Geological Society of Zimbabwe

National Museums and Monuments of Zimbabwe

# Summer Symposium

## 8am to 5pm, Friday 1st November 2024

## Natural History Museum of Zimbabwe

## Bulawayo

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| Summer Symposium and Macgregor Memorial Lecture 2024 | | |
|---|---|---|
| **Start** | **Topic** | **Speaker** |
| 7:30 | **Registration** | |
| 8:15 | Welcome | Ernest Mugandani-Geological Society Chairperson |
| 8:30 | Official opening | Edwin Gwaze - ZSM Principal |
| 8:50 | Economically important pegmatites in Africa | Judith Kinnaird |
| 9:15 | The petrogenesis of orbicular granites in the Diana's Pool area, Zimbabwe | Senamile Dumisa (Paul Nex) |
| 9:40 | An outline of the activities of the International Commission for the History of Geological Sciences, and a call for volunteers for “The INHIGEO 2026 Conference at Victoria Falls, Zimbabwe” | Sharad Master |
| **10:00** | **Tea** | |
| 10:20 | A review of the geology and Au-Ag mineralization in the Gwanda Greenstone Belt: Implications to exploration | Godfrey Chagondah |
| 10:45 | Some observations on the Dwaars River chromitite seams and a nearby breccia pipe, Bushveld Igneous Complex | Tony Martin |
| 11:10 | Regional zonation of rare-element pegmatites: Why understanding the distribution of LCT and NYF pegmatites matters | Paul Nex |
| 11:35 | The Limpopo Belt in Zimbabwe as a geological heritage | Forbes Mugumbate |
| 11:55 | The Dokwe gold discovery | William Collett |
| 12:35 | Modern-style and scale plate tectonics is Mesoarchaean in IGCP Project 280 'two cratons and an orogen' of southern Africa; novel kinematic and geodynamic constraints | Mark Tsomondo |
| **13:00** | **Lunch** | |
| 14:00 | Cast in stone | Theodora Rondozai |
| 14:40 | Summary | Sharad Master |
| **15:00** | **Tea - open to public** | |
| 15:30 | **Macgregor Memorial Lecture** - Zircon geochronology: a handle in plate reconstructions, geological evolution of mobile belts and assessment of mineral deposit fertility | Benjamin Mapani |
| 17:00 | Vote of thanks | Caston Musa – GSZ Vice Chairperson |

## Economically important pegmatites in Africa

**Judith Kinnaird and Paul Nex**

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*CIMERA: University of the Witwatersrand, South Africa*

Pegmatites occur across the African Continent. These principally range in age from Archaean to Neoproterozoic, correlating with orogenic events in the Kibaran (~1000 Ma) and the Pan-African (~550 Ma) orogens. In some provinces both LCT and NYF pegmatites were intruded at the same time such as in the Orange River Belt in South Africa and the Pan-African Damaran and Madagascar Belts. Many pegmatites have been mined for gemstones, tin, or tantalum with some having produced lithium mainly for the ceramics industry, such as Bikita in Zimbabwe. A reappraisal of a number of former Sn/Ta mines has led to the reopening of several prospects in response to the demand for lithium. Pegmatites in the Kibaran belt of East Africa are being re-evaluated for both tin and lithium production. The Manono-Kitolo pegmatite in the DRC, produced 140,000 tons of cassiterite 10,000 tons of coltan between 1915 and the mid 1980's. A recent re-evaluation suggested reserves of 120 Mt of spodumene-bearing ore, making it one of the largest lithium reserves globally. Similarly, the Uis mine in Namibia has re-commenced cassiterite mining but is also producing recently discovered lithium resources, while Acadia in Zimbabwe, a former Be-feldspar-Li mine has also re-opened for lithium production. In southwestern Mali, the undeveloped prospect of Goulamina, hosts steeply-dipping, spodumene-bearing pegmatites with Ore Reserve of 52Mt at 1.51% Li2O, with the Ewoyaa lithium project, on the Ghanaian coast also under development. It hosts ore reserves of 25.6Mt @ 1.22% $Li_2O$ in a Birimian-aged (c2.1-2.1 Ma) spodumene bearing pegmatite. Lithium is a critical material for a low-carbon future: between 2011 and 2020 the requirement for lithium in batteries increased from 27% to 71% of total lithium production (USGS, 2020) and the World Bank (2020) estimates that society will need a 488% increase in lithium production by 2050 to meet its needs for the transition to green energy.

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

**Senamile S. Dumisa**

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This work assesses a poorly studied 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.

