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Geological Society of South Africa

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news

Sunrise of a New Era of Mineral Exploration
The GSSA comment on recent legislation
Geotraveller: Eastern Limb of the Bushveld Igneous Complex

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Front cover photo:
"Structural feature along the Swartberg Pass, Prince Albert" by Billy Mills. First place winner in the Geoheritage Photo Competition at the Geoheritage Conference 2022.

Visit page 30 and 31 to see all the prizewinning entries from the competition.

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guest editorial

Errol Smart

Sunrise of a New Era of Mineral Exploration in South Africa

It's sometimes easy to slip into despondency as a geological explorer trying to operate in South Africa. The challenges that we have faced over the past 20 years have placed a heavy burden on those remaining active within South Africa. However, I sense that the tide is finally turning and we are possibly at the dawn of an incredibly exciting era.

Who would have thought that we would see the day that the importance of geological exploration is mentioned by the State President in his State of the Nation Address? I guess as geoscientists we should have known that the winds of change would eventually erode the cold stone tower of government policy and that even the dimmest of regulators would eventually have to recognise that what geologists have been telling them is actually correct and that the mineral supply chain is indeed running dry. We simply need more exploration worldwide and South Africa does, in fact, have exceptional potential for discovery and development of new mines.

It is ironic that it took a global pandemic to finally trigger the recognition of the importance of exploration and mining for South Africa. The economic crisis following the Covid 19 pandemic was only abated for South Africa by the windfall of earnings by the resurgent mining industry, bolstered by soaring global metal prices. The world and South Africa have also finally realised that as much as detractors are trying to convince the world to hate the "ultimate evil" of mining, it is in fact a critical industry that the world cannot do without. The truth is that if mankind cannot grow it, then we must mine it, but we have to have it!

Mining is in fact a critical industry for saving the planet. Without a sustainable, affordable supply of the aptly titled "critical minerals", the whole decarbonisation, electrification and greening of the planet cannot occur. So, suddenly even the greenest of critics are begging geologists to perform miracles. Mankind needs to discover and mine more metals in the next two decades than what we have extracted in the history of mankind (this estimate of global demand must be true…Robert Friedland recently proclaimed it!). So, after decades of begging by geologists, with no mercy shown from the table of bounty, we are now thrust into the forefront of saving the planet. Fortunately, it will be by doing what we wanted to do all along, exploring! We face the terrifying prospect of our wildest dreams suddenly becoming our greatest nightmares. We might soon get massive exploration budgets and then we will be whipped once again, this time to deliver discoveries in impossible short time.

So massive is the challenge, that even here in South Africa the impact will be felt. It appears that some genius politicians have finally awoken to the fact that we are sitting on one of the world's richest mineral treasure troves and that their ham-fisted regulations have effectively sterilised the potential bounty. Now at last, the bureaucratic dinosaur is awakening and realising it will need to change or else it will go extinct from hunger.

Realising that one has a problem is the first major step to rectifying it. However here in South Africa there is always the potential for political expedience or greed and corruption to steel the antidote from the lips of the patient. So, before we grab for our hand-lenses and hammers and go tearing off to the bush, whooping and hollering with glee, geologists first have to take the time to wade through a mountain of awfully drafted

paperwork and try to understand what the new rules of the game are. We also have to take the time to add our voices and to try influence the drafting before it becomes final. I am of course referring to the overdue collective behemoth of documents that have flooded out of DMRE and CGS over the past three months. These well-intentioned yet poorly drafted scripts do in fact kindle some hope when one cuts through the jungle of confusing and superfluous language.

Let's firstly examine the Geosciences Act Regulations published in April 2022. The regulations at least record the value of geoscientific data and the CGS's obligation to collect, safely archive and then make such data available to geoscientists. The unfortunate shortfall comes with the lack of understanding of the difference between "raw data" and the intellectual property (IP) developed and used by geoscientists to interpret such data. We all support a central repository of data, however, as geoscientists we are fiercely protective of our commercial competitive advantage yielded from the interpretation of such data and from the vectoring models that we develop and use to make new discoveries. Fortunately, this knowledge or IP is protected by Intellectual Property Laws. Unfortunately, the Geosciences Act skates perilously close to infringement on some of those laws and forcing us to hand over critical IP that is not limited to a specific prospecting right. We need to engage with CGS on the requirement of extended confidentiality on certain types of information.

Many of us have witnessed the sad damage done during decades of neglect by the under-staffed and under-resourced CGS. Irreplaceable original data were sometimes looted from CGS archives and incredibly valuable reference drill core and samples fell into neglect and were often irretrievably lost. We pray that the current fervour to gather what's left of historic geoscientific data remaining in private hands is supported by the required resources, in order to safe-guard those data and samples. It is certainly a huge, capital-intensive task that is set. We question the state's understanding of the scale of the task or its ability to budget appropriately for this task with the pressure of competing demands in our society.

Secondly, let's look at South Africa's Exploration Implementation Plan 2022. Eish! There are a lot of words! For anyone that has survived wading through it repeatedly in a quest for understanding, there is a positive undertone to be detected with some good, although very loose ideas that still need to be crystallised to become meaningful.

One key positive is the recognition of the urgent requirement for an effective, efficient, transparent mineral title and data management system, or "mineral cadastre". Unfortunately, it would appear that the important recognition has already fallen foul of government ineptitude with all the wrong cooks already fighting for the right to bake the cake, while the masses die of hunger. In fact, the masses were begging for bread and government decided it first needed to invent a cake to serve to the hungry povo.

A worrying topic introduced is that of ministerial discretion in determining who gets prospecting rights based on a meritocracy. This is mooted to replace the current first-come, first-served system that had the requirement of simple pre-qualification of a test of capability. Unfettered ministerial discretion could be a very dangerous weapon. One would have hated for the previous incumbent to have had access to such a weapon of mass destruction. One feels that a more prescribed decision criterion is the safer alternative to be imbedded in regulations that must stand the test of time.

Irrespective of all this regulatory noise, one senses that there is a gathering momentum for South Africa to indeed modify its burdensome red tape and regulations and to explore and develop its huge brownfield and greenfield mineral potential.

For all the known mineral wealth and the understanding of our geo-tectonic settings, it is astounding that South Africa has remained virtually unexplored for the past two to three decades. Exploration tools, developed with great success globally, have simply not been applied to our mineral potential in similar settings. The vast remote areas of the Northern Cape in particular present great potential, specifically for the critical minerals now in demand. It's here that the best potential for minerals such as copper, nickel, lithium and rare earth elements is located. Fortunately, this province accounts for nearly one-third of the surface area of South Africa, while it hosts only four percent of the rural population. This vastness with low population density reduces the potential for conflict over land use.

As geoscientists and explorers, we also have an important duty to ensure that during this boom, we do provide leadership and operate with responsibility to our environment and to all stakeholders. It is not only for the miners to practice high ESG standards. As the first point of contact with stakeholders, explorers have to behave in a disciplined manner and foster good relations with landowners and communities. We need to set the tone and establish the relationships that will allow future mine development to proceed with least resistance.

For me personally, the past five years have been the most exciting in my career. Finally, we are not being tasked to simply fill and extend the life of existing mills. At last, we are asked to find the minerals to fill future mills and identify the future commodity demand. One is filled with anticipation for what the next five years may offer. This is the once-in-a-lifetime opportunity that every explorer dreams of and we are on one of the most productive pieces of planet Earth.

The green shoots of an exploration super-cycle are in our hands; history will judge us on how we nurture and grow this opportunity to something substantive. Colleagues, it is finally our time. It's for us to seize the moment.

Errol Smart
Managing Director & CEO of Orion Minerals

executive manager's corner

Craig Smith

Geocongress has been a GSSA tradition for many years, though the timing was disrupted in 2016 due to 35IGC, and again in 2020 by the COVID pandemic. In 2018 the University of Johannesburg hosted a very successful meeting. With the COVID pandemic restrictions reducing, and a return to some sense of normality, the next Geocongress is kicking off. The event theme is "The Next 125 Years of Earth Sciences" and it will be staged at Stellenbosch University from 11–13 January, 2023, with two and a half days of technical sessions and a half day of field trips and workshops. The conference website is live at https://allevents.eventsair.com/geocongress/ and circulars have been distributed. Geocongress will be a hybrid event to enable participation for

those who cannot travel to the Western Cape; going online will also make it much easier for our international members to participate. Some key dates are 20 June (second call for session, workshop and field trip proposals closes), 1 July (abstract submission and registration opens), 30 September (abstract submission closes), 31 October (accepted abstracts announced), and 30 November (deadline for registrations and payments).

An objective of the meeting is to stage it as cost effectively as possible to make it accessible to students and young professionals in particular, and to do that we will need sponsorship; please contact craig.smith@gssa.org.za for further information about sponsorship opportunities.

The chair of the Organising Committee is Bjorn von der Heyden at bvon@sun.ac.za.

The GSSA has traditionally scheduled Geocongress in the middle of the year, but the local weather should be ideal in early January, and it will be an opportunity to take a couple of extra days' leave to enjoy the Cape.

Confirmed workshops include gold geology, a DSI-NRF CIMERA workshop, open-system modelling of geological processes and 3D geological modelling. Field excursions are planned to explore the geology of the Overberg, the Pan-African Saldania Belt, the Cape Fold Belt, and Namaqualand. A conference in the Western Cape would not be complete without a terroir trip to the Winelands.

The Annual General Meeting of the GSSA will be staged as a contact and online event at the CSIR Mandela Mining Precinct in Melville, Johannesburg on July 14. Invitations have gone out for both in-person and online participation. Due to COVID restrictions, in-person participants are limited to a maximum of 40 people. If you want to attend the event and participate in the post-meeting networking, be sure to register early. Drinks and light snacks will be served.

Members are reminded to please pay your 2022 GSSA membership fees. Despite the pandemic and shifting many activities to online platforms, the Society must continue to maintain and staff an office in Johannesburg. Going forward, new processes will be needed for event management, in particular as we transition from fully online to hybrid models. The Society strives to keep costs as low as possible, but financial risks to the Society will inevitably increase as we transition to hybrid operational models. The annual fees comprise the main source of operational income. Individual members are ultimately responsible for their fees, even if employers have agreed to cover the cost.

Craig Smith

Geological Society of South Africa

president's column

Tania Marshall

April was Freedom Month in SA. According to the government website, Freedom Month celebrations offer us an opportunity to reflect on progress made thus far in transforming our society, while also examining our challenges. I would like to review how this applies to our Geoscience community.

When the GSSA was first established in 1895, it was a pure Scientific or Learned Society. Its primary purpose was to promote the study and awareness of geology and the broader earth sciences, particularly in Africa; to provide a scientific forum for the publication and dissemination of scientific research in African earth science; to provide the general public with earth science information, as objectively as possible; and to promote the documentation and

preservation of important geological sites for the benefit of broader society. Throughout its 127-year history, the GSSA has remained true to these objectives, specifically through the publication of the *South African Journal of Geology* (SAJG).

The SAJG, the de facto 'journal of record' for southern African earth science research, with a global reach, is a peer-reviewed, scientific journal that first appeared in March of 1896 as the *Transactions of the Geological Society of South Africa*. Commencing with Volume 103 (March of 2000), SAJG began online publication at GeoScienceWorld. "Hybrid open access" was adopted in 2014 and, subsequently, the SAJG moved from periodical to continuous publication in 2018. Since 2019, the Journal Impact Factor (JIF) (a commonly used measure of the relative importance of a journal within its field) has consistently been above 1, resulting in a high-quality journal being available to our members easily and immediately.

Another significant change in the direction of the GSSA came as it also developed into a Professional Society along with its scientific focus. This was done to promote the interests of its members who were no longer just pure academics, but increasingly more practicing professionals. In this respect, the GSSA introduced a Code of Ethics and robust complaints and disciplinary procedures and developed strong ties with CRIRSCO (the international organisation dealing with the public reporting of Exploration Results, Mineral Resources and Mineral Reserves), and SACNASP, the South African Council for Natural Scientific Professions (the statutory body responsible for the registration of all practicing geoscientists). The GSSA continues to work with these and other organisations to promote professionalism. A recent initiative, in conjunction with SACNASP's Candidate Mentoring Programme (CMP) is to drive a mentorship programme. This CMP is being expanded to non-SACNASP graduates/students using online group sessions.

One of the objectives of the GSSA, as a professional society, is to inform and influence government policy and lawmakers regarding earth-science issues. While the GSSA does comment, both privately and publicly, on all issues affecting geoscientists, we do not appear to have much success impacting issues such as the latest Critical Skills List, a new cadastre system for the DMRE, the Artisanal and Small-scale Mining Policy, the new Geoscience Regulations and the Exploration Strategy and Implementation Plan. In fact, no-one seems to be able to influence these issues, as they appear to be driven by the state without much regard for the inputs from any of the interested and affected organisations. Irrespective, the GSSA will continue to lobby for the interests of geoscientists and to support them wherever we can.

The first Council of the GSSA (back in 1895) reflected the demographics of the day—100% white male. Today the Council is almost 50% HDSA (Historically Disadvantaged South Africans). MANCO comprises 80% HDSA. The GSSA has made significant strides in transforming itself over the years, with nearly 70% of its younger members being HDSA and approximately 50% female. Since 2001, the GSSA has had five women presidents, as opposed to none in the 106 years preceding. It is significant that in just the last 10 years, three of the last six presidents were women and in total five current and former presidents were from historically disadvantaged backgrounds.

Transformation also means a conversion process not just for how things look but how things work and how it is all put together. There are many reasons to transform, but they hinge around getting better than what you were before to serve the needs of an organisation that you are becoming. The GSSA has its own journey of transformation in keeping with changes in many aspects and continues to strive for improvements in terms of inclusiveness in race, gender and age representation, diverse participation of different

sectors and modernisation of the organisation. In all respects, the GSSA today is not the same that existed even three decades ago.

The major challenge faced by the GSSA, as with many other professional organisations globally, is financing—how to fund programmes while dealing with falling numbers of members. There are a multitude of reasons why membership numbers are decreasing, including dwindling overall numbers of geoscientists, difficult economic conditions resulting in geoscientists having to choose between statutory registration or membership with a voluntary organisation, perceptions of relevance, etc. Whatever the causes, lower membership numbers result in lower income, which results in less money available to initiate effective programmes and training events—a chicken-and-egg situation that has no real easy solution.

A second challenge is to find more volunteers to help drive the various subcommittees—members being willing to commit to assist with organising events, driving Branch and Division activities (and especially the Young Geoscience Professionals Division), promoting geoscience at school and university levels, being mentors for our formal and/or informal programmes, and assisting with sponsorship drives. The more such volunteers we have, the less work it is for current committee members. The GSSA will only survive if there is a conveyor belt of leadership—there is a definite need for more experienced geoscientists as well as graduates to put their hands up for leadership positions within Branches and Divisions and being willing to serve on Council as drivers of programmes, with the goal of being part of MANCO to ensure that the GSSA remains relevant into the future.

