GSSA
Geological Society of South Africa

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Morris Viljoen and the Bushveld Complex
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news


GSSA
Geological Society of South Africa

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Front cover photo:

The Merensky Reef on 23 level, K3 shaft, Marikana mine, from the MSc thesis by Nicole Wansbury. There are a number of facies variations of the reef around the western limb. This photograph shows the change from Rustenburg facies to Marikana facies.

For more explanation of the facies and their interpretation, read the article on Dr Hans Merensky on pg. 24. This year marks the 150th anniversary of Merensky's birth.

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guest editorial

Dr Luke Longridge

The Decade of the Geologist?

When I was considering studying geology at Wits around the turn of the millennium, jobs for geologists were few and far between after decades of depressed commodity prices. It was really the enthusiasm of the Wits geology faculty that led me to this career (thanks to Lew Ashwal and Sue Webb for the encouragement at the registration desk). Certainly, there didn't seem to be any obvious economic incentive at the time. Since then, we've been through the China-driven boom of roughly 2005 to 2011 (which contributed to the GDP of South Africa almost doubling during that time), and the total bust of most of the past decade, where geologists were lucky if we had a job.

We're now at the end of 2021. I can think of very few unemployed geologists, and it seems companies everywhere are on the search for geological expertise. This year has been one of dramatic increases in many metals prices, including record prices for some commodities. For example, the price of copper has reached over US$10,000/ton several times this year—the last time the metal price reached these levels was a spike to $10,190/ton in 2011. Tin prices have been above US$37,000/ton since mid-October until the time of writing in mid-November (tin's previous price record was a brief spike above $33,000 in 2011). Prices for zinc, lithium, uranium, cobalt and lead are all up this year.

Although the record prices of some commodities may be due to the short-term supply/demand imbalances from government lockdowns and supply-chain interruptions, for many commodities there appear to be longer-term structural deficits resulting from years of underinvestment in exploration and project development and a massive drive towards "green" energy and the electrification of transportation systems.

This transition appears to require vast quantities of metals, and so it appears that metals shortages could persist in the long-term, which may cause these high prices to stick around for a while. This is why some have called this the start of a new commodities supercycle, which is defined as "a decades-long, above-trend movement in a wide range of base material prices". This would lead to increased profitability for miners and increases in exploration expenditures. Already, global exploration spend is already up 35% year-on-year in 2021 (from $8.3 billion in 2020 to $11.2 billion in 2021).

The question is what this means for us, the average geologist? Clearly, the recent surge in demand for geologists is mostly a positive for those working in exploration, and is likely to lead to salary increases as competition for geologists heats up. However, it does have the potential to lead to overwork and burnout if there's too much work and not enough geologists.

Like the commodities that we search for, there has been underinvestment in training of geologists over the past decade and university enrolments in the geosciences is dropping in many developed countries. For example, universities in the UK are down from 6,105 undergraduate enrolments in geology programmes in 2016 to only 4,645 enrolments in 2019. In Australia, the trend is similar, with enrolments down from 3,485 in 2013 to 2,158 in 2017 (https://eos.org/opinions/australias-unfolding-geoscience-malady). It appears that increased commodity prices (and therefore job prospects for geologists) do lead

to more enrolments, so geoscience departments and those that work on training the next generation of geologists may see an increase in student numbers in the coming years. However, these graduates take time to train, and there is typically a lag of several years between commodity price increases and increased geology enrolments. This means that many of these students will hit the job market after the current boom. It also means the industry is unlikely to fill its current skills gap through traditional training. In addition to an increase in salaries and workloads, I expect we will see an increase in the use of automation and technology to replace some of the tasks typically undertaken by geologists (e.g., spectral scanning of drillcore to replace logging), or to improve efficiencies (e.g., using logging software).

Unfortunately, although the amount spent globally on exploration is up, South Africa's share of global exploration spend has been consistently declining since its peak of ~5% of global budgets in 2004–2005, to only 0.76% in 2021. It's not hard to understand why. South Africa is ranked 60th out of 77 destinations in terms of investment attractiveness according to the Fraser Institute's 2020 Survey of Mining Companies, and anyone who has had experience trying to obtain an exploration license from the DMR will know what I'm talking about. The SAMRAD system has long been a total disaster, and the DMR is reported to have a backlog of over 5000 applications, which would take over 10 years to clear based on pre-pandemic processing rates. I suspect that it is highly unlikely that a functional replacement for SAMRAD will be implemented timeously, despite availability of established cadastral management systems used by several of our neighbouring countries. It appears more probable that SA will lose out on the billions of dollars pouring into exploration at the moment—money that generally gets spent on geologists, drillers and the industries that support exploration. So, while geologists globally are experiencing a long-awaited boom, South African geologists are not so lucky.

So, what is a South African geologist to do? Despite the challenges of acquiring exploration licenses in South Africa, the country remains geologically prospective, so there may be an uptick in exploration by those already lucky enough to have licenses. Obviously, lobbying the government to open up the country as an attractive exploration destination once again would be a good idea, although this has been tried and has yet to yield results.

The alternative is to look globally, as myself and many of my colleagues have done. South African universities have a strong focus on economic geology and South African geologists are well regarded in the exploration sector. As competition heats up for geologists, I expect more companies to be looking more broadly for people. Many of our neighbouring countries are far more attractive exploration destinations, and there may be opportunities there for those who can obtain work permits.

Ultimately, this boom will not last forever. Eventually, the increase in investment should lead to increased production, which will catch up to demand, and both prices and money spent on exploration will drop. However, given the global focus on transforming the energy infrastructure of the planet, it appears unlikely that demand for metals will slow.

As someone who has chosen the tumultuous, boom-n-bust world of mineral exploration as the stage for my geological career, I am hopeful that we will all remember the 20's fondly as the "Decade of the Geologist".

Dr Luke Longridge

Vice President of Exploration at Canterra Minerals

CANTERRA MINERALS CORPORATION

executive manager's corner

Craig Smith

We have just received notice that flights between the UK and southern Africa are for the time being cancelled due to relatively few cases of a new COVID variant, B.1.1.529. Cases have been detected in South Africa, Botswana, Hong Kong and Israel. As of the time of writing, we do not know much about the new variant of the virus, and politicians are playing safe. It has not helped that only about half of the South African adult population is vaccinated; there might be a better case for keeping borders open if the vaccination rate was higher. Once again, we implore the membership to get vaccinated, and to get the booster once it is made available. At the cost of a minor inconvenience, it could save your life—and the lives of those you are in contact with.

The COP26 Conference is over, and some have branded the conference a failure, noting that it was just more 'blah, blah, blah', as Greta Thunberg succinctly stated. But I think some positive things came out of the Glasgow event. The GSSA does not have any inside information about the proceedings, but we have been in contact with participants. A key achievement of the conference was getting acknowledgement that climate change is real and anthropogenic in nature. Something this obvious was not enough for the climate activists, but has to be an agreed-on underlying principle to move forward. Many political leaders have been sceptics, but they will become more and more marginalised in future. There has been much post-conference analysis and discussion on the impacts for earth scientists, including a panel discussion in the GSSA Africa Exploration Projects Meeting staged 11–12 November. I would in particular like to thank Dr Sarah Gordon of Satarla, a London-based risk management consultancy, for her insights into what was happening at COP26. The basic message is that dealing with climate change is going to require more and not less earth science input. For geologists, this is a glass that is half full and not half empty. This is despite the fact that coal—and other fossil fuels—are over the long term going to have to be phased out, or neutralised with workable Carbon Capture and Storage (CCS). One of the outcomes of the COP26 was that the USA, the UK and the European Union have pledged US$8.5 billion to South Africa to transition from coal to other energy sources. The key words are 'long term'; this will be a very long process, which will require a feedstock of coal geologists for some time to come. It will also clearly require a set of protocols to ensure nothing is lost to corruption along the way—which is liable to be a challenge in South Africa.

Looking to the future, we are likely to move from the era of 'Mid-East Oil' to 'Third World Metals'—and that means a focus on Africa. South Africa will be forced to transition from its current policy framework of discouraging and impeding investment in the mineral resource sector, to a policy framework that is investment friendly and enabling. The critics of current policies need to propose politically palatable solutions going beyond the way things were done in the past. The Green Economy is going to require many more mines, which are going to be expensive to find and develop, and this message has to be driven home to the policy makers. The indication from COP26 attendees is that the political decision-makers have no understanding of this and will need to be educated. The conference was focused on coal; very little was

said about the raw materials that will be required. An example of the poor thinking is the UK's decision that all vehicles sold in the country will have to be electric in the medium term. The minerals economists note that for the UK alone this will require more than the world's entire current annual supply of some metals, particularly cobalt. The consequences of the political decisions have not been appreciated.

There are three approaches to dealing with climate change (besides doing nothing): mitigation, adaptation, and disaster recovery. All three will trigger the growth of new industries. While geologists will play a role in all three, there will be a particular focus on mitigation. Geologists of the future will require different skill sets, which means the university curricula will need to change. Professional registration criteria will need to change, and the risk factors guiding investment will change. For example, ESG principles could well trump Return on Investment in go/no go decisions.

We are winding down to the end of the year, and a number of GSSA members have not yet paid their 2021 fees. Most of these people are uncontactable, or at least not responding to email or phone messages. Please pay your fees so we can continue to offer needed support to the earth science community.

The GSSA staff and Council wish everyone a safe and relaxing end-of-year period. If you are traveling, take particular care on the roads and 'Stay Safe'.

Craig Smith

president's column

Tania Marshall

And so, another year draws to a close. After this year the words of Zayn Malik ring true: *"there comes a day when you realise turning the page is the best feeling in the world, because you realise that there is so much more to the book than the page you were stuck on."*

2021 has been a page with much negative content—from the loss of too many friends and family, to the ever-present spectre of loadshedding and everything else in between.

For the GSSA, we finished off the year on a very positive note. The Meetings Committee held a very successful "regional" meeting with delegates from all over Africa and speakers showcasing their projects and introducing various sister geological societies—the Geological Society of Africa, the West African Institute for Minerals, Mining and Petroleum, the Geological Society of Zambia and the Geological Society of Zimbabwe. This is the first ever such regional event (actually assisted by the videoconferencing forced upon us by Covid) and we hope it will not be the last.

We were also able to host the first of our purely contact events since the lockdown in 2020. The 2021 Fellows Luncheon was held at the Johannesburg Country Club at Woodmead. The daytime, partly outdoor event was a great success.

As more and more people get vaccinated in 2022 (we hope you have all done so or are planning on doing so shortly), the GSSA looks forward to being able to host more contact and/or hybrid events, getting

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back to field-trips and other face-to-face networking occasions. However, the success of online events has shown us how we can provide added benefit to our own regional and international members as well as to our sister societies and you can be sure that we will continue with many of these offerings.

The page we had all been stuck on also reflected a paucity of exploration in South Africa for a wide variety of reasons that are beyond the scope of this editorial. Suffice to say that it is hoped that the next page will have better news in this respect, starting with a working cadastre system at the DMRE so that we can more easily benefit from the rise in demand of certain minerals and metals. This new page must also be where we all promote Geoscience, to those practitioners who are, perhaps, a little jaded regarding future prospects; to those students who might be looking for a career in rocks and need to understand the multiplicity of new skills that might be required; and also to the regulatory powers that be, who need to understand better just how important the geosciences are to all of our futures. We need to take personal responsibility for this and not simply expect someone else to write the page.

By the very nature of our profession, geoscientists are required to be both optimists and pragmatists. No doubt, 2022 will bring its own challenges. But our book has many pages, and we need to turn them with courage and perseverance and more than just a little imagination.

Tania Marshall

all the news fit to print

University of the Witwatersrand

As this year draws to a close there is a lot to be thankful for, and a lot for us a School to celebrate. On 30 September there were lots of congratulations going around after the announcement of the NSTF-South32 Award winners.

Ray during his acceptance speech.

Big congratulations go to Prof. Raymond Durrheim (Department of Science and Innovation/NRF SARChI chair in Exploration, Earthquake and Mining Seismology), for being presented with the Lifetime Award for applying his many years of expertise in geophysics and seismology to make mining safer and more efficient. In an interview with Tamsin Oxford, Ray highlighted why his work has made such a difference "My work has evolved and works at the interface between science and society, doing the things that I believe are relevant, helpful and important. We are world class when it comes to mining in this country, and we really are considered a centre of excellence. People come from all over the world to work here, as they can't do this overseas. In our rockburst research, we work with people from as far afield as Japan—our underground mines are underground laboratories."

Congratulations also go out to the data team who were jointly awarded the Data for Research Award for establishing a Data Collection and Storage Facility at Wits and for developing techniques to use legacy data to explore for mineral resources, support safe

The data team (from top left): Gordon Cooper, Musa Manzi, Glen Nwaila, Grant Bybee, Susan Webb, Raymond Durrheim and Stephanie Scheiber-Enslin.

and efficient mining as well as assess and mitigate geohazards. It is well known that geological, geophysical and geochemical data are used to uncover mineral resources, but at great expense—hence the use of data collected by companies and government years ago, which are run through algorithms to interpret the data and then use machine learning to make predictions.

Prof. Tamiru Abiye unfortunately lost out this year at the NSTF-South32 Awards, but as a runner up for the Water Research Commission Award we want to take a moment to recognise his hard work in the field of hydrogeology.

Lastly on the awards front, at the Vice Chancellor's Awards on 8 October, Prof. Musa Manzi was presented with the VC's Academic Citizenship Award in recognition of the many outreach activities he does behind the scenes for the students and their communities.

Still on the theme of outreach, the School of Geosciences was involved in the Wits Integrated Experience (an outreach program to the top Grade 11 learners from some of the top feeder schools based in Johannesburg), during September and October. The scenario that the learners tackled this year was a 'cause of death' mystery at the site of a building collapse. Each faculty contributed towards determining whether the 'victim' was either murdered, or involved in the accident. As part of the scenario the victim had elevated Pb levels with evidence of potential heavy metal poisoning. The School contributed 3 different activities for the learners. Firstly, handheld XRF analyses were conducted with the learners to determine whether there were elevated Pb concentrations in the soil at the site. TIMA analyses were then conducted and presented to the learners to identify the reason for the building collapse. The Wits Isotope Geosciences Laboratory (WIGL) contributed Pb isotope data to determine what potential sources for the elevated

Musa (centre) next to Vice Chancellor Zeblon Vilakazi (right).

The Wits Integrated Experience's Earth Sciences Cluster team. Representing the School of Geosciences was: Gillian Drennan, Kimberley Beaton, Priyanka Davechand, Linda Iaccheri, Nonkuselo Madlakana and Marlin Patchappa.

Pb in the blood of the victim could be. Lastly, Palaeosciences exposed the learners to microscopic investigations of pollen samples that provided information on the victim's background.

PhD candidate Priyanka Davechand was the guest speaker at the Wits Integrated Experience Graduation where she shared her journey through academia with the learners.

The learners returned to campus 5 weeks later to present their findings, using all of the evidence they had accumulated on the information-gathering day. The presentations were all very good, making selecting the winning schools very challenging. Luckily, however, the university was able to offer two first, second and third prizes each this year. The two winning schools each received a cheque for R50 000 to be used towards developing teaching and learning facilities at their schools. Overall, the Wits Integrated Experience was a great success; with the learners enjoying the exposure to the many different facets of what the Geosciences have to offer. View a short YouTube video of some of the highlights here: https://youtu.be/vYTg9YIUsUw.

