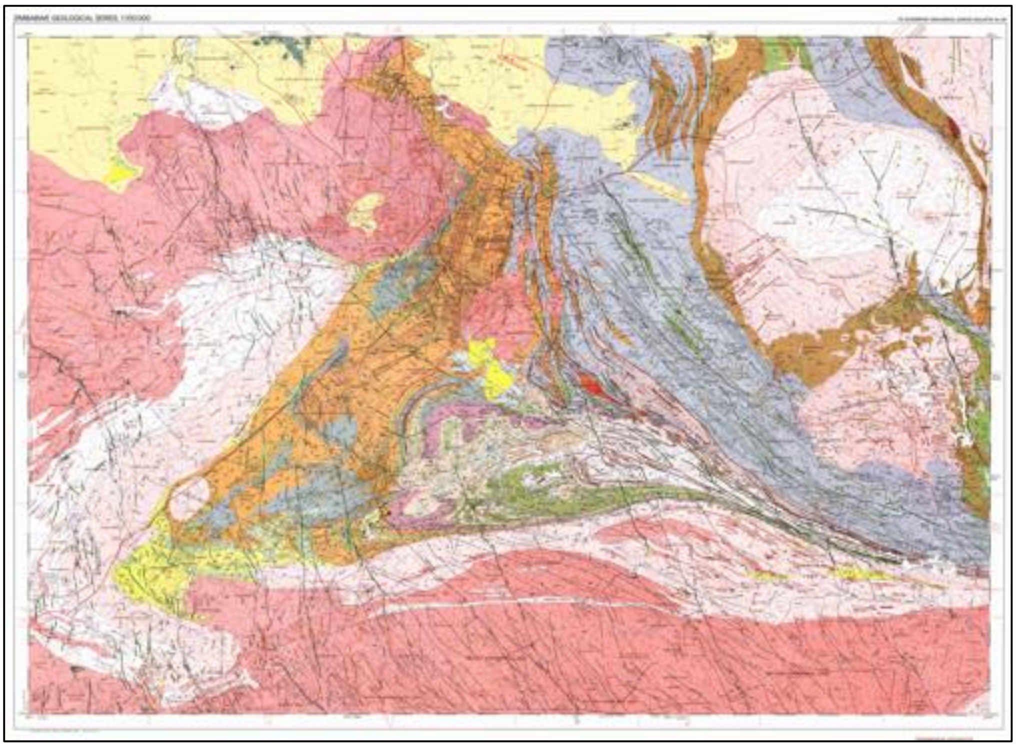


Figure 1 Bulawayo Geological Map Garson (1995) ZGS Bulletin 93

Garson recognised Lower and Upper Greenstone successions which he assigned to the Bulawayan, and also identified a number of different granitic rocks surrounding the Belt.

The Lower Greenstones comprise two Formations of mafic and intermediate-to-felsic volcanic rocks which Garson equated with the Brooklands Formation of the Belingwe Belt (Martin, 1978).

Six Formations were assigned to the Upper Greenstones with the lowermost sedimentary unit successively overlain by a variety of volcanic and sedimentary rocks.

Table 1 Greenstone Stratigraphy

UPPER GREENSTONES	TONBRIDGE FORMATION	*Meta-basalt and meta-gabbro*
	UMZINGWANE FORMATION	*Meta-sedimentary*
	AVALON FORMATION	*Meta-andesite rhyodacite and dacite*
	SAUERDALEFORMATION	*Meta-komatiitic flows and intrusions*
	UMGANIN FORMATION	*Meta-basalt and meta-gabbro*
	WESTACRE FORMATION	*Meta-sedimentary*
	Unconformity	
LOWER GREENSTONES	LONSDALE FORMATION	*Meta- Rhyodacite Rhyolite Andesite*
	VREIGEVIGHT FORMATION	*Amphibolite meta basalt meta komatiite*

Granitic Rocks

There are numerous granitic bodies surrounding and intrusive into the Bulawayo Greenstone Belt with a wide variety of compositions and textures.

The youngest is the Hillside Syenite (2172 ± 101 Ma, Rb/Sr, whole-rock) which is described in more detail below.

Granites of the c. 2600 Ma Chilimanzi Suite include plutons to the NW of the Greenstone Belt and to the south in the Matobo area, ranging from potash granites to tonalites and granodiorites with textures from porphyritic to massive and micro-granitic to gneissic see Appendix 2).

The c.2700 Ma Ncema Complex to the west of the Bulawayo Belt and is considered by Garson to be part of the tonalitic Sesombi Suite (Wilson 1995). It consists of the Heany Junction and Esigodini Plutons which are composite bodies of a number of intrusions, mainly tonalitic, with some granodiorite and granite.

The oldest granitic rocks are phenocryst-free gneisses which locally incorporate greenstone xenoliths. These flank the north-western and southern margins of the Bulawayo Belt with small areas to the NE and SE.

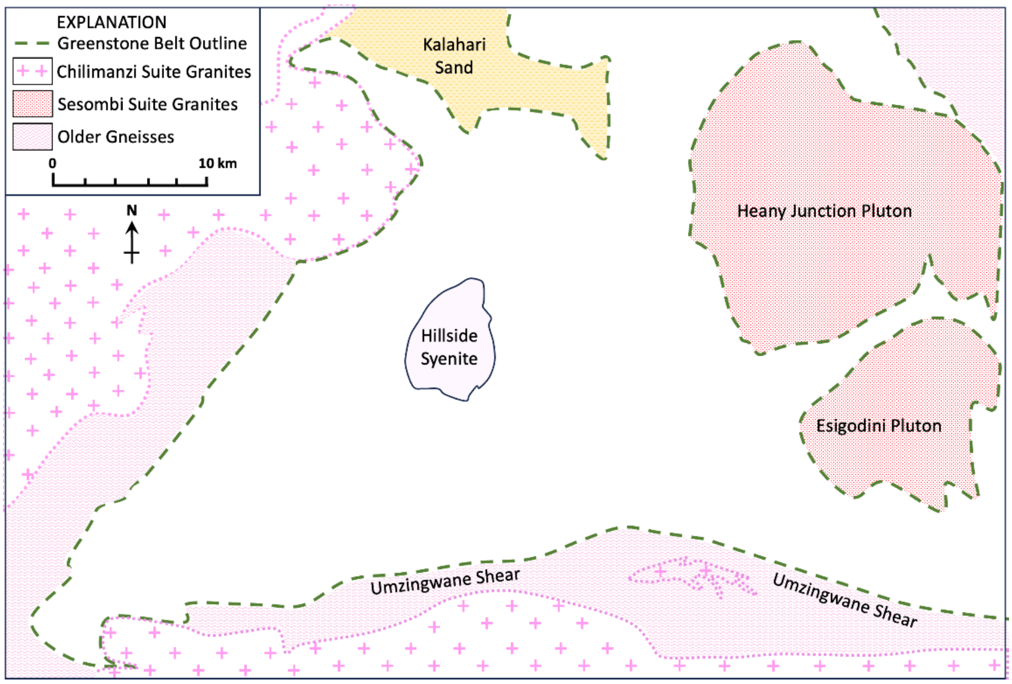


Figure 2 Granites and Gneisses in Bulawayo Area

Structural Aspects

The Bulawayo Greenstone Belt has been highly deformed, particularly along its southern margin and south-western corner where a number of thrusts duplicate the stratigraphy. This deformation affects both the Upper and Lower Greenstone Sequences. While Coward (1976) considered much of the intense deformation to be associated with older granitic diapir emplacement, Garson provides evidence of thrusting, shortening and associated shearing post-dating the intrusion of the diapiric granites but possibly associated with the intrusion of the later Chilimanzi Suite.