Tania Marshall

all the news fit to print

UNIVERSITY OF JOHANNESBURG

(INCLUDING CIMERA AND PPM)

Staff news

Prof. **Nic Beukes** has been associated with UJ (ex-RAU) for more than 50 years. During his tenure, he has garnered numerous awards and accolades. For example, his is an A1-rated NRF scientist, a three-time winner of the GSSA's Jubilee Medal for the best publication in the South African Journal of Geology, the Draper Medal, UJ's Vice-Chancellor's Medal for Research Achievement, the Centenary and the Havenga Medals of the "Suid Afrikaanse Akademie vir Wetenskap en Kuns", and the NSTF-South 32 Lifetime Award. He can now add another: he has been elected as an International Member to the US National Academy of Sciences. This comes from an electorate that consists of some of

Nic Beukes, newly elected to the US National Academy of Sciences, the only southern African geologist currently a member.

the highest-rated geologists in the United States working on Precambrian geology. In addition, there are currently only three other South African scientists on the list of members of the Academy. These are two specialists in environmental sciences and ecology, and one other in human environmental sciences, so Nic is the only South African geoscientist to become a member of the Academy.

Prof. **Hassina Mouri** was recently awarded a Research Chair in "Medical Geology in Africa" by UNESCO. This is the first time a chair in Medical Geology has been awarded by the programme and is credit to the superlative efforts of Hassina and her fellow researchers in establishing the field, and in demonstrating its role in bringing disciplines together in pursuit of sustainable development goals.

We are bidding farewell to Dr **Derek Rose**, who is leaving to take up a position at MINTEK. However, the department is happy to welcome Mr **Ntando Ngwenya**, who started as an assistant lecturer in April 2022. He will be helping out with the service teaching for engineering students on UJ's Doornfontein Campus. Ntando is working on his PhD under Professors Fanus Viljoen and Sebastian Tappe, focusing on diamondiferous kimberlite and lamproite magmatism in southern Africa.

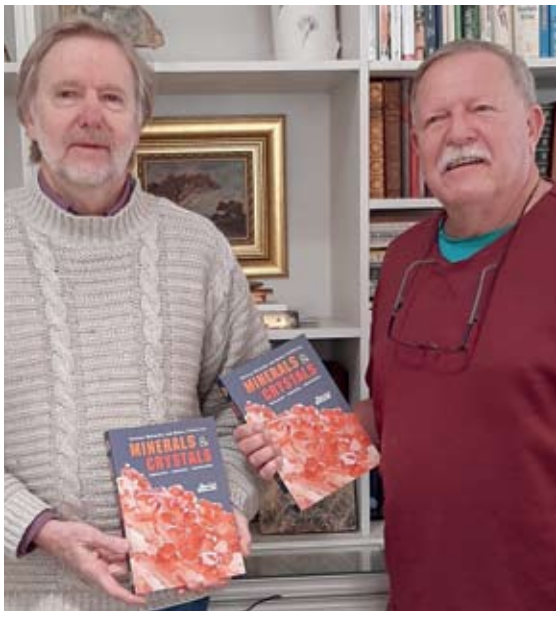
Ntando Ngwenya, in action at the microscope.

Student news

Laurine Travers, a French PhD student co-registered at the University of Montpellier (France) and the University of Johannesburg, arrived in South Africa on the 18th of April 2022 for a one-year stay at UJ, as part of a newly established joint-degree programme between the two institutions. Her project focuses on the structural geology and hydrothermal alteration of the Barberton Greenstone Belt and surrounding granite gneisses, with implications for gold mineralisation and Archaean tectonic modes. The project falls under the umbrella of a large collaborative research effort between South Africa and France titled BuCoMo. Laurine is supervised by Alain Chauvet at the University of Montpellier and Jeremie Lehmann at the University of Johannesburg. During her year in South Africa, Laurine will perform field work and analyses at the universities of Stellenbosch and Johannesburg.

Books and more books

In 2015, Bruce Cairncross (now Emeritus Professor at UJ), and Terence "Spike" McCarthy (Emeritus Professor at Wits) wrote and published a book titled "Understanding Minerals & Crystals". Last year there were very few copies left and the publisher decided not to have it reprinted. We (the authors) felt this should not happen, so Spike approached Sibanye Stillwater for potential sponsorship to



Emeritus professors Bruce Cairncross, UJ (left) and Terence "Spike" McCarthy, Wits University (right) with their newly revised and reprinted book.

Bruce Cairncross and his latest book.

reprint the work and they generously agreed to do so. Some updates and editing were undertaken, plus a new cover and title, and the new "Minerals & Crystals: Morphology, Properties, Identification" was reprinted last year by Struik Nature. This book was always intended as an introductory text for geology students. Because of Sibanye's sponsorship, a deal was struck whereby a complimentary copy would be donated to every first-year student majoring in geology at a South African university. Books have been couriered via the GSSA office to all the relevant heads of departments/schools, for distribution to the students.

Still on the subject of books, Struik Nature publishers approached Bruce Cairncross in 2020 to consider revamping his "Field Guide to Rocks & Minerals of Southern Africa" that first appeared in 2004. He agreed to do this and the result is a brand new book titled "Minerals & Gemstones of Southern Africa". The format has changed, as it is no longer a field guide. The book includes a brief introduction to the geology of the region—encompassing Botswana, Eswatini, Lesotho, Namibia, South Africa, southern Mozambique and Zimbabwe—followed by detailed descriptions of minerals and gemstones. The book is 320 pages long and features over 1,000 full-colour photos of minerals, rough and faceted gemstones, and scenic imagery.

Conferencing

The 38th Meeting of The Society for Organic Petrology (TSOP) will be an online/virtual experience, due to ongoing restrictions on travel. The Organising Committee includes representatives from each continent, with Dr Marvin Moroeng (Department of Geology, UJ) representing Africa. The meeting will take place between the 12th and the 16th of September 2022.

The conference includes a two-day short-course titled "Spatially resolved techniques and applications of organic petrography in shale petroleum systems" and three days of technical talks. A special roundtable discussion on "The role of fossil fuels in a net-zero-emissions energy sector" will be held on the 16th of September. The discussion aims to provide attendees with regional perspectives on the alignment between industry, policy and the public concerning the energy transition, and the outlook for regional greenhouse gas emissions reduction.

This year's meeting focus will be the role of organics in the geological cycle. Organic material is ever-present through the history of Earth. Organics in the geological cycle work as a window into past climates and tectonics and are the key to understanding our planet's future.

Participants will include geochemists, coal and petroleum geologists, palynologists,

Signage outside the ICDP BASE Centre, Barberton.

climatologists, basin tectonic experts, palaeobotanists, carbon-credit negotiators and all others who deal with the past and future of organic material on Earth.

CIMERA

DSI-NRF CIMERA and the ICDP Moodies BASE project team, led by Prof. Nic Beukes (UJ) and Prof. Christoph Heubeck (University of Jena, Germany), are nearing completion of the eight borehole cores drilled in the Barberton area as part of the Moodies BASE ICDP Project (ICDP: Intercontinental Drilling Program). The total allocated budget is R25 million, and the purpose is to obtain core to address questions pertaining to early life and ancient climates of the Archaean. The core is being curated on site by the UJ team; half will be retained at the CGS Core Yard, and half will be shipped to Germany for sampling and research. To follow the progress and obtain further information, the reader is referred to https://www.icdp-online.org/projects/world/africa/moodies-s-africa/daily-news/. As reported in the weekly updates by Profs Heubeck and Beukes, and commended by the ICDP Executive Committee, a great success of the BASE drilling project has been the outreach component of the project. Thikho (UJ Honours graduate 2021), Victor (local employee), and Phumi (Wits MSc candidate) work on the EOP (Education/Outreach/Publicity) aspects of BASE. Local schools have visited the BASE Hall and the team has also started to visit local schools in order to teach learners about the greenstone belt, the World Heritage Site, and the BASE drilling project. The Barberton UNESCO World Heritage site hosts a fabulous array of rocks that have been incorporated into the Barberton-Makhonjwa Geotrail. DSI-NRF CIMERA intends to support the outreach events and the current ICDP BASE display until the end of the year. It is hoped that discussions with Mpumalanga Tourism will enable a more permanent solution.

DSI-NRF CIMERA is also privileged to be involved in the second South African ICDP project, namely the Bushveld Complex Drilling project. This project, with a budget of around R43 million, is gaining momentum and seeks to obtain approximately

Following aspects of the Geotrail, Barberton.

3600 m of new core to further scientific research into this Large Igneous Province. Profs Sue Webb (Wits) and Dr Robert Trumbull (Germany) are the lead PIs.

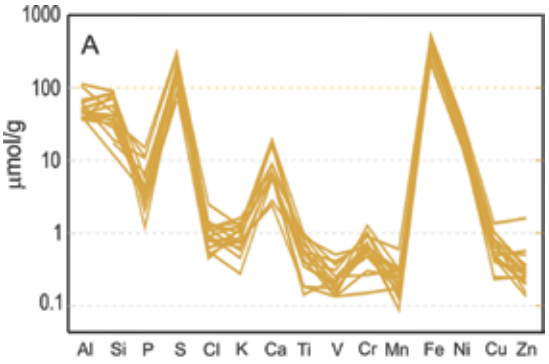
Sequel to the Hypatia story: the gift that keeps on giving Professor **Jan Kramers**, Dr **Georgy Belyanin** and co-authors have continued their research on the extraterrestrial "Hypatia". The parent body of the carbonaceous, diamond-bearing stone nicknamed "Hypatia" appears to be assembled from interstellar dust, and the stone has a chemical signature remarkably similar to the modelled yield of a supernova Ia.

Prof. Kramers reports the story of this fascinating stone:

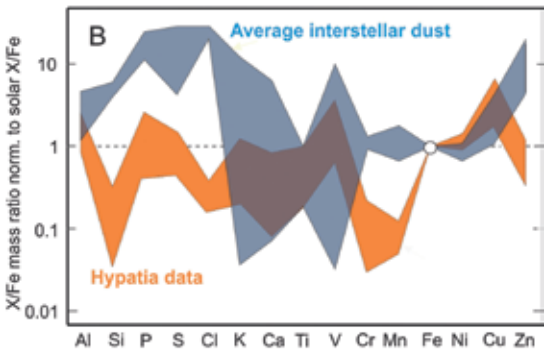
Ten years ago, in *Geobulletin*, we suggested that the 30 g pebble found in 1996 in the desert of south-west Egypt could be a comet fragment. The stone was found by Aly Barakat, an Egyptian geologist who accompanied an Italian expedition sponsored and led by the late Giancarlo Negro, a visionary businessman and explorer. While members of

Tony Ferrar (the Ecology Control Officer and author of the book on the Barberton-Makhonja Geotrail) unpacks the significance of the 'crinklies' hosted in early-life rocks.

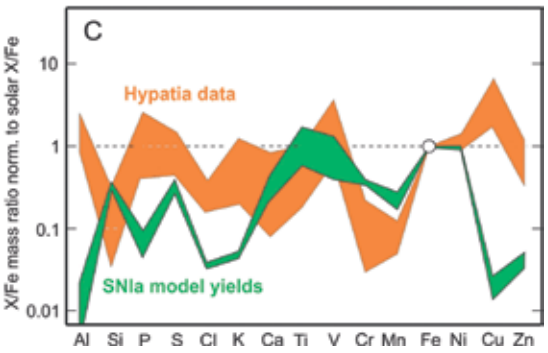
ICDP BASE display, Barberton.



A: Concentrations of the elements analysed in Hypatia by PIXE, showing a consistent pattern.



B: Concentrations normalised to Fe and solar abundances, compared to inferred average interstellar dust values normalised in the same way.



C: Compared to the modeled element production of one specific class of Supernova Ia events.

the team were busy repairing their Land Rover in Wadi Zerzura, Aly looked around and picked up this half-buried small pebble. Later, in the lab, it shattered Aly's cutting wheel when he tried to cut it, revealing its high diamond content. The stone passed through the hands of a number of eminent meteorite experts, including at Wits University, who generally dismissed it as a piece of coal that had been impacted. Our suggestion and proof that the material was extraterrestrial in origin was based on argon isotope measurements at UJ (*EPSL* v. 382, 21–31)—some of the first work done after the noble gas mass spectrometer donated by De Beers Geosciences was re-commissioned.

The extraterrestrial origin was later confirmed with much better precision by teams in Zürich and Nancy, who also showed that the material dated back to the first 40 Myr of the solar nebula, and that the stone was a fragment of a body at least several metres in diameter. Nitrogen isotopes showed that it was not related to any known cometary matter (*EPSL* v. 432, 243–253). Very strange chemical anomalies were detected using Proton Induced X-ray Emission (PIXE)

spectroscopy, using the proton microprobe in Somerset West (*Nucl. Instrum. & Methods* v. 363, 79–85), and in 2018 we published petrographical work that demonstrated that the carbonaceous matter was primitive, i.e. had hardly been thermally processed in the solar nebula (*GCA* v. 223, 462–492).

In the latest study (Kramers, J.D., Belyanin, G.A., Przybyłowicz, W.J., Winkler, H., Andreoli, M.A.G., 2022, *Icarus* v. 382, 115043), we tried to find and evaluate a common denominator in the chemistry of the stone. In areas that had stood out due to high Fe and S contents in previous analyses, we found a consistent abundance pattern of elements Al to Zn analyzed by PIXE, characterised by high Fe and S and relatively low Si (which we already knew) but also conspicuously low Cr and Mn. Thus, the common denominator turned out to be as weird as the anomalies so far found. This clearly non-carbonaceous-chondritic (i.e. non-solar) abundance pattern could not be the result of magmatic fractionation (because there had not been any heat), and gravity separation of sub-micron grains does not happen in the microgravity of the solar nebula.

We searched the astrophysical literature to find if there was an explanation outside the solar nebula for the strange abundance pattern. Separation of dust grains from each other and from gas could not offer a solution, because this is not found to be a valid mechanism in interstellar space. Looking at ratios of element abundances to iron, the average composition of interstellar dust in our part of the galaxy yields an interesting picture in that it is also different from the solar values. But again, this yields anything but a fit for Hypatia.

Next, we looked at the actual stellar processes that produce chemical elements. These are asymptotic giant branch (AGB) stars (stars like the sun at the end of their life) and two main kinds of Supernova events. AGB stars don't fit because they yield mainly C, N and O as well as elements heavier than Ni. The core-collapse explosions of Supernovas II (stars larger than about 15 solar masses at the end of their life) don't fit. For instance, they yield more Si than Fe, because most of the Fe that is produced in them falls into their core, which becomes a neutron star or a black hole. The only reasonably close fit (at least for elements with even proton numbers, i.e. Si, S, Ca, Ti, Cr and Ni relative to Fe) is achieved by comparison with the modeled yields of one type of supernova Ia. The relatively high abundances of odd-proton elements and Zn in Hypatia could be explained by inheritance from an AGB precursor.

