GSSA
Geological Society of South Africa

geobulletin

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VOLUME 63 NO. 1

Mining Technology Trends
Maggie Newman's paintings in Parys
Exhibition of the Vredefort Dome

news

CENTREFOLD: pg 26 and 27

Maggie Newman's paintings in the Parys Museum Depicting the Vredefort Meteorite Impact Event:

1. A meteorite the size of Table Mountain approaching the Earth 2,023 million years ago, travelling at a speed in excess of 40,000 km per hour.

2. As the meteorite impacted the Earth it exploded with a force equal to thousands of atomic bombs, with temperatures equal to those on the Sun. This caused down-folding, faulting and melting of the flat-lying rock sequences (Witwatersrand, Vrentersdorp and Transvaal Supergroups) overlying the granite–greenstone basement.

3. While the meteorite itself was mostly vaporised, massive rebound of the granite–greenstone basement caused uptilting and overturning of the originally horizontal rock layers. Shattered rock and rock fragments were blasted into the air, some falling back to Earth around the site of impact. Rock dust formed air-borne clouds that were carried around the Earth, probably blocking out sunlight for many years.

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Front Cover:
Cleaved green diopside crystals in a phlogopite/biotite(?) matrix from Palabora mine.
Bruce Cairncross collection and photo.
See article on pgs. 34-35.

Geological Society of South Africa

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from the editor's desk

Chris Hatton

Well, all good things must come to an end. This issue is my last as editor of Geobulletin. I have greatly enjoyed my efforts to amuse and occasionally annoy the members of the Geological Society of South Africa. The principal sources of annoyance are probably my support for the view that humans play a part in causing climate change and my unfavourable opinions of the benefits of coal mining to South African society. The debate on anthropogenic climate change will continue to rage for years to come, but simple economics signals the end of coal mining. At 52c per kilowatt hour, renewable energy is apparently now the cheapest form of energy on the market. Combined with the public's ever increasing distrust in the ability of centralised organisations to function efficiently, the shift away from coal-fired electricity generation to solar power looks set to exponentially accelerate.

The new editor of Geobulletin is Trishya Owen-Smith of UJ. Trishya will be leading an experiment with a new format where guest editorials will replace the traditional editorial. The next editorial could well be from someone who strongly disagrees with our pessimistic assessment of the future of the coal mining industry and who wishes to present the case for clean coal. This is for the future to tell. The guest editorial is open to anyone who wishes to express opinion on any aspect of South African geology. Please contact Trishya with your ideas.

I will be continuing my involvement with the Geological Society in the Geoheritage Division, so for the rest of this editorial I will be putting my new Geoheritage co-ordinator hat on to present a guest editorial on the paths that Geoheritage in South Africa could follow.

The Geoheritage Division is one of the divisions of the GSSA, established in 2017 to serve primarily as a networking and communication channel. South Africa is blessed with a diverse geology that can be highlighted in all the provinces. Thus far the representatives are:

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Cameron Penn-Clarke cpennclarke@gmail.com

Based at the Bellville offices of the CGS, Cameron Penn-Clarke's passion is the Cederberg, so although the population resides largely along the coast, the inland parts of the Western Cape will not be ignored. The connection to European science through Charles Darwin's visit to the Sea Point contact is something that the Western Cape Branch has well in hand, as can be seen in the previous issue of Geobulletin. Doug Cole's book on the building stones of Cape Town provides a further illustration of the historical aspects of geology that are preserved in the Mother City. Cape Town is also a strong centre of academia and it was at the University of Cape Town that John Gurney assembled his invaluable collection of mantle xenoliths. The Messengers from the Mantle exhibition, built on this collection, is now on display at the Lourensford wine estate near Stellenbosch.

Most of the xenoliths in the John Gurney Mantle Collection at UCT were carried into the crust in the kimberlites near Kimberley in the Northern Cape. Kimberlite geologist Jock Robey is extensively involved in the display at the Big Hole in Kimberley. Also around Kimberley are the Nooitgedacht glacial pavements, where the inland San used the glacially scoured pavements as their canvas. In the quiet reaches of the Northern Cape is the Square Kilometre Array, where signals from the universe, free of human chatter, can be gathered and then transferred to the global community of astronomers attempting to trace the history of the universe back to the Big Bang. The Northern Cape appears to be the ideal area to explore the link from the Big Bang to the rocks deep beneath us.

Cape Town may be the Mother City but all roads lead to Gauteng. Here Richard Viljoen of Bushveld Minerals, together with his brother Morris and Alan Roxton-Wiggill, is co-ordinating the development of the concept of Geoheritage Destinations. A well-established destination in Gauteng is the Cradle of Humankind. Using the concept of Geoheritage Destinations, a cheery visitor to the Mantle Messengers Destination at Lourensford might be enticed to stop off at the Diamond Destination in Kimberley, then continue his journey to a Golden Destination in Gauteng, perhaps at the Walter Sisulu Botanical Gardens, in convenient proximity to the Cradle.

Gold is the precious metal of Gauteng, but in remarkably close proximity is the Platinum Province. The Harties cableway takes visitors to the top of the Magalieberg, from where they see the platinum mines of the North West Province to the north and the gold mines of Gauteng to the south. Appropriately enough, the Viljoen twins are instrumental in highlighting the twin sightings of precious metals from this vantage point.

The gold leaf wrapping the Mapungubwe beads and rhinoceros originated in the ancient kingdom of Mwenemutapa/Munhumutapa and the trade routes connecting Great Zimbabwe, Thulamela and Bosutswe to the world pass through this Gateway Destination of the Limpopo Province. The best exposures of the iconic Bushveld Complex occur in Limpopo. Ndivhuwo Cecilia Mukosi in the Polokwane offices of the CGS is the co-ordinator of Goeheritage in Limpopo and serves on the Legacy Committee established after the 35th IGC. In addition to providing funds to support student attendance at future IGCs, the Legacy Committee supports our Geoheritage effort.

In Mpumalanga, the highlight is the Barberton Makhonjwa Mountains World Heritage Site and the associated Geotrail, with its evidence of ancient life and komatiites. Chris Rippon, Chairman of Friends of the Museum, Barberton, has identified several additional sites in this province, against the backdrop of the escarpment magnificently exposed in the Blyde River Canyon.