The north-westerly to northerly trend of the Avalon Formation along the eastern edge of the Belt has clearly been influenced by the Heany Junction and Esigodini Plutons to the east of the Greenstone Belt.

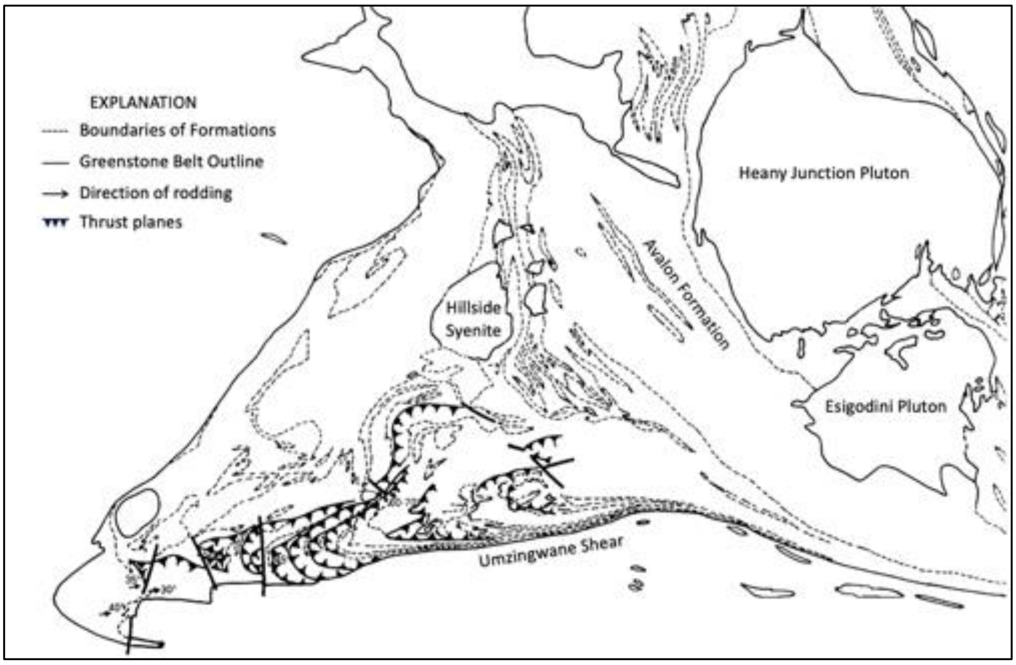


Figure 3 Structural Summary of Bulawayo Area

From a regional perspective, the Tectonic map of Zimbabwe shows a major thrust extending from the Avalon Formation into the Filabusi Greenstone Belt to the East.

Figure 4 Portion of Tectonic Map of Zimbabwe

Erosian Surfaces

The Bulawayo area lies along the watershed between the Zambezi and Limpopo Rivers and on the 'Central Axis' defined by Lister (1988). A small remnant of the pre-Karoo surface lies in the centre of the area surrounded by a north-easterly trending strip of the Cretaceous to Oligocene African erosion surface. North-east and south is the Post-African surface of Miocene age with minor patches of Kalahari sand and recent alluvium.

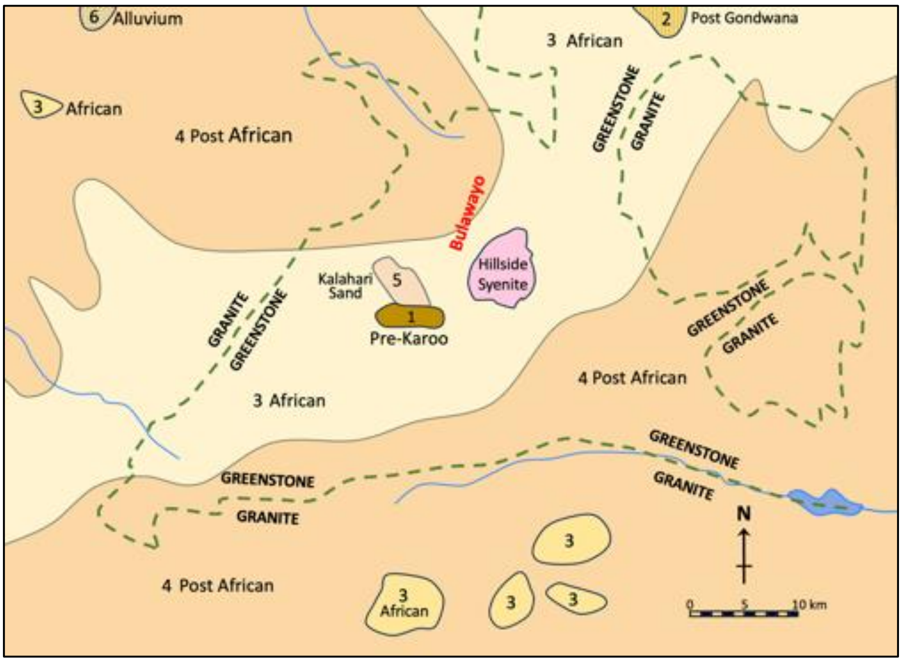


Figure 5 Erosion Surfaces in Bulawayo Area

Outcrops to be visited

The two outcrops that will be visited are the Hillside Syenite on the outskirts of Bulawayo and the orbicular granite to the south of the Greenstone Belt.