A supernova Ia event can occur when a white dwarf star (the remnant of an AGB event) accumulates mass from a companion star in a binary system, which loads it to the point of collapse, leading to a thermonuclear explosion. Supernova Ia events are known to have produced most of the Fe in the Universe, which fits neatly with our observed high Fe/Si ratio. Geochemists can only be amateur astrophysicists, and therefore Hartmut Winkler of the UJ Physics Department came in to help with these issues.

This single fit found may not be the only possible scenario, but the search for an explanation of Hypatia's consistent chemical pattern has highlighted two things: first, the dust in interstellar space is heterogeneous on a grand scale, and second, such heterogeneities could be preserved in the formation of the solar nebula.

Compiled by ***Bruce Cairncross*** *from various departmental contributors*

branches & divisions

"Diamonds are forever and so are the memories we will forever embrace of the successful West Coast Diamonds Event.

Special thank you to Alexkor RMC JV for hosting us and to the speakers for their interesting talks - Dr. Asriel (Assie) Van Der Westhuizen, Brett Coller and Eugene Snyman. Including Mike De Wit and Robin Baxter Brown, for sharing their rich knowledge during the field trip. To all who attended, what an amazing time with you all!

Thank you to our sponsors, your contribution was greatly appreciated."

Loni Gallant (NC Branch Chairperson)

ESG@GSSA

The aims of the ESG division are to create and promote awareness whilst forming a platform for GSSA members and the broader earth sciences community to interact and learn about all things ESG.

On the 01 June 2022, an Extraordinary General Meeting was held in order to ratifiy the branch constitution and nominate the newly formed ESG GSSA division EXCO.

An EXCO was nominated and accepted, with the exception of a Vice Chair, which will be nominated in due course. The following persons have been elected for the EXCO:

Chairperson: . Lynne Soulsby

Secretary: Joshua Kilani

Treasurer: Timothy Marais

Additional committee members: Lilli Gramberg-Danielsen
Itumeleng Mogatusi-Sekgota

The ESG division will hold lunch time talks and workshops which will be distributed to division members and communicated through the ESG and GSSA website.

Environmental

Social

Governance

Should you wish to become a member or are interested in playing an active role in the ESG GSSA division please visit www.https://www.esg-gssa.co.za

Alternatively please send a mail to info@esg-gssa.co.za

GSSA
Geological Society of South Africa

hot pot

The Geological Hot Pot

Professor Jan Kramers at the University of Johannesburg and his research team have been doing amazing work on a unique meteorite that fell in the Egyptian desert and was found in 1996. They named it “Hypatia”, and their latest research has led them to conclude that it is a fragment of rock that formed in a supernova explosion. For an in-depth and readable account of their publication, together with links to interviews with the researchers, see *SciTech Daily.*

On the subject of meteorites, the finding of an Allan Hills meteorite, named AH94001, in Antarctica in 1984 led to renewed and vigorous research about the origin of life. In 1993, a team of researchers from the National Aeronautics and Space Administration (NASA) determined that AH84001 came from the planet Mars. Such meteorites are very rare to start with, but AH84001 provided a further surprise when microscopic structures resembling bacteria were found in 1996. This caused intense interest and controversy over the next decade, with claims and counterclaims about the structures being signs of life. Although most scientists now accept that the AH84001 structures are abiogenic in origin, the debate sparked the current race to find evidence of life on Mars. The question as to whether we are alone in the Universe could possibly be settled in the next few years from research results from Mars. A good summary of the topic is provided by CNET.

Our third extraterrestrial article deals with the Chicxulub meteorite that hit the Earth about 66 million years ago and is believed to have been the main cause of dinosaur extinction (birds excepted). The impact released a huge amount of sulphur gases that reached the stratosphere and spread around the globe. These gases caused significant global cooling that contributed to the demise of 75% of all animals on Earth. A summary of the research is provided in this *SciTech Daily* article.

Sharad Master, George Henry, Thomas Wallmach and Michael Meyer, all from Wits (and no, not aliens), posing on the Hoba meteorite in Namibia in 1988. The Hoba is the largest meteorite found so far on Earth.

Speaking of dinosaurs, were they warm-blooded or cold-blooded? This question has remained unanswered since the first dinosaur fossils were found and named. Perhaps until now. A paper published recently in Nature claims to have the definitive answer: dinosaurs were warm-blooded. A short discussion is given in *SciTech Daily*. The evidence is provided by a novel approach using chemicals preserved in dinosaur bones to estimate the metabolic rates of the animals. A high metabolic rate indicates higher activity and hence warm-bloodedness.

How old is Earth's earliest crust? And how do you identify it? An answer to these questions is provided in an Open Access paper published in the *Proceedings of the National Academy of Sciences* (PNAS). The rocks studied are 3.22 to 3.55 billion years old and collected from the Kaapvaal Craton in southern Africa. Tungsten isotope geochemistry is used to infer that Hadean (>4 billion years old) proto-crust was subducted into the mantle, and recycled into the younger rocks. A short account is given in *SciTech Daily*, together with a link to the paper.

Many of us would love to visit Antarctica, either as a tourist or, even better, as a geological researcher. I've not had the privilege, but several colleagues have been lucky enough to do so. Antarctica has only one active volcano, and it has an unusual composition. A recent study of the alkaline volcano suggests that the lava pool formed at the bottom of the crater is due to presence of abundant carbon dioxide. The gas drives the alkaline magma upwards from a mantle conduit imaged using magnetotellurics. A good account is given in *SciTech Daily*.

We are now all familiar with the concept of plate tectonics and how the configuration of the Earth's land masses changed over time in the past. But have you ever imagined how the Earth would look like in the distant future, millions of years from now? Well, a couple of possibilities are provided in this BBC article, where a geologist, in following up on his research on the unusual Lisbon earthquake in 1755, realised that the earthquake was caused by rifting. This was unexpected since Portugal is on a passive continental margin. Joao Duarte proposed that, if the rifting continued, the Atlantic Ocean could close, hence leading to reconfiguration of the continents. So, in just a few hundred million years, we may be able to walk all the way to Los Angeles without getting our feet wet!

Cretaceous ammonite exposed on the beach at the Wild Coast Sun. Ammonites became extinct at the same time as the dinosaurs.

GEOCONGRESS 2023
11-13 JANUARY

Stellenbosch

GSSA

The next 125 years of Earth Sciences

June circular

Despite all the delays that Geocongress has experienced over the last two years, we are very pleased to announce that over 90% of the original sessions, field trips and workshops are being retained in the January 2023 version of the event! This is an excellent testament to the enthusiasm for the event displayed by our esteemed colleagues within the southern African earth sciences community.

To further enhance the conference's offerings, a call for additional sessions, workshops and field trips is currently open until 20 June 2022. Once these additions have been finalized, the abstract submissions portal will open on **1 July 2022**. Additional information is available at the conference website https://allevents.eventsair.com/geocongress/ which will be updated periodically.

Confirmed workshops:

Gold geology	Neil Phillips	2 days
DSI-NRF CIMERA workshop	Nikki Wagner	half day
Pressure-temperature constraints, phase equilibria and open system modelling of geological processes	Matt Mayne	1 day
3D geological modelling	Ian Basson (TECT)	

Confirmed field trips:

Rock Around the Overberg - a 600 million year geological tour along the southern Cape Coast	John Bristow	3 - 5 days
Terroir in the Cape Winelands	Western Cape SEG student chapter	half day
Geology of the Malmesbury Group and Cape Granite Suite of the Pan-African Saldania Belt	Alex Kisters, John Clemens	2 days
Cape Fold Belt and Karroo	DeVille Wickens	4 days
Namqualand geology	Paul Macey	5 days

To suggest any further workshops or field schools, please email Prof Alex Kisters directly (akisters@sun.ac.za)

Environmental	Geobiology
	Acid mine drainage and other mine pollution issues
	Environmental Geochemistry
	Geoscience for a sustainable energy-environment nexus
	Current and future outlook for Carbon Capture and Storage in South Africa and abroad.
	Advances in Southern African Hydrogeology
Energy	Future of petroleum geosciences in Southern Africa
	Solid fossil fuel resources
Igneous	Diamonds, kimberlites and cratonic lithosphere: a session in honour of John J. Gurney
	Advances in Bushveld Petrogenesis and Ore Genesis
	Igneous beyond the obvious
	Felsic rocks of the Bushveld complex: Petrogenesis and metallogeny
Metamorphism	Differentiation of the Earth's crust at the metamorphic:igneous interface
Earth Evolution	Archaean Processes and Environments
	The Proterozoic of Africa
	Central Africa
	Africa's Phanerozoic tectonic evolution and associated magmatism
Planetary	Planetary Geology: Earth, Moon and Beyond
Ore	Applied Mineralogy Session
	Sediment-hosted ore deposits
	Ore-structure relationships
Sedimentary	Detrital Zircon: Methods, problems, applications
	Sedimentary basins in Southern Africa
Society	Geoscience and society
	The Future Geoscientist

To suggest any further sessions, please email Bjorn von der Heyden directly (bvon@sun.ac.za)

We in the field of geological sciences are fully aware that our country has a real wealth and age range of rock types that are part of our heritage. Ongoing research on these rocks has greatly contributed to our understanding of earth processes through time, inclusive of the origin of many mineral deposits that are crucial in our modern industrial society. Although much of the research work has been undertaken by South Africans and their collaborators, both local and overseas, there have been instances of "helicopter research" where foreigners conduct research on our rocks and publish without local involvement. This practice happens in other scientific disciplines as well and was discussed at the World Conference on Research Integrity held in Cape Town from 29 May to 1 June 2022. A summary of the proceedings can be found in this article in *Science*. Of importance is the issuing of the Cape Town Statement that draws attention to the problem with the aim of reducing, if not ending, it in the future.

A small fragment of fossil bone, probably dinosaurian, from the Cretaceous rock outcrops on the beach at the Wild Coast Sun.

The following study is after the hearts of many of us, giving us an excuse to enjoy a tipple or two! Our very distant ancestors enjoyed eating fruits that were naturally fermented and hence slightly alcoholic. So we can blame (or celebrate) our behaving like monkeys when we've imbibed one too many on our genes—we can't avoid evolution! The article can be accessed via *SciTech Daily.* Disclaimer: Being a teetotaler with only

Archaean pillow lavas in komatiitic basalts in the type section of komatiite in Mpumalanga.

Playful but larcenous vervet monkeys at the Richards Bay Caravan Park. If you turn your back, they snatch anything edible within reach.

occasional sips of alcohol (on special occasions), I have witnessed many instances of simian behaviour after sundowners at the end of a tough day in the field.

If you have allowed your genes to get the better of you and caused you to overindulge, science comes to the rescue, again! And the ingredients that can help you get over your hangover are, thankfully, widely available and cheap—and are listed here.

George Henry

GSSA comment

GSSA Comment on recent legislation

Over the past few months, the Department of Mineral Resources and Energy (DMRE) has gazetted a number of regulations and policies affecting the minerals industry (and geoscientists in particular). These are:

- The Artisanal and Small-Scale Mining Policy 2022 (30 March 2022)
- The Geoscience Act Regulations 2022 (30 March 2022)
- The Exploration Strategy for the Mining Industry of South Africa (14 April 2022)
- South Africa's Exploration Implementation Plan (14 April 2022)

Artisanal and Small-Scale Mining Policy

It is well known that existing mining policy and legislation is focused on large-scale operations. These existing regulations are extremely onerous for artisanal and small-scale operators and prejudice their chances at survival. The Artisanal and Small-Scale Mining (ASM) Policy was to be an attempt to simplify procedures and requirements for this important sector. The GSSA provided feedback to the CGS/DMRE on a public draft of these regulations in July 2021. It is disconcerting to note that our comments went unheeded in the final policy document gazetted on 30 March 2022.

Some of the on-going concerns are highlighted below:

- There is still an unworkable and impractical definition of small-scale mining.
- ASM licenses are to be reserved for local South Africans. This raises concerns, as even the smallest projects may take significant funding to execute well, and this could well require a component of international support. Such support will not be forthcoming if an ownership stake is impossible. Secondly, it will encourage 'fronting'. That in turn will enable corruption.
- The allocation of ASM licenses within the boundaries of large-scale mining operations raises various questions regarding transparent administrative process, including safety implications.
- Applications for small-scale and artisanal licenses are envisaged to be online, through the SAMRAD system—not only is the SAMRAD system a failure, but many artisanal and small-scale operators do not have ready access to the technology required.
- Illegal mining is not particularly well addressed. Illegal mining and sale of illicit commodities is a very serious

problem, which requires enforcement of existing law, not necessarily new laws. This also requires special attention to corruption. Furthermore, expecting illegal miners to simply "come forward and subject themselves to the process of formalisation" will not happen easily.

- The policy proposes what seems to be a new administrative structure to deal with ASM regulation. The GSSA believes that this would be very wasteful, particularly so at this point in time. Government departments need to be cutting expenditure where possible and not expanding.
- The policy does not address many of the issues identified by SADPO (the organisation promoting the interests of the alluvial diamond industry).

Geoscience Act Regulations

Also on 30 March 2022, the DMRE gazetted the final version of the Geoscience Act Regulations. The GSSA and numerous other organisations and companies submitted comments on an early draft in July 2021. Again, the DMRE/CGS appears to have taken limited cognisance of the concerns raised by the geoscience and mining industries. The major concerns regarding this document are three-fold: capacity (or lack thereof), over-reach and financially onerous burdens on companies and individuals.

- While it is standard practice in most countries for geological progress reports to be lodged with the local or national geological surveys, the regulations demand a high level of detail, with three major questions arising immediately. First, does the CGS (Council for Geosciences) have the capacity and budget to archive and manage in perpetuity? We suspect not. Second, the requirements do not differentiate between major development projects (mines), rapid reconnaissance exploration, or desktop targeting studies. The latter tend to be small scale and fast, and quite likely junior companies will not be able to comply with the detail required. This will discourage exploration investment. Third, what is the intent for legacy data, information, and physical samples? If interpreted literally it would mean that any historical data or information even remotely linked to the resource sector would need to be turned over or copied to the CGS. This would, for example, effectively transfer ownership of museum, university or private sector research collections to the CGS. For many types of documents, this contravenes internationally recognised copyright agreements and intellectual property ownership principles. And it must all be made available to the CGS by September 2023 (18 months from gazette date of March 2022). No mention is made of who has to pay for all of this!
- The lodgement of historical data and information not related to prospecting and reconnaissance is not well defined and it must all be made available to the CGS.
- The requirement to lodge resource and reserve estimations may conflict with stock-exchange regulations for listed companies, depending on the frequency and timing of required reporting. There could be conflict with international reporting codes guidelines as well, especially since the definitions of Competent Person, Mineral Resource and Mineral Reserve may conflict with that required by international public reporting codes.
- South African and foreign governments, public entities and private institutions or individuals intending to undertake geoscience research within the Republic must notify the Council in writing prior to commencement of the intended

research and must also submit the results of their geoscientific research to the CGS. This clause is problematic in that foreign governments are not subject to the wishes or mandate of the CGS or the DMRE; universities do not fall within the mandate of the DMRE or the CGS; as regards private citizens, it is not at all clear what is required. Field notes? Photograph collections? Geoheritage? Private libraries? This clause is also meant to apply to 'individuals', and it would be nearly impossible to practice as a geologist without being in breach of these regulations.