*Compiled by **Sarah Glynn** from various contributors within the School.*

University of Stellenbosch

Successful completion of the BSc Honours year and all field school modules

The 2021 academic year is winding down, and for our Honours cohort, the academic year is already completed. On Friday 19 November, the final Honours defences were made by oral presentation, and both external examiners (Prof Russell Bailie (UWC) and Prof Chris Curtis (UJ)) were highly impressed by the standard and calibre of the research projects. Overall top performers were Brynn Hunink in the Environmental Geochemistry BSc Hons stream, and Katrien Wassenaar in the Applied Geology BSc Hons stream. Congratulations to these two students and to the entire Honours cohort for making a success of the year, and for making the most of the learning opportunities. We look forward to welcoming some of you back into our MSc program in 2022, and wish the rest of you the best of luck with your future

Top performing Honours students from the 2021 SU Earth Sciences cohort. Left: Brynn Hunink, top achiever in the Environmental Geochemistry stream; Right: Katrien Wassenaar, top achiever in the Applied Geology stream.

careers, where hopefully you will make meaningful contributions to the southern African and global geosciences sector.

Undergraduate programs are currently concluding, with final exams being written at the end of November and start of December. Importantly, and since we regard field exposures as a crucial component of the training syllabus, we are very pleased to report that we ran all of our key fieldwork programs over the duration of the year (despite having to work around the restricting Covid measures). Finally, the year has also seen conclusion of several MSc and PhD studies, with many of our students achieving *cum laude* (>75% aggregate mark) for their research work (much of which also has been published in various international peer-reviewed journals). We look forward to celebrating with you during the December graduations.

Head of Department Prof Alex Kisters awarded the prestigious Draper Memorial Medal

We are exceedingly proud of our Head of Department, resident structural geologist, and self-proclaimed

Prof Alex Kisters posing in front of the geology of South Africa, a topic to which he has devoted much of his illustrious career.

PhD candidate Laurine Travers (U. Montpellier/ U. Johannesburg), Dr Alain Chauvet (U. Montpellier), and Dr Bjorn von der Heyden (SU) prepare to go underground in the abandoned Clutha Mine (Barberton greenstone belt).

'part-of-the-furniture' Prof Alex Kisters on his recent award. The Draper Memorial Medal is awarded annually by the Geological Society of South Africa for career-long exceptional contributions to geological science, with particular reference to the advancement of South African geology. Prof Kisters has certainly achieved this through his high-impact research, which has focussed on topics ranging from the Barberton Greenstone Belt, the Damara Belt, the Namaqua-Natal metamorphic province, Karoo dyke swarms, the Saldania Belt and several further-flung research sites (Greenland, Tanzania, Zimbabwe). This body of work is exceedingly well-cited by other researchers (Google Scholar: >2600 citations), and in addition to research outputs, he has contributed significantly to training of future generations of southern African earth scientists (i.e., he has graduated more than 65 BSc Hons, 20 MSc and 10 PhD graduates). His leadership qualities manifest in the way he continues to guide the SU Department of Earth Sciences from strength to strength, achieved in part by setting an example in his approaches to and results arising from his teaching and research endeavours.

A return to fieldwork and active north–south collaboration

Some members of the International Research Project BuCoMO (Building Continents from Mantle to Ore) recently met to conduct fieldwork on the Barberton greenstone belt and associated granitoids. The people involved were Alex Kisters, Bjorn Von der Heyden, Gary Stevens, Tahnee Otto (PhD student), Mariana Werle (MSc student) and Marcel Vinícius (PhD student) from Stellenbosch University; Jean-François Moyen from the University of Saint Etienne; Alain Chauvet and Laurine Travers (PhD student) from the University of Montpellier; as well as Steve Kitoga (PhD student) who is a joint degree student between the University of Clermont (Auvergne) and the University of Stellenbosch. Three projects were worked on during November 2021: structures associated with gold mineralisation in sites of active and historical mining; the petrogenesis of ~3.1 Ga syenites and syenogranites; and the search for seafloor alteration signatures in TTG plutons. For most of the participants this was the first major period of fieldwork since the start of the Covid pandemic and it was a truly glorious experience to once again be actively engaged in research in the field.

Top performing post-doc

Stellenbosch University annually honours its top performing post-doctoral research fellows. This year, Dr Jared van Rooyen, a post-doctoral researcher in the Department of Earth Sciences, isotope hydrologist in the Biogrip unit of the Central Analytical Facility, and chair of the Early Career Hydrogeologist Network (ECHN) was one of the 20 Stellenbosch University post-docs who received this award. His recent publications have considered the distribution of tritium (a hydrogen isotope) in groundwater, and how this distribution can be used to inform detailed hydrogeological models. Congratulations to Jared!

Bjorn von der Heyden

Dr Jared van Rooyen, recent recipient of a SU post-doctoral researcher excellence award.

changes

Exploration Technology Changes

New technologies are finding their way into the geological exploration sphere, with a couple of game-changer technologies set to radically change the industry.

The idealised image of the exploration geologist walking through the bush, chipping away at rock outcrops with a hammer and making hand-drawn maps, for months on end, or sitting next to a drill rig in a remote location, is slowly fading. The modern exploration geologist now finds themselves conducting an increasing amount of their time behind computer screens, working to find the next big discovery.

The first major change is the migration of decades' worth of exploration data from private and government exploration programs. All the data are increasingly being captured into databases and accessed around the globe. Paper geological maps are digitised and ingested into GIS platforms along with a myriad of loose core logs and geochemical results, from soil grid sampling programs to percussion chip and core sample analyses. Manual evaluation and sorting of these results would have taken months if not years to conduct. The increased access to powerful off-site processing facilities has allowed the modern exploration geologist to run archive data through Artificial Intelligence (AI), Deep Learning and Neural Networks to define and delineate potential target areas, in a fraction of the time. All of these systems do, however, require a significant amount of training data, which still needs to be created manually by the operator. However, as more reference sets become available, the accuracy and effectiveness of these methods will also increase.

This also includes historic reports and studies that gathered dust in libraries, which are now made available online. Forgotten deposits from the colonial era can now also be "re-discovered" by simply filtering through the old geological survey reports and maps. A recent example is the gold rushes in Malawi, where a small group of Indian venturers accessed historic data from the then Nyasaland Geological Survey, to locate historic low-grade known gold occurrences. The result was a short-lived gold rush to these areas where the low-grade, near-surface deposits were mined and sold to the venturers. The same is happening with old Belgian reports from areas in the now Democratic Republic of Congo (DRC), Rwanda and Burundi to locate vein-hosted deposits of commodities that are essential to the current fourth industrial revolution (4IR), such as cassiterite, monazite and other minerals.

Historic core can also be re-investigated using hyperspectral imaging. The core is cleaned and fed through the hyperspectral instruments. Each mineral has a unique spectral signature, which allows detection of trace amounts of mineralisation that would previously have been missed with visual inspection and logging for sampling of the core. This is also a massive boost to increasing the geometallurgical characterisation of deposits, which moves the exploration phase faster up in the mining value chain. This is an incredibly effective way of detecting marginal deposits, which can now be extracted economically with improved recovery and beneficiation processes. The implication is that current operations can be expanded to nearby satellite intrusions, brown-fields sites can be revisited and re-evaluated, or operations placed under care-and-maintenance can be revitalised.

Increased accuracy and precision of handheld XRF devices also allow for quicker turn-around times and validation of geochemical results, which guide the focus area of exploration activities, such as chip logging. This aids in defining the exploration footprint more cost- and time-effectively.

The advent of more mobile modular processing plants has allowed bulk sampling of exploration sites to be conducted effectively and increase the recoveries from the bulk sampling to such an extent that more of the initial exploration costs can be recovered in the initial phases of the operational ramp-up period.

Regional exploration for new deposits can also be performed using both satellite and airborne hyperspectral imaging. Hyperspectral imaging is applied to delineate regional geological structures and lithologies based on the outcrops. In the case of large exploration or prospecting lease areas, the focus areas can be delineated from interpretation of these results. Due to the cost consideration, satellite-based hyperspectral imagery is used on a regional scale to identify areas of interest. Once the areas of interest have been identified, the higher-resolution, but more expensive, airborne surveys can be conducted in parallel with airborne geophysical methods.

The funding of exploration activities is also potentially set to change. Previously, exploration required access to extensive risk financing or venture capital, only available to large companies. Crowd-source funding for exploration projects is now in the concept phase, where the details are being worked out. The use of blockchain technology to create a virtual crypto-coin is in the final proof-of-concept stages. In brief, it entails the generation of a virtual coin that can be bought by individuals at the start of the project during the capital-raising phase, with the guarantee that the virtual coin can either be traded or exchanged for the value of the coin or physical material once the actual mining and production of the mineral or metal has commenced, over the life-of-mine. There are, however, still a number of legislative and regulatory hurdles that need to be sorted out.

Regardless of all of these technologies, the exploration geologist will still find the opportunity to go to the field to conduct groundtruthing. Considering the large extent of land that has not been explored to date, due to inaccessibility caused by dense vegetation or extreme conditions in the deserts or arctic regions, the potential for exploration remains high.

Nicolaas C Steenkamp
Independent Consultant (ncs.contract@gmail.com)

distinguished alumnus

Rochelle Wigley: a distinguished alumnus of South African geoscience

Out of the many South African geoscientists practising their craft abroad, and away from the local limelight, as it were, I would like to take this opportunity to highlight the achievements of Rochelle Wigley. Rochelle was born and raised in the Eastern Cape (East London). After completing her BSc and Honours degrees at Rhodes University, she continued her postgraduate studies at the University of Cape Town, completing a MSc (1995) and a PhD (2005), combined with employment at the Council for Geosciences in South Africa (Belville), developing her expertise and interests in improving our understanding of the ocean floor. In 2007, she was one of six candidates, selected annually from an international pool of applicants, to undertake GEBCO (GEneral Bathymetric Chart of the Oceans) training at the University of New Hampshire (USA)—a one-year programme that she successfully completed. She continued to develop and apply her expertise in South Africa, but subsequently returned to the University of New Hampshire, where by 2012 she was employed as the Director of the Indian Ocean Project for GEBCO. She subsequently acquired a Nippon Foundation/GEBCO Postgraduate Certificate in Ocean Bathymetry (2014), becoming the GEBCO Project Director at the Center

for Coastal and Ocean Mapping / Joint Hydrographic Center (CCOM/JHC).

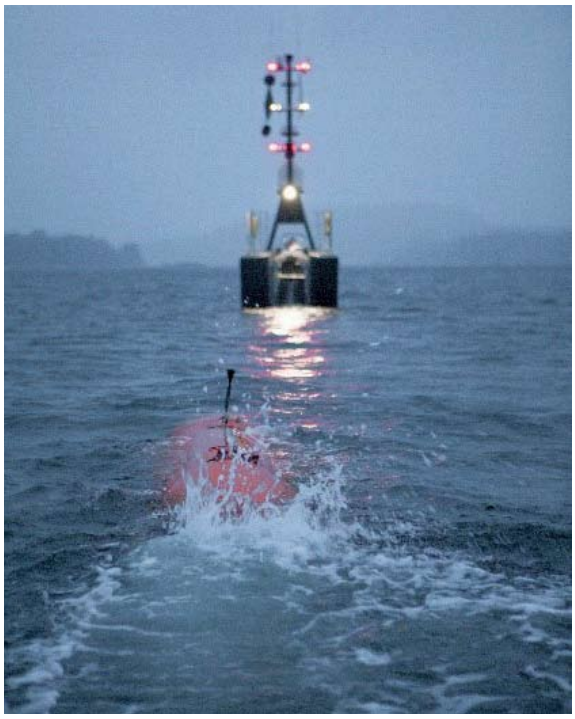
Rochelle made the international science news in 2019 as the Project Coordinator for the International GEBCO-Nippon Foundation Alumni team, who were awarded a $4 million USD prize (the Shell Ocean Discovery XPRIZE) for their development and application of the SEA-KIT Uncrewed Surface Vessel (USV) Maxlimer, used in conjunction with the Kongsberg Maritime HUGIN Autonomous Underwater Vehicle (AUV) System. This endeavour was conducted towards the stated ambition of the Nippon Foundation-GEBCO Seabed 2030 Project of mapping all of the world's oceans. The XPRIZE goal for mapping includes not only high-resolution 3-D spatial mapping, but also collecting high-definition images of biological, archaeological and geological features on the sea floor. The team's strength was that they also focused on the data-to-information pipeline, ensuring that the collected data were accessible as useful information. One year later, in July–August 2020, the award-winning AUV designed by her team was put to work, successfully mapping around 1000 square kilometres of Atlantic sea floor off the European coast, with team members remotely managing survey operations. The USV Maxlimer would likely be considerably busier if it were not for COVID-related restrictions over the past year. This is all just the beginning of a programme designed to map 100% of the ocean floor by 2030, which is not all that far off. Dr Wigley, who continues to be based at the University of New Hampshire, is the first and, to date, the only woman directing such a team to win this prestigious prize.

Dr Wigley also teaches and trains students and professionals in bathymetric techniques, and has published over 50 scientific papers, reports, maps and conference proceedings, with more than 1200 citations to her work.

Why is ocean floor mapping important?

Is ocean floor mapping all just about finding the wrecks of the Titanic and the Bismarck, and looking for lost Atlantis? No!

Remote Control Showing launch of the HUGIN AUV from SEA-KIT USV at Horten, Norway.



Lining up for HUGIN AUV recovery into SEA-KIT USV. (Photos courtesy of Inner Space Center and R. Wigley)

Mapping of the seafloor represented one of the key revelations in our understanding of how the Earth works. Work conducted by navy pilots and geologists in the 1950s revealed that the topography of the ocean floor was dramatically different to the Earth's surface. This eventually led directly to the discovery that the Earth's tectonic plates could move relative to one another and to the Earth's interior, which completely changed the way we view our planet and its geological history. This includes not only how and why mountains and volcanoes form and explaining the past distributions of plant and animal life across the planet, but also factors influencing climate change and mass extinction events. Subsequent more detailed studies (using submersibles, which are small research submarines) of mid-oceanic ridges, which are seams in the ocean floor where new ocean crust is created by underwater eruptions, led to the discovery of unique ecosystems fuelled by volcanic

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heating, far below the reach of the light and energy of the sun's rays. Recent mapping of ocean floor (in the last five years) has revealed new volcanoes (one bigger than Mt Vesuvius, found on the Indian Ocean floor), new deep water coral reefs, and helped to constrain fishing resources.

Other features that distinguish the sea floor and the deep ocean from continents, polar ice caps, and the more accessible offshore shelves next to the continents, include:

- *Reservoirs for hydrocarbons in the form of frozen gas hydrates (also known as clathrates) in deep ocean sediments*. These represent possible significant additional non-renewable fuel resources, and also reservoirs, or sinks, for potentially atmospherically damaging hydrocarbons were they to be spontaneously released as gas, such as by unfreezing them in warmer ocean waters. This is in addition to the considerable known resources of offshore oil and gas, as well as other mineral commodities such as diamonds, manganese and other metals that collect on the ocean floor.
- *Habitats for deep ocean life that does not depend directly on daily access to warmer and brighter near-surface waters, as well as habitats for deep-diving mammals*.
- *Reservoirs for made-made waste*. This might have floated once to get it out into the oceans, but eventually it biodegrades under the influence of corrosive salt water and sunlight, and the residues of those materials collect on the ocean floor with, at present, largely unknown consequences and implications.
- *The "source" of ocean currents, where cold deep ocean waters flow as submarine rives in the lower ocean*. Their distribution and role in ocean function is a subject of ongoing study.