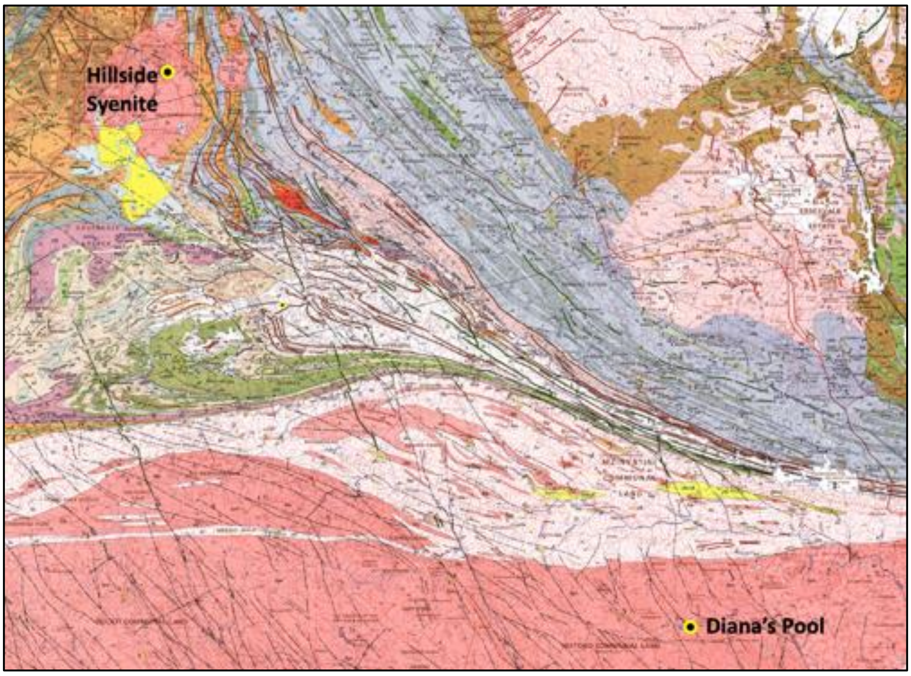


Figure 6 Bulletin 93 Garson (1995) location of Outcrops

HILLSIDE SYENITE

The Hillside Syenite lies south-east of Bulawayo centre. It covers 30 km^2 with four smaller intrusions to the north and east of the main intrusion. It forms castle kopjes and flat exposures, interspersed with pale, eluvial soil. The bulk of the intrusion is medium- to coarse-grained and pink to buff with small clusters of mafic minerals which are more prevalent in coarser-grained rocks (Locke, 1971).

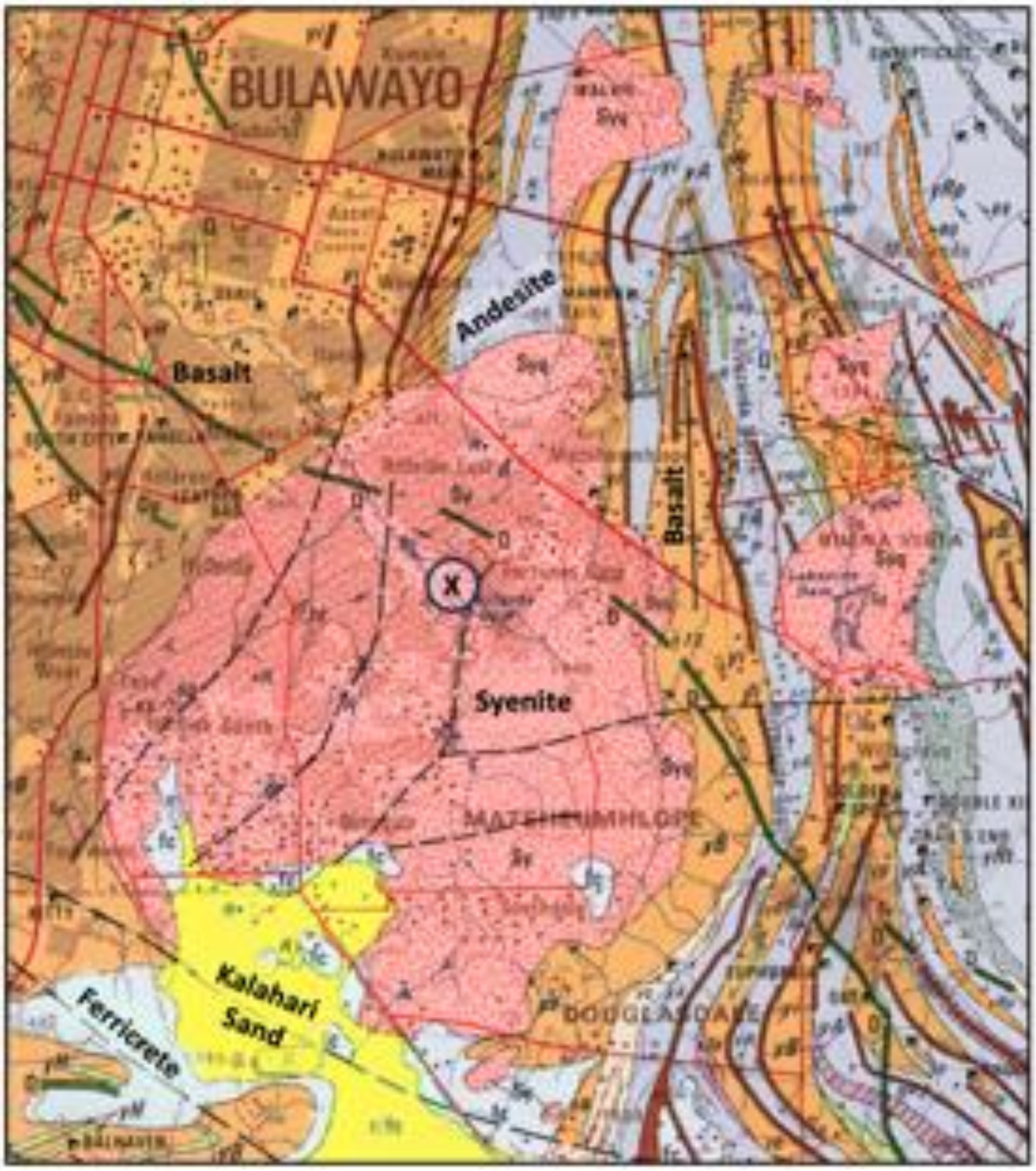


Figure 7 Bulletin 93 Garson (1995) location of Hillside Syenite

Garson (1995) quotes an age of 2172 ± 101 Ma for this syenite from an Rb/Sr whole-rock determination but does not give a source for this.

The syenite is granular to porphyritic and consists of microcline-microperthite (75-90%) with subordinate finer-grained microcline and albite-oligoclase. Quartz is a very minor constituent or absent. The mafic minerals comprise subhedral pale-green pyroxene, darker-green amphibole, euhedral sphene and apatite and subhedral titaniferous magnetite.

A prominent near-horizontal foliation was presumed by Garson (1995) to be jointing related to shrinkage on cooling, but is more likely to be due to reduction of the lithostatic stress resulting from weathering.

The shape of the complex is interpreted to be that of a widening-upwards, steep-sided cone, and the paucity of roof pendants suggests that the current erosion level is well below the original top of the intrusion.

Figure 8 Hillside Syenites

ORBICULAR GRANITE

The orbicular granite exposure is situated in a porphyritic granite of the Chilimanzi Suite.