The rocks of the Free State preserve relatively recent developments in the evolution of life, including the transition from reptiles to the very earliest mammal-like reptiles and dinosaurs. The discovery of some of the oldest dinosaur eggs containing embryos, coupled with the wealth of fossil material from the area, has prompted the construction of a fossil museum at Golden Gate Highlands National Park near Clarens. The Groenewald family have been running educational trips highlighting the palaeontological heritage of the

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Clarens/Golden Gate area for the last 25 years, and David Groenewald's current research focus at Wits is on the mid- to late Permian faunal assemblages from the Free State and KwaZulu-Natal. Emerging beneath the fossiliferous Karoo sediments in the Northern Free State is the Vredefort Dome World Heritage Site, a special interest of Elizaveta Kovaleva at UFS. The Vredefort impact structure is one of the largest and the oldest meteorite impact sites discovered on Earth. It is deeply eroded, allowing us to access the lower stratigraphic levels of the large impact basin and giving us a point of comparison with such structures observed on the Moon, Mars and other planetary bodies.

Northern KwaZulu-Natal hosts some amazingly well-preserved Archaean terranes. Here, one can marvel at underwater lava flows as you traverse through an ancient rift valley, explore old tidal flats that host fossilized remains of some of Earth's earliest life and search for gold in a Witwatersrand-type conglomerate. Nigel Hicks, at the Pietermaritzburg offices of the CGS, has proposed that a Geopark could form part of the Emakhosini–Ophathe Heritage Park in the Emakhosini valley (Valley of the Kings) near Ulundi. Southern KwaZulu Natal is beginning to reveal an extraordinary record of the very earliest San populations. The diet of these coastal San relied heavily on seafood, an ingredient regarded as essential in the massive expansion of the human brain relative to our primate ancestors. If continued research validates this and other suggestions for human origins in KZN, this province may well have a strong claim as a First Peoples Destination.

Like it or not, burning of fossil fuels is not going to stop overnight, so mechanisms to deal with carbon emissions are vital in attempts to manage climate change. Coastal deposits of KZN, with which Nigel Hicks is quite familiar, provide a possible site for sequestration of carbon dioxide. The climate of KZN remained remarkably stable during the evolution of modern humans, so this province appears well suited to be the site where the multifaceted aspects of climate change are considered.

The end goal of Geoheritage is to promote Geotourism in South Africa. The national and provincial game parks are a tourism magnet that attracts people to see the animals, the birds, the plants and maybe even to the rocks that underlie everything. The Field Guide Association of South Africa is interested in incorporating more geology into the training program of aspirant field guides. Matt Mullins, Director of Tecoma Strategies, has launched a pilot project at the Kariega Game Reserve in the Eastern Cape. The field guide that is in preparation can serve as the template for similar reserves in the Eastern Cape, and a workshop to present and discuss the guide and the associated training material is planned for May 2020. This Workshop will include FGASA, GSSA and Kariega Park representatives.

The above are just a few aspects of the Geoheritage of South Africa with much more that could be included, but at this early stage, we need to prioritise our efforts. The first priority of the Geoheritage co-ordinators is to identify ten or so premier geological locations in each province. The initial list will appear in the next Geobulletin. If you have any favourites, please let us know.

Chris Hatton
chatton@geoscience.org.za

executive managers corner

Craig Smith

The major story of the first quarter of 2020 is the effect of the coronavirus outbreak as it spreads from China to the rest of the world. The virus seems to be less deadly than, for example, the Spanish flu pandemic of 1918–1920, but is more easily transmitted, which is a serious problem in a much more connected world. It appears to be only a matter of time before it is given pandemic status by the World Health Organization. The consequences for the earth science community are serious. The 36th IGC has been postponed until November, and in my opinion, there is no certainty that the virus will have run its course by then. The effect on other major international conferences in the 2020 calendar is likely to be severe, though as of the time of writing no others have been cancelled or postponed. Geologists travel more than practitioners of other professions – not just to conferences – and I expect that the virus will reduce movement. It is not so much the threat of being infected, but the possibility of having to endure a two to three-week quarantine if one individual in a plane full of passengers is found to be infected. Another imponderable that has not been receiving much coverage on the news channels is the rate of false positive diagnoses, which is a problem in medicine generally, and particularly so in the developed world. The authorities are going to err on the side of caution, particularly as the number of cases of infections without an obvious source increases.

The economic effects of the virus on the travel and conferencing industries are immediate and severe, and given that China produces much of the world's manufactured goods, supply chains will also likely be increasingly disrupted over the next few months. Simple things that we take for granted in our day-to-day lives (such as batteries?), as well as specialist products (surgical instruments, medicines?) may become harder to find. On the upside, the severe drop in the global stock markets may be a great buying opportunity. To all the younger professionals who are not yet invested in the share markets, now may be a great time to get started.

The GSSA meetings program for 2020 remains unaffected, given that southern Africa has so far recorded no coronavirus cases, with local travel being relatively unaffected to this point. If this should change, the membership will be notified.

Geocongress 2020 is on track, with the conference website being updated continuously; see http://allevents.co.za/geocongress/index.html for the latest. The event is being staged at Stellenbosch University, commemorating the 125th anniversary of both the GSSA and Department of Earth Science at Stellenbosch.

There has been a personnel change at Geobulletin. Chris Hatton is stepping down as editor, after a decade of service. He has done an exceptional job leading the production of one of the two flagship journals of the GSSA. The GSSA management team extends its gratitude to Chris, and his employer (Council for Geoscience) for allowing him to spend time on this important task. Chris will take over from Genevieve Pearson as head of the newly formed Geoheritage Division of the GSSA. We thank Genevieve for her efforts in establishing the Division, which we believe will increase in relevance and importance in GSSA affairs with time.

The incoming Geobulletin editor is Trishya Owen-Smith (University of Johannesburg), and she will no doubt bring fresh thinking to Geobulletin, one idea being soliciting invited editorial articles on any of several topics relevant to the earth sciences in southern Africa. Welcome Trishya, all the best for this new challenge!

Craig Smith

president's column

Sifiso Siwela

Happy 125th Birthday, GSSA

The official "founding" of the GSSA on 4th February 1895 was prompted by the discovery of Witwatersrand (Wits) gold in 1886, which also coincides with the founding of Johannesburg. This discovery caused the scientific and technical centre of gravity to shift from Kimberley to Johannesburg and therefore the concentration of the geological, financial and greater mining fraternity in Johannesburg, which was in its infancy.