On this evidence, the most exciting and profound discoveries from ocean floor mapping have been the ones that nobody expected, and nobody was even looking for specifically. Who knows what more detailed geological and biological mapping might reveal? Only 20% of the ocean floor has been examined, and only 10% in any detail. There is a lot out there yet.

Ocean floor mapping challenges

Current research vessels cost up to $100,000 per day to operate, and could take hundreds of years to map the sea floor at the current rate. The designation of automated, un-manned submersibles to this job can do it better, faster, more economically and more efficiently.

Logistical challenges include creating a device that can survive the hardships of ocean currents and waves and obstacles, can interface with a wide range of vessels and software, and can remain stable and rightside-up in order to function at its highest level under unpredictable conditions. It must be able to collect and transport suitably large volumes of materials of interest from the ocean floor, and travel long distances without maintenance or recharging.

Dr Wigley's team's device can collect and carry and dispense up to 2.5 tons of material, and is designed to survive impacts at sea, and is self-righting (if it tips over, it tips itself back upright automatically). The awarding of the XPRIZE indicates that their design performed best of all of the competing alternative designs at these tasks.

What is the XPRIZE?

The Shell Ocean Discovery XPRIZE was set up in 2015 by a non-profit organisation based in California (USA) following the disappearance of Malaysia Flight 370 over the Indian Ocean, which prompted extensive prolonged international searches of previously poorly studied areas of the oceans. In the end, eight teams competed for the prize, involving six nationally identified teams from the USA (two), Japan, the UK and Europe, as well as and one international team (Dr Wigley's). A total of 37 AUVs (autonomous underwater vehicles) participated, with Dr Wigley's team devising only one of those—the winner! (Many

The Maxlimer at rest (from MarineTraffic.com in the UK)

teams constructed multiple vehicles, with the Swiss team contributing 20!)

Seventeen such prizes have been awarded in a variety of science and technology areas since 1994, comprising over $140 million in prize money, starting with a $10 million XPRIZE for private spaceflight and going from there.

Steve Prevec
Department of Geology, Rhodes University

the bushveld complex

Morris Viljoen and the Bushveld Complex

Morris Viljoen was associated with the University of the Witwatersrand (Wits) throughout his adult life, ultimately serving as Professor of Mining Geology for many years. His first major encounter with the Bushveld Complex, however, was not through the university, but rather when employed by the Johannesburg Consolidated Investment Corporation (JCI) in 1964 to map the southern sector of the Eastern Limb of the Bushveld Complex. He was specifically tasked with recording all outcrops of the Merensky Reef, as well as any chromitite or titaniferous magnetite layers, but also mapped discordant pegmatite bodies. The pegmatite body that Morris identified on Spitskop was sampled for a study some 20 years later and is generally included in field excursions. By the late 1970s, Morris was consulting geologist to Rustenburg Platinum Mines (the forerunner of Anglo-American Platinum). While with JCI, he initiated and assisted with obtaining material and funding for a broad range of research projects, not only at Wits but also at Rhodes University with a group led by Professor Hugh Eales, including MSc and PhD studies undertaken by Billy De Klerk, Johan Kruger, Mike Botha, Andrew Mitchell, and Roger Scoon. In addition, Morris was external examiner to the MSc programme in Exploration Geology at

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Rhodes over many years, mostly in conjunction with Professor John Moore.

Morris's lifetime obsession with compiling details of mineral deposits soon led to seminal articles on the company mines, published in 1986 by the Geological Society of South Africa in a two-volume special, "Mineral Deposits of Southern Africa". These articles, co-authored by Morris with a team of mine and exploration geologists, include detailed mine plans and maps, cross sections, and stratigraphic columns. They remain an invaluable resource and form the basis for the format of geological science that Morris espoused and taught throughout his career. Descriptions focussed on the Merensky Reef resulted in subsequent articles on the origin of this prominent orebody, including fundamental observations on the occurrence of enigmatic regional and localised "pothole" structures. Morris was co-author of one of the earliest publications on the isotopic systematics of the Platreef, with Grant Cawthorn as the senior author. Morris had an exceptionally detailed knowledge of this component of the Bushveld Complex, having been involved in mapping of the early underground exploratory mining on the Overysel property, an area now incorporated into a giant open-pit operation. Apart from his contributions on the layered rocks, Morris's interest in the discordant bodies of the Bushveld Complex resulted in him being jointly responsible for naming a new rock-type. The "iron-rich ultramafic pegmatite" bodies (IRUP) were introduced to an international audience in an article published in *Economic Geology* in 1985. In some cases, the IRUP bodies crosscut and bedevil mining of the layered reefs, but in the Mooihoek and Onverwacht pipes they were the first PGE orebodies to be exploited in the intrusion. Morris's involvement with these historically significant orebodies developed logically into a passion with Geoheritage, including publicising the possibility of establishing a "platinum trail" in the Eastern Limb of the Bushveld Complex in the local *Geobulletin*, as well as in an international journal, *Geoheritage*, in 2019.

Morris published a comprehensive overview article on the mineralised reefs in the Bushveld Complex in the journal *Episodes*, as part of the 35th International Geological Conference (IGC) held in Cape Town in 2016. Morris was a major contributor to the conference, at which he presented multiple papers, including an overview of his ground-breaking work in the Barberton Mountainland with his twin brother Richard, which resulted in the naming of a new rock type, "komatiite", and its landmark identification as an ultramafic lava. Morris organised and led three field excursions as part of the IGC, including one to the Eastern Limb of the Bushveld Complex. The interest in Geoheritage resulted in articles in "Africa's Top Geological Sites", a Geoheritage-style book jointly edited by Morris and Richard as part of the 35th IGC.

During the latter part of his life, Morris together with Richard established several exploration projects in the Bushveld Complex. The first of these led to a major drilling program, which led to the sale in the mid 2000's of the Akanani project, one of the largest unexploited resources of PGE associated with the Platreef orebody. As part of Bushveld Minerals, Morris and Richard established an extensive exploration project directed at the iron and vanadium deposits in the Upper Zone of the northern limb. A drilling programme culminated in identification of multiple orebodies and a new understanding of both the stratigraphy and the mineralisation in this segment of the intrusion. Morris published some of this information in 2016. Subsequently, Bushveld Minerals purchased an operating vanadium mine in the western limb. In these ventures, Morris and Richard applied a strategy espoused by Hans Merensky, that of directing their energy towards deposits with large resources.

On a personal note, I have been extraordinarily fortunate to have had Morris as a friend and geological mentor for more than 40 years. As part of supervising my PhD thesis, Morris insisted I spend almost a year in the field mapping and sampling. There was no quick fix to Morris's approach to geology: it was based on obtaining a thorough understanding of field relationships and compiling detailed observations. Morris guided me on innumerable field trips, many to the Eastern Limb, and was instrumental in inviting me to lead international field trips to the

region, including for the SEG conference held in 2008, for which he and Richard were the principal organisers. A mark of his professionalism was that for our trips for the 35th IGC, Morris insisted on 3–4-day reconnaissance trips. We revisited his favourite geosites and spent hours reminiscing about localities such as the Dwarsriver UG1, the Merensky Reef outcrops, and the Onverwacht pipe, which he had introduced me to almost 40 years earlier. Morris was instrumental in putting together and co-leading the MINSA field excursion to northern Tanzania in 1995. I was also fortunate to be invited on field trips to visit areas where Morris was involved with his most recent passions, notably the geology of the Kruger National Park. Morris lived for the last years of his life in the Garden Route of the Western Cape Province and recently published a field guide to the geology of this most scenic region. The COVID pandemic took the life of both Morris and his life partner Maureen during August of this year, and if it weren't for this Morris would no doubt have been assembling his maps and hammer and planning yet another geological adventure.

Submitted by ***Roger Scoon*** *with input from* ***Richard Viljoen***

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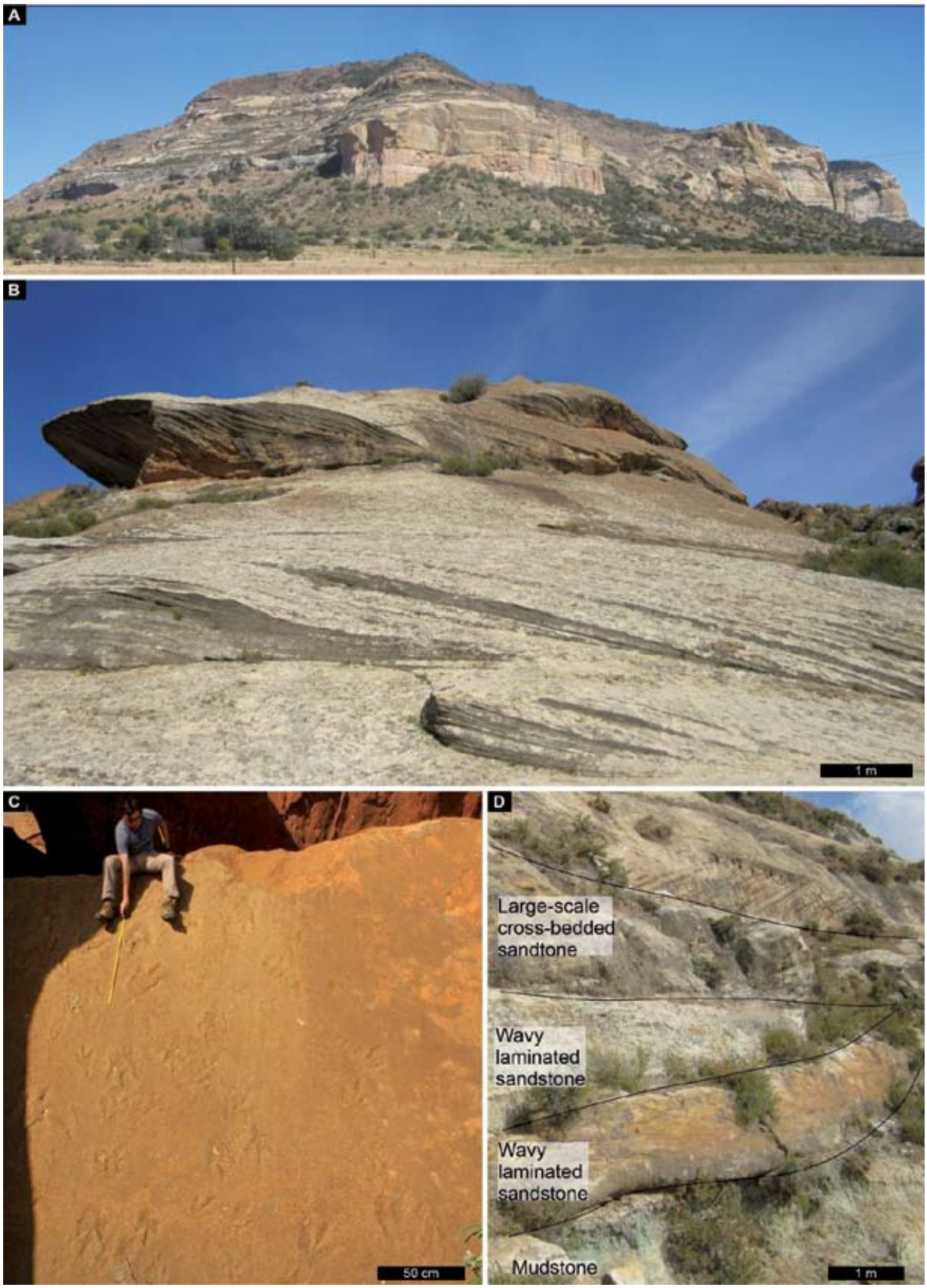
REI report

REI Report: The detrital zircon age dating of the iconic Clarens Formation, Karoo Supergroup, southern Africa

Forming impressive sandstone cliffs, the Lower Jurassic Clarens Formation is the youngest sedimentary unit of the Stormberg Group in the main Karoo Basin of South Africa and Lesotho, and has several facies equivalents across southern Africa. The aeolian origin of the thick to very thick, massive, and large-scale cross-bedded sandstones is well-established, and the interaction of lacustrine, fluvial and aeolian sedimentary processes during deposition have also been noted by numerous prominent South African researchers, including Alex du Toit, Nic Beukes, Mike R. Johnson and Pat Eriksson. However, there is still a limited understanding of the interaction of the main sedimentary processes, and their geodynamics, including depositional rates. Therefore, the aim of our ongoing basin-wide doctoral study is to: 1) test the regional validity of the tripartite facies zonation by reconstructing the spatial and temporal facies changes at a high(er)-resolution; 2) show how the complex aeolian, fluvial and lacustrine processes interacted within this Early Jurassic erg system, and 3) assess the role of preservation bias in the distribution of the various facies within the main Karoo Basin.

Our preliminary results already suggest that several wet interdunal and permanent lake systems that developed during humid phases of the Clarens depositional episode. The interdune facies are characterised by massive to laminated, green to dark grey mudstones that are associated with lenticular sandstones preserving ripple marks, hummocky cross-stratification, soft-sediment deformation structures, microbially influenced sedimentary structures, desiccation cracks and vertebrate footprints (particularly dinosaur footprints). The current Sinemurian to Pliensbachian age estimate for the Clarens Formation is derived from the vertebrate biostratigraphy and radioisotopic dates from the conformably underlying Elliot Formation and overlying Drakensberg Group, respectively. Dating of detrital zircons in the Clarens Formation, thus, is key not only for a firmer age determination but also for a better understanding of the spatiotemporal facies distribution, as well as rates of sedimentation and climatic cycles in this vast desert system of southern Gondwana.

In 2020, we applied for financial support from the GSSA's Research Education and Investment Fund (REI) to complete the LA-ICPMS analysis of detrital zircons that we extracted from Clarens sandstone samples, and in June 2020, we were excited to be awarded an REI student research grant towards this dating project. Despite the challenges related to the national lockdown due to the COVID-19 pandemic, we were able to complete the LA-ICMPS analysis of the samples at the EARTHLAB (University of the



A) Clarens Formation at Wonderkop farm, Free State, South Africa. Note the massive sandstones at the base of the cliff.
B) Large-scale cross-bedded sandstones characteristic of the middle zone, Eastern Cape, South Africa.
C) Tridactyl dinosaur footprints on a fallen sandstone block, Tsikoane, Lesotho (for details, see Abrahams et al., 2021).
D) Wet interdune facies of the Clarens Formation, Makanyaneng, Lesotho.

Witwatersrand) in collaboration with Prof Robert Bolhar, and in true pandemic style, were able to do this remotely by late November. All data have been received and interpretation with regards to maximum depositional ages and provenance for the Clarens Formation is underway. The results will be incorporated into the PhD thesis (to be submitted for examination in late 2021) and then published as journal articles. We are grateful to the GSSA REI committee for the financial support towards this project and their generosity in supporting postgraduate students in the geoscience community. We also look forward to sharing our results at the GSSA colloquium scheduled for 2022.

Howard Head *(PhD student) and* ***Emese Bordy*** *(supervisor), University of Cape Town*

IUGS, IGCP, IGC

South Africa's role in geoscience globally: the IUGS, IGCP and IGC

South Africa plays a crucial role in geoscience globally and this is through its involvement and support to the International Union of Geological Sciences (IUGS), the International Geoscience Programme (IGCP), and the hosting of the International Geological Congress (IGC). Such activities are formally administered through the South African National Committee (SANC), whose affiliation to these international bodies is funded and co-ordinated by the National Research Foundation (NRF) of South Africa.