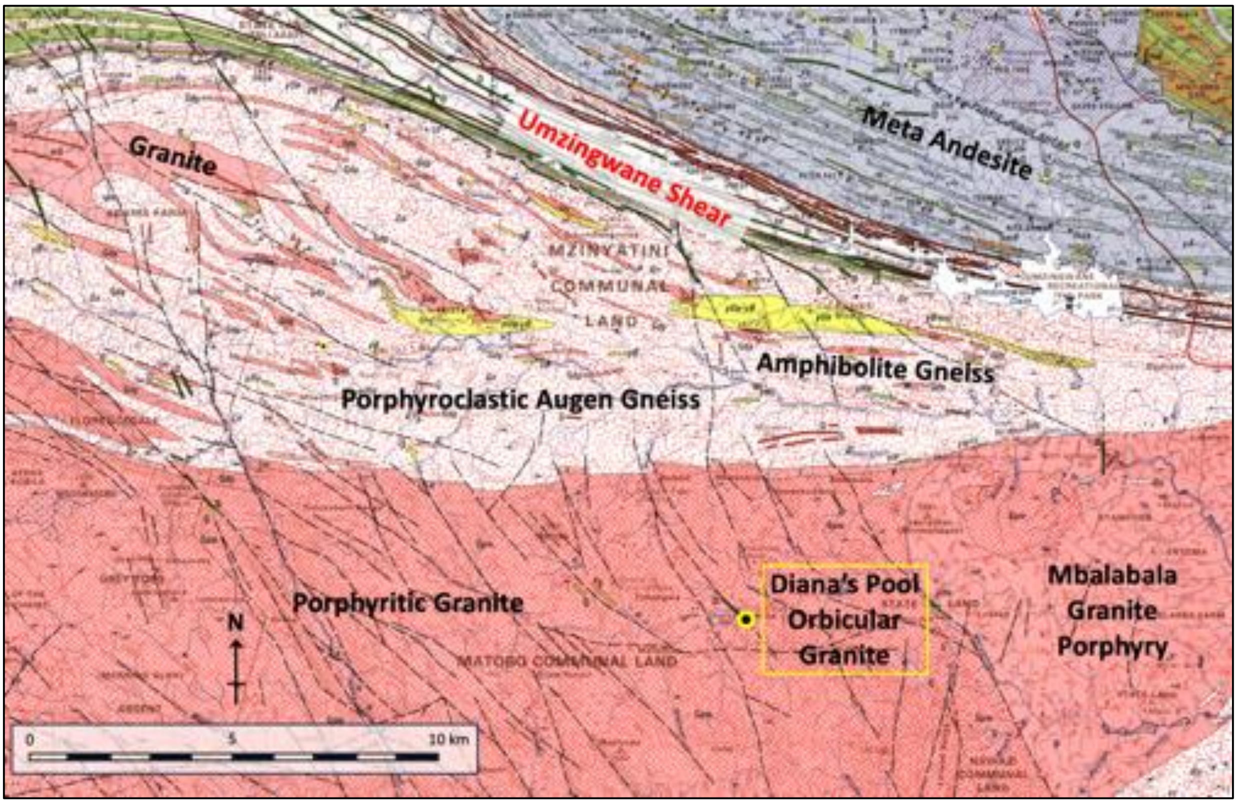


Figure 9 Bulletin 93 Garson (1995) location of Diana's Pool Orbicular Granite

The outcrop is very small with irregular contacts which in part are shallow dipping, suggesting that the orbicular zone is tabular. In places there is a banding of finer granitic rocks along the contact and elsewhere the orbicules are in direct contact with the granite.

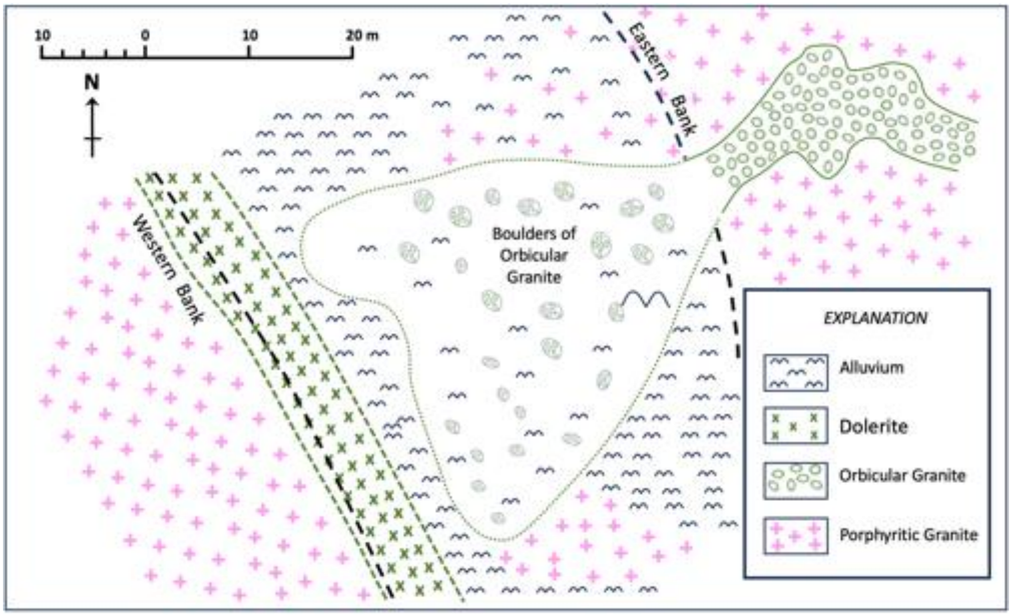


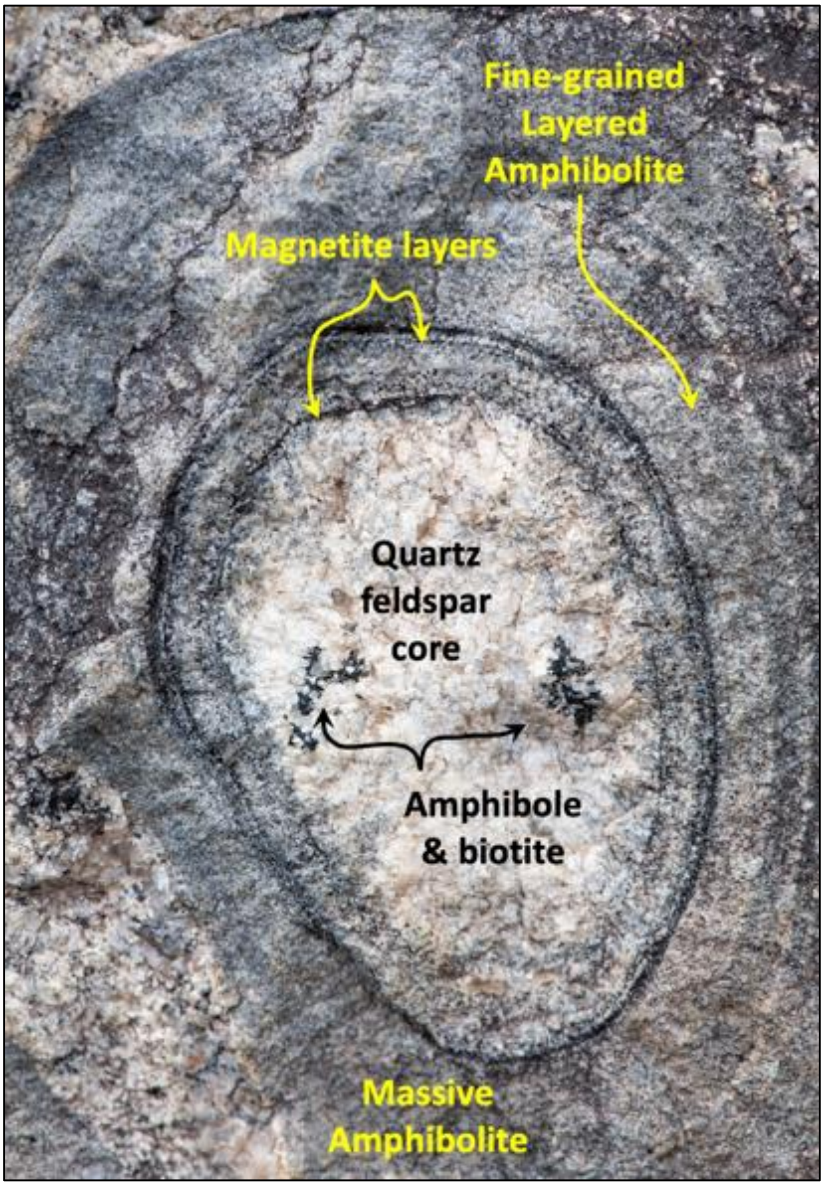
Figure 10 Sketch Plan of the Diana's Pool Orbicular Granite site (modified after Garvie, (1969)