In this first column of our 125th birthday celebration year, I reflect on the story of the "founding father of the GSSA". Dr David Draper's career not only had significance in the "professionalisation" of geology, but also emphasised geology's importance in the political, economic and social history of South Africa. Most of the various quotes and references I have given here come from the article *"The making of a South African Geologist"* (Chetty, 2018), which is based on Draper's unpublished and incomplete memoir. This article traces Draper's life from the mid-19th century to the mineral discoveries and the South African War in the early 20th century. It uses the story of Draper to show the complexities and tensions in the creation of a South African identity, at a time when the nation was in its infancy. The article also stresses that the history of geology cannot be divorced from the history of the country, mirroring the processes of colonial domination, conflict and eventually the creation of an independent state.

Draper was born in the former Cape Colony in 1849. As the son of one of the English Settlers who came out to South Africa in 1820, he had a rocky upbringing in the Eastern Cape. Most of Draper's brief schooling was in Colesberg, after which he worked for a time for his stepbrother as a storekeeper and later on a sheep farm. In his teens, Draper joined the diamond rush as a digger, working first on the Vaal River, then at Du Toit's Pan in 1870 and in Kimberley in 1871. The experience he gained here was invaluable, as it gave him insight into the geology of how diamonds were formed. After active involvement in the diamond mines with some success, he then went to Lydenburg and Barberton Goldfields to join the growing number of alluvial prospectors there, not to strike it rich with gold, but rather for commercial opportunities caused by the rapidly growing settlement, from owning a brickyard to selling sewing machines.

Due to his experience on the diamond mines, he was officially appointed as a geologist during the gold rush shift between Lydenburg in the 1870s and Johannesburg in the 1880s. Draper initially assisted with tracking gold reefs and was eventually made manager of Natalia Company's Pioneer Reef, Moodie, in Lydenburg. His success there prompted his move to Johannesburg, where he took up a position at the Compton & Gardiner Black Reef Mine. Draper then made the transition to become part of the gold mining industry that underpinned the South African economy. His practical knowledge of diamonds, supplemented with gold, set him on his career path.

Due to his constant pursuit of discovery, he settled for some years in the former Natal, where he eventually got involved in the extensive coalfields there. Draper's move to Natal in 1876 was by chance. Here he started a business in wool washing, which aided in his financial success and allowed him to start a family. As he was

experiencing both financial and domestic stability for the first time, Draper could now focus on his long-neglected education and embark on his career as a geologist.

He purchased the book *"The Principles of Geology: An attempt to explain the former changes of the Earth's surface by reference to causes now in operation"* by Charles Lyell (1830). Lyell and his predecessor, James Hutton, are considered the founders of modern geology. Hutton was the first to propose the notion of uniformitarianism or gradual change, as opposed to earlier views of catastrophism or dramatic change being the key agent for geological change. The book formed the foundation for Draper's education in geology as he used it as a reference guide when walking around his farm studying the rock formations until he was able to distinguish sedimentary from igneous rock and had developed a rudimentary understanding of the geology of the land.

Using his newfound knowledge, Draper discovered a coal seam running across his Natal farm, within the Ecca Formation of the then northern Natal coalfields. The coal was found with shale, which even today presents some confusion for an inexperienced geologist, such as Draper. While extracting and supplying coal to dealers, gaps in his education showed when he was unable to distinguish coal from shale, leading to some unhappy customers and the invaluable lesson that, *"not everything black is coal"*. Still, Draper was relentless and continued in his pursuit of education and acquired a reputation for his growing geological expertise. He even persuaded the Natal Government Railways to use coal mined in Natal both on trains and in industry in general, therefore stimulating coal mining in the province.

Draper later purchased two farms in Natal hoping to start an iron foundry and even went to England to learn how to produce iron and steel. During his visit there he was elected a Fellow of the Geological Society; the first South African to achieve that status. Ironically, he also discovered here that his foundry would not be commercially viable, which brought financial difficulty and forced another move to the Transvaal, where he was hired by the Chamber of Mines to conduct a survey and collect fossils north of Pretoria.

Once financially stable again, Draper focused in greater detail on the academic nature of geology, contributing many geological papers to the Geological Society of London including the articles *"Geology of South-Eastern Africa"* and *"Marble beds in Natal"*. He then saw the need for a professional body of geologists in which members could pool their knowledge to the advantage of the expanding mining industry. The envisaged association would incorporate all engaged in geological work from explorer, to prospector, to the formally trained geologist, and the mining engineer. Draper has been described as the "midwife" who brought the society into being. The founding meeting was held at the then Transvaal Chamber of Mines (now Minerals Council) in Market Street, Johannesburg, and consisted of the following founding council members:

- **Honorary President**
  Lionel Phillips
  (also Chairman of the Chamber of Mines);
- **Honorary Vice President**
  Prof Thomas Rupert Jones;
- **Honorary Vice President**
  Dr William Guybon Atherstone;
- **First elected President**
  Dr Hugh Exton;
- **Vice President**
  Arthur Robert Sawyer;
- **Vice President**
  John Ballot; and
- **Secretary and treasurer**
  Dr David Draper.

The remainder of the 1895 Council consisted of 20 distinguished members. A constitution, based on the Geological Society of London, was adopted. At this historic meeting, Draper also presented the first paper, on the interesting topic of the gold-bearing conglomerate on the Wits. Later, in his capacity as the curator for the Chamber of Mines Museum, Draper was also responsible for persuading the Chamber to donate its mineral collection to the GSSA, which later formed the core of the museum.

Certain later events put Draper at odds with the powerful mining interests on the Wits. As the son of a British immigrant, Draper's sense of nationalism was complicated in the late 19th and early 20th centuries. Draper's allegiance to people of Dutch/Afrikaner descent conflicted with his work as an English-speaking geologist who depended on the powerful, profit-seeking mining companies for his livelihood. Draper lost work as a mining geologist due to his support of the ZAR government. He had also become a citizen of the Transvaal and was therefore no longer considered British. There are interesting stories in Chetty's article about Draper's involvement in Paul Kruger's (president of the South Africa Republic) and Cecil John Rhodes' (British mining magnate and Prime Minister of the Cape Colony) control wars for Transvaal, which were driven to some degree by the minerals rush. He also assisted in the war as a non-combatant Red Cross Officer. Even though he took an oath of neutrality, Draper was made a prisoner of war and held in Ladysmith. Another lesson for geologists is to strive for our principles and values.

In Brazil during 1908, Draper noted similarities between South African and South American rocks, which led Alex du Toit, amongst others, to make the case for continental drift less than a decade later. Even though Du Toit is the South African geologist most associated with continental drift, Draper made early reference to the connection between the two continents, even before Alfred Wegener received international recognition for it.