The South African National Committee (SANC) for IUGS and IGCP

The SANC comprises 8 members appointed by the NRF, with representation from industry, academia, governmental organisations, as well as earth science membership bodies including the Geological Society of South Africa (GSSA; www.gssa.org.za), South African Geophysical Association (SAGA; www.sagaonline.co.za and the South African Institute for Engineering and Environmental Geologists (SAIEG; www.saieg.co.za). The committee currently comprises Dr Geoff Grantham (Chair, UJ), Dr Sharad Master (Wits), Sue Frost-Killian (MSA), Dr Craig Smith (GSSA), Prof. Ray Durrheim (SAGA, Wits), Dr Trishya Owen-Smith (UJ), and Dr Hayley Cawthra (CGS, Bellville WC office). An Engineering Geology representative will be appointed in 2022. In addition an ex-officio member, a previous chair of the committee, Prof. Hassina Mouri, is currently the Vice President on the executive of the IUGS, having been elected in November 2020 for a period of 4 years (until 2024). The committee activities and appointment of its members are managed by the NRF, represented by Ms Busisiwe Molefe.

The role of the SANC involves representing South African interests at the quadrennial IUGS General Assembly, where adhering countries (council members) discuss and decide on various matters including the host of the International Geological Congress (IGC), the flagship event of the IUGS, and to elect the officials of the IUGS as well as representatives to serve on the various committees and structures under the auspices of the union. Representation and voting rights at the business meetings are typically aligned to the financial membership fee made by the adhering countries in proportion to defined contributions, with voting proportions varying between 1 and 10 votes. South Africa's membership level currently permits 4 votes, with wealthier nations typically subscribing for 10 votes in business meetings.

IUGS

The International Union of Geological Sciences (IUGS; www.iugs.org), is one of the world's largest and most active scientific organisations and a member of the International Science Council (ISC; https://council.science/).

12 IKC POSTPONED TO 2022

The 12th International Kimberlite Conference is postponed to

15 - 19 August 2022

The postponement reflects the COVID-19 situation and resulting difficult times for the diamond industry together with the goal of maintaining the symbiotic mix of industry and academia that makes International Kimberlite Conferences unique. This change has the full support of the International Kimberlite Conference Advisory Committee

The intention is to host the 12IKC at the same venues in Yellowknife, with the same scientific programme, field trips, short courses and social events, but delayed by one year.

Further updates will be available on the 12 IKC Bulletin Board as well as via the 12 IKC mailing list.

We look forward to welcoming you to Yellowknife in 2022!

Prof Hassina Mouri, Vice President of the IUGS for 2020–2024.

The union encourages international co-operation and participation in the earth sciences in relation to human wellbeing. It works in close collaboration with a number of international organisations, such as the ISC, in line with its vision of "*Science as a global public good*", and with UNESCO, in order to contribute to the 2030 agenda of the United Nations Sustainable Development Goals. It provides financial support to various research activities, such as the International Geoscience Programme (IGCP) in cooperation with UNESCO, as well as many other research initiatives, task groups and commissions that are all very important in advancing research in geoscience for the benefit of society.

Currently the union is busy preparing for its 60th anniversary, to be celebrated through a series of scientific events during the year 2022. The union disseminates geoscience information globally through various platforms including the journal *Episodes*, which is the flagship quarterly journal of the Union published in Seoul, Korea. *Episodes* is an international and interdisciplinary open-access and free-publication journal that covers all geoscience disciplines (https://www.iugs.org/episodes). This is in addition to various other platforms such as a monthly e-Bulletin for current news and events (https://www.iugs.org/ebulletin), and social media through Facebook (https://www.facebook.com/iugspage), LinkedIn (https://www.linkedin.com/company/international-union-of-geological-sciences-iugs/), and Twitter (https://twitter.com/theIUGS).

IGCP

Besides contributing to the general assembly meetings of the IUGS, held during the IGC event, an additional role of the SANC is to assist with the pre-evaluation of proposals for funding from the IGCP. The IGCP is a research program jointly funded by UNESCO and IUGS, where applications for funding in support of geoscience activities can be made annually.

Up to 60% of nations involved in this programme are classified as developing—this includes the African countries. This programme has been considered one of the most successful channels for the transfer of knowledge from the developed to the developing nations.

A call for applications is open to all UNESCO members of state early in the year with a final deadline for submission of applications to the UNESCO office fixed to mid-September and a pre-evaluation deadline for submission to the SANC is fixed to the last week of August (3 weeks before submission to UNESCO). Financial support is aimed at funding activities related to research initiatives through workshops. The funding is not intended to support formal research projects themselves and it is assumed that the latter should be funded from alternative sources. Successful projects are typically funded for three to five years, with the level of support typically being of the order of $10 000 per annum. Five focussed themes are proposed by IGCP, however all applications within the geoscience field are considered during the evaluation process. For the year 2021, only one special topic was agreed on during the 6th council meeting held in March 2021, namely "Enhancing Societal Acceptance of the Sustainable Development of Earth's Geological Resources".

Applications are evaluated by a scientific committee comprising several experts for each theme. This is followed by a thorough evaluation and ranking of the application by the council and then a recommendation for funding to UNESCO. The amount of funds allocated per project depends on the scientific merit of the project, its objectives, the importance of the collaboration, and involvement of young and early

career scientists and females, among others. The IGCP council is composed of 6 members appointed for a period of 4 years by the UNESCO Director General.

Together with the 60th anniversary of IUGS, the IGCP will be celebrating its 50th anniversary in 2022.

Further information on the IGCP programme, its structure and activities can be found at https://en.unesco.org/international-geoscience-programme.

IGC history

South Africa has hosted the IGC event twice in its history. The first occurred in 1929, when it hosted the 15th IGC in Pretoria. One of the major topics discussed at that congress was the debate on continental drift, which was lead by Alex du Toit. The second was in 2016, when it hosted the 35th IGC held in Cape Town. The 36th IGC was planned to be held in New Delhi India in 2020, but was initially postponed to 2021 and then later cancelled due to the Covid-19 pandemic. All activities (including the website) and refunds related to participation to this event have been closed by the end of October 2021.

The next IGC (37th) is scheduled for 2024, to be held in Busan, Korea (www.igc2024korea.org). The webpage in support of the congress is actively permitting registrations of interest, but with many pages remaining to be populated, from the attendant uncertainty as to what the situation is with the Covid-19 pandemic going forward. Further information on the history of IGC can be found at https://www.iugs.org/igc.

IGC —South Africa 2016 Legacy

The 35th IGC hosted by South Africa in 2016, which was managed mainly by the Geological Society of South Africa and the Council for Geoscience, with support from several other institutions and organisations, was yet another successful event in its history on the African continent and globally. Surplus funds generated from the 35th IGC were used to set up the 35thIGC Legacy Fund as a registered not-for-profit company, with the intent of funding research in the earth sciences, with a particular emphasis on Geoheritage. The first round of funding in 2019 was aimed at supporting participation in the 36th IGC in India, but with the cancellation of the conferewnce, the Legacy Fund is in the process of collecting unspent funding from grant recipients. The second funding round was in 2020/21, with several Geoheritage projects scheduled for completion in 2021 having been supported. Applications for the funding round in 2022 can be submitted until December 31 (www.35igclegacyfund.org.za). The goal of the Fund is to provide support for the earth sciences, while at the same time benefitting from growth over time.

*Compiled by **Geoff Grantham** (Chair of the SANC), **Hassina Mouri** (VP-IUGS and IGCP council member), and **Craig Smith** (GSSA and IGC Legacy Fund manager)*

Some of the members of the South African National Committee for the IUGS, with representatives from the NRF.

geoheritage

Dr Hans Merensky

Dr Merensky was born 150 years ago (16 March 1871; in Sekhukhuneland). He had astonishing geological insight into many different geological settings. The title of the biography by Lehmann, "Look Beyond the Wind",[1] neatly epitomises his remarkable intuition. There is also another biography by Machens[2] and a number of other entries about him on websites. This writer is unqualified to provide much beyond that. I can only summarise what became his most important contribution, namely the discovery of the Merensky Reef in 1924 (previously compiled in an article in the *South African Journal of Geology*,[3] from which much of this text is extracted, together with unpublished notes by Merensky made available to me in the 1990s at the Hans Merensky Trust).

The platinum group elements had been found in very minor quantity in the Witwatersrand gold reefs, and also in the Bushveld chromitite layers, but in 1923 quartz veins containing platinum were found in the Waterberg. Expectations exceeded reality and the venture proved a costly failure, but the farming community in the northern Transvaal (as it then was) was inspired to go prospecting on their lands. One such was Andries Lombaard on the farm Maandagshoek, 25 km west of Burgersfort. Below is a photograph of Lombaard's house in the early 1990s, which at that time was used as a hostel for nurses at the Mission Station 1 km to the north. On the next page is a view from the northeast across the farm Maandagshoek towards the Loelo Mountains.

In May 1924, Lombaard panned a dense white mineral, and sent it to Merensky in Johannesburg via a lawyer, suggesting that it was platinum. Merensky concurred. (Lombaard's optimism may have been based on the fact that there was also gold in his concentrate, and these white grains presumably lay on the denser side of the gold in his pan.) Wagner[4] indicated that Lombaard panned a "likely looking site", and one may wonder what would constitute a likely looking site. Based on subsequent descriptions

Lombaard's house on Maandagshoek, photographed in the 1990s. The mountain behind is called ga-Ratau (father of the lion) according to Lehmann.[1]

View across the Moopetsi River valley on Maandagshoek (underlain by Critical Zone) to the Leolo mountains (Main Zone). The reef lies a short distance in front of the mountains.

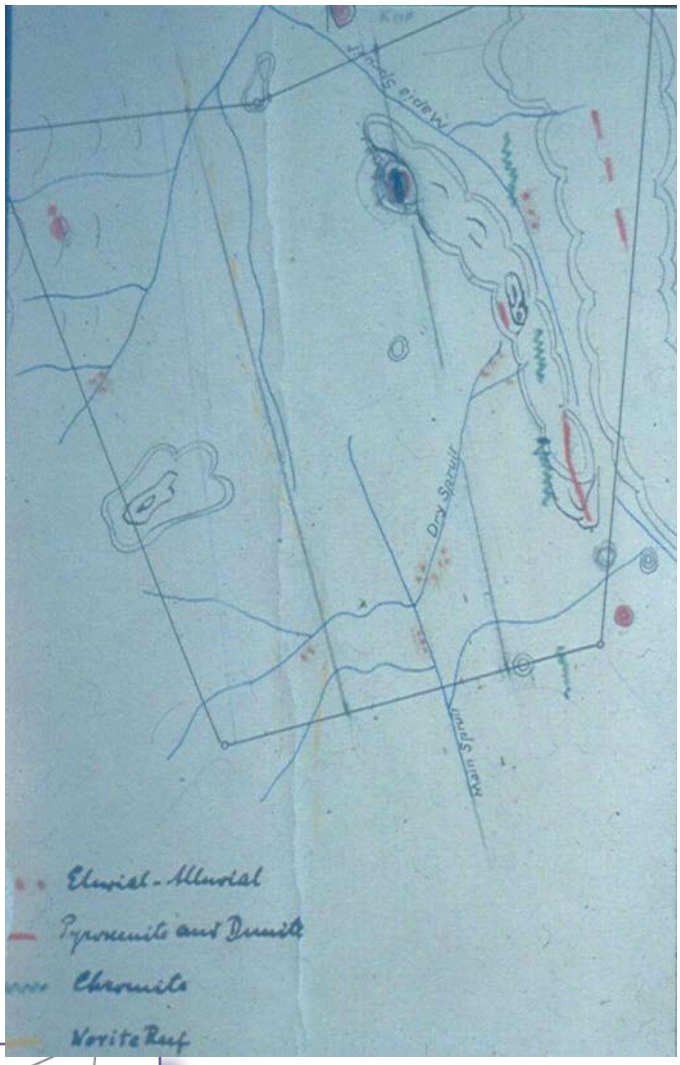
and maps,[3] I surmise that the site is as shown below —a perfect, natural Wilfley table in the Moopetsi River, with deep joints cutting obliquely to the stream flow. We subsequently extracted some 6000 grains of platinum group minerals from these joints.[5] On the following page is an aerial view of this dry stream on Maandagshoek.

Dr Merensky began an exploration programme, finding platinum grains in several streams nearby. His team began sampling ultramafic rocks, taking them to Lombaard's farmhouse for crushing and panning. The adjacent Mooihoek and Driekop pipes followed by the reef were quickly identified. Realising the major importance of his discovery, Merensky wrote a long report and drew a geological map for the Lydenburg Exploration Company on 31 December 1924 of their work on Maandagshoek, which is stored at the Merensky Trust. The map was published with the Trust's permission as the front

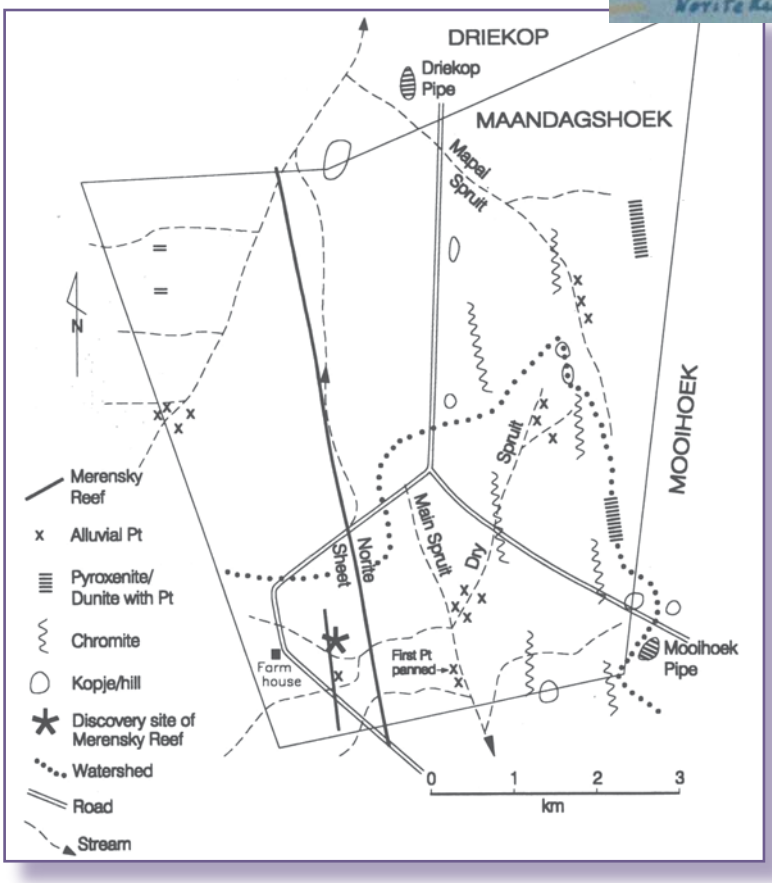
The possible site of the first panned platinum in the Moopetsi River. Wagner[4] referred to a likely site, shown here as a natural Wilfley table.