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# A review of the geology and Au-Ag mineralization in the Gwanda Greenstone Belt: Implications to exploration

**Godfrey S. Chagondah[1], Mbongeni Manyere[2] and Peter T. Zizhou[3]**

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The ca. 2.70 Ga Gwanda Greenstone Belt (GGB) located on the south-western part of the Archaean granite-greenstone Zimbabwe Craton is famous for hosting orogenic Au-Ag deposits. The belt is one of the most productive greenstone belts in Zimbabwe. Mineralization occurs both as narrow (< 1.0 m), lenticular quartz-carbonate veins/reefs and wide (5-30 m) replacement ore bodies hosted in metavolcanic and metasedimentary rocks. Mineralization occurs as disseminations, massive and massive sulphidic impregnations of pyrite, chalcopyrite, arsenopyrite, galena and sphalerite. Mineralization is structurally-controlled and occurs in high-order shear zones, which splay off the regional NW trending, South Gwanda Shear Zone. A few deposits in the GGB are associated with lithological contacts e.g., Farvic gold mine At least five gold camps are recognized in the GGB including the Blanket-Vumbachikwe, Kemel, Freda, Bar 20 and Farvic clusters. The Blanket-Vumbachikwe camp is by far the most important and reliable cluster with consistent gold production since the 1890s. For example, Blanket Mine's annual production is currently ca. 80 000 oz per year. Au-Ag mineralization in this camp is recognized to extend below 1 200 m vertical depths.

Au-Ag mineralization is mainly hosted in Fe-rich mafic metavolcanic rocks including amphibolites, chlorite schists and banded iron formations. Felsic volcanic schists and meta-conglomerates are sub-ordinate host rocks. Au-Ag mineralization is associated with pervasive brittle-ductile shear zones and it pinches and swells both on dip and strike-length. Rocks of the GGB show variable degrees of alteration including carbonation, silicification, chloritization and sericitization. Thus, explorers should pay attention to the lithological, structural and alteration aspects of the GGB during Au-Ag mineralization campaigns. Zn and Cu constitutes major pathfinder elements.

# Some Observations on the Dwaars River Chromitite Seams and a nearby Breccia Pipe in the Bushveld Igneous Complex

**Tony Martin**

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The Bushveld Igneous Complex is by far the largest in the world, and has been divided into five zones:

Upper Zone: Gabbro

Main Zone: Gabbronorites with pyroxenite and anorthosite

Critical Zone: Chromitite interlayered with dunite, harzburgite, pyroxenite, norite and anorthosite

Lower Zone: Pyroxenite, harzburgite, dunite

Marginal Zone: Norite and gabbronorite partly contaminated by Transvaal Supergroup sediments

The Critical Zone is further subdivided into Upper and Lower units and within an anorthosite layer of the Upper Critical Zone there is an unusual breccia pipe approximately 10 m in diameter. It consists of clast-supported anorthosite and other minor lithologies within a pyroxenite matrix. The clasts are of variable size and most are well rounded. This breccia is considered to be the result of something similar to a phreatic explosion whereby fluids trapped in underlying rocks become overpressured and blast through the overlying rocks, ripping off and rounding the clasts as they move upwards.

The famous Dwaars River exposure of interlayered chromitite of the UG1 layer and anorthosites has been studied in much detail by many researchers. While there are areas of typical alternating monomineralic layers reflecting crystal settling, the focus here is on the bifurcations in the layers and “xenoliths” of chromite in anorthosite and vice-versa. These have been attributed to post-depositional processes occurring prior to complete solidification.

# Regional zoning of rare-element pegmatites: why understanding the distribution of LCT and NYF matters

**Paul Nex and Judith Kinnaird**

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Historical rare-element pegmatite classifications have frequently divided them into two groups: LCT (lithium-caesium-tantalum) and NYF (niobium-yttrium-fluorine). With the current focus on lithium as a commodity vital for Li-ion batteries and the transition to a greener economy the term LCT pegmatite has become much more common in academic and industry literature. The suggestion that these two groups can be distinguished by tectonic setting (Martin and de Vito, 2005) and the recognition that LCT pegmatites occur predominantly in a late orogenic environment (McCauley & Bradley, 2014; Bradley et al, 2017) could lead to silo-based approaches to exploration and understanding of these pegmatites.

In fact, recent investigations into the distribution of pegmatites in the inland Damara belt of Namibia and the Namaqualand part of the Namaqua-Natal belt in South Africa show that in these orogenic belts LCT and NYF pegmatites are broadly contemporaneous, yet spatially segregated. Within these belts NYF pegmatites are found in areas with higher metamorphic grade, typically upper-amphibolite to granulite facies while LCT pegmatites are located in amphibolite facies lithologies. Although there is no direct genetic relationship between host lithologies and the pegmatites, this is interpreted as a result of the conditions of anatexis during the formation of magma from which the pegmatites were derived.