In *"A Ramble through the Geology of South Africa"*, Draper wrote of the findings of the Indian Geological Survey that suggested a connection between India and Africa, based on similar fossil evidence across the landmasses, which he later reinforced by comparing evidence from South America with that of South Africa. His awareness showed the convergence between geology as an intellectual discipline and economic geology and demonstrated Draper's genuine love for the science. Draper also displayed a curiosity in the origins of the San people who still lived in the caves of South Africa, who he felt could provide insight into the evolutionary past.

After an eventful life, one of Draper's final academic contributions was the manuscript *"The Birth of the Diamond Industry in South Africa"* that describes the early diamond mining history that he had witnessed, through use of his own drawings and words, and also documents the history of an emerging discipline and a new country. He was awarded an honorary doctorate from Wits University in 1927.

In 1932, the David Draper Medal was introduced by the GSSA as a means of paying homage to one of the society's founding members. This is the GSSA's most prestigious award and is presented to geologists who have made a significant contribution to the discipline of geology and the particularly the furthering of South African geology. Alex du Toit was its recipient in 1933.

As I emphasised in my inaugural address at the AGM on Mandela Day and my first Geobulletin column, it is important that we as geologists should recognise our individual power to make an impact and change the world around us. *"Everyone has the ability and responsibility to change the world for the better"* – Nelson Mandela. The career of Draper showed that geologists can be relevant in many facets of society and we should continue with this. Draper was more pragmatic than intellectual in his approach, with his self-taught geology drive to gain experience. This emphasises the importance of field work and observations, even in this age of technology and remote sensing. An important motivation for geologists is the quest for mineral wealth, but the geologist also functions as the "all-seeing" eye that renders the land knowable for the purposes of exploitation. This knowledge could be applied to agriculture, industrialisation, mining and settlement.

Another Draper quote in Chetty's article:

> *"The geologist is probably the only class of person who has to traverse large areas with his eyes open, not to one class of phenomena only … He is led into … many facts with regard to the distribution of animals and plants, and the dwellings, occupations and characteristics of the people can scarcely escape his observations; neither can he shut his eyes to historic and prehistoric facts. Thus a geologist is generally possessed of a store of knowledge reaching far beyond the strict bounds of his science."*

Two months before Draper's death in 1929, the British Association for the Advancement of Science visited South Africa, and this coincided with the 15th IGC in Pretoria; the first on the African continent and in the southern hemisphere. The conference symbolised the growing assertion of scientific expertise in the southern hemisphere and the intellectual and political independence of the former colonies. Draper passed away at the age of 80, the same year as Dr Percy Albert Wagner, who was also distinguished in economic geology and a Fellow of the GSSA.

Draper was active in key decades that shaped the state, which included colonisation, conflict and capitalism, all of which were related to the country's geology. Draper epitomises the amateur geologist whose expertise was built through fieldwork rather than formal education, but who became an integral figure in the professionalisation of geology. The financial insecurity that led to Draper's various economic activities as an adult highlights the ways in which geology, in the South African context, serves both pragmatic (economic) and intellectual interests. This financial insecurity manifests itself in the current mining industry and I believe we as geologists can change this.

The "Founding" Council Members of the GSSA in 1895 consisted of the who's who of the South African geologists at the time and we are grateful for the learned society they have formed. South Africa has a rich mining history that we can all be proud of and this evolution continues in the current day and age of the so-called 4th Industrial Revolution.

This year we will celebrate the 125th anniversary of the GGSA through various events, including a formal event, the 2020 Geocongress, meetings and branch events. Our Geoheritage activities will have a large focus on the Eastern Cape region, which was an environment that had an important impact on Dr Draper. I appeal to the membership to get involved in 2020 to celebrate this evolution with us.

Sifiso Siwela

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the SAMCODES

THE PROFESSIONAL (AFFAIRS) CORNER

The SAMCODES –
a vital Code of Practice for Geoscientists

The SAMCODES, the South African Mineral Reporting Codes, set out the minimum standards, recommendations and guidelines for the Public Reporting of mineral-related issues in South Africa. They currently comprise three Codes, two Guideline documents and an affiliated National Standard:

I. SAMREC Code: The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves
II. SAMVAL Code: The South African Code for the Reporting of Mineral Asset Valuation
III. SAMOG Code: The South African Code for the Reporting of Oil and Gas Resources
IV. Commodity- or subject-specific guidelines:

- SAMESG Guideline: The South African Guideline for the Reporting of Environmental, Social and Governance parameters within the mining and oil and gas industries
- SAMREC Diamond Guidelines: SAMREC Guideline Document for the Reporting of Diamond Exploration Results, Diamond Resources and Diamond Reserves (and other Gemstones, where Relevant)
- SANS 10320: South African guide to the systematic evaluation of coal resources and coal reserves (updated document due to be published in 2020). This document is a South African National Standard, published by the South African Bureau of Standards.

The aim of the SAMCODES is to maintain and develop the trust of investors and other interested and affected parties by promoting high standards of Public Reporting. They provide minimum standards for Public Reporting; add credibility to declarations by project promoters and assist in comparisons because of a uniform basis of declaration; assist professionals providing them guidance; and assist the Competent Person ("CP"), Competent Valuator ("CV") or Qualified Reserve Evaluator ("QRE") to demonstrate the legitimacy of the declaration and provide credibility to the Public Report.

The SAMCODES have wide application throughout the extractive industries, as attracting finance for exploration, mining and oil & gas production ventures is a critical part of the resource business environment today. A SAMCODES declaration allows the investor to understand the technical and financial risks associated with the project/mine. With the increase in the number of non-listed (private) companies and individuals seeking to obtain financial assistance, it is important to appreciate that issues of public reporting are not confined to listed companies only.

The use of the SAMCODES is not limited, however, to the needs of investors – financial statements and legal documents can benefit from internationally standardised principles and terminology such as Mineral/Hydrocarbon Resource, Mineral/Hydrocarbon Reserve, Feasibility Study and Valuation. Also, social, environmental and governance matters (Sustainability Reports) can be issued according to a consistent set of criteria.

The SAMCODES do not specify the technical details relating to Exploration Results, Resource and Reserve estimation and valuation. The interpretation of the raw data, the geological interpretation, engineering

design, infrastructure requirements, and governmental, social, environmental and economic inputs all require the involvement of specialists. Because the geological model is open to interpretation and has a huge influence on the mine design and associated financial outlook of the mine, field or project, there is a need for guidelines. The SAMCODES provide these guidelines and a mechanism to assist in the progression of mining/production projects, which includes holding various registered professionals accountable for their work.