The orbicules vary in size, shape, composition and compaction. Some are in contact with each other and elsewhere are separated by granite - with an analogy to clast- and matrix-supported conglomerate. They appear to be ellipsoidal with slightly flattened ends, but the paucity of three-dimensional exposure does not allow a definitive assessment of their shapes. In places, particularly near the margins of the zone and where the orbicules are closely packed, there is evidence of ductile deformation of some orbicules.

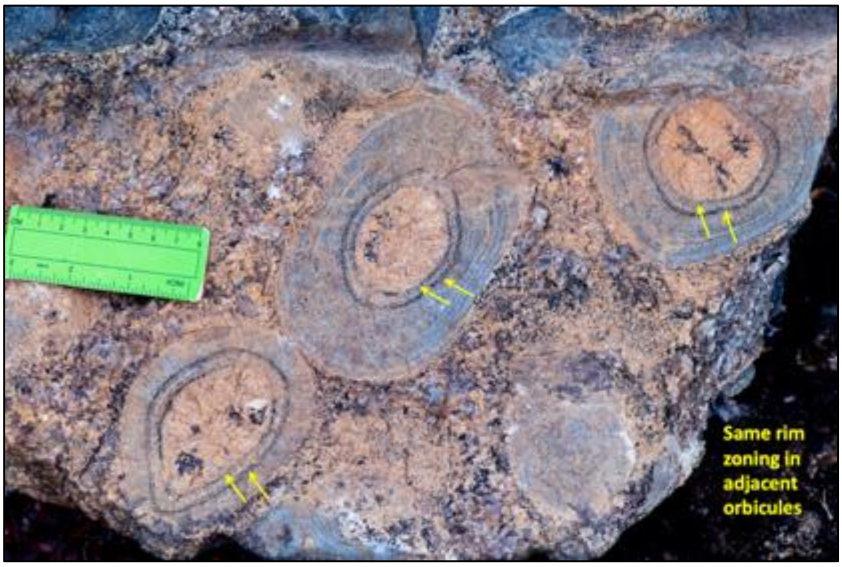
Commonly the orbicules consist of a core of felsic material, some containing coarse, mafic minerals. The rims around the core are more mafic, banded and typically contain magnetite. The mineralogies of the orbicules and their matrix are described in detail by Dumisa et. al., 2024.

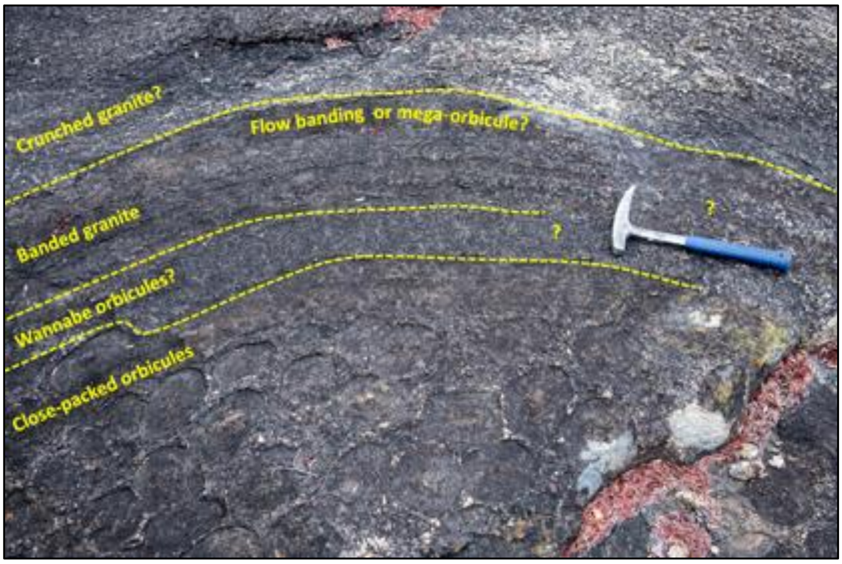
There is also evidence from some adjacent orbicules of the same crystallisation sequence of the rims. The photos below show some of the features of the orbicular outcrop.

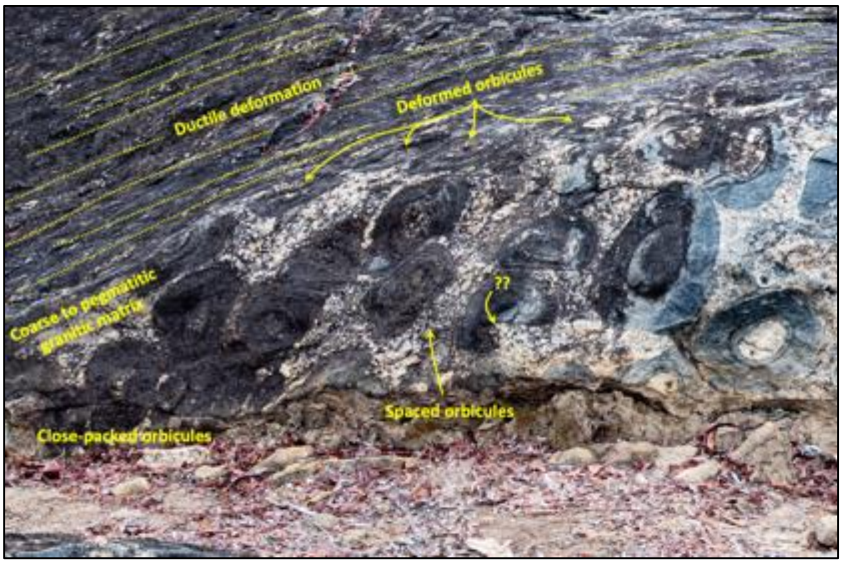
No attempt is made here to discuss the origin of these rocks which has been covered by Paul Nex's talk and Dumisa et. al., 2024. The abstracts of this paper and two others are given in an Appendix below.