Aerial view of the Moopetsi River looking southeast with Maandagshoek in the foreground.

cover of the *South African Journal of Geology*, 1999, number 3. In the next few years, a number of more detailed and historical observations were added (especially by Wagner[4]) and a revised map of the geology of the farm was presented (see below).[3] Note that Merensky's map has north pointing to the right, and so the two maps do not immediately appear similar. What is interesting is that Merensky referred to the layer as "norite reef" on the map. There is a surprisingly good outcrop at the discovery site indicating why it was called norite. The name alternated between Lombaard Reef (as used in a copy of a letter to Lombaard from Merensky on behalf of Lydenburg Platinum Syndicate dated 15 October 1924, which I was given by Neels de Klerk) and Main Reef in newspaper reports. (The presumed line of occurrences now known to be pipes was called the Kopje Reef.) Based on Lehmann's sequence of events in about November 1924,[1] there was an allegorical conversation between Lombaard, his two cousins (who were involved in the exploration) and Merensky that favoured the name Merensky Reef, and so it has remained. Within months the reef had been traced for many tens of kilometres, even to the east of the Steelpoort River.



Geological map by Dr Merensky of the farm Maandagshoek, dated 31 December 1924, reproduced on the front cover of the South African Journal of Geology (1999, issue 3) with permission from the Hans Merensky Trust. Note north is to the right.



Revised geological map of the same farm with additional information compiled from later publications.[3]

Until 1924, almost all platinum had been mined from alluvial deposits, specifically Russia. Given the failure of hard-rock mining in the Waterberg, Merensky's commitment to tracing the reef was remarkable (looking beyond the wind). Using the Russian alluvial platinum model in the Urals, Merensky then undertook sampling of the banks and flood plains of the Main Spruit (Moopetsi River) and into the Steelpoort River, but found essentially nothing. So here is a calculation (surely Merensky did something similar by the end of 1924). The Merensky Reef had been traced along the length of the valley floor from near the Olifants River through

View down the valley from Winnaarshoek southward. Note the high parallel valley sides. The reef lies along the valley floor.

the Mohlaletsi, Mometsi and Moopetsi Rivers to the east of the Steelpoort River, a distance of over 70 km. The valley is mainly flanked by parallel hills which are over 200 m high above the valley floor. Assume the reef dips at 15 degrees, is 2 m thick, contains 4 g/t platinum and density is 3.3 g/m^3. The weight of platinum eroded from that valley (top of the hills to valley floor) is 70*1000 (m length) * 200 ÷ sin 15^o (m down dip from hill top to valley floor) * 2 (m thick) * 3.3 (density) * 4 (g/t) ÷ 28 (convert to ounces). Potentially 50 million ounces! (And maybe double it for the UG2 chromitite layer, but Merensky did not know that). Essentially none has ever been found!

A geomorphological interpretation of the area concluded that the valley was a palaeo-erosion surface excavated by the Dwyka glaciation, infilled by Karoo sediments and now re-exhumed.[6] Du Toit also made a very vague suggestion along those lines, but never published the details. So all the eroded platinum is geographically and geologically long gone. But the legacy of Merensky's perspicacity lives on.

Grant Cawthorn
University of the Witwatersrand

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Discovery site of the "norite reef", later to become the Merensky Reef.

The Merensky Reef on 23 level, K3 shaft, Marikana mine, from the MSc thesis by Nicole Wansbury. There are a number of facies variations of the reef around the western limb. This photograph shows the change from Rustenburg facies to Marikana facies. In the Rustenburg facies, the footwall anorthosite is overlain by a thin chromitite, a pegmatoidal pyroxenite, another chromitite and a pyroxenite of normal grain size. In the Marikana facies there is only one chromitite layer, which is overlain by a pyroxenite of normal grain size. Detailed electron microprobe analyses of the chromite grains show that the single layer (Marikana facies) has the same composition as the upper layer in the Rustenburg facies, very different from the lower layer. This relationship proves that the lower chromitite layer and pegmatoidal pyroxenite in the Rustenburg facies were eroded before deposition of a continuous chromitite layer across both facies.

Geoheritage

mineral scene

Graphite

This Mineral Scene is partly extracted from Cairncross (2019), with permission from Struik Nature.

When it comes to aesthetic, colourful, well-crystallised collectable mineral specimens, graphite would not be at the bottom of the list, it probably would not even feature on the list. Usually found in metamorphic rocks such as graphitic schists, marbles and gneisses, it forms black to silvery-black masses or crudely formed small crystals that very easily get crushed or damaged due to the softness of the mineral; a characteristic of graphite is its softness and ductility, allowing flaky crystals to bend without breaking. The fact that it is very soft and has a black streak accounts for its use in pencil lead. In recent times, graphite's uses have multiplied, for example in the manufacture of brake linings, carbon brushes, crucibles, lubricants and refractory bricks. Other uses include nanotubes (in nanotechnology) and carbon-fibre-reinforced products such as bicycle frames, fishing rods, tennis and squash rackets, and even jetliner bodies. When graphite is mixed with radar-absorbing materials, it decreases the risk of radar detection, a property that has seen its use on some early stealth fighter jets. Graphite foil is used in smart phones and tablets, as well as in lithium-ion batteries.

Tanzania (and Mozambique) have Africa's largest deposits of graphite. It is found in the Merelani area in Tanzania and was mined during the mid-1990s. These deposits are considered to be among the richest in the world.[1,2] The graphite-dominated gneiss at the Mahenge Liandu mine is earmarked to become a major source of graphite, while another important economic deposit of graphite is the Bunyu Project in south-eastern Tanzania, which has reserves of over

A matrix specimen completely covered with beautiful tabular graphite crystals, with green chromian diopside and white mesolite scattered on the specimen. Field of view is 6 cm; Karo mine, Merelani Hills, Tanzania. (Specimen: Philip Hitge; photo: Bruce Cairncross)

Gem-quality green chromian diopside crystals on large, well-formed grey graphite crystals. Field of view is 3 cm; Karo mine, Merelani Hills, Tanzania.
(Specimen: Philip Hitge; photo: Bruce Cairncross)

100 million tons. In addition to being an economic deposit in its own right, graphite is also intimately associated with other gemstones found in the region.

Up until fairly recently, impressive graphite crystals were few and far between. So having established that graphite has multiple uses, yet does not form impressive specimens, why feature it in this Mineral Scene? The reason is that some extraordinary crystalline graphite has been found at the Block D of the Karo mine area, Merelani Hills, Tanzania. These were first found in 2007. The grey-black hexagonal crystals are up to several millimetres in diameter. Some cabinet-sized specimens display completely pristine, undamaged platy crystals, which is quite extraordinary for such a soft delicate mineral. They form aggregates or nests of crystals that contain other important minerals such as brilliant green chrome diopside. Other associated minerals are axinite-(Mg), chabazite-Ca, fluorapatite, gypsum, halite, laumontite, mesolite, prehnite, pyrite, titanite, tremolite and zoisite variety tanzanite.[3]

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A mass of graphite flakes forms the matrix to numerous green tsavorite crystals (gem grossular garnet) together with some minor pyrite. Field of view is 3 cm; Karo Mine, Merelani Hills, Tanzania. (Specimen: Philip Hitge; photo: Bruce Cairncross)

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.

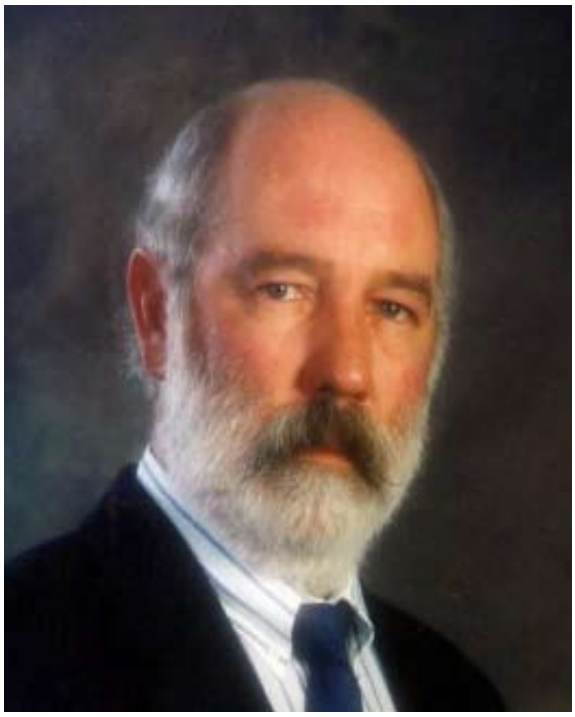
DATE	EVENT
8 February - 1 March (4 x ½ days) + self-study	Drilling Methods and Techniques in Resource Exploration
15 March	CPD Workshop
3 - 7 April	Geoheritage Conference
10 - 12 May	Diamond Course
20 - 22 May	Advanced Structural Geology/Field Trip
15 June	Energy Day
7 - 8 July	Minrom Geological Maps: 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

obituary

Larry Edwin Neuhoff †

Larry Edwin Neuhoff

27 September 1950 to 13 April 2021



Larry Neuhoff's life and career chronicles one of the more stimulating and exhilarating periods in the history of Southern African mineral exploration. Born on the East Rand gold field in 1950, he spent most of his youth in Zimbabwe, matriculating from Plumtree High School in 1967. Immediately thereafter, he started work as a field technician with the Department of Water Affairs, where one of his prouder achievements was to manage his time so as to optimise field allowance and overtime provisions—perhaps an early glimpse of the impressive entrepreneurial flair that was to mark the latter part of his professional career. He returned to South Africa in 1971 to read Geology at Rhodes University, where he was awarded BSc Honours in 1974.

The 1970s were halcyon years for field geologists in South Africa: the discovery of a major copper deposit near Prieska had sparked a base metal exploration rush to the Northern Cape Province and southern Namibia, with a number of powerful SA and international groups competing fiercely to secure prospecting rights over vast tracts of semi-desert. Demand for geological services far outstripped supply at the time. Freshly graduated Larry was recruited by the UK mining giant Rio Tinto Zinc to participate in an extensive drilling campaign on a porphyry-type copper deposit known as 'The Haib', on the Namibian side of the Orange River. A favourite watering-hole at the time was the Vioolsdrift Hotel, renowned for its stunning (but evidently unaccommodating) barmaids. Although a caravan in the desert—where summer temperatures routinely exceed 40 °C—would seem to be a less than auspicious place to start a family, the Neuhoffs spent five happy years in that region. It was, however, probably something of a relief to return to Grahamstown, where Larry successfully completed the MSc Minex programme in 1979.

The following year Larry joined the US mining group Texasgulf (TG) as a senior geologist. TG triumphantly invaded the hallowed stamping ground of the SA Mining Houses, with the discovery of a hitherto unidentified extension to Driefontein, at the time one of the world's largest and most profitable gold mines. During his three years with TG, Larry gained a wide range of experience in various parts of the world. In 1983, however, TG was compelled to withdraw from South Africa as a result of sanctions imposed by the US government (the 'Sullivan era' sanctions), resulting in retrenchment of all SA-located personnel. Larry was immediately recruited by Selection Trust/BP Minerals to take on the role of Country Manager for Botswana. This proved to be the start of his long and very productive involvement

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in the diamond industry. A couple of years later, Larry was transferred to Johannesburg, to take technical charge of BP Minerals Southern Africa. Despite their impressive success in developing the Oryx extension to the Free State gold field, around 1988 BP resolved to abandon its foray into the mining sector. By this stage, Larry was feeling the urge to leave the corporate sector and to again flex his entrepreneurial wings. The timing of this professional mid-life crisis was less than auspicious, coinciding as it did with a massive global financial meltdown. In line with other sectors, mining companies became disenchanted with the prospect of supporting internal 'non-productive' activities—such as mineral exploration. This trend resulted in large-scale retrenchment of permanent staff in the sector.

Where mineral exploration still continued, mining companies increasingly elected to outsource exploration services. With his excellent technical and managerial credentials—and swashbuckling personality—Larry flourished in this environment, taking on the management contract for all of the Gencor group's diamond exploration activities in Botswana. His entrepreneurial instincts were also triggered, prompting him to take on responsibility for the provision of all of the project's support infrastructure (vehicles, caravans, geophysical equipment, etc.), a bold step that placed considerable pressure on his own household finances. The profitability of the infrastructure component of the contract was torpedoed to a large extent when Gencor was taken over by BHP Billiton, whose first-world health and safety regulations left virtually no room for manoeuvre.

The advent of democratic change in SA in the early 1990s heralded the opening up of many doors previously closed to South African exploration geologists. Larry's fascination for diamonds led him inexorably into the Bermuda Triangle of mineral exploration investment: the diamond fields of Angola and the DRC. In 1997, he was working as a contractor on Petra Diamonds' Alto Cuilo project when civil war suddenly flared up again, with the project itself coming under direct attack (the civil war was largely about control of diamond resources). In this incident Larry very nearly sacrificed his own life while recklessly attempting to salvage a mobile Flowsort X-ray diamond recovery plant. While the assault led to numerous fatalities and destruction of assets, the project personnel are proud to have formed the logistical backbone of the civilian refugee column. The bullet-riddled Flowsort is still out there.

Back in South Africa, Larry was again contracted by Petra Diamonds, this time to assume general management of the creaking state-owned diamond mining operations at Alexkor, and in the process to restore the entity to profitability in a period of two years. Under his hands-on custodianship, the stated goals were all achieved within the prescribed period, within budget and without significant retrenchment of staff—surely an achievement unmatched among SA parastatal entities.

Excellent exploration opportunities arose when all undeveloped privately owned mineral rights in South Africa were nationalised in 2004. Being in possession of a very extensive database of unpublished prospecting records (mainly those of foreign companies that had withdrawn from SA in the 1980s), companies in which Larry held a substantial interest were able to identify and secure a number of exceptionally attractive exploration targets. Prominent among these were large proven and indicated reserves of metallurgical quality coal in the Limpopo province of SA, and in the Tete province of Mozambique. Several of these assets were turned to account between 2006 and 2010 (shortly before the commodity fell out of popular favour for environmental reasons). Two companies founded on Larry's entrepreneurial and executive talents are currently traded on international stock exchanges.

Larry was able to realise his lifelong dream of becoming a gentleman farmer when, in 2015, the Neuhoffs acquired and moved to a beautiful cattle

farm at Karkloof in the KZN midlands. While the tranquil and stable lifestyle on the farm proved to be a welcome change from the stresses and disruptions of the business world, Larry stayed in touch with developments through his ongoing involvement in the Geological Society. Larry had been one of the main drivers of making the GeolSoc more vibrant and participative by promoting the Divisions and Branches within the Society. The Divisions allowed members to focus on aspects of personal interest without getting too close to the machinations of the monolithic and often boring 'mother body'. Larry was a founding member and organiser within the Economic Geology Division, and was an active member of the "Fellows Committee" who, inter alia, are responsible for the proposals and adjudication of candidates for the various awards bestowed each year by the Society.

It was while working on the farm towards the end of 2020 that Larry fell ill and months later succumbed to cancer. He is survived by his loving wife Jacqui, his four children Simon, Kirsty, Julia and Matthew, seven grandchildren, and four siblings. He is also sorely missed by colleagues, employees and many friends.

Hamba kahle, patrao.