Authors of Code-compliant documents are required to be registered with an applicable statutory/professional organisation and have sufficient relevant experience in the aspects that they are reporting. In fact, since the professional organisations are founding signatories to the SAMCODES, all of their members are required to uphold the tenets of the Codes in their professional conduct. In this respect, it is necessary to take note of the term "Public Report". It is incorrectly assumed that "Public" refers only to companies listed on a stock exchange – it applies to all forms of public reporting, whether the company is listed or not; public reporting also includes press releases, information memoranda, technical papers, website postings and even public presentations. In effect, it includes any and all documentation that may eventually find its way into the public domain, in printed, electronic or even verbal format, including social media.

In addition, regulatory authorities such as the Department of Mineral Resources (DMR) and the Council for Geoscience (CGS) are increasingly requiring SAMCODE compliance for prospecting/mining right applications and on-going reporting requirements.

SAMREC CODE (The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves)

The SAMREC Code sets out minimum standards, recommendations and guidelines for Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves in South Africa. The first version of the SAMREC Code was issued in March 2000 and adopted by the JSE in their Listings Requirements later that year. The Code has been adopted by the SAIMM (Southern African Institute of Mining and Metallurgy), GSSA (Geological Society of South Africa), SACNASP (South African Council for Natural Scientific Professions), ECSA (Engineering Council of South Africa), IMSSA (Institute for Mine Surveying in South Africa) and SAGC (Geomatics Council of South Africa), and it is binding on members of these organisations. A second edition of the SAMREC code was issued in 2007, with an amendment being published in 2009. A third edition was released in May 2016 and came into effect, superseding the previous version of the Code, in January 2017.

The fundamental guiding principles of the SAMREC Code are:

Materiality: A Public Report contains all the relevant information that investors and their professional advisors would reasonably require, and expect to find, for the purpose of making a reasoned and balanced judgement.

Transparency: The reader of a Public Report must be provided with sufficient information, the presentation of which is clear and unambiguous, to understand the report and not be misled. It is stressed in the Code that the Competent Person should not remain silent on any issue for which the presence or absence of comment could impact the public perception or value of the deposit.

Competency: The Public Report is based on work that is the responsibility of suitably qualified and experienced persons who are subject to an enforceable Professional Code of Ethics. The author of the Public Report should be satisfied that: his/her work has not been unduly influenced by the organisation, company or person commissioning a report or any report that may be deemed a Public Report; that all assumptions are documented; and adequate disclosure is made of all material aspects that the informed reader may require in order to make a reasonable and balanced judgement.

At the centre of this declaration is the Competent Person who takes responsibility for the declaration. In order

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to take that responsibility, the designated Competent Person must be sure that they fully understand the meaning of that designation and the responsibilities that go with it and must be satisfied in their own mind that they can face their peers and demonstrate competence in the commodity, type of deposit and situation under consideration. The Competent Person is not only required to be registered as a professional but must be able to attest to having a minimum of five years of relevant professional experience in the nature of the work that he/she undertook as well as in the deposit type or style of mineralisation.

The Code has provided a comprehensive checklist (Table 1 in the Code) to assist the Competent Person to ensure they have addressed all the necessary aspects and can easily defend themselves to their peers.

The Code has definitions for Prefeasibility Study (PFS) and Feasibility Study (FS). These definitions are relevant as the minimum requirement for the declaration of a Mineral Reserve is a Prefeasibility level study. The detailed requirements, although broadly understood, are frequently selectively considered. To assist in providing a common understanding, a table has been included in the Code (Table 2) to provide some detail and reduce the ambiguity of the definitions. It must be noted that these are generally recognised guidelines and not fixed definitions.

The SAMREC Code has four commodity-specific sections, for coal, diamonds (including a Guideline document outlining requirements for diamond and other gemstone deposits), industrial minerals and metal equivalents.

SAMVAL CODE (The South African Code for the Reporting of Mineral Asset Valuation)

The SAMVAL Code should be applied in the valuation and reporting of all styles of solid mineralisation. The guiding philosophy and intent of the SAMVAL Code is that Mineral Asset Valuations (MAV) should be undertaken by Competent Mineral Asset Valuators (CVs) and all relevant information should be fully disclosed (SAMVAL, 2016).

In addition to the fundamental guiding principles of materiality, transparency, competence and reasonableness, partiality, responsibility and independence are also applicable for SAMVAL compliant valuations.

There are three valuation approaches, namely, Market Approach, Cost Approach and Income Approach from which the CV is required to use the two most appropriate approaches for the type of valuation being undertaken. Valuation methods are a subset of valuation approaches. Valuation approaches and methods may be more generally acceptable depending on the circumstances and this should be considered.

Whatever approaches and methodologies selected for the valuation by the CV, all relevant technical and related parameters, assumptions, premises, constraints and modifying factors used need to be disclosed, including but not limited to Mineral Resources and Mineral Reserves, mine plans, production schedules, mining recovery, mining dilution, metallurgical test work, metallurgical recovery, process plant design, project engineering, construction schedules, environmental impacts, permitting, socio-economic aspects, political risk reclamation and rehabilitation, capital costs, operating costs, smelter terms, product marketing and sales contracts, commodity prices, exchange rates, inflation and escalation rates, the cost of capital and discount rates.

Valuations that include exploration targets and Inferred Resources are associated with a higher level of risk due to the low level of confidence in the estimates. The CV should qualify such a valuation by stating the level of confidence in the resource and its concomitant risks. It is not acceptable to include 'potential resources' or hypothetical resources as these do not conform to SAMREC and CRIRSCO definitions of Mineral Resources and Mineral Reserves.

The SAMOG CODE (The South African Code for the Reporting of Oil and Gas Resources)

The SAMOG committee has developed a working relationship with the Alberta Securities Commission (ASC) in order to assist with the practical application

and maintenance of the SAMOG Code, for which disclosure requirements were guided by the Canadian National Instrument NI 51-101 (petroleum reserves and resources disclosure rules). Adaptations have been made so the SAMOG Code complies with the specific South African stock exchange requirements. To comply with the SAMOG Code, the Qualified Reserve Evaluators (QREs) will have to use either the COGEH or the PRMS as the technical reference for the petroleum reserves and resources disclosures.

Reserves and resources evaluation that will be disclosed to the public must be prepared by a Qualified Reserves Evaluator (QRE). The QRE should be a suitably qualified and experienced person who is subject to an enforceable professional code of ethics and must have a minimum of 10 years practical experience in petroleum engineering, geology or geophysics, with at least three recent years of such experience in the evaluation of reserves and resources.

The disclosure of reserves and other information must follow the guidelines as described in Form A published in the SAMOG code.