This approach and interpretation provides a greater understanding of the distribution of pegmatites in orogenic belts, has major implications for exploration and provides an explanation for the lack of a genetic relationship between granites and pegmatites exposed at surface. From a mineral systems perspective it is particularly important to consider the source of magmas in a system fundamentally controlled by the composition of the associated igneous rocks. NB, it should be noted that this work may not apply to Archaean environments and has only been considered in Proterozoic and Phanerozic examples.

Bradley, D.C., McCauley, A.D., & Stillings, L.M. 2017 *Mineral-deposit model for lithium-cesium-tantalum pegmatites*. USGS Scientific Investigations Report 2010-5070-O pp48.

Martin, R.F. & De Vito, C. 2005 The patterns of enrichment in felsic pegmatites ultimately depend on tectonic setting. *Canadian Mineralogist* **43** 2027-2048.

McCauley, A.D., and Bradley, D.C. 2014 The global age distribution of granitic pegmatites. *Canadian Mineralogist* **52** 183-190.

## The Limpopo Belt in Zimbabwe as a geological heritage

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Geological terranes are important blocks in the jig-saw puzzle of the understanding of the assembling of the Earth's crust. The terranes exhibit different degrees of usefulness of geological information for building a coherent story about the evolution of the Earth. Geological environments that reveal critical yet controversial information with globally recognised geologic, scientific, and educational significances, can be considered to be part of any country's heritage. The neo-Archaean Limpopo Mobile Belt (LMB), a distinct zone of high-grade metamorphic rocks that strike ENE for about 700 km, and separating the Archaean granite-greenstone Zimbabwe craton to the north, from the Kaapvaal craton to the south by over 250 km, is one such terrane. It is one of the largest high grade metamorphic belts of this antiquity in the world. This and the interpretation of other features of the belt such as; age; geology, deformation and metamorphism; the nature and the evolutionary history; relationships with adjacent terranes; metallogenesis, and implications of the belt to regional and global geotectonics, are still debatable despite half a century of studies. This makes the LMB a most remarkable structure that has put Zimbabwe on the world map of influential geological features. The LMB can therefore be considered to be a geological heritage.

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## The Dokwe Gold Discovery

**William Collett**

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The Dokwe Gold Project represents a significant greenfield discovery within a previously undefined Archaean Greenstone Belt in Zimbabwe, underscoring the potential for new mineral exploration successes in underexplored regions. Leveraging Exclusive Prospecting Orders (EPOs) and modern exploration techniques, including geochemical, geophysical, and structural analysis, the Dokwe discovery has unveiled a substantial gold deposit in an area long obscured by overlying sediments and complex geological structures. This discovery not only highlights the critical role of EPOs in providing the necessary tenure security for extensive exploration activities but also demonstrates how contemporary exploration methodologies can unlock the mineral potential of frontier regions. The success at Dokwe serves as a testament to the value of integrating innovative exploration strategies with systematic geological investigation, paving the way for future discoveries in similar greenfield settings.

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## Modern-style and scale plate tectonics is Mesoarchean in IGCP Project 280 'two cratons and an orogen' of southern Africa; novel kinematic and geodynamic constraints

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The conclusions of 3 decades of study are that modern plate tectonics with its convergent, divergent and transform boundaries is arguably Mesoarchean in scale and analogous Gondwanan-style features (e.g., Swazi ribbon continent, V-shaped Witwatersrand break-up back-arc basin (BAB) on concave-north, Aegean-like, Kaapvaal orocline) on the Kaapvaal craton including a terminal, diachronously east-to-west, Neoarchean continent-continent collision with the Zimbabwe craton across a composite, south-convex Limpopo orogen. This collision was driven by a stiff, India-type, north-amalgamating (since 2.97 Ga) Swazi ribbon microplate that also drove continental subduction of a Kaapvaal pro-plate to form the exhumed wedge of the 2.72-2.71 Ga UHT-HP Southern Marginal Zone of the Limpopo orogen. Plate tectonic theory requires seafloor spreading and transform faults, two key plate boundaries with different preservation potential and hitherto difficult to define in the Archean. Can we therefore define, the extent of Archean plates, the nature of plate boundaries, and the geometry and kinematics of their relative and finite motions from geological and geophysical datasets of preserved continental crust and in the absence of extant Archean oceanic lithosphere? What is the appropriate scale of investigations of plate-like behaviour? Is it the famous Barberton or Belingwe greenstone belts or the more pancratonic dichotomy of the 2.75-2.68 Ga Bulawayan Supergroup of the Zimbabwe craton into an Eastern and Western Succession or even hard rock lithium metallogeny in collisional belts? What is the transform boundary condition for compressional orogenic cycles that were coeval with extensional orogenic cycles in the 3.08 to 2.5 Ga intracontinental cover of the superlative Dominion-Pongola-Witwatersrand-Ventersdorp-Transvaal Supergroups that span the proposed (Kalahari) supercontinental cycle-hence rejecting reconstructions of Valbarra or Zimvalbarra supercratons? These Supergroups were historically interpreted as reflecting a transition from Barberton granite-greenstone style to a stable, platformal style. Is it stability or rather the weakness of thinned/extended back-arc basin (BAB) substrate and tectonic inheritance along ancient sutures like the Saddleback-Inyoka Fault (SIF)? Do we understand what constitutes protocratons, cratons, microcontinents (Grunehogna), host-continents, ribbon continents-oroclines- supercontinental cycles in Archean granite-greenstone terrains? Arcs and versatile BABs? Previous structural/tectonic models tended to invoke complex and controversial horizontal tectonics on both cratons that attracted challenge from similarly controversial plume-related vertical 'tectonic' models of granite-greenstones deformation? Is the assumption of a pre-existing "supercontinent" that breaks up into daughter continents in the Wilson cycle valid in Early Archean protocratons? Against common assumptions of faster moving 'plates' in the 'hotter and mobile' Archean, Archean supercontinental periodicity (from U-Pb peak frequencies) of breakup, dispersal and assembly appear to match younger, post-Archean supercontinents? When does plate-like behaviour therefore start given the evidence of old (3.6-3.5 Ga) and cold protocontinental nuclei of Tokwe and the Ancient Gneiss Complex (AGC) of South Africa and Swaziland? The