Carl Slade

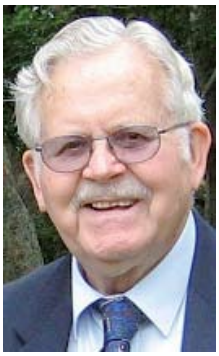
obituary

Nicolaas Johannes Grobler †

Nicolaas Johannes Grobler
7 December 1930 to 18 October 2021

Prof Nick Grobler's passing away on 18 October 2021 was noted with sadness by colleagues and his ex-students at the Geology Department of the University of the Free State, where many graduated under his supervision from 1970 to 1990. He was a humble gentleman and an exceptional person in our educational history. Prof Nick's early career in industry brought special impact to his courses, especially economic geology, helping us in our careers in the competitive world of international mining and exploration.

Prof Willem van der Westhuizen: I have known Prof Nic from the early 1970s during undergraduate studies. He acted as my supervisor from 1974 on the geology south of Prieska and environs. He was a gentleman—I am honoured to have been associated with him. He instilled in his students a love for volcanic rocks, which led to much research that he, Gert Meintjes and I conducted on the Ventersdorp Supergroup. Prof Nic, I salute you!



Thinus Jordaan: To us students in the 1970s, his door was always open to share his knowledge and skills. But his patience was sorely tested at times: despite our best efforts at surveying and triangulation with a theodolite from the special platform at the top of the geology building, the results were not always up to his standards, or could conceal our shrewd fudging of the results! I was honoured to run with the team in the 1970s that led to the ultimate discovery of the Asis West resource that he earlier modelled and predicted from his geophysical surveys.

Gerhard Meintjes: As supervisor of my postgrad studies in the 1980s, Prof Nick generously cared for me and other post-grad students, introducing them to the wide world of industry and creating networking opportunities. During a field excursion, Willem and I had the dubious privilege to observe Prof Nick in the only ungentlemanly moment ever—he almost stepped on a snake and enthusiastically

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voiced his displeasure with the situation, in detail! His abhorrence of snakes stemmed from a puffadder bite during his Tsumeb days, which cost him most of a calf muscle.

Noleen Pauls: I was at the Geological Survey of Bophuthatswana during Prof Nick's tenure there, after South Africa suspended the position of Counsellor for Minerals and Energy he held in London. What I remember most is what a gentleman he was, and how he brought out the best in people through example. We spent many hours being regaled with stories about his experiences with the Embassy in London, and birding stories, even after he moved to Johannesburg.

Prof Nick was a private person devoted to his family. We offer our condolences and pray for strength to the Grobler family to deal with the loss.

Nick Grobler was born in Senekal, Free State, on 7 December 1930. He matriculated from Senekal Hoërskool and received his BSc and subsequently MSc and DSc degrees (the latter on the Pietersburg Greenstone Belt in 1972) from the then University of the Orange Free State (UOFS).

In 1954 he joined Tsumeb Corporation as Assistant Geophysicist and later as Geophysicist, using the newly developed pulse potential (later IP) method to explore for sulphide deposits in Tsumeb Corporation's concession area in the Otavi Mountain Land. Two anomalies on the northern flank of the Otavi syncline eventually proved to be small mineable satellite copper deposits to the Kombat Mine. During this period, he was also seconded to Newmont Exploration to use the IP method for exploring satellite sulphide deposits adjoining the copper–molybdenum Atlas Mine on Cebu Island, Philippines. On return, he took on the role of Tsumeb mine geologist and was also responsible for exploration around the Tsumeb mine.

Nick married Sydney Lawrence in 1956 and the couple had two sons, Stephen and Philip. Sydney passed away in 2018.

Nick joined Anglo American Corporation in 1964 as Regional Geologist in the far northern Transvaal where he led a team of 7 geologists and support staff, examining mineral deposits. In the last 6 months of 1969 he directed a team of geologists exploring for base metals in the Tati Greenstone Belt, Botswana.

In 1970, Nick joined the staff of the Department of Geology at the UOFS, first as Senior Lecturer and since 1973 as Professor, a post he held to the end of 1989. He threw his weight in behind the effort to build up the UOFS Geology Department into a first-class institution. He was mainly responsible for teaching Economic Geology and devoted most of his research on the Ventersdorp Supergroup. Supervision of contract geological mapping for the Geological Survey (now Council for Geoscience) in the Northern Cape and Western Transvaal formed part of his duties. He also did contract research through students for mining companies. Under his supervision, a total of 10 MSc and 5 PhD theses were completed during his term. Alone and in conjunction with colleagues and students Nick published 29 papers in scientific journals. Some of these dealt with the regional setting and geohydrology of Florisbad, and the relation of pans in NW Free State to paleodrainage.

In 1990, he was seconded to the Department of Mineral and Energy Affairs (DME) as Counsellor for Minerals and Energy at the South African Embassy in London, where he diplomatically represented the DME in the United Kingdom, Portugal, Spain, Greece, Israel, Turkey, Irish Republic and later also Bulgaria. His main aim was promotion of the sale of SA minerals and information on privatisation of electricity and water in the UK and other European countries.

When the posts in London, Paris, Tokyo and Washington were suspended in March 1993, Nick accepted the post of Director of the Geological Survey of Bophuthatswana/Northwest Province and in 1995 moved to the Department of Minerals and Energy (DME) in Pretoria as Director International Relations, a post he held until 1997 when he retired. This post involved mainly co-ordination of participation of the DME in the SADC Mining and Energy Sectors, and

liaison with other line function state departments, academic institutions and the private mining sector.
Nick was a Corporate Member of the Geological Society since 1956, Fellow since 1980, Council Member since 1980, convenor of Awards Committee since 1987 and Vice-President since 1989, a position that had to be relinquished when he left for London in 1990.

Nick was a member of the Wildlife Society of SA (Wessa) and Ornithological Society (now Birdlife South Africa). Birdwatching was his absorbing hobby. He was a founder member and President of the Orange Free State Ornithological Society (now Free State Bird Club) and honorary editor of *Mirafra*, its newsletter since its inception in 1984, to 1989. He was also co-author of "*First atlas of bird distribution of the Orange Free State*". Since August 2005 he was honorary editor of *BotSoc Chat*, newsletter of the Bankenveld Branch of the Botanical Society of South Africa, and served as Chairman of Bankenveld for two years and as committee member.

Nick leaves his sons, Stephen and Philip, and two grandsons, Nico and Charl.

Gerhard Meintjes

By Roger N Scoon*

Isle of Skye, Scotland:

Scenic Coastal Landscapes and the Cuillin Complex

The mountainous core of Skye.

The Isle of Skye is the largest of the islands in the Inner Hebrides, an archipelago on the west coast of Scotland. The island has an area of 1,656 km^2 with an irregular, indented coastline that includes numerous narrow peninsulas divided by sea lochs. The island has a mountainous core with some of the most dramatic scenery in the British Isles. The coastal landscapes, which include spectacular sea cliffs, also attract large numbers of visitors. Skye has been the subject of intense geological studies for several hundred years. The investigations in 1895–1901 by Alfred Harker, one of the pioneers of modern geological science, unravelled the complex relationships between lavas (basalt), dykes and sills (gabbro and dolerite) and intrusive igneous rocks (layered ultramafic–mafic intrusions and granitic bodies). The geology of Skye enabled many of the controversies that persisted through the 19th century to be resolved.

The Isle of Skye has been populated since Neolithic times and many of the names reflect inhabitants that included Vikings, or Norsemen, and the Gaelic-speaking highlanders. Tourism is an important part of the local economy and many of the small settlements, including the capital of Portree, occur in scenic locations. The "Skye Boat Song" is a song recalling the journey of Bonnie Prince Charlie to the Isle of Skye as he evaded capture by government troops after his defeat at the Battle of Culloden in 1746. The stories

Trotternish Ridge is a prominent feature in the northeast of Skye.

The small harbour at Portree.

behind the prince and his relationship with Flora MacDonald are celebrated throughout the island, including at Dunvegan Castle. Skye has a relatively temperate climate, due to the influence of the Gulf Stream, but is wet and windy as may be expected from the northerly location. Visitors may approach Skye by ferry from Mallaig to Ardvasar and return on the Skye Bridge.

The excursion guide of Bell and Harris[1] is an invaluable reference to the geology of Skye and includes descriptions of all the important geosites. Many of the geosites have subsequently been listed as Sites of Special Scientific Interest (SSSI) and are protected by law. A popular style guidebook published by the Scottish Natural Heritage and British Geological Society is also recommended.[2] A simplified geological

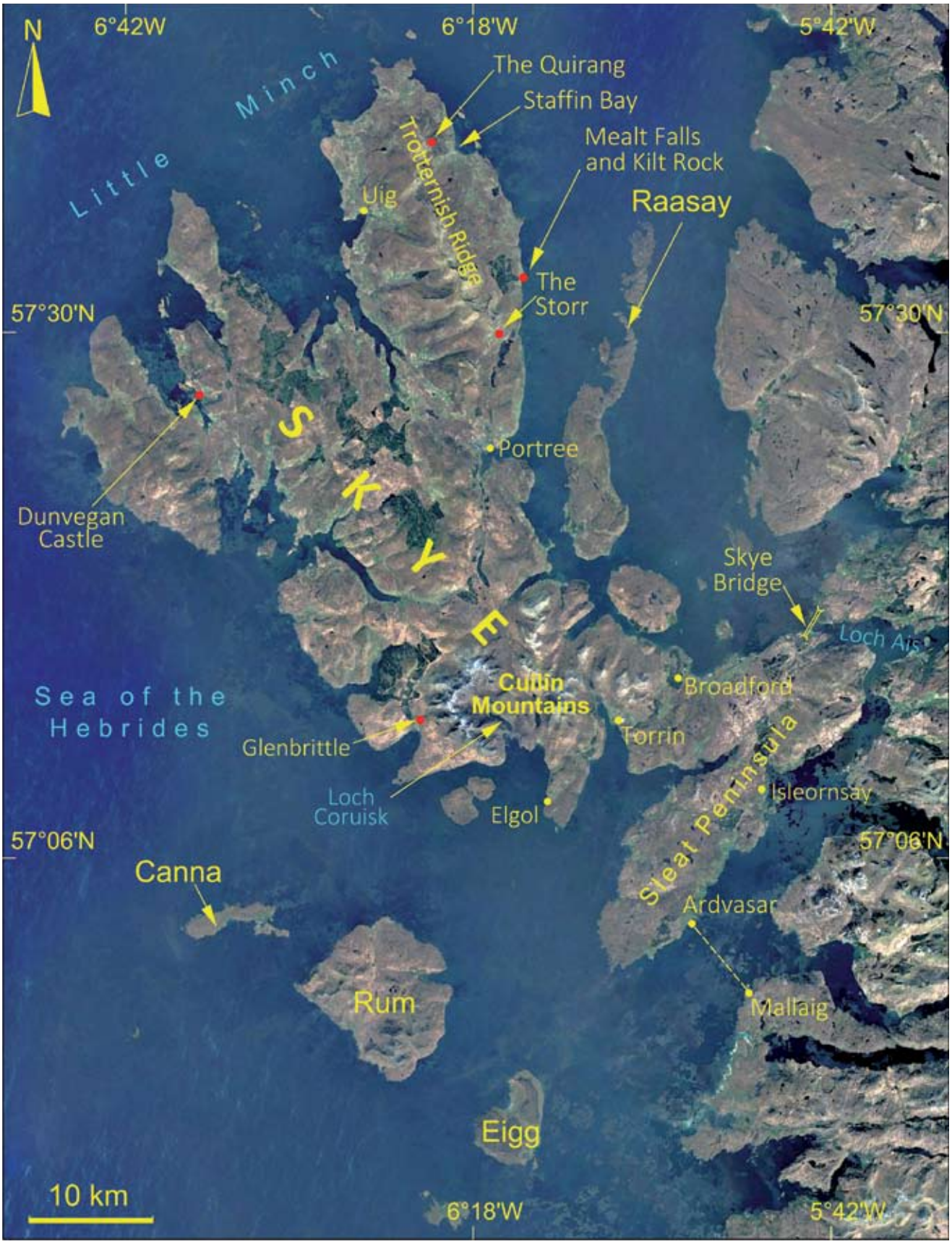
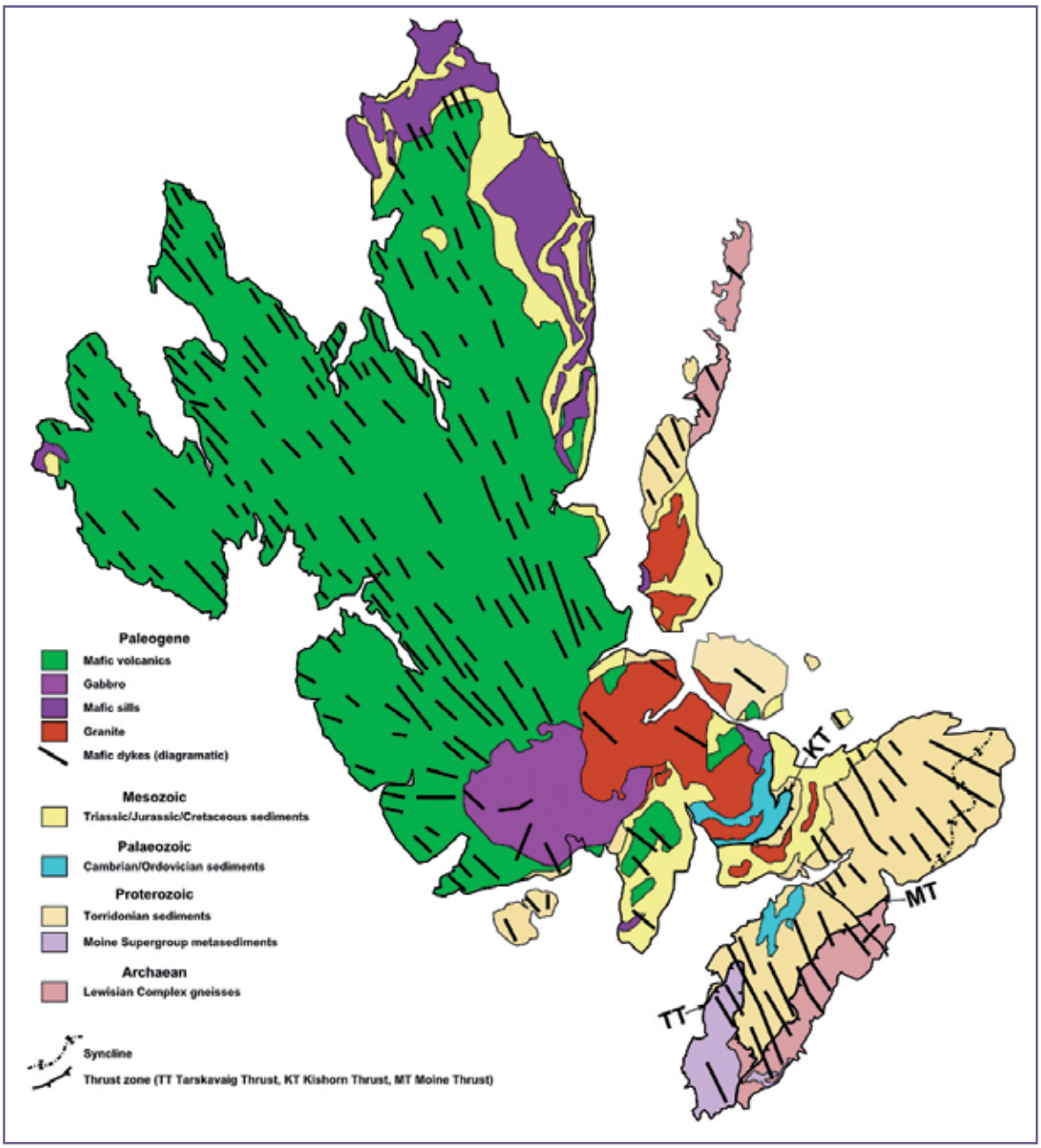


Image of Skye showing the indented coastline and geosites described in the text.
(Source: Google Earth, with labelling by Lyn Whitfield)



Simplified geological map of Skye. (Source: Mikenorton, Wikimedia Commons)

map shows the broad geological terranes identified on Skye.