SAMESG (South African guideline for the Reporting of Environmental, Social and Governance Parameters)

International reporting standards and codes are becoming increasingly stringent when considering the requirements for accurate and appropriate disclosure of organisational social and environmental liability. The Environmental and Social aspects and associated Governance therein (ESG) that are associated with projects are often technically complex and span the entirety of the project value chain.

There is an extensive selection of technical standards available that provide a detailed framework for the reporting of social and environmental (socio-environmental) liabilities in the extractive industries. These frameworks span various business units in an organisation, addressing the technical, engineering, management and financial accounting requirements for operational socio-environmental management, closure practice and remediation.

The SAMESG Committee has responded to this shift in global recognition of the importance of competent assessment of and reporting on socio-environmental liability through the publication of the South African guideline for the reporting of environmental, social and governance parameters within the solid minerals, oil and gas industries (the SAMESG guideline).

The SAMESG provides guidance on the reporting of the following aspects:

- organisational structure, systems, policies, procedures and risk control management plans;
- compliance-related ESG aspects;
- key environmental parameters;
- external social and political parameters;
- internal social parameters;
- conformance and compliance audits;
- ESG liability; and
- risk analysis and materiality processes.

Although initially compiled as a technical guideline for Competent Persons Reports, the guideline has evolved to provide direction on ESG reporting requirements for public reporting, as defined in the SAMREC Code. The intention of SAMESG is to define the key ESG aspects that influence the reasonable prospects for eventual economic extraction as well as the Modifying Factors. There are nine items that must be reported on within the existing framework established by Table 1 of the SAMREC and SAMVAL Codes. These nine items are clearly defined in Section 2, 3 and 4 of the SAMESG. To the extent that any one of the items, or any component of an item, specified in SAMESG does not apply to a reporting entity and its activities and operations, or is not material, reference must be made to why that Item or component is not applicable or not material (i.e., the "If not, why not" principle applies).

The SAMESG also provides guidance on the technical supporting information required when compiling compliancy documents for frameworks such as the Equator Principles, United Nations Principles for Responsible Investment ("UN PRI") and Global Reporting Initiative ("GRI"). These standards, principles and frameworks encourage collaborative

engagement towards more inclusive and transparent analysis of environmental, social and governance matters, which in turn influence decision-making and project development practices.

The SAMCODES Standards Committee ("SSC")

The SAMCODES are developed, maintained, administered and promoted through the SAMCODES Standards Committee (SSC), which operates under the joint auspices and funding of the GSSA and the SAIMM. The SSC is chaired by appointees, alternatively from the GSSA and the SAIMM, for two-year periods. The Chairperson of the SSC for the 2020/2021 period is Dr Tania R Marshall, who is also the VP (Professional Affairs) for the GSSA. The Deputy Chair is Mr Andy McDonald (from the SAIMM). The GSSA representative on the SSC is Mr Sifiso Siwela, who is also the President of the GSSA.

The SSC comprises a number of member organisations as well as interested and affected observers and the Chairs of each of the Committees (SAMREC, SAMVAL, SAMOG and SAMESG). As of February 2020, the members of the SSA are Council for Geoscience, Department of Mineral Resources, GSSA, Geostatistical Association of South Africa, Institute of Mine Surveyors of Southern Africa, Investment Analysts Society, JSE Limited (including the Chairs of the relevant Readers Panels), Law Society of South Africa, Minerals Council of South Africa, South African Institute of Chartered Accountants, SAGC, South African Oil & Gas Agency, and SAIMM. Non-voting interested and affected (observer) organisations are SACNASP, ECSA, the General Council of the Bar and the Financial Sector Conduct Authority (FCSA).

Right from the inception of the SAMREC Code, the JSE has been a staunch supporter of the process, incorporating SAMCODE compliance into its Listing Rules. As a result, all submissions associated with certain categories of transactions are required to be reviewed by a Readers Panel – members of the Reader's Panel are appointed by the JSE, based on submissions through the SSC and are recognised experts in the commodity and deposit under consideration. There are separate Readers Panels for Solid Minerals reporting according to SAMREC/SAMVAL and for Oil & Gas reporting according to SAMOG.

The SSC's relationship with the FSCA (Financial Sector Conduct Authority) means that, going forward, all new Stock Exchanges in South Africa will also be required to include SAMCODE compliance in their Listing Rules for Minerals Companies.

The SSC promotes the highest ideals of ethics and professionalism in the fields of practice associated with the purpose of the SAMCODE relied upon by the public to provide expert opinion and service, in the public interest. The SSC also, in conjunction with the professional bodies, provides regular training opportunities in order to promote practical application of the Codes at both introductory and advanced levels.

The SSC also maintains an active website (www.samcodes.co.za) that provides information on industry best-practice, acceptable (or not acceptable reporting practices), the current versions of the Codes, Guidelines and Stock Exchange Listing Regulations, on-going research into all aspects of professional ethics, the latest international trends, as well as upcoming workshops and training programmes.

Compiled by **Tania Marshall** with contributions from **Ken Lomberg, Roger Dixon, Kelly Redman, Peter Dekker** and **Sarah Magnus**.

SAMCODES
THE SOUTH AFRICAN MINERAL REPORTING CODES

SACNASP
South African Council for Natural Scientific Professions
Register to be Recognised!