It is likely that the CGS, the DMRE and many companies will spend years in litigation over these well-intended, but badly conceived regulations. And as for the small operator, it is likely that these regulations will have exactly the opposite effect to that envisaged by the ASM policy above.

Exploration Strategy and Implementation Plan

On 14 April 2022, the DMRE gazetted two documents—"The Exploration Strategy for the Mining Industry of South Africa" and "South Africa's Exploration Implementation Plan"—in an attempt to "attract mineral exploration investment, reignite mineral development, accelerate new mineral discoveries and encourage optimal utilisation of the South African mineral resources in line with the environmental, social, and corporate governance principles" and to "secure a 5% share of global exploration expenditure, catalyse mineral exploration to increase mining contribution to the economy of South Africa in the next five years." This, in the face of the fact that, for many years, investment in South African exploration (as opposed to mining) has stagnated to the point that in the latest Fraser global survey of the heads of resource companies, South Africa is relegated to the bottom 10 globally as regards attractiveness to exploration spend.

The strategy accepts that, while there are a number of reasons for this, the key factors are policy instability and process impediments in the DMRE.

- A number of barriers to investment and exploration have been formally recognised by these documents, including the SAMRAD debacle. The barriers are subdivided into regulatory, process, financial, research and investment shortcomings. The solutions to these challenges are many and varied, but are mostly unrealistic in terms of application and timelines. For example, since 2001 the DMRE has been advised to replace SAMRAD, and Minister Mantashe has recently admitted (MiningMx, 7 April 2022) that he was still not in a position to state when a new system would be introduced. The Exploration Plan and Implementation principles now expect this to be fixed within three to five years!
- There are some particularly problematic clauses that will have the opposite effect of what is claimed to be the goal of incentivising exploration investment. It is proposed to drop the first-come-first-served principle as regards licensing and replace it with a "meritocratic" system (no details specified except to note that it must consider national development imperatives), along with appropriation of land for the advancement of prospecting. These solutions will actually incentivise corruption because licensing will become capricious and even more uncertain than it is now. Combined with the stated goal of increasing investment funding to local empowered start-ups (apparently to be funded by the current miners), there is very fertile ground for corruption to thrive.
- The plan itself is long on self-congratulatory messages of accomplishments, most

of which are contradicted by the lived experience of the South African minerals community. It has grandiose and laudable objectives but is very short on details of applications, along with realistic expectations and timeframes. Nowhere is this more evident than in the expectation of interventions by various social partners, the JSE, the DMRE, the Minerals Council and unidentified financial services, all within three months (i.e., by mid-September 2022) and "not longer than 12 months"! This plan also includes, by implication, the solving of the energy instability crisis (i.e., Eskom), labour unrest and corruption in the administration of applications.

Could it be, as said Pierre Corneille, "Alas, I emerge from one disaster to fall into a worse"?

Tania Marshall

mineral scene

Grossular garnet variety tsavorite, East Africa

This article is partly extracted from Cairncross (2019) 'Minerals & Gemstones of East Africa', with permission of Struik Nature, an imprint of Penguin Random House South Africa (Pty) Ltd.

Grossular $Ca_3Al_2(SiO_4)_3$ is the calcium-bearing variety of garnet and can form beautifully coloured crystals. These commonly occur as dodecahedrons and can be orange, red, yellow or green. Grossular forms in contact metamorphosed limestones often associated with diopside and vesuvianite.

One of the most popular gemstone varieties of grossular is emerald-green tsavorite $Ca_3(Al,V,Cr)_2(SiO_4)_3$, the colour caused by traces of chromium and vanadium. The deeper green colour of tsavorite, versus the lighter-coloured so-called "Merelani mint" or "mint garnet" is caused by the higher content of vanadium and/or chromium.[1] Research has further shown that manganese also plays a role in the garnet's trace element chemistry and can influence its colour. These three metals characterise different types of tsavorite that Feneyrol et al.[2] categorise as Type 2 (V>Mn>Cr), Type 3 (Mn>V>Cr) and Type 4 (Mn>Cr>V). Tanzanian tsavorite has all three types represented, while the Kenya stones are only Type 2 and Type 4.

Tsavorite was named after Tsavo National Park in Kenya, which is located close to the border with Tanzania. The discovery of tsavorite in Tanzania in 1967 and subsequent discovery in Kenya in 1970 by the geologist and gem prospector Campbell R. Bridges has been well documented.[3,4] However, it is rarely reported that Bridges had already

A 1.6 cm gemmy tsavorite crystal. Merelani Hills, Lelatema Mountains, Simanjiro District, Manyara Region, Tanzania. (Specimen: Ronnie McKenzie; photo: Bruce Cairncross)

Two views of a 3.28 carat antique cushion-cut tsavorite set in a 0.52 carat diamond ring. The band is adorned with 1.16 carats of smaller faceted tsavorites. (Jewellery and photo: Bruce Bridges)

found tsavorite in Zimbabwe six years earlier, in 1961.[4] Following his discovery 13 km southeast of Komolo in Tanzania, believing this to be a part of a larger geological deposit that extended into Kenya, Bridges began prospecting in that country, finding tsavorite there in 1970. Bridges was granted a permit to mine the deposit and in 1973, the name tsavorite was coined by Bridges and then President of Tiffany & Co. Henry B. Platt, who named the green garnet after the Tsavo locality in Kenya. In 1980, Bridges opened the Scorpion mine in Taita-Taveta County in southeastern Kenya. This mine has continuously produced outstanding tsavorites until Campbell Bridges' murder in 2009.

A rough 4.2 cm tsavorite nodule and a faceted 0.53 carat gem cut from this material. Voi, near Tsavo National Park, Kenya. (Specimens: Philip Hitge; photo: Bruce Cairncross)

For six years following this tragedy, the mine lay dormant, but was reopened by his son Bruce Bridges in January 2015.[5] Since then, operations have become more mechanised and production has once again yielded excellent quality tsavorite rough and in addition, fine, well-formed crystals of gem tsavorite for the mineral collector. However, during 2017, due to various security, social and political issues, mining was again put on hold and the supply of tsavorite dropped accordingly.

At the Scorpion mine, and most other deposits, tsavorite is hosted in graphitic gneiss, interbedded with pelitic schist and marble layers. However, the origin and location of the tsavorite in the rocks is structurally controlled, with the garnets forming in boudins in the hinge zones of tight recumbent folds. The tsavorite occurs as nodules at the Scorpion mine.

Equally high-quality grossular variety tsavorite comes from Merelani Hills, Manyara Region in Tanzania. The crystals are bright green, many of gem quality and associated with similar mineral assemblages to those from neighbouring Kenya. The deposits at Lamshuku and Namalulu contain tsavorite in graphitic gneiss and calc-silicate rocks.

Due to the popularity and commercial value of tsavorite as a gemstone, it has also been the subject of scientific scrutiny and used to interpret geological processes that led to its formation. The work of Feneyrol et al.[6–9] has documented the geological setting of the tsavorite deposits and described how the gemstones formed from original evaporitic deposits. These authors have also isotopically dated the tsavorite and obtained an age of 600 million years. Similarly, Martelat et al.[10] dated zircon, monazite and rutile associated with tsavorite to further constrain the age of formation. They concluded that the metamorphism in the region occurred from 620 to 580 million years ago, coincidental with the age of the tsavorite. In addition, Giuliani et al.[11,12] used isotope analyses to unravel the origin of tsavorite and further described the gemological aspects of the gemstone.

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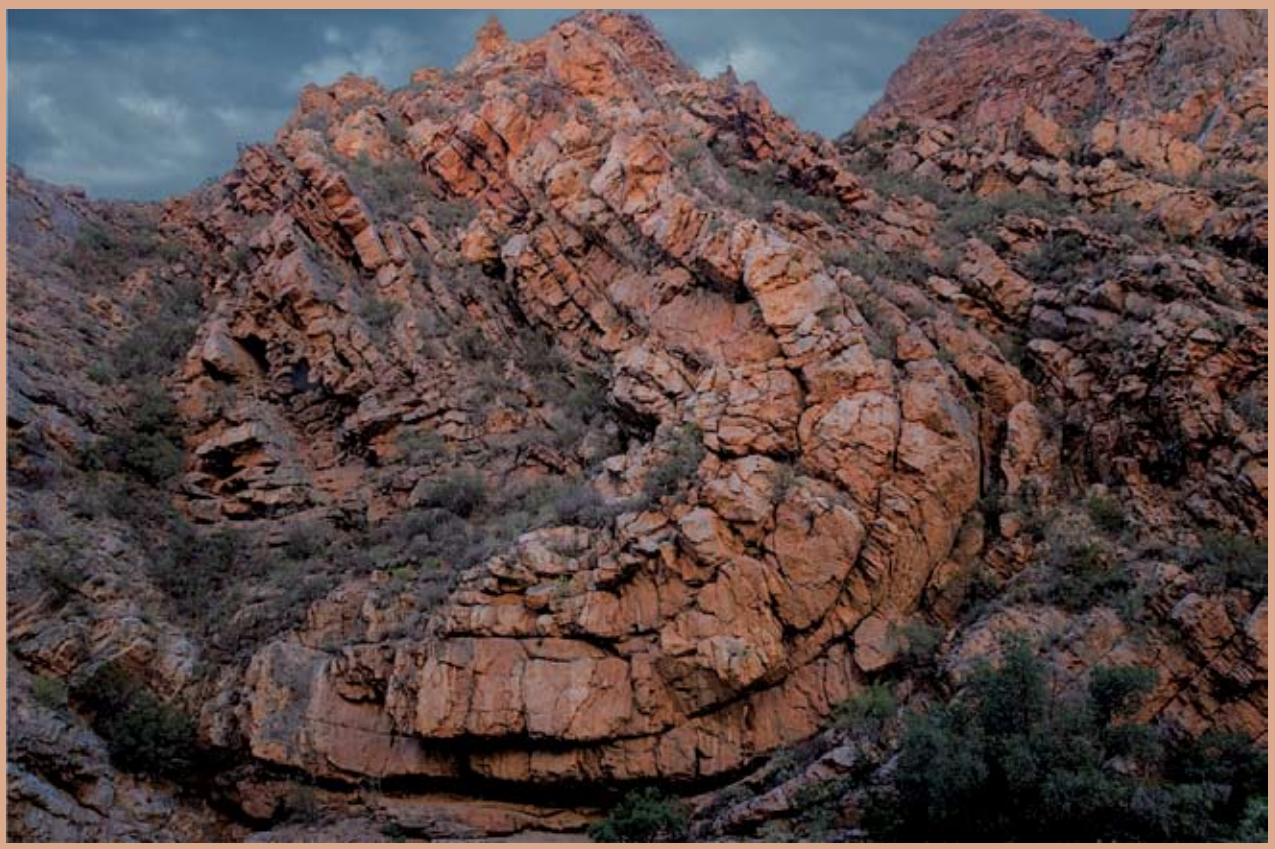
GEOHERITAGE PHOTO COMPETITION

As part of the Geoheritage Conference 2022, the GSSA invited allcomers to submit contributions to a photo competition. The 70 entries, from professionals and amateurs showcased the amazing variety of Geoheritage of South Africa. The winning photographs will be used as cover photos for the upcoming Geobulletins; the winners will also receive a copy of the book "Africa's Top Geological Sites" and a cash prize sponsored by the GSSA.

The winners are:

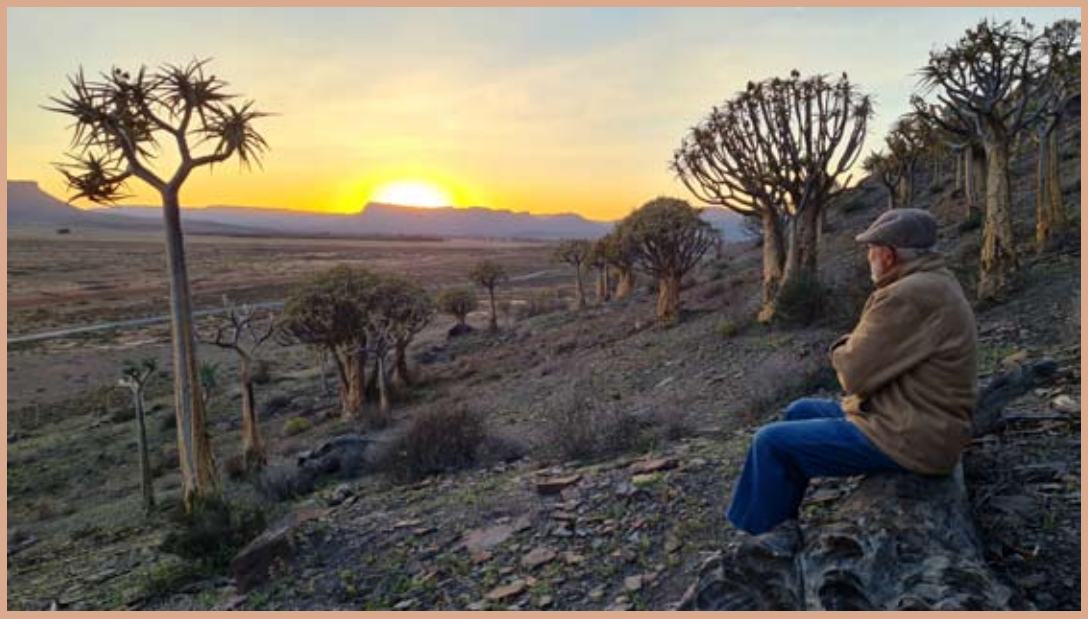
FIRST Place:

"Structural feature along the Swartberg Pass, Prince Albert" by BILLY MILLS



SECOND Place:
“View of the Wolkberg, Limpopo”
by CILLIERS MARAIS

THIRD Place:
”A waterfall in Rustenburg”
by SHAYLAN CHETTY



SPECIAL MENTION:
“Gannabos Quiver tree
forest at Sunrise”
by JOHAN SMIT

GSSA events 2022

January 2022 – November 2022

2022 will be a combination of virtual, physical and hybrid events.
The GSSA reserves the right to make changes to the calendar.