The oldest rocks occur in the Sleat Peninsula and in the vicinity of Broadford, in the southern part of the island. High-grade metamorphic rocks, primarily granitic gneiss and amphibolite, of the Archaean-age Lewisian Gneiss (2,800 Ma), outcrop near Isleornsay. These rocks are unconformably overlain by schist of the Moine Supergroup and sandstone of the Torridonian Group (Neoproterozoic). The latter is in turn separated from the Cambrian and Ordovician rocks (part of the most northerly of the disjointed Caledonide terranes in the British Isles) by a further unconformity. The sequence of rocks is complicated by regional thrusting associated with the Caledonide orogeny. The Moine Thrust—in which thick sheets of the Lewisian and Moine have been thrust over both the Torridonian and the Cambrian-Ordovician—extends for over 200 km in the highlands of Scotland and the Hebridean Islands. The exposure of the Moine Thrust at Knockan Crag, on the mainland, is one of the principal localities where, during regional mapping, geologists Benjamin Peach and John Horne confirmed the concept of thrusting, which resolved one of the great controversies of the time (https://www.geolsoc.org.uk/GeositesKnockan).

The outcrop of the Moine Thrust at Knockan Crag in the Assynt Mountains (Sutherland) is one of the classic geosites on the mainland of Scotland. The thrust is located below the Moine schists (dark brown; uppermost unit) and is underlain by a sequence of Cambrian strata of which the Durness limestone (light grey) is the highest component. (Source: Geological Society of London)

The northern part of Skye is dominated by a basaltic plateau (Palaeocene) that reveals stepped landforms and includes columnar jointed dolerite sills

The plateau in the northern and central parts of Skye is associated with an extensive lava field (Palaeocene). The plateau lavas are the most voluminous component of the Skye igneous centre (details below) and form a stepped landscape. The gentle westward dip has given rise to steep scarps. In the uppermost part, the plateau lavas are intercalated with Jurassic sandstones and shales, which outcrop in cliffs on the eastern side of the island. Dolerite sills intruded the sedimentary strata, giving rise to spectacular landforms.

The mountainous core of Skye is in part associated with the Cuillin Complex. Three components occur: a layered ultramafic–mafic intrusion; a granitic body; and dykes, sills and cone sheets. The layered rocks form the rugged peaks of the Black Cuillins. The horseshoe-shaped massif includes Sgùrr Alasdair (992 m), the highest peak on Skye, the traverse of which requires 15–20 hours and is the most strenuous mountain walk in the British Isles. Three younger intrusive centres of granite and felsite post-

A quarry in northeast Skye exposes a thick sequence of basaltic lavas (Palaeocene) intruded by metre-thick sills of olivine gabbro that have a similar age.

date the Cuillin Complex. The main granitic body, together with the younger granites, is associated with the rounded hills of the Red Cuillins, the peaks of which are several hundred metres lower than the Black Cuillins. Swarms of mostly basic dykes (with a pronounced NW–SE alignment) crosscut the older rocks on Skye, including the plateau lavas and the Cuillin Complex.

The glaciation associated with the Late Pleistocene Ice Ages has impacted the geology of Skye and exposed large areas of rock pavement.[1,3] The main ice sheets, derived from the mainland, flowed in a westerly direction. During the local Last Glacial Maximum in the Hebridean Islands (30,000–26,000 BP), Skye sustained an independent ice centre. Modification of the igneous terranes in the core of the island

View of the ice-scoured rocks of the Cuillin Complex with the Black Cuillin Mountains in the background (approach to Loch Coruisk).

by successive ice sheets and mountain glaciers has produced radiating troughs and cirques, pinnacled arêtes and glaciated trap topography.[3] During the recent Loch Lomond Stade (12,900–11,700 BP), Skye and Rum hosted mountain glaciers that deposited end, lateral and recessional moraines. The outlying peninsulas of Skye contain rounded hills where the glacial activity was less intense. Thick glacial deposits cover the bedrock in the lower-lying regions. Major ice-induced landslips are a feature in the northern part of the island.

Skye Igneous Centre

This is one of the main centres of the North Atlantic Igneous Province (Palaeocene–Eocene). Magmatism is associated with opening of the North Atlantic Ocean. The magmatism in the Hebridean islands, which includes centres on Harris, Mull and Rum, includes both basaltic and felsic variants. The earliest activity on Skye was eruption of plateau basalts. The basalts attain a thickness of 1.7 km and cover an area of 1,550 km^2. The age varies between 60.53 ± 0.08 Ma and 58.91 ± 0.07 Ma.[4] Based on the eruption interval of 1.6 Myr, the flow rate is estimated at $1.5x10^{-3}$ km^3/year.[5] The main lava types are basalt, hawaiite, and mugearite. The lavas are associated with tuffs, which include volcanic bombs and lapilli-sized fragments. The sills associated with the plateau lavas, which have a similar age, display a range of compositions from picrite to dolerite.

The Cuillin Complex intruded into the plateau lavas, but the age of 59.30 ± 0.7 Ma is within error of that of the lavas.[4] The principal lithologies of the layered intrusion are coarse-grained peridotite and gabbro, resistant lithologies that constitute the highest peaks. Pronounced igneous layering includes mineral banding on a cm-scale. The layered intrusion is interpreted as a subvolcanic magma chamber from which the plateau lavas had previously erupted.

The Cuillin Complex is crosscut by pipe-like bodies of pyroclastic rocks and by cone sheets (typically less than 1 m thick) that dip outwards from a central locality. The subsidiary intrusive centres are Eocene features; the Western Redhills granite, for example has an age of 53.5 ± 0.3 Ma.[4] The younger centres include, in addition to the granitic bodies, felsic pyroclastic rocks that form ring-shaped intrusions. They are interpreted as the final subvolcanic activity in the region.

Geosites

The exposures of the Moine Thrust Sheet near Isleornsay on the Sleat Peninsula occur on wave-cut platforms and coastal sites that can only be reached at low tide.[1] The thrust sheet includes several lithologies with a metre-wide band of mylonitised gneiss. The mylonite is overlain by foliated Lewisian gneiss (bands of acid gneiss, amphibolite, and phyllite) and underlain by Torridonian sandstone. A blue-grey serpentinite forms a distinct ridge aligned NE–SW. An outcrop of Lewisian gneiss reveals light-coloured bands of feldspar and quartz and dark bands rich in chlorite and actinolite. Centimetre-sized pods of pink granite aligned parallel to the foliation occur in the gneiss. A unit of amphibolite near the outcrop of the banded gneiss contains metre-sized zoned ultramafic bodies. The cores of the ultramafic pods have altered to talc dolomite; the rims relate to metasomatic reaction with the gneiss.

The Cambrian–Ordovician strata exposed in southern Skye include beds of Skye Marble, a high-quality dimension stone, related to thermal metamorphism during the Lower Cenozoic. The quarry at Torrin includes a dolerite sill next to which unusual minerals occur in the marble.[2]

The Broadford area, located 25 km south of Portree, has scenic views both inland and of sea lochs. This gently rolling landscape contains small farms and crofts. Outcrops of the Torridonian sandstone and of Jurassic sedimentary rocks can be observed in the wave-cut platform.[1] The unconformity is not exposed. On the western side of Broadford Bay, calcareous siltstones and shales of the Broadford Beds (Lower Jurassic) outcrop. A 5 m-thick basic sill

Mealt waterfall on the northeast coast of Skye plunges over the 55 m cliffs of Staffin Bay into the sea.

has intruded the sedimentary rocks. The sedimentary strata and sill are further cut by thin dolerite dykes. The Middle Jurassic strata outcrop at Bearreraig Bay. The cliffs comprise marine sandstones intruded by dolerite sills. The sandstones are fossiliferous, and contain belemnites, bivalves, and crinoids. Fossils can be collected from fallen blocks but not from the cliff face. Carbonaceous marks (or fucoids) occur in the sandstone together with concretions of sandy limestone. In a separate section, near waterfalls, a shale member occurs that is rich in ammonites. On the inland side of the main road, a thick sequence of Lower Cenozoic plateau lavas occurs.

The Mealt Falls and Kilt Rock are popular geosites located 15 km north of Portree on the northeast coast of Skye.[1] The waterfall is fed by the outflow of Loch Mealt, a square-shaped inland loch or lake (1 km in size) located several hundred metres from the coast and situated on the volcanic plateau. The outflow drops over the near-vertical, 55 m high sea cliffs into the Inner Minch. A viewpoint by the main road (looking north) reveals the waterfall with the Kilt Rock in the background. The cliffs consist of the flat-lying Valtos sandstone (Middle Jurassic) and two dolerite sills (Lower Cenozoic). The sills constitute the capping and the wave-cut platform. Kilt Rock is associated with prominent columnar jointing in the upper sill. The vertically aligned joints resemble the pleats in a kilt. The most well-known occurrence of columnar-jointed dolerite in the region is, however, Fingal's Cave, on the uninhabited island of Staffa situated off the west coast of Mull.

The region between Kildorais and Staffin Bay, 29 km north of Portree, is a spectacular section of coastal cliffs. The cliffs are composed of steeply dipping sedimentary strata (Upper Jurassic) disrupted by a swarm of dolerite sills, plugs, and dykes (Lower Cenozoic). Thermal metamorphism has resulted in baked sediments adjacent to the intrusions. The sequence is faulted due to landslips that occurred during the Upper Pleistocene Ice Ages. In the northern part of Staffin Bay, the vertically dipping Flodigarry Shale member contains ammonites and belemnites. Prominent concretions (up to 50 cm in diameter) occur and the shales (which have baked contacts) have been intruded by dolerite dykes. In the northern part of the section, a sequence of Lower Cenozoic lava flows dips gently to the southeast. Each

Kilt Rock is associated with two sills of columnar-jointed dolerite.

flow is separated by palaeosols—laterite profiles up to 30 cm thick. The tops of the underlying flows have been partially lateritised.

The Trotternish Peninsula in northeastern Skye is dominated by a high ridge composed of sedimentary strata (Jurassic) and sills (Palaeocene). The spectacular scenery—which has appeared in recent films such as King Arthur and Prometheus—has been shaped by major landslides. Large blocks were transported eastward in the latter part of the Ice Ages (15,000–11,000 BP). Landslides were triggered by the occurrence of dense and resistant lava flows or sills (Lower Cenozoic) overlying Jurassic-age sedimentary rocks, which are less dense and more readily deformed. Retreating ice sheets and glaciers caused isostatic rebound and the rising land surface became unstable. The advancing and retreating ice sheets have severely deformed the basement rocks. Features that can be seen on the hillsides include ice gouges and deposits of ice-shattered rocks, including screes. The Quirang is a popular tourist site where five dislocated and rotated blocks can be viewed from a 6 km-long trail that starts near Staffin Bay. The blocks overlie a dolerite sill. A disused quarry located at the base of the ridge reveals a 20 cm-thick laterite that caps a porphyritic basalt lava. The lava contains 1–2cm-thick pipe amygdales of weathered zeolites aligned almost vertically.

The landslips associated with The Quirang on Trotternish Ridge, northeast Skye, include dislocated and rotated blocks located beneath a prominently jointed dolerite sill. (Source: wildernesscotland.com)

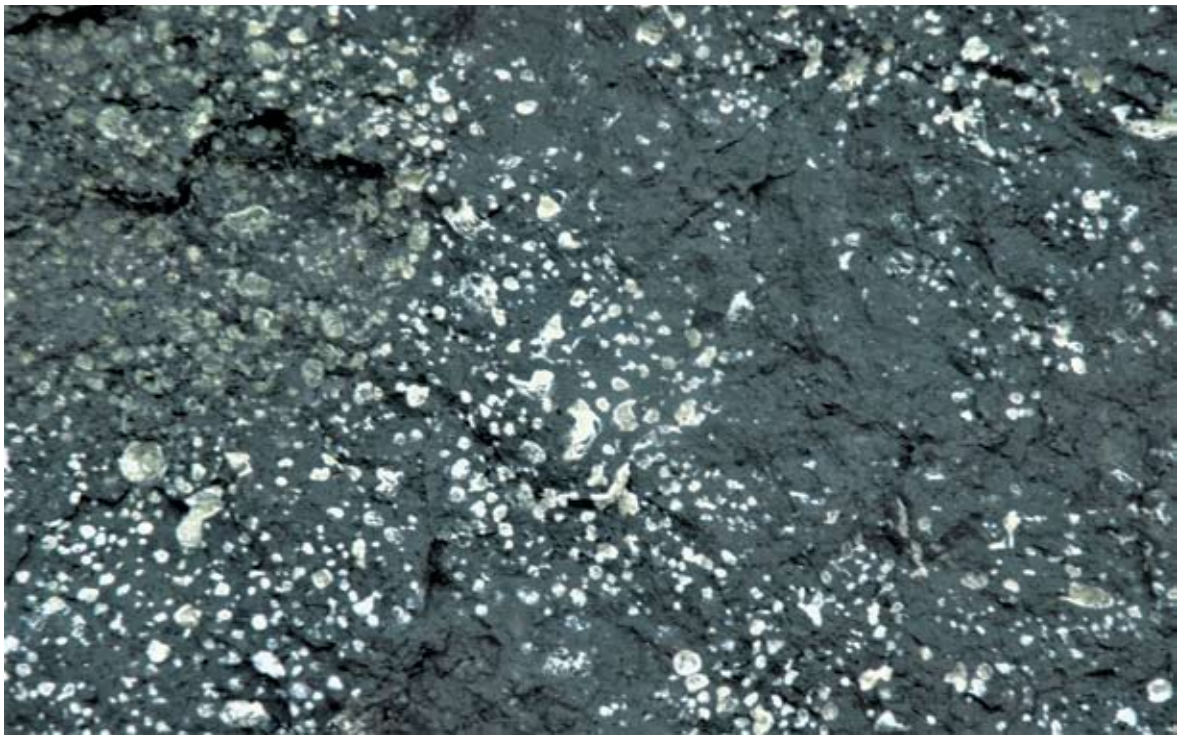
In the southern part of the Trotternish Ridge a prominent hill (719 m asl) is capped by a group of pinnacles known as "The Storr", which are approached by a 7 km circular trail. The pinnacles consist of resistant lavas with amygdales of zeolite (up to 3 cm in diameter). In a section at the base of The Storr, 24 basaltic flows, each separated by laterite palaeosols, occur. Vertical gullies in the cliffs are related to dolerite dykes.

View of Trotternish Ridge with the pinnacles of The Stoor.