very pre-condition of plate tectonics, plate rigidity is an inherent feature of the 3.6-3.5 Ga old, cold protocratons; to this assemblage, the negatively buoyant, old and colder oceanic lithosphere by Mesoarchean times likely drove modern plate subduction tectonics and subduction rollback on southern margin of protoKaapvaal host-continent. Can we imagine, therefore, a Swazi ribbon continent (advance orogen) as a rigid plate spawned during Mesoarchean accretionary tectonics from more rigid lithosphere that include portions of the AGC within the eastern Kaapvaal lithosphere? A western marginal Tokwe ribbon continent represents the remnants of a larger Tokwe host-continent that was destroyed by collision-indentation during the coeval evolution of the 2.75-2.68 Ga Bulawayan Supergroup.

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**Cast in Stone**

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*BESA Connect*

Fractals, characterized by self-similarity and complexity at various scales, can be a useful lens through which to examine organizations. This presentation will be a lighthearted exploration of the intriguing parallels between fractal patterns and organizational systems, revealing how behaviours and structures within organizations often reflect fractal patterns. We will begin by highlighting the key attributes of fractals and their relevance in various fields. Drawing on examples from organizational theory, we will illustrate how **hierarchical structures** in organizations often mirror themselves at diCerent scales, from the overarching corporate framework down to individual teams. Moreover, we will examine **communication** and **decision-making** processes that display fractal characteristics, showing how patterns of interaction and approaches to problem-solving are replicated across departments. This self-similarity enhances coherence and resilience within the organization, enabling it to adapt eCectively to external challenges. Even **organisational adaptability** and **cultural patterns** can display fractal characteristics. By using case studies and practical examples, attendees will gain insights into how recognizing fractal patterns can inform strategies for enhancing organizational behaviour, fostering innovation, and improving overall eCectiveness. Ultimately, this presentation aims to illustrate the powerful connection between fractals and the behaviour of systems in the workplace.

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## Macgregor Memorial Lecture

### Zircon geochronology: a handle in plate reconstructions, geological evolution of mobile belts and assessment of mineral deposit fertility

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Zircons have been used in geology as good geochronometers since 1907, when Bertram Boltwood measured two rock samples that were 422 my and 2200 my. Zircon is one mineral that can undergo a varied cycle of geological processes, from igneous processes, where it is formed, through metamorphic and sedimentary and back again in igneous systems. Zircon can go through these processes several times over and still retain a record of its full history. In each of these processes it acquires a unique signature. The technique of using zircon as a thermometer has been improved and refined from multigrain composite ages to laser ablation methods and finally now to the Sensitive High Resolution Ion Microprobe (SHRIMP) which has become standard. With the SHRIMP method, we are now able to target several spots on a single zircon grain and assemble a chronology of geological events. The dating techniques coupled with a good understanding of zircon petrography and textures has resulted in resolving geological processes at crystalline level, temperature inference and a complete reconstruction of tectonothermal histories of terranes. The high temperature range of zircon means that it can record most geological events. The understanding of continental crust has been catapulted by the powerful properties of zircon: it can fractionate appreciable amounts of trace elements such as lutetium and hafnium. This property has made it possible for us to identify and estimate crustal residence times. These in turn have allowed us to complete the story of continental crust development, with precision on identifying mantle and continental derivatives. Finally, now zircon is routinely used in forensic nuclear science to fingerprint uranium sources from different mines and in understanding groundwater contamination sources in areas that operate uranium mines.

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