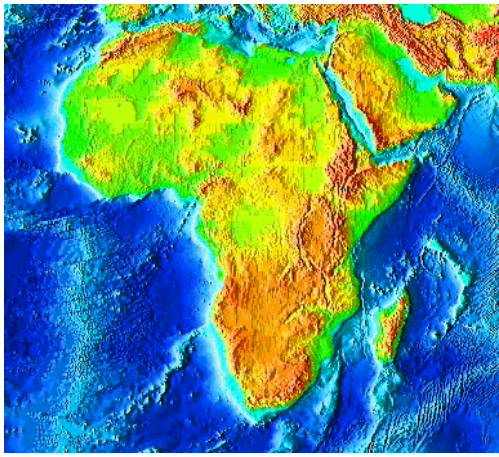
DATE	EVENT
7 - 8 July	Minrom Geological Maps: field data to making maps and GIS
6 - 9 September (4 x 1 day)	Minrom Project Management for Geologists
13 September - 4 October (4 x ½ days) + self-study	Drilling Methods and Techniques in Resource Exploration
7 October	3-D Geological modelling
8 November	ESG Inquisition Feedback
17 - 18 November	Technology and African Exploration Showcase

ANNOUNCEMENT OF A CIMERA SHORT COURSE

PLATE TECTONICS AND METALLOGENY – WITH A FOCUS ON AFRICA

WHEN: ***Wed 20TH to Fri 22nd JULY 2022***
WHERE: ***ROOM 101, GEOLOGY BUILDING, UNIVERSITY OF THE WITWATERSRAND***
PRESENTED BY: ***CIMERA***
COST: ***No charge***
TO REGISTER & PAY: ***Contact Reshmi Singh at reshmi.singh@wits.ac.za or on 011 717 6564***

WEDNESDAY 20th JULY			
0900 TO 1030	***1100 TO 1230***	***1330 TO 1500***	***1530 TO 1700***
Crustal evolution over geologic time [CH]	Plate tectonics and metallogeny [LR]	Africa - geophysical and tectonic perspectives [SW, MM]	The Archaean cratons of Africa [AH, RD]
THURSDAY 21st JULY			
0900 TO 1030	***1100 TO 1230***	***1330 TO 1500***	***1530 TO 1700***
Archaean and Proterozoic orogenic gold systems in Africa [AK, BvH]	The Witwatersrand Basin and its mineralization [GN, LR]	Great Oxidation Event, the Proterozoic terranes of Africa, and mineralization [BS]	Layered mafic intrusions and anorthosites in Africa and mineralization [RL, GB]
FRIDAY 22nd JULY			
0900 TO 1030	***1100 TO 1230***	***1330 TO 1500***	***1530 TO 1700***
Kibaran of Africa and its mineral deposits [SM]	The Pan-African and its mineral deposits [PN, JK]	African cratons, the supercontinent cycle and metallogeny [MdK]	Kimberlites, carbonatites and the petroleum basins of Africa [PJ, JH]



[PRESENTERS: Chris Hawkesworth, Laurence Robb, Sue Webb, Musa Manzi, Axel Hoffmann, Ray Durrheim, Alex Kisters, Bjorn von der Heyden, Glen Nwaila, Nic Beukes, Bertus Smith, Rais Latypov, Grant Bybee, Sharad Master, Paul Nex, Judith Kinnaird, Michiel de Kock, Phil Janney, John Hancox]

Field Excursion to commemorate the Centenary of the discovery of PLATINUM in the Eastern Limb

Key Dates & Accommodation:

Thursday 15 to Sunday 18 August 2024
Gethlane Lodge, Burgersfort

The discovery of economic platinum mineralization by Hans Merensky and his Lydenburg Platinum Syndicate at Mooihoek, on 15th August 1924, is one of the most significant geological and mining events in South Africa. This initiated a "Platinum Rush" which led to discovery of three additional mineralized pipes and the Merensky Reef.

The field excursion will include the following sites (dependent on permissions from mining companies):

- Famous geosites: Dunite Pipes (Driekop Mooihoek, Onverwacht); Merensky Reef, UG1 and UG2 chromitites; Discordant IRUPs
- Underground visit to historical workings on the Merensky Reef at Winnaarshoek
- Cultural sites: Botshabelo Mission (Hans Merensky' place of birth, in 1871); Battle of Sekhukhune; Tsjate Cultural Centre

Contact Dr R N SCOON or the GSSA for details and an expression of interest. (rnscoon@iafrica.com)

GSSA

RHODES UNIVERSITY
Where leaders learn

Hans Merensky (1917)

Hans Merensky (3rd from right) and his team panning for platinum at Onverwacht (Photograph from Lehmann, 1955)

The glory hole at Onverwacht, the world's oldest hard rock platinum mine

Geoheritage of the Eastern Limb

THE GEOTRAVELLER

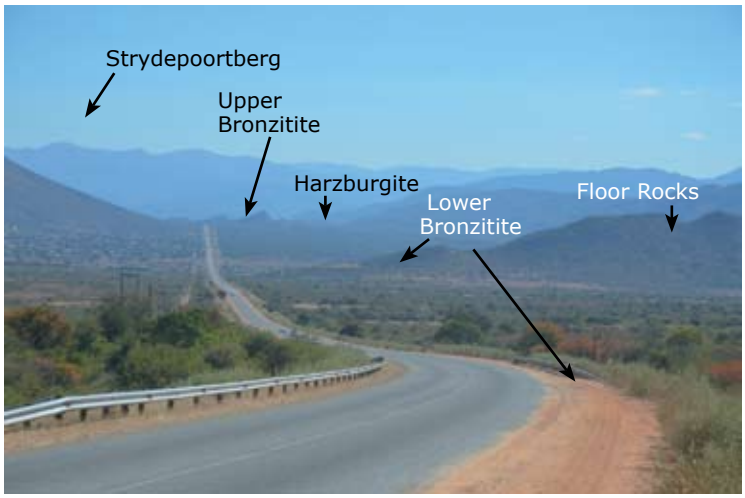
By Roger N Scoon*

Geoheritage of the Eastern Limb of the Bushveld Igneous Complex:
Spectacular Landforms, Famous Geosites and Discovery of Platinum

The Eastern Limb of the Bushveld Igneous Complex (BIC) is situated in the Mpumalanga and Limpopo Provinces, South Africa. The Eastern Limb is an area of spectacular landforms, where the igneous rocks, together with the metamorphic rocks of the thermal aureole, outcrop in north-to-south aligned ridges and formidable escarpments. The region has a long history of human habitation and the broad, flat-floored valleys of the Olifants and Steelpoort River systems support a large, semi-rural population. Geoheritage recognises cultural and archaeological sites as well as the unique geological features. Also of interest is the occurrence of endemic species of grasses and aloes. Pockets of indigenous forest and bushy savannah ("bushveld") occur in some valleys. The mountain ranges, which include the Leolo Mountains, are remote wildernesses.

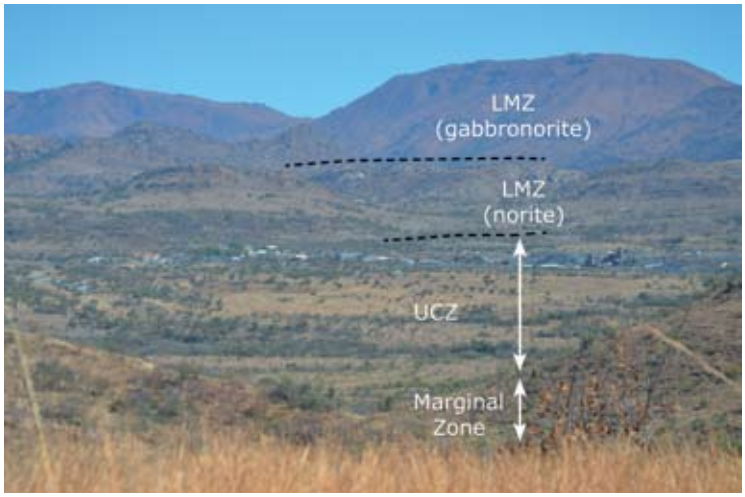
The world-famous geosites of the BIC, together with the 1924–1929 "platinum rush" that led to discovery of the world's largest resource of platinum, mean that the region has potential to support either a "platinum trail" or a "geopark". The role of Hans Merensky in the platinum discoveries, along with the work of geologists Arthur Hall and Percy Wagner who provided the first detailed descriptions of the geology and mineral deposits, are significant. The Eastern Limb is accessed by tarmac roads that link the regional towns of Burgersfort, Steelpoort, and Roossenekal with either Middelburg (southern route) or Polokwane (northern route). A visit to the region can be combined with geotourism in the

A three-dimensional satellite image (two times vertical exaggeration) of part of the Eastern Limb looking north from Die Berg, with the deeply incised valleys of the Groot and Klein Dwars Rivers in the foreground. The irregularity of the basal contact, particularly between the towns of Steelpoort (S) and Burgersfort (B), contrasts with the planar nature of the roof. (Source: Landsat 7 image for the year 2000 sourced from the University of Maryland Global Land Cover Facility and processed by Philip Eales of Planetary Visions)



The topography of the Lower Zone subchamber at Olifants River reveals the three subzones (Lower and Upper Bronzitite; Harzburgite). The mountainous landforms of the thermal metamorphic aureole are visible in the background (view looking north).

A high ridge west of the main Burgersfort–Polokwane Road at Winterveld reveals prominent igneous layering of the Lower Critical Zone (LCZ) and Upper Critical Zone (UCZ). Outcrop of the LG6 chromitite can be traced along strike for >70 km in this sector (Photograph: Morris Viljoen).



View looking west from the basal contact of the RLS at De Grooteboom of the rugged landscape of the Dwars River Valley. The valley is underlain by the Upper Critical Zone (UCZ)—where the platinum-rich UG2 chromitite is being mined—and noritic portion of the Lower Main Zone (LMZ); the prominent ridge consists of resistant gabbronorite, also of the LMZ.

mountainous region of eastern Mpumalanga and the Kruger National Park.

The most remarkable feature of the BIC is the occurrence of a 7–10 km-thick sequence of layered ultramafic–mafic rocks (the "Rustenburg Layered Suite" or RLS). Metre- or cm-scale igneous layering—which includes ore deposits locally known as reefs—are delineated on surface for tens of kilometres. There are several viewpoints accessed by the main roads. The gently dipping, broad-scale igneous layering defines a stepped (cuesta) topography in the vicinity of Mecklenburg. A viewpoint looking north towards the Olifants River reveals a succession of ridges, with ultramafics (lower part of the RLS) in the foreground and resistant metamorphic rocks of the thermal aureole in the distance. A ridge located on the western

Igneous layering at the Dwarsrivier National Monument shows bifurcations of the UG1 chromitite layer (dark) intruding anorthosite (white). The main UG1 layer is visible top left.

Slabs and xenoliths of partially digested anorthosite, ripped from the crystalline floor, occur in the basal part of the chromitite.

side of the Burgersfort–Polokwane Road reveals a broad stratigraphy: metre-thick igneous layers can be discerned. The most well-known example of igneous layering is the bifurcating layers and stringers of the UG1 chromitite at the Dwarsrivier National Monument. This exposure reveals the complexity of the processes associated with igneous layering.

Geomorphology

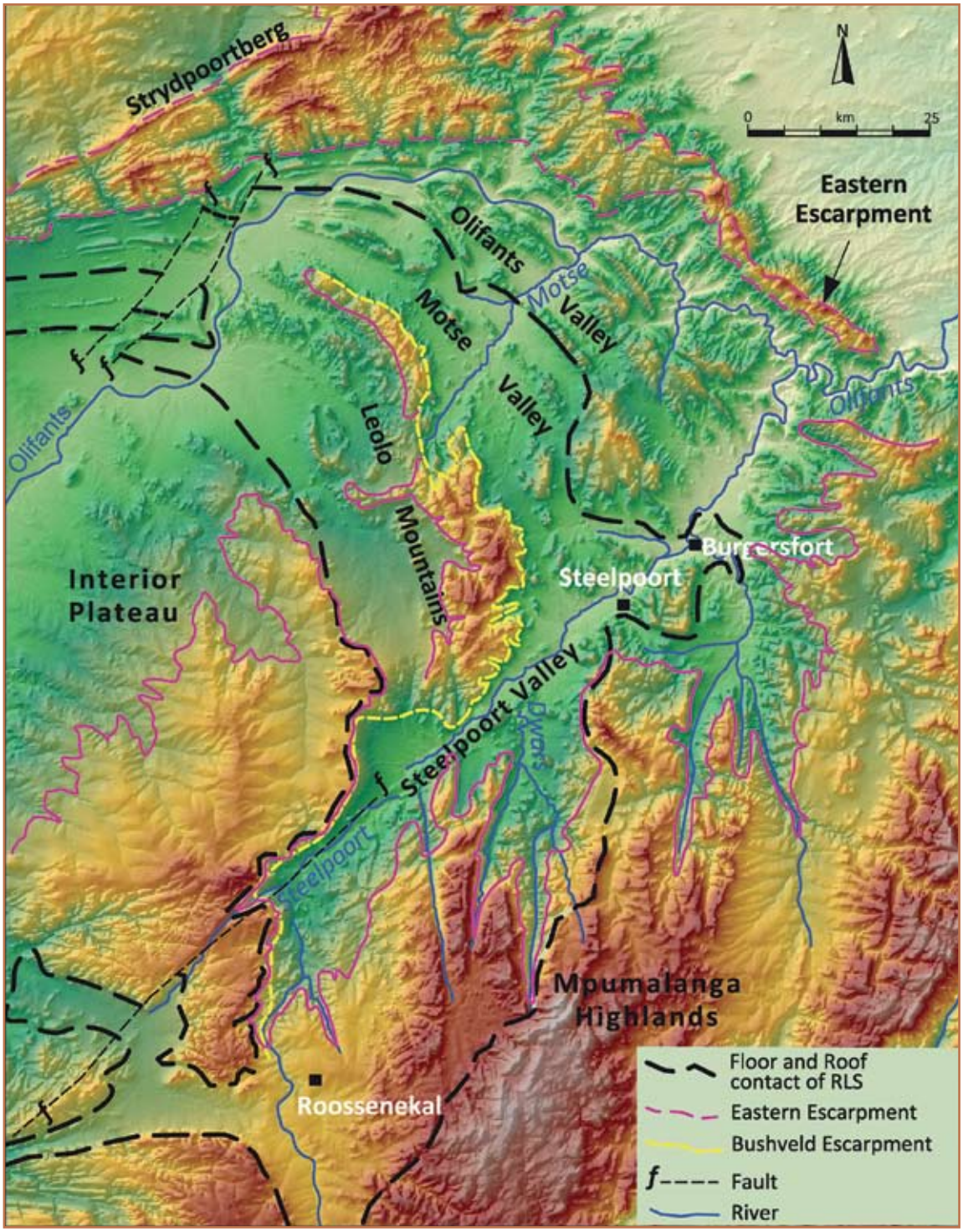
The landforms of the Eastern Limb are part of the "Middleveld", a discrete physiographic region located between the coastal plains ("Lowveld") and the interior plateau ("Highveld"). Uplift of the African Plate, initiated during break-up of the palaeo-continent of Gondwana, triggered intense cycles of erosion. Resistant rocks of the BIC and

Thin stringers of chromite in the anorthosite at Dwarsrivier reveal evidence of syn-intrusion deformation.