all the news fit to print

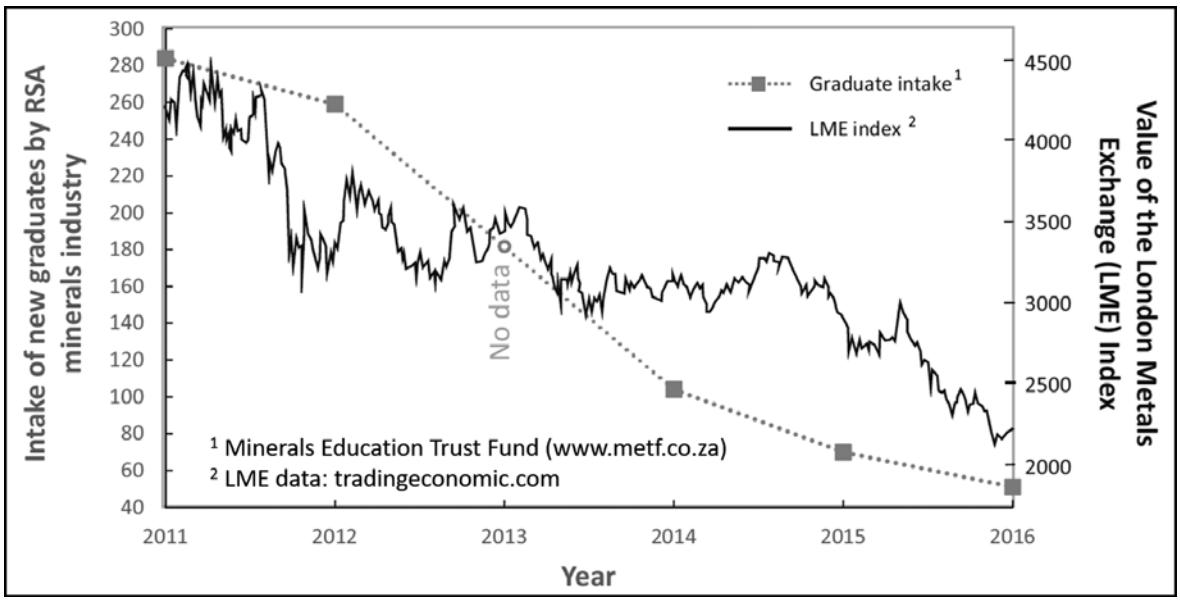
Stellenbosch University

To borrow a turn of phrase, the Stellenbosch University 2020 academic year has started off with a bang. In fact, it's been quite bangful. Or bang-like. Or perhaps; decidedly bangish. Irrespective of the word choice here, this year's start has seen notable successes in student numbers, exciting upgrades to the Department of Earth Science's facilities, and a rampant advancement in the preparations for the 2020 Geocongress.

Student matters: quantity and quality, in and out

As with the broad minerals resources industry, student numbers (both intake numbers and numbers graduated) in an Earth Sciences degree program are highly cyclical. Indeed, part of the reason for this may be related to the economic status of the minerals sector and the resultant availability of employment for graduated earth scientists. Unfortunately, there seems to be evidence for these cycles being slightly decoupled or out-of-sync. For example, when the mining sector is booming, it is highly lucrative to be a geoscientist and thus many school leavers elect to enter into this field of study. All going to plan (i.e., students do not get caught up partying to much at student bars such as Mystics or Bohemia), these students will only graduate four years later with their B.Sc. (Hons.) degrees. By this time, the status of the mining industry may have undergone significant changes and these graduates may need to explore other sectors to find their employment opportunities. Possibly because of this relationship, student first year student numbers at SU and many other Earth Sciences departments have been experiencing a decline in numbers over the last few years. This year, however, we are very pleased to announce that the trend has reversed and that we have enrolled 36 first year students- the first increase in numbers in the last five years. We also attribute the recent rise in the LME index (2654 on 21 Feb 2019) from the 2016 loww to our increased student intake, and with one hand pat ourselves on the back for our far-reaching influence on metal prices, whilst concurrently using the other hand to remove the tongue lodged against our cheek walls.

On the other end of the spectrum, we are also very pleased to announce the graduation of 3 Ph.D. and 7 M.Sc. degrees in the last round of graduations. The recent Ph.D. graduates were **Dr Lunga Bam** who developed methods to optimize X-ray Computed Tomography scanning of geological materials (e.g.,



*Relationships between commodity price trends and graduate student intake by the Southern African minerals sector (adapted from von der Heyden (2019) **Interviews with professional geologists enhance learning about the applied aspects of economic geology for final-year university students**).*

core samples); **Dr Andre Coetzee** who evaluated the controls on Karoo dyke emplacement; and **Dr Sandi Smart** who contributed to our understanding of Southern Ocean biogeochemistry by investigation nitrogen isotope cycling. The Department of Earth Sciences at Stellenbosch University is proud to continue its high throughput of excellent students who go on to contribute meaningfully to the South African and international professional and academic arenas.

Departmental seminar series continues to attract high caliber speakers

The 2020 seminar series has continued where it left off in 2019 with a sequence of high profile speakers exchanging knowledge with our broader department. Since the advent of the semester, we have hosted Prof Shanaka de Silva (Oregon State University), who provided us with his perspectives on arc magmatism; Prof Daniel Weidendorfer (LMU Munich), who gave an excellent presentation on his field and experimental petrology results related to the formation of carbonatite melts; and Paul Leach (Longford Exploration Services, Canada), who provided our student cohort with some insights into early career opportunities in the Canadian minerals exploration sector. Should you be in the Stellenbosch area and wish to present at our seminar series, please contact Dr Martin Klausen (klausen@sun.ac.za). Alternatively, should you wish to attend as an audience member, our seminar series occurs on a Wednesday between 1 and 2pm and is open to the public.

Award certificate presented to Jean Loock for presenting the best post-graduate research presentation during the annual departmental seminar series.

The seminar series is also a space in which our students can share their results with their colleagues and receive constructive feedback from the staff and student cohort alike. To stimulate student involvement in the series, we now offer a prize to the best student presentation over the course of the year. Last year's post-graduate presentation prize was awarded in December to Ph.D. candidate Jean Loock. His work on the trace element chemistry of Southern Ocean sea-ice duly reflects our Department's strong environmental and ocean geochemistry research. It is hoped that this year's competition will prove equally difficult to select a winner from the excellent work conducted by our post-grads.

125 is the magic number, let's celebrate with a Geocongress!

In 2020, the Department of Earth Sciences at SU turns 125 years old, which perhaps not coincidentally is the same age as the Geological Society of South Africa. To celebrate this auspicious anniversary, the Department and the GSSA have teamed up to present the 2020 edition of the Geocongress to the Southern African earth sciences community. The event, as many of you well know, is taking place between 28 June and 1 July 2020, and includes a host of exciting thematic areas, field excursions, and conference workshops. The sessions have been finalized and comprise a comprehensive array of earth science sub-disciplines; everything from hard rock and soft rock geology, to environmental geochemistry, to extraterrestrial geology, to geoheritage and geoscience education. The conference aims to cater for academics and industry professionals alike, and there is a strong drive towards facilitating and

encouraging student involvement. The venue is located in the heart of the Stellenbosch winelands at the world-class Adam Small theatre facility (newly renovated), which is conveniently sited directly across the road from the iconic student bars Bohemia and Mystics (see section on Student Matters: students who have too much of a good time and do not complete their studies in the stipulated time frames). For students from SU who did complete their degrees at the Earth Sciences Department (either timeously or non-timeously), there will be an Alumni Event planned for one of the evenings of the conference. Watch this space.

The abstract submission portal is now open and the southern African geoscience community is encouraged to sign up for this exciting event. Please see the conference website: http://allevents.co.za/geocongress/abstract-submission.html.