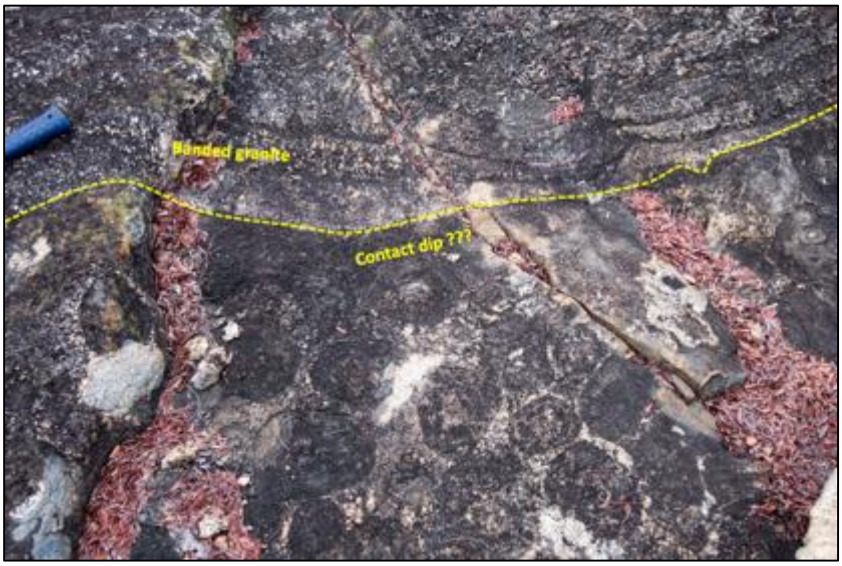

Fine-grained
Layered
Amphibolite
Magnetite layers
Quartz
feldspar
core
Amphibole
& biotite
Massive
Amphibolite

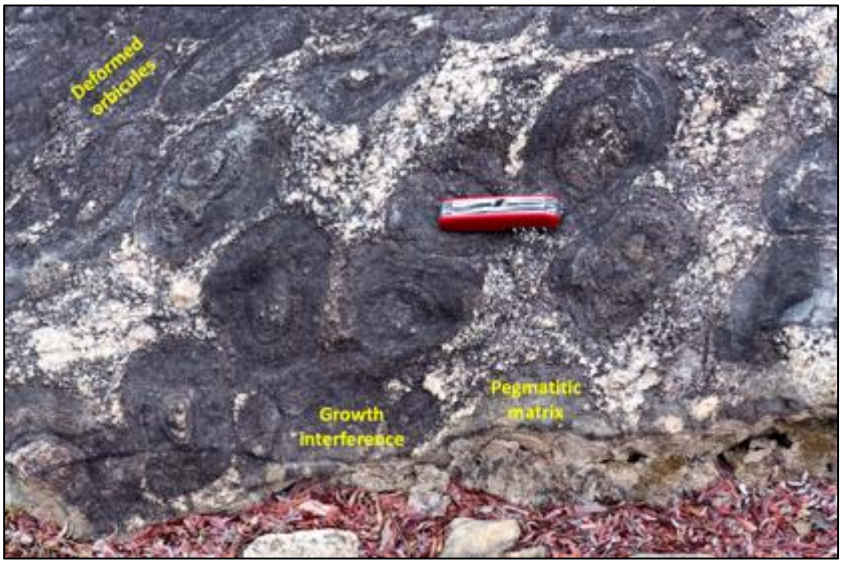

Pegmatitic
matrix
Felsic Core,
Amphibolitic
matrix
Granitic
matrix
Concentrically
layered mafic rim


Same rim zoning in adjacent orbicules

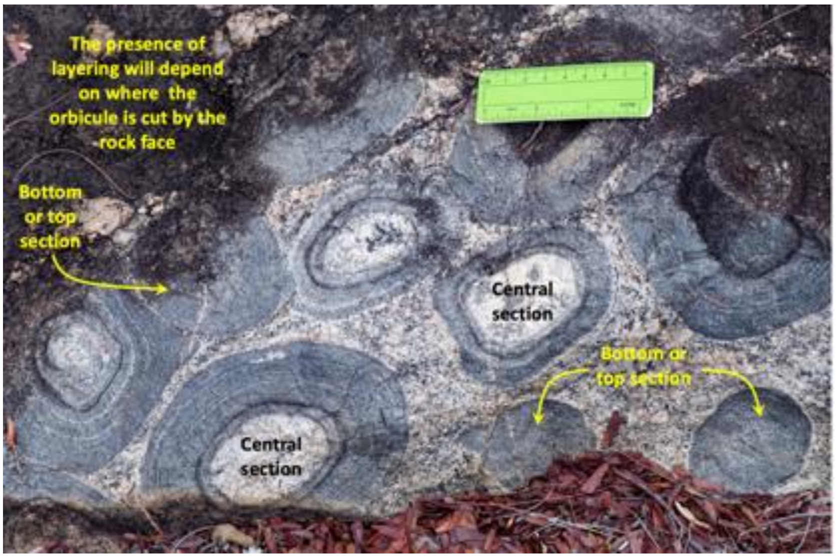

Crunched granite?
Flow banding or mega-orbicule?
Banded granite
?
?
Wannabe orbicules?
Close-packed orbicules

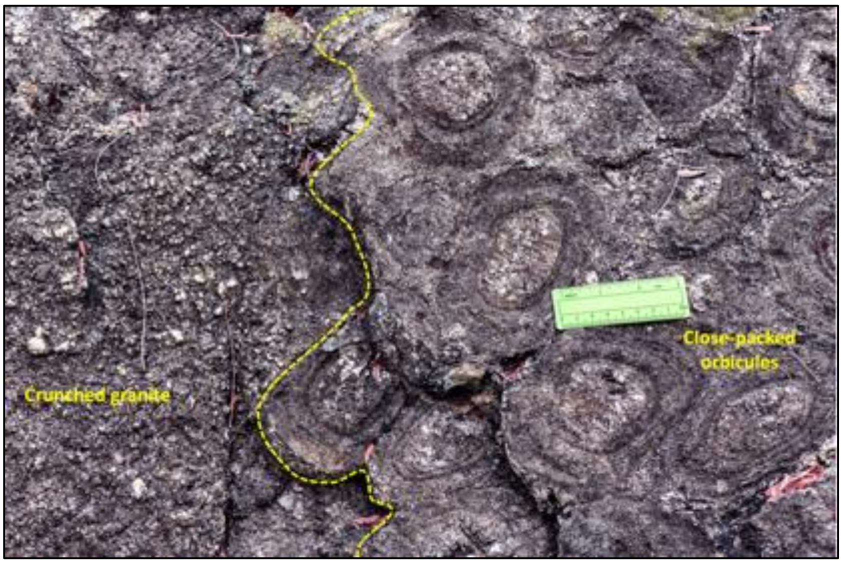

Ductile deformation
Deformed orbicules
Coarse to pegmatitic granitic matrix
??
Spaced orbicules
Close-packed orbicules