Dendritic oikocrysts of pyroxene (grey) in the anorthosite at Dwarsrivier may be ascribed to remelting and draining downward of interstitial melt.

thermal aureole are preserved in the erosional embayment. Headward erosion of the Olifants and Steelpoort River systems has dissected the interior plateau into erosional relicts. The rivers have retreated in part on linear, structurally controlled features. The postulate that the deep, flat-floored valleys are glacial features should be discarded.

Several mountainous areas are recognised. The ranges of the Eastern Escarpment comprise resistant metamorphic rocks of the thermal aureole. The highest range is the Strydpoortberg, where thick sequences of dolomite form rugged landforms. The Olifants River has carved a sinuous passage through alternating units of quartzite and hornfels (which form high ridges) and shale-rich



A digital terrain image shows the retreating scarp faces of the Olifants and Steelpoort Rivers, with areas of high relief (shades of yellow and orange) and low relief (shades of green).

beds (valleys). The Mpumalanga Highlands are related to erosional relicts of the interior plateau. The Leolo Mountains is a localised range on the eastern side of the interior plateau. The Bushveld Escarpment is restricted to the Eastern Limb.

Two broad geomorphic regions are identified in the Eastern Limb. The northern sector is transgressed by the eastward-flowing Olifants River. This region is relatively remote and has the most rugged landforms. The thermal aureole is notably well developed in this region. A tributary of the Olifants, the Motse River that is sourced in the Leolo Mountains, has cut through the layered igneous rocks. Subsidiary, mostly ephemeral streams (including the Moopetsi Spruit at Maandagshoek) of the Motse River have eroded valleys parallel to strike. These streams occur in the broad "Platinum Valley", named for the platinum reefs that subcrop below the black turf soils. The "Platinum Valley" is

constrained to the east by a high ridge (exposed at, for example, Winterveld) and to the west by the Bushveld Escarpment. The southern sector reveals a broad valley of the northward-flowing Steelpoort River, constrained on the western side by the Bushveld Escarpment. Near Roossenekal, the landscape softens and gives way to a broad valley with fertile soils. The river is crossed by the Malakane Steel Bridge, a heritage feature built in approximately 1926. The deeply incised valleys of tributaries that include the Groot and Klein Dwars Rivers are a feature of this sector.

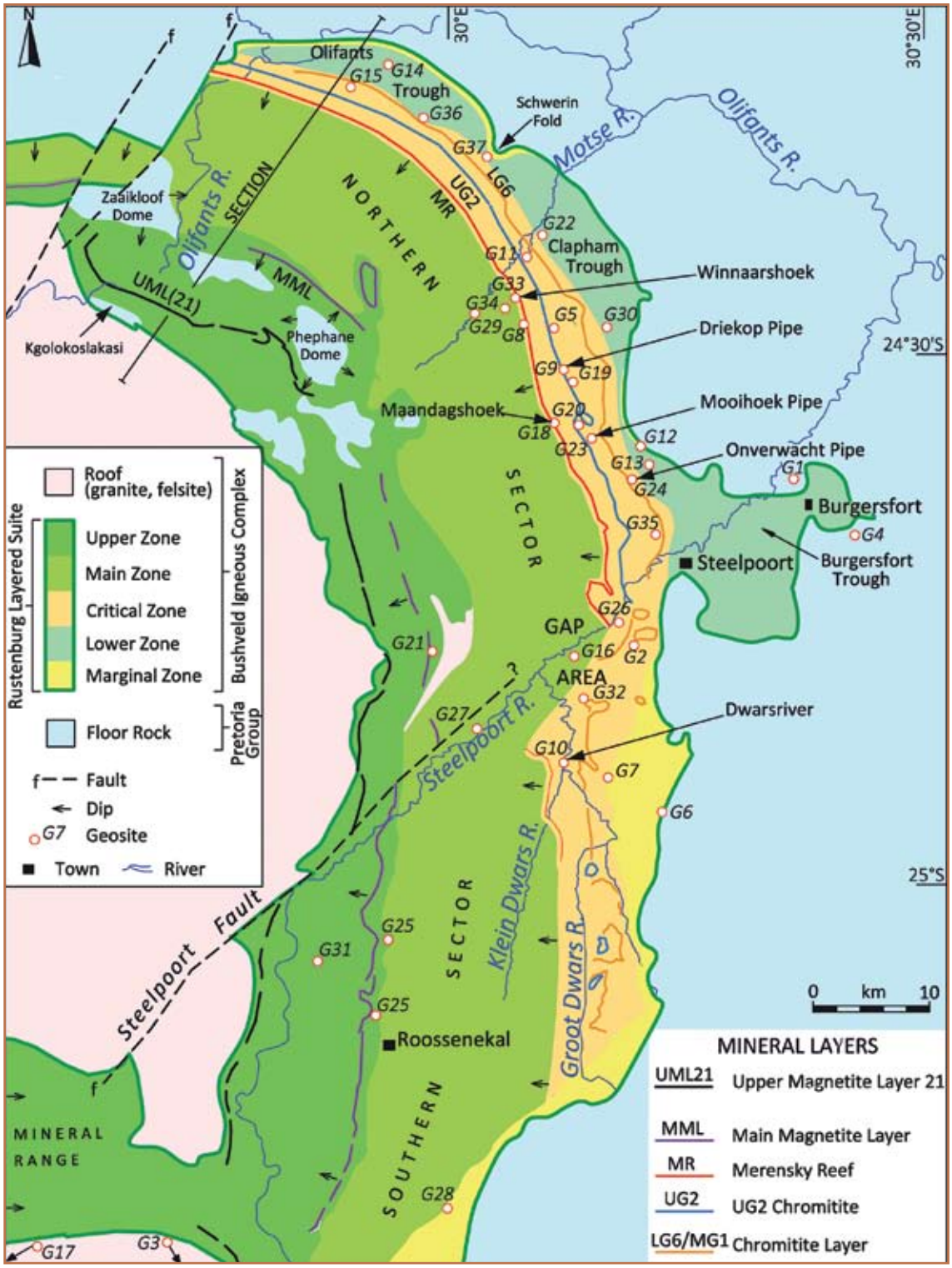
Bushveld Igneous Complex

The BIC was emplaced in the approximate centre of a large Palaeoproterozoic basin. The basin is associated with the Transvaal Supergroup (2.4 Ga), a thick sequence of mostly metasedimentary rocks that contain an extensive thermal aureole related to the RLS. The BIC has three principal components. The oldest is the rhyolite and subordinate granophyre of the Rooiberg Group. The mafic to ultramafic RLS is an intermediate feature. The Lebowa Granite Suite (which also contains granophyre) is the youngest component. All three components of the BIC formed in a relatively short interval (2.06–2.05 Ga).

The felsites of the Rooiberg Group are part of a giant volcanic event in which rhyolite lavas flooded the interior of the basin. The RLS was injected beneath the felsites into the uppermost part of the Transvaal metasedimentary rocks. The granites were primarily intruded above the RLS (and below the felsites) and appear to have exploited a similar plane of weakness. The felsites and granite occur in the centre of the Transvaal Basin, but the RLS outcrops as three large, arcuate limbs of lobes (together with minor satellite bodies). The spectacular outcrops of the Eastern Limb are not duplicated in the other limbs, as they occur on the interior plateau.

In the southern sector of the Eastern Limb, the roof to the RLS is formed of flat-lying layers of felsite. In the northern sector these rocks give way to the granite. Irrespective of the lithology, the roof is a planar feature and thermal effects in the (older) felsites are minimal. The basal contact (visible on the satellite image) is, however, extraordinarily irregular and the extensiveness of the thermal aureole of the Transvaal Supergroup is emphasised. The RLS constitutes a mostly tabular and arcuate, sill-like body, intruded between the Transvaal rocks and the overlying felsite or granite. The sill-like nature is, however, disrupted by three large troughs—canoe-shaped subchambers (Burgersfort; Clapham; Olifants River)—located at the base of the RLS. Each subchamber is constrained by upwarps in the floor rocks.

The regularity of the igneous layering in the Eastern Limb has enabled an informal stratigraphy of zones, subzones and marker layers to be constructed. The Critical, Main and Upper Zones constitute a thick sill-like component in which layering dips gently westward. The subchambers (which are structurally complex and reveal steep dips) contain the underlying marginal rocks (which include the fine-grained Maruleng Norite) and the Lower Zone. The former are sequences of stacked sills, the thickness of which varies markedly along strike, but the Lower Zone (which is restricted to the three subchambers and is therefore not found in the southern sector) is a thick sequence of ultramafics in which igneous layering is prominent. The marginal rocks also occur as thin rinds on the upwarps between the subchambers and may be relatively thickly developed in the southern sector. The complex boundary zone in the vicinity of Steelpoort separating the northern and southern sectors was known to the early prospectors as a "Gap Area" (the platinum reefs do not occur on surface). The structural disruptions are due to domes and regional faults. Similar floor-rock domes (the core-parts consist of the Transvaal Supergroup) are found in the interior of the northern sector (e.g., Phephane, Zaaikloof). The domes (and upwarps that isolate the subchambers) are syn-Bushveld features related to diapirism in the thermal aureole.



Simplified geological map of part of the Eastern Limb showing zones, reefs, and geosites. The distribution of the marginal rocks and Lower Zone is very schematic. (After 1:250,000 maps published by the Council for Geoscience)

Each zone within the RLS is correlated with the geomorphology and soils. The marginal rocks at the base of the intrusion are comparatively easily eroded and may be covered by surficial deposits. The ultramafic rocks of the Lower Zone define a sequence of serrated ridges (made of orthopyroxenite) and valleys (harzburgite). Pyroxenitic lithologies in the Critical Zone are covered by brownish soils with scattered boulders; norite and anorthosite may form high ridges. The noritic uppermost part of the Critical Zone and noritic lowermost part of the Main Zone tend to be deeply weathered and are covered by thick, black turf soils. Attapulgite clay has been quarried from weathered norite in the Motse Valley. The Main Zone is dominated by resistant gabbronorite (Bushveld Escarpment). The Upper Zone weathers to reddish clay soils and includes extensive magnetite scree (e.g., in the appropriately

The basal contact of the RLS at De Grooteboom includes calc-silicate xenoliths (white) derived from the Vermont Formation and fine-grained marginal rocks (dark) (scale provided by Morris Viljoen, 2016).

The marginal rocks in (a) include a migmatite in which irregular bands of micropyroxenite (dark) appear to have intruded a fine-grained norite or gabbronorite (light).

The basal contact of the RLS at Hendriksplaats reveals a rheomorphic breccia containing blocks of micropyroxenite (dark) embedded in a matrix of quartz-rich granophyre (pale pink). The matrix may have been derived from partial melting of the impure quartzite floor.

Aerial view looking north at the Olifants River subchamber showing layering in the Lower Zone (Photograph: Morris Viljoen).

named Magnet Heights). Areas of badlands in the Motse and Steelpoort Valleys are ascribed to reworking of Upper Zone soils transported from the interior plateau.

The BIC supports a large mining industry with extensive deposits of platinum, chromium, vanadium, and dimension stone exploited from the RLS. Industrial minerals (andalusite and asbestos) are quarried in the thermal aureole. Magnesite has been exploited from a large peridotite intrusive complex situated in the thermal aureole near Burgersfort. The peridotite is spatially and genetically related to the Lower Zone.

The orthopyroxenite at Jagdlust (Upper Bronzitite subzone, Lower Zone) reveals pronounced mineral lamination. The ridge in the background is capped by light-coloured norite and anorthosite of the Upper Critical Zone (UCZ).

The dunite and harzburgite at Jagdlust (Harzburgite subzone, Lower Zone) is serpentinised and includes a trelliswork of magnesite veins.

Participants of the 2016 IGC field trip to the Eastern Limb examining the 2 m-thick Main Magnetite layer (black) and underlying layer of (discoloured and weathered) anorthosite in a stream bed at Magnet Heights.

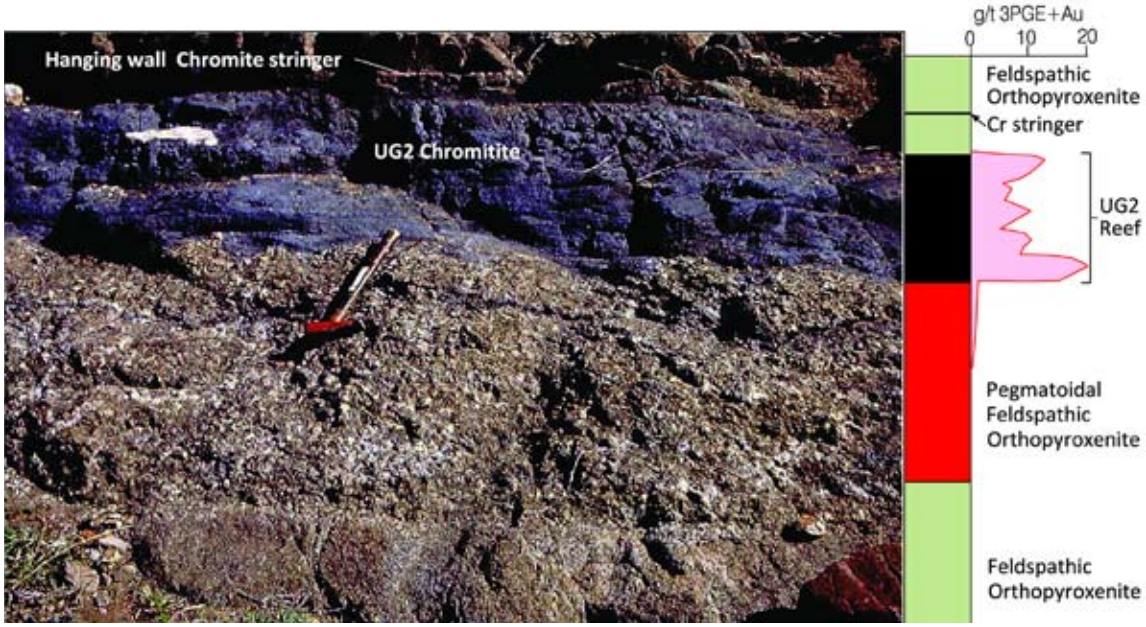
The Middle Group anorthosite at Jagdlust is a regional marker intercalated with feldspathic orthopyroxenite. The anorthosite is overlain by the MG3 chromitite and underlain by a thin "reaction" chromite stringer on the lower contact.