The steep path to The Storr ascends the basaltic plateau and has views of the indented and mountainous coastline

A boat excursion from Elgol to Loch Coruisk, southwest Skye, is one of the highlights of a visit to the island and has been listed as one of the best nature excursions in the British Isles. The dramatic scenery of the ice-swept, rocky shorelines is enhanced by sightings of dolphins, seals, and a range of seabirds. The crossing includes views of the Small Isles (Rum, Eigg and Canna) across the Sea of the Hebrides. The mountains of Rum are dominated by a layered intrusion that is broadly like the Cuillin Complex. Loch Coruisk is a 38 m deep, inland lake with an 11 km circular trail. The trail starts at the

The Old Man of Storr and Needle Rock are pinnacles of resistant lavas. (Source: wildernessscotland.com)



The pinnacles of The Storr consist of basalt lavas with amygdales of zeolite.

foot of the loch, near the Coruisk Memorial Hut. An alternative to approaching by boat is to walk a trail that takes a full day from Kilmarie, which includes a traverse over a rock ledge next to the sea known as the "Bad Step." The outcrops on the margins of Lake Coruisk are part of the layered intrusion. This area can also be reached from Glen Brittle, on the western side of the Cuillins. This entails a 16 km hike with outcrops of the layered cumulates and plateau lavas.[1]

Cuillin Complex

The complex has similarities with the Bushveld Igneous Complex and the following summary may be

Gabbro of the Lower Layered Series, Cuillin Complex, next to Loch Coruisk, shows ice striations and differential erosion associated with mineral layering.

of interest. The layered ultramafic–mafic component is a saucer-like feature (or lopolith) with a surface diameter of 8 km.[1,6–9] Layering dips at 10–20° towards the centre, whereas dips at the margins increase to 60–70°, consistent with a funnel-shaped intrusion that may extend to a depth of 16 km. The layered intrusion includes peridotites and gabbros. The thermal effects of the intrusion have resulted in metamorphism of the Torridonian sandstone, Jurassic sedimentary rocks and the plateau lavas. Additional features include younger dykes, sheets, sills, and cone sheets. The largest of the granitic bodies in the Red Cuillins (the Coire Uaigneich Granite) has a similar age, but other granites (and felsites) are younger.

Two rock names that are no longer in common usage form part of the descriptions of the Cuillin Complex. *Allivalite* is a coarse-grained plutonic rock, or troctolite, consisting of calcic plagioclase (the dominant phase) and olivine. Olivine may form skeletal or dendritic crystals. Pyroxene may be absent. The type locality is on the Isle of Allivale, off the coast of Rum.[10] *Eucrite* is a coarse-grained plutonic rock, or gabbro, consisting of calcic plagioclase and magnesian clinopyroxene. The name is used to discern the primitive nature from the more evolved gabbros.

The outermost (and earliest) component of the layered intrusion is the Outer Marginal Gabbro. This unit is unlayered and contains two or more distinct types of gabbro (± olivine) indicative of multiple intrusions. The Outer Marginal Gabbro is succeeded by a Border Unit that includes fine-grained tholeiite with xenoliths of olivine gabbro. The Border Unit occurs on the *inner* contact of the Outer Marginal Gabbro and represents multiple intrusions into the upper part of the gabbro and roof rocks. The Border Unit is capped by the White Allivalite, a prominent marker (thickness of 200–500 m) that is coarse-grained or even pegmatitic. The White Allivalite is ascribed to intrusion of a parental melt that was picritic and yet contained abundant phenocrysts (or xenocrysts) of calcic plagioclase.[8] Multiple phases of magma intrusion and replenishment are associated with the Border Unit; the final phase involved a large pulse of magma, 2 km thick, which jacked up the roof. This created a magma chamber from which the White Allivalite and the overlying layered series crystallised.

The White Allivalite is overlain by the Layered Peridotite Series (thickness of 500 m), the lowermost of the cumulates. The peridotite reveals a broad upward trend (olivine is more magnesian in the lower part), in which dunite is succeeded by feldspathic peridotite and allivalite. Elongate, dendritic crystals of olivine may occur. Discontinuous layers of chrome spinel (up to 1 cm thick) occur within the peridotite. The irregular distribution of the peridotite has been linked to ring fracturing and downward movement from the magma chamber. This may also account for the intrusion of peridotite into sections of the Border Unit. An alternative explanation envisages the later intrusion of the peridotite from multiple sequences of picritic magma that crosscut the earlier-formed layered rocks.

The peridotite is overlain by the Outer Layered Series, in which three series or units are identified:

(i) *Allivalite Series* (thickness of 1,800 m), which is prominently layered and includes five subgroups. Plagioclase is the dominant phase (An_{87-82}); olivine is distinctly subordinate (Fo_{84-81}).

(ii) *Eucrite Series* (thickness of 1,600 m) in which three subzones are identified: (a) plagioclase-olivine-clinopyroxene orthocumulate (or olivine gabbro); (b) olivine-rich adcumulate; (c) olivine-magnetite adcumulate. Cryptic trends are identified (plagioclase An_{75-67}; olivine Fo_{74-67}). The presence of phenocrysts of calcic plagioclase (constant composition of An_{85}) is interpreted as evidence of recharge by a batch of primitive, porphyritic magma at the height of subzones (b) and (c).

(iii) *Gabbro Series* (developed in only one locality).

The Allivalite Series was deposited as a cumulate on the margins of the funnel-shaped intrusion. This component of the intrusion overlaps the peridotites and is in part banked up against the White Allivalite.[8] The complex relationship with the underlying peridotites and older Border Unit is explained by the ring faulting. The presence of olivine rather than pyroxene in the calcic plagioclase-rich allivalite is interpreted as indicating that these rocks are a fractional crystallisation product of the (picritic) magma from which the underlying peridotite developed. The abrupt change to the pyroxene-rich eucrite represents a new pulse of (basaltic) magma fed into the chamber.

Near Loch Coruisk, the olivine gabbro of the Eucrite Series (subzone a) is poorly layered and contains xenoliths of peridotite and blocks and fragments of allivalite and gabbro.[1] The blocks distort the layering of the primary olivine gabbro. Blocks are interpreted as having slumped into an unconsolidated magma mush. Similarities with blocks described in the Skaergaard Intrusion[11] may be applicable.

Unit of olivine gabbro (or eucrite) with chaotic banding, Outer Layered Series, Cuillin Complex, near Lake Coruisk.

Leucocratic gabbro forming irregular bands in the olivine gabbro; note the blocky nature of the upper contacts.

Well-defined blocks of leucocratic gabbro in the olivine gabbro.

Rhythmic layering in iron-rich gabbro, Druim Hain (Inner Layered Series).[2]

The Outer Layered Series is separated from the Inner Layered Series (the uppermost component) by the Druim nan Ramh Eucrite, a coarse-grained gabbro with no layering. This unit has a width of 200 m, displays vertical contacts, and is interpreted as a significant intrusive event. The Inner Layered Series encompasses three subdivisions that mimic those in the Outer Layered Series, i.e., Allivalite Series (thickness of 500 m); Eucrite Series (thickness of 450 m); Gabbro Series (thickness of 750 m). The Inner Layered Series gabbro outcrops on the Druim Hain ridge, the structurally highest part of the intrusion with the most evolved compositions and where the best example of rhythmic (mineral) layering in the Cuillins occurs.[1] Crystals of Ti-magnetite are concentrated at the base of cycles that reveal a gradational increase in the content of plagioclase upward. Apatite is a cumulus phase at this height. Cryptic variation is reported in the Gabbro Series (plagioclase An_{69-58} and olivine Fo_{66-58}). The gabbros, however, may also contain calcic plagioclase with a similar composition to that found in the Outer Allivalite Series, an indication batches of the porphyritic magma were still being fed into the chamber.

The only granitic body associated with the Cuillin Complex, the Coire Uaigneich Granite, formed by the mixing of a partial melt of Torridonian sedimentary rock and an acid differentiate of the basaltic magma from the main chamber.[12]

More than 40 breccia pipes intrude the Cuillin Complex. Blocks of ultramafic and mafic lithologies are contained in a dolerite or tuff matrix. The breccia pipes are related to the final escape of gas from the system.

Dykes of peridotite associated with the Cuillin Complex (and the Rum Complex) are reported as being

Dolerite sill intruded into the Lower Layered Series, Cuillin Complex.

identical to the layered peridotite.[13] The mechanism of adcumulus growth of the layered peridotite as an early gravitative concentrate in a magma chamber is inapplicable to the dykes, which have formed by flow differentiation.[13] A magma with suspended crystals of olivine subsequently underwent near-equilibrium crystallisation. This process was applied to the dunite pipes of the Bushveld Complex,[14] in part based on the evidence from Skye. The presence of an ultramafic magma can, therefore, also be applied to the peridotite layers on Skye and in the Critical Zone of the Bushveld intrusion, e.g., the olivine-bearing Pseudoreefs and Merensky Reef.[15] This impacts on assumptions of the parental liquids and in the case of Skye suggests that a peridotite magma as well as a basaltic magma, distinguished in part by the percentage of entrained olivine crystals, was involved.[13]

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

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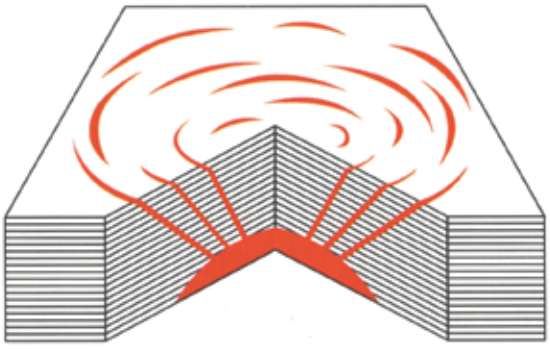

Arrangement of concentric cone-sheets above a magma chamber

Schematic showing arrangement of cone sheets above the uppermost part of a funnel-shaped magma chamber.

Skye Bridge (opened in 1995) crosses Loch Aish and connects Skye to the mainland of Scotland via an islet.

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35 IGC legacy fund

2022 Call for Grant Applications: 35 IGC Legacy Fund support

The generous support received from sponsors, donors and over 4,000 registered delegates resulted in a financial surplus after the 35th International Geological Congress that was held in Cape Town during 2016. Provision has been made for the investment of these funds that are administered by the Board of 35IGC Legacy Fund to ensure that the legacy of this successful event will benefit the South African geoscience community long into the future.

Annual grants will be advertised to promote geoheritage themes or activities in support of deserving geoscience students and researchers. A thematic focus will be identified every year. The level of funding available annually for disbursement will vary in relation to investment income and the need to maintain or grow capital from which sustainable support can be provided.

2022 call for grant applications

The COVID-19 pandemic has ravaged the world during 2020/2021. Most geoscientists have been forced to change their work activities. Long-term plans have been severely disrupted. The future of scientific conferences has swung towards digital events and field-based activities have been hampered.

Accordingly, the 2022 call for grant applications by 35IGC Legacy Fund is aimed at a broad spectrum of activities in themes that support or promote:

- Geoheritage
- Geotourism
- Geoscience education
- Geoconservation

i) The thrust of proposals should be product-focused and applicants must outline how the grant will be utilised to establish a long-term presence that will promote activities associated with any of the themes listed above.

ii) Proposals that include additional sources of funds will be favoured.

iii) Where proposals aim to create products in support of facilities housed in a national or provincial park, world heritage site or any other established heritage or tourism-focused facility, the written support of the controlling institution must accompany the application.

As only limited funds are available, compliance with the above conditions does not guarantee acceptance of any applications submitted. All provisionally successful applications will be reviewed and evaluated by the Management Committee/ Board of the 35IGC Legacy Fund and their decision is final.

Applications must be made on the prescribed form available as an attachment to this notice and submitted to Ms Ndivhuwo Cecelia Mukosi at 35IGCLegacy@geoscience.org.za before 31 December 2021. No late applications will be accepted. The applications will be adjudicated and the outcome announced early in 2022.

The Department of Earth Sciences at Stellenbosch University,
the Geological Society of South Africa,
the Igneous and Metamorphic Studies Group,
the Global State of Affairs, and the local state of the vaccine drive

regret to announce:

EVENT POSTPONED AGAIN

Dear Southern African Earth Sciences community

Earlier this year, the Geocongress Local Organising Committee (LOC) again took the decision to postpone Geocongress on account of continued uncertainty related to public health and the corona virus pandemic. The likelihood of an imminent 'third wave' justifies this decision. If the ongoing vaccination drive proves successful, then we remain hopeful that Geocongress can be run as an in-person event in 2022. It is the LOC's firm belief that such an interpersonal engagement is crucial for the local earth sciences community especially as we emerge from this period of limited interpersonal contacts. As such, we remain committed to running the event at a yet-to-be decided date next year.

In the interim, and to maintain momentum, the LOC plans to run a three week long **GEOCONGRESS APPETISER SEMINAR SERIES (*19 July – 6 August 2021*)**. This will comprise a series of nine lunch time webinars using the GSSA's online Zoom presentations and Youtube recording platforms. The themes of the nine webinars closely match those that were suggested as sessions for the original Geocongress and thus encompass the range of different earth science sub-disciplines being advanced in the southern African context. Please continue to monitor the Geobulletin and the GSSA's mailing list for updates related to this exciting seminar series!

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Quarter Page	R 5 200.00	R 4 500.00

Colour

Full Pg F/C	R17 600.00	R16 850.00
Half Pg F/C	R13 750.00	R13 000.00
Quarter Pg F/C	R10 850.00	R 10 400.00

Special Positions

(Front & Back)	Inside Cover F&B	Outer Cover F&B
	R26 450.00	R25 400.00

Professional Directory: (Black & white only)

Company:	R1 050.00	R1 058.00
Individual:	R 800.00	R 800.00

Size: 45 x 90 mm wide

Advertorial rate per column per cm

Full column, ± 500 words:

R3 750.00	R3 750.00

2. MECHANICAL DETAILS

Trim Size:	297 mm x 210 mm
Full Bleed	297 mm x 210 mm + 5 mm all round
Type Area:	Full Page: 275 mm x 190 mm
Half Page:	275 mm x 95 mm (Vertical ad) 135 mm x 190 mm wide (Horizontal ad)
Quarter Page:	135 mm x 95 mm (Vertical ad)
Screen:	300 DPI or more
Material:	CD or High resolution PDF in CMYK

3. PRINTING MATERIAL

Material to be supplied as a digital PDF file. Accompanying images should be high resolution in CMYK format (NO RGB or Pantone colours). Any full page material to be trimmed to 297 x 210 mm must include a bleed of 5 mm all round. Any modifications supplied material will be charged to the advertiser at R300.00 per hour.

4. LOOSE INSERTS

R8 050.00 Printed material to be supplied. Please ensure that the inserts do not exceed the trim size of 297 x 210 mm. All inserts must be e-mailed to the GB Editor.

5. DEADLINES FOR COPY AND ADVERTISING MATERIAL

March issue:	15 February 2022
June issue:	15 May 2022
September issue:	15 August 2022
December issue:	15 November 2022

6. CANCELLATIONS

At least 4 weeks prior to deadline

7. CIRCULATION

Geobulletin is issued in digital format to all members of the GSSA and its local and overseas exchange partners. A printed option is also available for those who opt for it, and the electronic version is available as an open access download on the GSSA website.

8. ADVERTISING BOOKINGS AND SUBMISSION

Contact person: GSSA
e-mail: **lully.govender@gssa.org.za**
accounts@gssa.org.za

9. ADDITIONAL CONTACT INFORMATION

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SOCIETY OFFICE

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The design and layout of the adverts is the responsibility of the advertiser. If you wish to utilise the services of the GB graphics and layout supplier, please contact Belinda directly, well in advance of the advert submission deadline to make arrangements.

2022

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Geological Society of South Africa