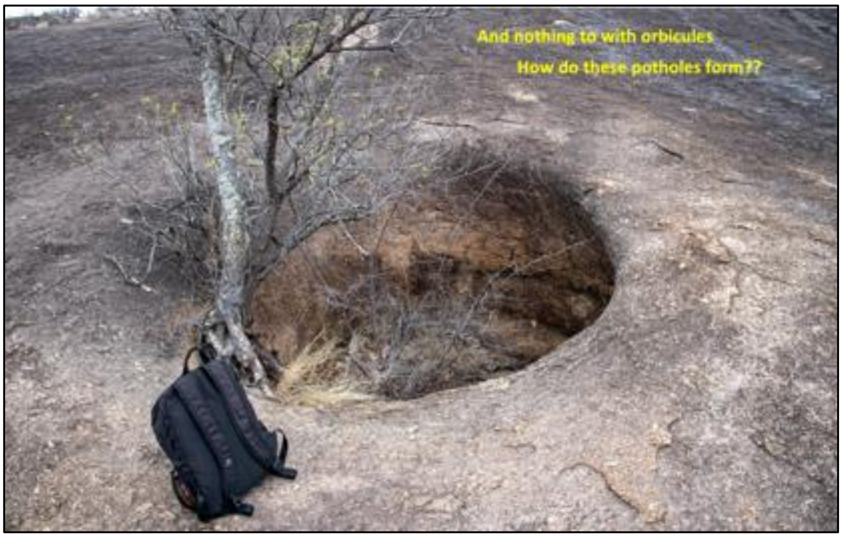

Banded granite
Contact dip ???


Deformed orbicules
Growth interference
Pegmatitic matrix


??????


The presence of layering will depend on where the orbicule is cut by the rock face
Bottom or top section
Central section
Bottom or top section
Central section


Close-packed orbicules
Crunched granite


And nothing to with orbicules
How do these potholes form??

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Dumisa, S.S., Bybee, G. M., Nex P.A.M., and Jogee, B.A. 2024. The petrogenesis of orbicular granites in the Diana's Pool area, Zimbabwe. SAJG Volume 127(1) pages 1-16

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Appendix 1 Relevant Abstracts

The petrogenesis of orbicular granites in the Diana’s Pool area, Zimbabwe

S.S. Dumisa, G.M. Bybee, P.A.M. Nex and B.A. Jogee

SAJG Volume 127(1) pages 1-16

Abstract

This paper assesses an outcrop of orbicular granite from the Matopos granite batholith in the Diana’s Pool area, Zimbabwe. Historical samples from Diana’s Pool exhibit closely packed orbicules in a granitic matrix. They are 9 to 14 cm in diameter and are characterised by different types of orbicules containing coarse-grained felsic cores, fine-grained and alternating ferromagnesian and feldspathic shells, and a coarse-grained matrix. The orbicules are generally spherical to ellipsoidal in shape, however, some appear to be abraded and deformed. The compositions and grain sizes of cores and the matrix are comparable. Both the matrix and the cores are medium- to coarse-grained and dominated by plagioclase (the matrix probably in slightly lesser proportions), microcline (in variable proportions, and seemingly absent in some cores), quartz, biotite and accessory hornblende and magnetite. Contrary to the cores and matrix, shells are fine-grained and exhibit polygonal textures. In addition to this, the shells are dominated by biotite and magnetite; however, they do not contain hornblende. Plagioclase shows an almost complete overlap of An contents, $\bar{x} = 26 \pm 2.3$ (core), $\bar{x} = 24 \pm 0.9$ (shell) and $\bar{x} = 25 \pm 2.0$ (matrix). Biotite composition in the shells is significantly less magnesian ($\bar{x} = 16 \pm 2.4$) than in core ($\bar{x} = 27 \pm 2.2$) and matrix ($\bar{x} = 25 \pm 2.2$), whose compositions overlap. Average initial $^{87}Sr/^{86}Sr$ ratios from plagioclase in all the analysed shells ($\bar{x} = 0.70226$) are slightly more radiogenic than in the matrix ($\bar{x} = 0.70193$) and cores ($\bar{x} = 0.70187$). Cores are autoliths, which are plagioclase-rich, cumulate, or rim fragments reworked by new magma inputs or injections. Heterogeneous nucleation leading to the formation of orbicular shells around the cores is attributed to adiabatic decompression of magma pulses ascending in dykes, leading to superheating and resorption of early solids, and volatile exsolution, inducing undercooling, supersaturation, and shell crystallisation. The coarse-grained matrix crystallised later, after the orbicules formed, creating the groundmass and locking the orbicules in place. The deformation of shells and cores suggests that the orbicules continued to evolve in the presence of a melt (matrix material). As part of the Matopos Hills World Heritage Site, the Diana’s Pool orbicular granites present a unique and noteworthy petrogenesis, which should be preserved as part of the region’s important geoheritage.

Orbicules: An indication of the crystallisation of hydrosilicates, I

John N. Elliston

Abstract

Observations relative to orbicular granites support later rimming layers built up on a previously formed nucleus; plasticity and a soft stage during the development of the orbicule; initial fluidity and a repeated fluidity of the inter-orbicular matrix after or during orbicule formation; diffusion of material to add onto and build up individually in each orbicule the successive rhythmic “shells”; continuous growth of the orbicules even after some disruption; and crystallisation of the orbicular material later than the formation of the orbicular structure.

To be consistent with these observations, the “magma” in which orbicules develop must have the diffusive and rheological properties of a concentrated macromolecular paste or gel of mixed hydrosilicates. The way in which all available water “dissolves” in such rock-forming magmas at elevated temperature is by reaction with the silicates to form disordered solvated pre-crystalline hydrolysates such as silica gel, clay and hydrous ferromagnesian minerals. Such an intrusive mass has the appropriate diffusive and thixotropic properties for: (1) the formation of accretions (aggregated

nuclei); (2) the overgrowth of concretions (rhythmic rimming structures); and (3) the repeated isothermal re-liquefaction of the inter-orbicular matrix.

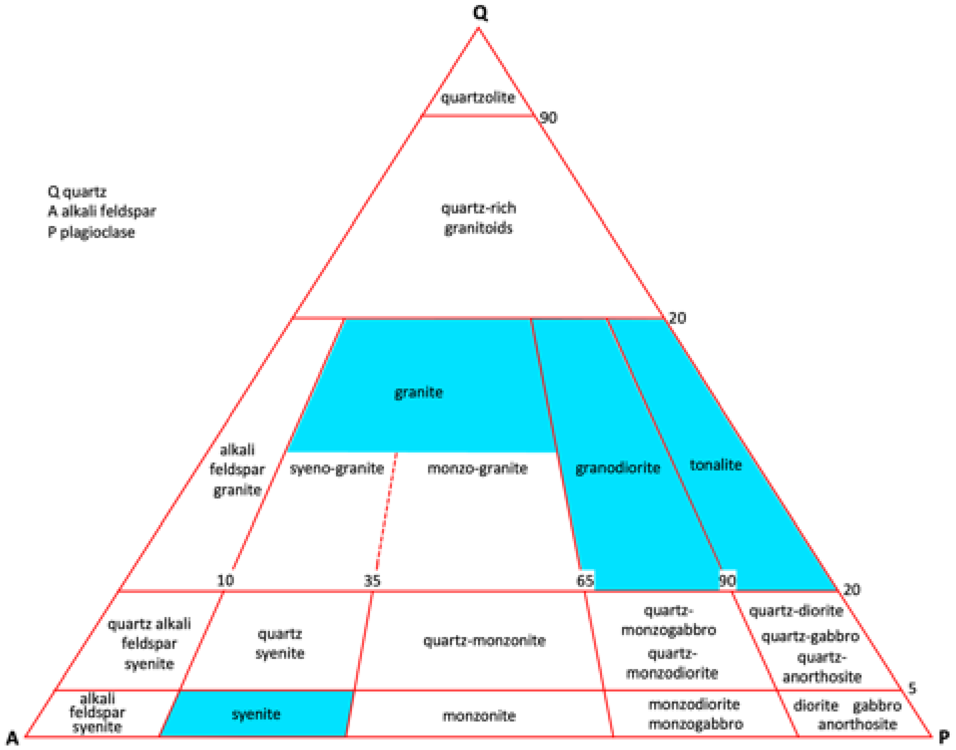
The orbicules and matrix have subsequently crystallised and further heated by exothermic dehydration reactions where the rate of reaction is governed by the rate at which water escapes from the system. Crystallisation is not by cooling through a melting point.