Geosites

Eastern Limb geosites—which have been described in field guides for international conferences—are plotted on a simplified map. Geosites are referenced by an informal stratigraphy with zones and marker layers (see Table). In addition to the geosites of the RLS, exposures of the thermal aureole (Burgersfort), the Rooiberg Group (Loskop Dam) and Nebo Granite (Jane Furse) can be examined. Some of the most well-known geosites are illustrated here. The migmatite and calc-silicate xenoliths exposed at De Grooteboom are associated with the basal contact.

The contact is also exposed at Hendriksplaats, where an unusual rheomorphic breccia outcrops. The ultramafic layering of the Lower Zone is exposed at Jagdlust, in the Olifants River subchamber. The chromitite layers of the Critical Zone, including the metre-wide LG6 layer, outcrop on the flanks of high ridges. The MG3 anorthosite is a regional marker that subdivides the lower and upper parts of the Critical Zone. The vanadium-rich Main Magnetite Layer (MML), which has been strip-mined over tens of kilometres, is exposed at Magnet Heights.

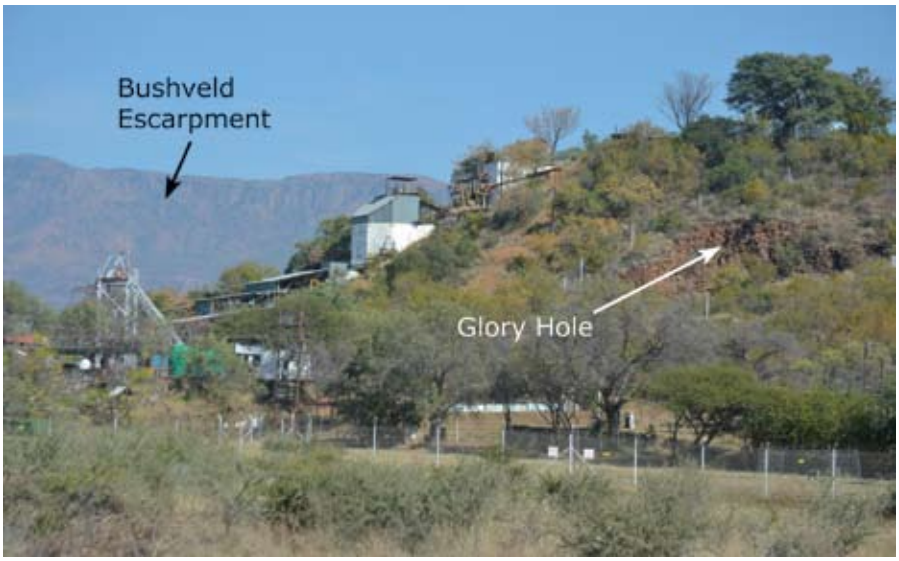
The UG2 chromitite at Hackney is anomalously thin as it occurs adjacent to a pothole. The vertical profile shows the distribution of the PGE. (Photograph and profile: Morris Viljoen)



GEOSITES AND HISTORICAL LOCATIONS, EASTERN LIMB

Location	Latitude (S)	Longitude (E)	Description	Geosite
Aapiesdoorndraai	**24°38'52"**	**30°20'53"**	Ultramafic Sill; Magnesite Quarry	**G1**
Annex Grootboom	**24°51'46"**	**30°07'47"**	MG Chromitites; LCZ-UCZ contact	**G2**
Blinkwater	**25°27'19"**	**29°49'08"**	Viewpoint; Rooiberg Felsite	**G3**
Burgersfort	**24°43'49"**	**30°21'07"**	Sills in thermal aureole	**G4**
Clapham	**24°29'58"**	**30°03'43"**	Marula Platinum Mine	**G5**
De Grooteboom	**24°57'26"**	**30°09'39"**	Viewpoint and marginal rocks	**G6**
De Grooteboom	**24°55'44"**	**30°08'44"**	MG Chromitites; LCZ-UCZ contact	**G7**
Driekop	**24°31'35"**	**30°04'16"**	Merensky's Office	**G8**
Driekop	**24°32'43"**	**30°06'05"**	Pt Dunite Pipe	**G9**
Dwarsriver	**24°54'39"**	**30°06'11"**	UG1 Chromitite & Anorthosite	**G10**
Hackney	**24°27'38"**	**30°03'28"**	UG2 Chromitite	**G11**
Hendriksplaats	**24°37'09"**	**30°10'39"**	Basal contact and marginal rocks	**G12**
Hendriksplaats	**24°37'59"**	**30°11'18"**	Calc-silicate Xenoliths	**G13**
Jagdlust	**24°15'38"**	**29°53'16"**	LZ Traverse	**G14**
Jagdlust	**24°16'10"**	**29°53'21"**	LG6 Chromitite; LCZ-UCZ contact	**G15**
Kennedy's Vale	**24°49'34"**	**30°06'32"**	Disused V mine, discordant IRUP	**G16**
Loskop Dam	**25°25'14"**	**29°22'00"**	Rooiberg Felsite (not on map)	**G17**
Maandagshoek	**24°35'42"**	**30°05'32"**	Merensky Reef (Discovery Site)	**G18**
Maandagshoek	**24°33'31"**	**30° 06'16"**	UG2 Chromitite in stream bed	**G19**
Maandagshoek	**24°35'54"**	**30°06'42"**	UG3 Chromitite in stream bed	**G20**
Magnet Heights	**24°48'40"**	**29°58'28"**	Main Magnetite Layer	**G21**
Mecklenburg	**24°25'39"**	**30°04'47"**	LZ; Magnesite Quarry	**G22**
Mooihoek	**24°36'26"**	**30°07'49"**	Pt Dunite Pipe	**G23**
Onverwacht	**24°39'09"**	**30°09'59"**	Pt Dunite Pipe	**G24**
Roossenekal	**25°10'23"**	**29°54'02"**	Disused V mine (MML)	**G25**
Spitskop	**24°47'05"**	**30°09'16"**	Discordant IRUP body	**G26**
Steelpoort River	**24°53'36"**	**30°01'02"**	Steel Bridge	**G27**
Tonteldoos	**25°19'00"**	**29°58'54"**	Tennisball Marker	**G28**
Tsate	**24°30'22"**	**30°00'56"**	Sekhukhune Memorial	**G29**
Twyfelaar	**24°30'02"**	**30°07'59"**	Pt Dunite Pipe; Magnesite Quarry	**G30**
Tygershoek	**25°06'25"**	**29°51'52"**	View point of escarpment	**G31**
Tweefontein	**24°51'22"**	**30°07'07"**	Discordant bodies in UCZ	**G32**
Winnaarshoek	**24°29'58"**	**30°03'43"**	Merensky Reef (old mine workings)	**G33**
Winnaarshoek	**24°30'27"**	**30°02'39"**	Main Mottled Anorthosite	**G34**
Winterveld	**24°41'49"**	**30°12'09"**	Eastern Chrome Mines	**G35**
Wintersveld	**24°16'31"**	**29°55'19"**	LG4 Chromitite	**G36**
Zwartkoppies	**24°18'23"**	**30°00'18"**	Marginal rocks and basal contact	**G37**

The brown-weathered Merensky Reef is exposed in the entrance to a historical decline at Winnaarshoek. The reef includes a 2–3 m-thick layer of feldspathic orthopyroxenite with thin chromite stringers. Sulphides in the upper part of the pyroxenite have weathered to a gossan, which aided the discovery in 1924. The planar nature of the upper chromite stringer contrasts with the irregularity of the contact with the leuconorite or spotted anorthosite. The vertical profile shows the distribution of the PGE.



The Driekop pipe forms a prominent koppie in the centre of the Platinum Valley. The mineralised core-zone (note the small glory hole) was accessed by a vertical shaft (headgear is intact) located in the barren dunite. The Bushveld Escarpment is visible in the background.

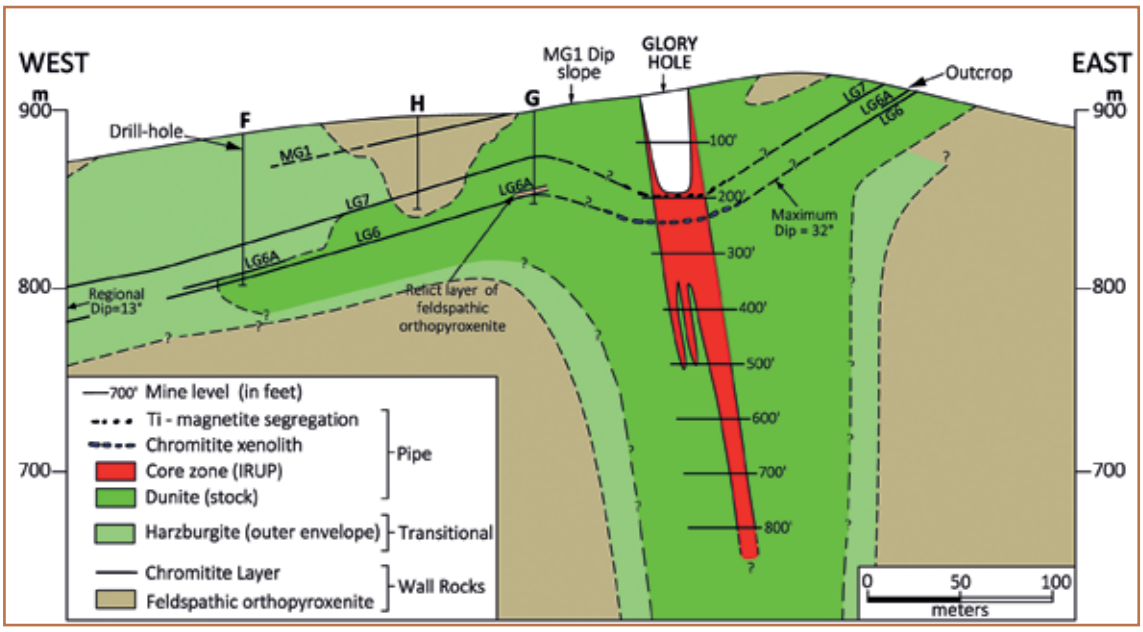
The glory hole associated with the mineralised core-zone at the Onverwacht pipe shows veins of secondary magnesite in the dunite. A protuberance of the iron-rich dunite of the richly mineralised core-zone is shown.

An irregular, and markedly discordant, body of IRUP (dark) has partially replaced a sequence of norite, feldspathic orthopyroxenite and chromitite in an open pit at the De Grooteboom mine.

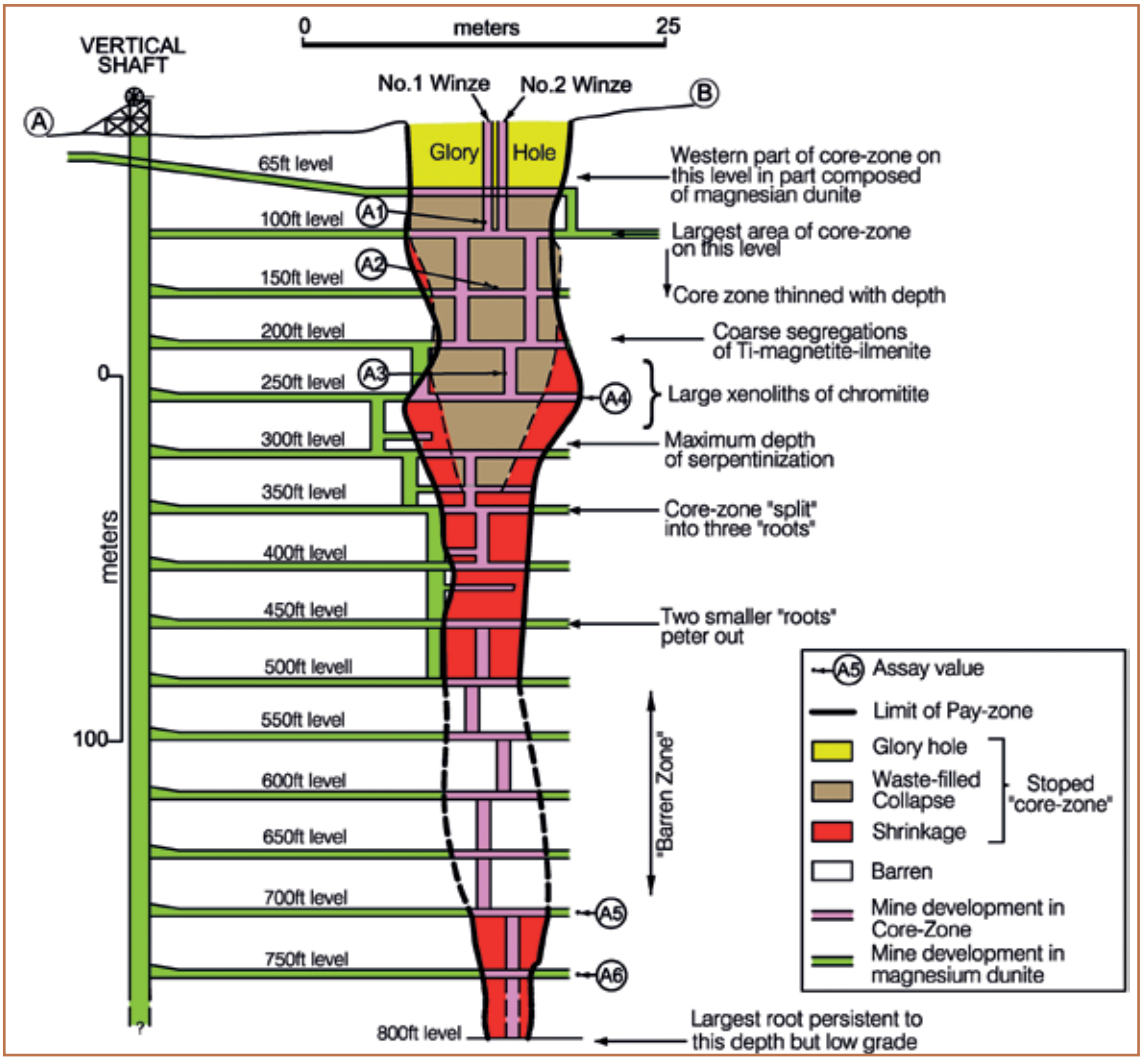
Platinum Deposits

The UG2 chromitite and Merensky Reef (both of which occur in the aptly named Critical Zone) are the principal platinum orebodies in the Eastern Limb. Outcrops of the UG2 chromitite occur on the eastern slopes of a ridge at Hackney. The PGE are primarily constrained to the chromitite. The Merensky Reef comprises multiple layers of feldspathic orthopyroxenite in which two thin chromite stringers are identified. The Merensky Reef outcrops on the eastern slopes of a low ridge at Winnaarshoek and Driekop. Historic declines driven into the side of the ridge could possibly be reopened for geotourism.

Platinum mineralisation also occurs in semi-concentrically zoned pipes that cut perpendicularly across the primary igneous layering. The pipes consist of large stocks of dunite enveloped by irregular rims of either harzburgite or clinopyroxenite. Several dozen dunite pipes are known (they are restricted to the northern sector), yet only four are mineralised. The low-grade Twyfelaar pipe (which was prospected but never mined) occurs in the Lower Zone. The high-grade Onverwacht and Mooihoek pipes, together with the modest-grade Driekop pipe, occur in the Critical Zone. The platinum in the mineralised pipes occurs in small, downward-tapering core-zones—replacement features within the much larger bodies of dunite. The relatively iron-rich and ultramafic nature of the core-zones in the mineralised pipes is comparable to replacement bodies of iron-rich ultramafic pegmatite (IRUP).



Section of the Onverwacht pipe aligned approximately W–E and looking north.



Mine section aligned approximately N–S and looking east, based on the original from Onverwacht Platinum Limited with four times horizontal exaggeration.

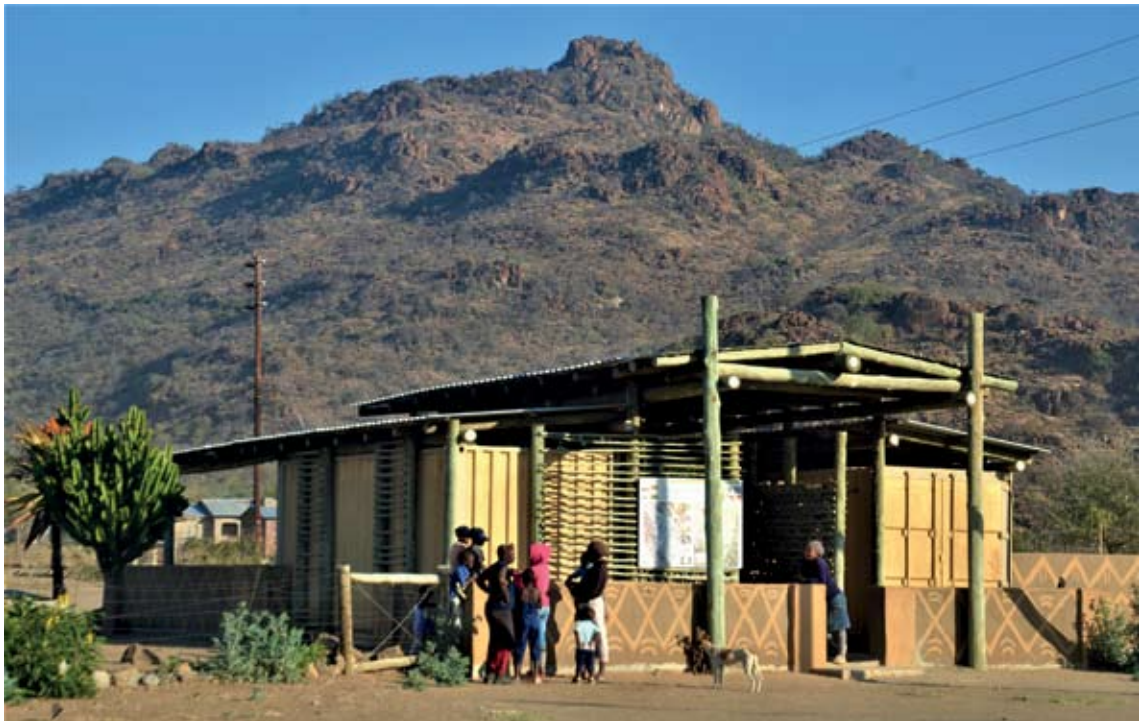
The IRUP are widely distributed and can be found in most sections of the RLS. The replacement bodies are generally barren and locally disrupt mining of chromitite ores and stratiform platinum deposits. A specialised variant of the IRUP known as "Replaced Merensky Reef" is the only situation (other than the dunite pipes) where the IRUP is mineralised.

The first of the platinum deposits to be discovered in the RLS was the Mooihoek pipe, as discussed below, but Onverwacht is the worlds' oldest underground platinum mine (except for small-scale workings in the Ural Mountains, Russia). The original resource was estimated at 55,000 tonnes with a remarkable grade of 16 g/t PGE (>90% Pt) to a depth of 76 m. As mining progressed—the pipe was eventually mined to a depth of 320 m—the resource increased. The principal ore minerals, sperrylite ($PtAs_2$) and PtFe alloy, were sufficiently coarse-grained as to be amenable to gravity concentration. Production costs were estimated at less than half the value of the ore. During the mid–late 1920s the Pt price was five times that of Au, a short-lived boom before metal prices collapsed in 1929 due to the worldwide depression.

Human Habitation and Cultural Features

The mild climate encouraged indigenous peoples to occupy the Middleveld for long periods of history. The Khoisan may have lived and hunted in the region for tens of thousands of years, but the earliest evidence of habitation by Bantu-speaking peoples dates to the African Iron Age (1600–1000 AD). Archaeological evidence has been found at Tsate (or Dsjate) in a broad valley cut into the Bushveld Escarpment (at the base of the Leolo Mountains). Between 1830 and 1879, King Sekwati and his son, King Sekhukhune, united rural communities into the formidable Pedi Empire. They established their capital at Thaba Mosega, Tsate,

The memorial to the Battle of Sekhukhune (1879).



The Tsate cultural centre, which includes a statue of King Sekhukhune, is located at the base of a resistant ridge of gabbronorite (Main Zone).

and defended their mountain fortress against attacks from tribal groups, as well as from European settlers, until 1879 when the Sekhukhune uprising was met by a combined assault from British troops and Swazi warriors led by Sir Garnet Wolseley. The Battle of Sekhukhune is marked by a memorial and the interpretive centre at Tsate.

In 1861, Alexander Merensky of the Berlin Missionary Society, together with his wife and young family (although Hans was not born at the time), was granted permission by King Sekwati to build mission stations at Kgalatlou, on the farm Schoonord, and at Ga-Ratau ("By the Son of the Lion"), at the foot of a prominent landmark (Lion of the Leolo Mountains), at Maandagshoek, approximately 15 km south of Tsate. However, this proved to be a short-lived relationship and in 1864, as a precursor to the Sekhukhune uprising, the family (and their Christian converts) were forced to flee across the Steelpoort River, the then boundary of the Transvaal Republic, to seek safety in the vicinity of Lydenburg. The family finally settled at Botshabelo ("place of refuge"), near Middleburg, where they established a mission station that includes "Fort Merensky" (built in 1865). Botshabelo has been refurbished and can be visited together with mission stations in the Eastern Limb. Botshabelo was used as a headquarters by the British army and Sir Garnet Wolseley in the subjugation of the Transvaal. In 1882, Alexander Merensky and his family resettled in Germany.

Mapoch's Caves near Roossenekal are a provincial heritage site of archaeological significance. The caves were constructed in resistant outcrops of gabbronorite by Mapoch, one of the earliest leaders of the Ndebele peoples. Extensive stone walling joins small cliffs and large boulders. In 1882, some of the Ndebele people fled to the caves after local skirmishes with both settlers and the Sekhukhune people. One of the leaders of this group was captured and hanged for his part in the killing of King Sekhukhune.

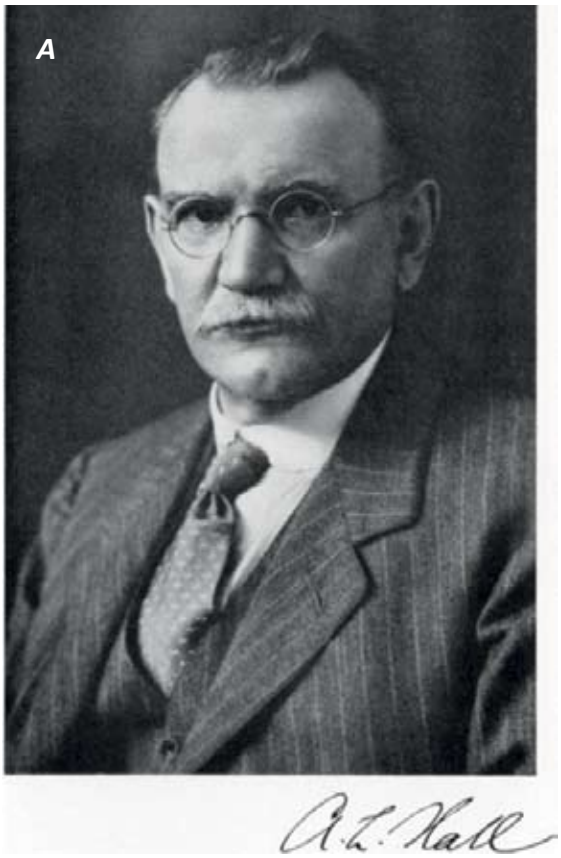
Three Historical Geologists

Arthur Lewis Hall (1872–1955) was born in England, partly educated in Germany, and spent most of his life in South Africa. Hall's 1932 memoir, based on field mapping undertaken over 29 years, remains the only comprehensive field guide to

(a) A.L. Hall (Photograph: Haughton 1956);

(b) Hans Merensky (at Pietermaritzburg, 1917) (Wikipedia);

(c) P.A. Wagner (Photograph: Spencer 1930).



the Eastern Limb. Supplies and equipment were brought into field camps in what at the time was an almost road-less region by ox wagon. The geology was brought to an international audience by the Shaler Memorial Expedition, an extended excursion in 1922 led by Hall. Notable findings included observations on the lateral continuity of layers of chromitite and Ti-magnetite and discovery at Zwartkoppies of a discordant body of dark, coarsely crystalline olivine and augite (IRUP).

Hans Merensky (1871–1952), Alexander Merensky's son, was born at the Botshabelo mission station, educated in Germany, but returned to South Africa with qualifications in both geology and mining engineering. Merensky became one of the world's most famous geologists. His discoveries included the PGE deposits of the BIC, the Namaqualand diamonds, the apatite deposits at Phalaborwa and the extension of the Witwatersrand goldfields into the Free State. Despite his fame (and wealth), Merensky was interned in South Africa during WWI due to his German heritage. After he had retired, he was restricted to Westphalia, his country estate in Magoebaskloof, during WWII. The Hans Merensky Foundation continues to operate in South Africa under guidance of his bequests.

William Bettel reported on the occurrence of platinum in chromite ore from the RLS in 1905. Merensky provided samples of chromitite layers from Sekhukhuneland that were found to contain substantial PGE (results published in 1908). These layers, possibly the LG6 and UG2, did not constitute orebodies due to the fine grain size of the mineralisation. These findings were discussed by Merensky and Hall, who were convinced for many years that the Eastern Limb would contain substantial deposits of exploitable platinum.

"Panning platiniferous ground close to the fabulously rich platinum pipe at Onverwacht. Dr Merensky is third from the right" (Caption and photograph: Lehmann, 1955). Note that the pipe occurs on the western slopes of a low, bushy ridge to the east of the Moopetsi Valley (view looking north).

Percy Albert Wagner (1885–1929) was born at Richmond (Northern Cape) to German parents and primarily educated in English in Cape Town. Despite his family origins, Wagner was interned in Namibia (then governed by Germany) during WWI. Wagner published numerous scientific articles including the most detailed reports on the dunite pipes (in 1925). Descriptions of mine workings are invaluable and his book "The Platinum Mines and Deposits of Southern Africa", published in 1929, is widely known. Obituaries in international journals described Wagner as South Africa's greatest mineralogist and geologist. His untimely death was purported to be from illness brought on by overwork.

View looking west of an eroded gulley associated with the Moopetsi Spruit at Driekop. The Merensky Reef outcrops on the low ridge (pyroxenite and norite of the Upper Critical Zone). The Bushveld escarpment is visible in the background.

1924–1929 Platinum Rush

The events leading up to the discovery of the dunite pipes and Merensky Reef are well known. Sources include original articles by Merensky and others, as well as editorial comments in the popular mining press of the time. In June 1924, Andries Lombaard, a local farmer, panned the ephemeral Moopetsi Spruit at Maandagshoek. The grey-white concentrate was dispatched to Merensky's office in Johannesburg. Merensky had first visited Maandagshoek in 1904, immediately on his return to South Africa, as this was the location of one of his father's mission stations. The assay returned high concentrations of Pt, together with and Au and Rh, and Merensky immediately set off on a visit with the financial support of a potential investor. Merensky then formed the "Lydenburg Platinum Syndicate", raising capital from friends in Johannesburg. On his return to Maandagshoek, Merensky found that Schalk and Willem Schoeman, Lombard's cousins, had found platinum in soils they had panned east of the Moopetsi Spruit. Three days later, on 15 August 1924, Merensky located high-grade Pt from rock-chip samples of "dark, lustrous crystalline pyroxenites and ultrabasic rocks" (IRUP) from the adjacent farm, Mooihoek. This was the first of the mineralised dunite pipes to be discovered and the syndicate, which subsequently located the Driekop and Twyfelaar pipes, registered claims in the mining office at Pilgrims Rest. The Onverwacht pipe was found by Rand Mines geologist F.W. Blaine in October 1924.

In September 1924, Merensky directed his team to conduct rock-chip sampling of the ultramafic layers of the RLS back at Maandagshoek, as he was convinced economic concentrations of platinum would also occur in the layered rocks. This resulted in "the far more important finding", this time by Andries Lombaard, of a mineralised layer (the Merensky Reef) at Maandagshoek. The syndicate then formed Lydenburg Platinum Limited (LPL) to provide additional capital to evaluate and trial-mine the pipes and reef. The Merensky Reef (which was first named the "Lombaard Reef") was delineated over 100 km of strike in the northern and southern sectors of the Eastern Limb. Workings from this period can be examined at Driekop (where a building of dressed anorthositic blocks is known as "Merensky's Office") and Winnaarshoek (outcrops at Maandagshoek are comparatively poor). In 1925,

LPL was purchased by Gold Fields and floated on the Johannesburg and London stock exchanges. Gold Fields established mines at Mooihoek and Driekop, a few months after the Onverwacht mine became operational.

Acknowledgements

This Geotraveller is based on an article* published jointly with the late Morris Viljoen. Morris introduced the author to the Eastern Limb in 1981, and during many subsequent field trips discussed the potential of a platinum trail or geopark.

*Scoon, R.N. and Viljoen, M.J. (2019). Geoheritage of the Eastern Limb of the Bushveld Igneous Complex, South Africa – a uniquely exposed layered igneous intrusion. Geoheritage, 11(4), 1723-1748. DOI: 10.1007/s12371-019-00360-7

All photographs, unless otherwise referenced, are by the author.

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Editor's note: *This Geotraveller—the 50th in a series that has entertained and inspired Geobulletin readers over more than a decade—is sadly also the last. Readers looking for a geological travel fix are encouraged to purchase a copy of one of Roger's latest books: 'The Geotraveller: Geology of Famous Geosites and Areas of Historical Interest' (Springer Nature) and 'Geological Highlights of East Africa's National Parks' (Struik Nature).*

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