Twenty-eight characteristic features of orbicules are described and illustrated which fully accord with twelve properties and phenomena attributable only to particle interactions in an alternately dynamic and static colloidal system. Such an extraordinarily high correlation between the unique properties of the envisaged system and the resultant distinctive complex orbicular structures leaves little room for any alternative interpretation. Therefore, orbicules can be confidently assumed to be an indication of the crystallisation of precursor hydrosilicates.

Petrology and geochemistry of the orbicular granitoid of Sierra de Velasco (NW Argentina) and implications for the origin of orbicular rocks
Grosse P, Toselli, Rossi A.J., Juana N.
Published online by Cambridge University Press: 15 December 2009

Abstract
The Velasco orbicular granitoid is a small (65 × 15 m), irregularly-shaped body that crops out within the Huaco granite, central Sierra de Velasco, NW Argentina. It consists of ellipsoid-shaped orbicules of 3 to 15 cm length immersed in an aplitic to pegmatitic matrix. The orbicules are formed by a core made up of a K-feldspar megacrysts, partially to totally replaced by plagioclase, an inner shell of radial and equant plagioclase crystals, a layer of tangentially oriented biotite laths, and an outer shell of plumose plagioclase crystals, containing diffuse rings of tangentially oriented biotite. The orbicular granitoid formed in situ in a pocket of evolved and volatile-rich melt segregated from the surrounding partially crystallized Huaco granite, possibly via a filter pressing mechanism. The segregated melt entrained relatively few K-feldspar megacrysts into the pocket, leaving behind a concentration of megacrysts around the pocket. High water concentration caused effective superheating of the melt and destruction of nuclei, with only the large megacrysts surviving as solids. Sudden water-pressure loss and exsolution of the volatile phase, perhaps related to a volcanic eruption or fracturing of the surrounding granite, caused rapid undercooling of the melt. The orbicules grew in the undercooled melt by heterogeneous nucleation on the megacrysts, which acted as nucleation seeds, and crystallization of reversely zoned radial plagioclase and sporadic crystallization of tangential biotite rings according to fluctuations in its saturation. Orbicular growth gave way to crystallization of the equiaxial inter-orbicular matrix in two stages, when sufficient polymerization of the melt was attained. The time scale of formation of the orbicular granitoid was fast, possibly a matter of a few weeks or months.

Appendix 2



Q
Q quartz
A alkali feldspar
P plagioclase
quartzolite
90
quartz-rich granitoids
20
granite
alkali feldspar granite
syeno-granite
monzo-granite
granodiorite
tonalite
10
35
65
90
20
quartz alkali feldspar syenite
quartz syenite
quartz-monzonite
quartz-monzogabbro
quartz-monzodiorite
quartz-diorite
quartz-gabbro
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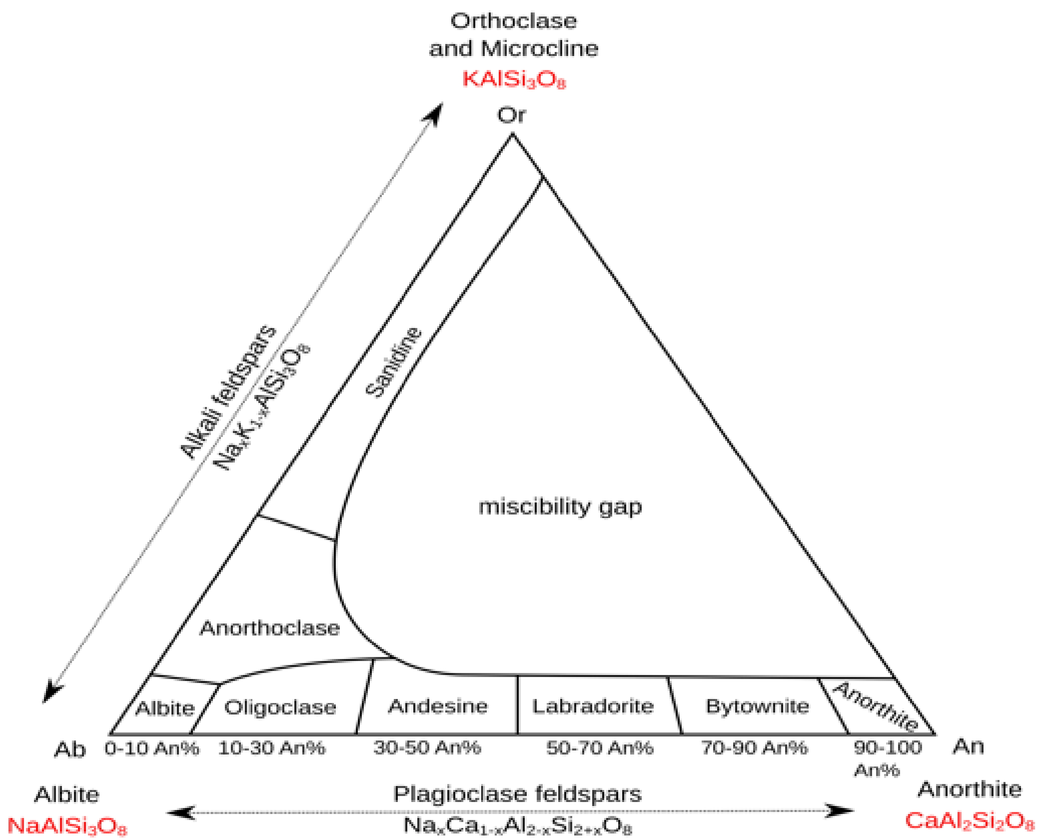

Orthoclase and Microcline
$KAlSi_3O_8$
Or
Alkali feldspars
$Na_xK_{1-x}AlSi_3O_8$
Sanidine
miscibility gap
Anorthoclase
Albite
Oligoclase
Andesine
Labradorite
Bytownite
Anorthite
Ab
0-10 An%
10-30 An%
30-50 An%
50-70 An%
70-90 An%
90-100 An%
An
Albite
$NaAlSi_3O_8$
Plagioclase feldspars
$Na_xCa_{1-x}Al_{2-x}Si_{2+x}O_8$
Anorthite
$CaAl_2Si_2O_8$