Facility upgrades: keeping relevant in an evolving tertiary education sector

Inasmuch as there is something special about the familiarity of musty rock displays in old geology departments (remember, ours is 125 years old this year!), there is also a continued need to keep relevant in an ever-modernizing society. To address this, the Department of Earth Sciences at SU has invested heavily in infrastructure upgrades in 2020. These include revamping the said musty display cabinets with new multi-lingual labelling, development of a new M.Sc. computer laboratory with new infrastructure and computers to fit >45 students, and upgrade of the Honours computer lab facilities. This investment in especially the computing power within the department is exceedingly important given the high-level computer skills required by the modern geoscientist, as a necessary complement to a strong grounding in field work, which our students derive from their extensive field work in undergraduate and Honours.

The display at the entrance to the Department is a sandstone slab comprising the trace fossils (e.g., footprints) from the Moesdam Farm in the Sandveld region, which has been upgraded with new lighting, models, plaques and an updated information board. This modified display was recently unveiled during a small ceremony with the family of the original donors of the slab.

Bjorn von der Heyden

Unveiling of the upgraded fossil track display at the Department of Earth Sciences entrance hall. From left to right: Mr George Olivier (SU), Dr Ryan Tucker (SU), Mr Koos Veldsman (family of original donors), Prof Alex Kisters (SU HoD), Mrs Lettie Veldsman (family of original donors), Prof Louise Warnich (SU Dean of Science), Dr Hannes Theron (retired geologist who worked extensively on the Cape Supergroup).

University of Johannesburg (including CIMERA and PPM)

Successful DSI-NRF CIMERA Annual Colloquium 2019

The Department of Science and Innovation (DSI)-National Research Foundation (NRF) Centre of Excellence for Integrated Mineral and Energy Resource Analysis (CIMERA) held its Annual Colloquium in the Protea Auditorium at the School of Tourism and Hospitality (STH), University of Johannesburg Bunting Road Campus on the 7th and 8th November 2019. The event was very successful, with 27 oral presentations made and 18 posters presented by post-graduate students and postdoctoral fellows supported by DSI-NRF CIMERA. 85 delegates attended the event – the highest turnout to date. Both the presentations and posters were of a high standard, and the PG students are to be thanked for the great effort they put into them.

An invited key note talk was given by Mr Henk Langenhoven, Chief Economist at the Minerals Council of South Africa, on "The Economics of Mining". This informative talk provided a good insight into the rands-and-cents issues around our mining industry, and was a reality check for us as geoscientists.

A sumptuous braai was held at the Design Café opposite STH on the evening of the 7th November that allowed all to socialize and network, especially with delegates from industry.

We thank the staff of STH and Design Café for making our Colloquium run smoothly. Our colleagues who travelled from afar (Fort Hare, Stellenbosch, Cape Town and Thohoyandou) deserve special thanks for making the effort to attend.

Staff activities

In October 2019, **Marlina Elburg** took part in a field trip to the high Andes in northernmost Chile, organised by Gerhard Wörner from the University of Goettingen. A select group of 13 participants from Germany, Australia, the US and South Africa spent 8 days studying the deposits of the ignimbrites and various other volcanic deposits of Parinacota and Taapaca volcanoes. Considering that most of the time was spent at more than 3500–5000 metres above sea level, the participants whose home turf was at higher altitudes had a distinct advantage. Even then, it's still more than 2000 meters higher than Johannesburg, and the altitude starts making itself known. Despite breathlessness, headaches and apermanently runny noses as a result of the relentless wind, all participants had a great time – and survived the experience. Young volcanic deposits in a desert environment (close to the Atacama) are decidedly more impressive than the 2.2–3.5 Ga deposits that we normally deal with in South Africa. A selection of samples was taken back to South Africa, so the UJ undergraduates will be able to enjoy truly fresh volcanics in their next igneous practicals.

Ms Bridget Murathi (left) and Ms Juliet Akoh, both PG students at UJ, during the poster session. Ms Murathi won the book prize for the best poster presented at the Colloquium.

Record attendance at the DSI-NRF CIMERA Annual Colloquium.

During February 2020 we bid farewell to **Lauren Blignaut**. She and her family have relocated to Canada and the Department wishes them all the best for the future in their new homeland.

During the Fellows Dinner in November last year, **Bruce Cairncross** was awarded the Draper Memorial Medal by the GSSA. It is awarded annually to a member of the Society for career-long exceptional contributions to geological science, with particular reference to the advancement of South African geology, and is the highest scientific award of the Society. It was awarded in honour of the significant contributions made during his career to a number of geology disciplines, including but certainly not limited to, Bruce's internationally renowned and recognised status for gemstone and mineralogy nomenclature, Karoo coal deposits and a career long commitment to student teaching and guidance. On the publication front, Bruce had his latest book "Minerals and Gemstones of East Africa" released late-2019 and this was reviewed in the previous issue of Geobulletin.

On the 15th January 2020, **Hassina Mouri** travelled to South Korea to attend the Executive Committee Meeting of the International Union of Geological Science. On the 15th December 2019, she went to Rio de Janeiro to meet with colleagues from the Geological Survey of Brazil and other institutions in order to discuss collaboration in Medical Geology under the BRICS program. She was nominated by the National Research Foundation of South Africa for the

Field trip participants in front of the altered Miocene lavas of the Cerro Cospilla.

Vice President position for the International Union of Geological Science and was shortlisted for this position by the nominating committee of the Union. Elections will take place at the council meeting of the 36th IGC in Delhi, March 2020. She received a B3 rating by the National Research Foundation of South Africa. In August 2019, she was invited to give a keynote talk at the International Medical Geology Conference in China.

Bertus Smith did a lecture tour in Germany in December 2020 with the support of the SPP "Building a Habitable Earth" fund. He gave a talk on South Africa's early Earth sedimentary record at the Free University of Berlin, Jacobs University Bremen and the University of Cologne. During his tour he also co-presented the annual Technische Universität Bergakademie Freiberg Economic Geology short course on iron and manganese deposits at the Helmholtz Institute in Freiberg. **Nic Beukes** was also a co-presenter at this short course.

Bruce Cairncross seen receiving the Draper Memorial medal (and a bottle of wine!) from the GSSA President Sifiso Siwela.

During January 2020, **Michiel de Kock** spent three weeks in India in collaboration with Prof Sarbani Petranabis-Deb and Prof Joydip Mukhophadyay of the Indian Statistical Institute and the Presidency College of Kolkata, respectively. The purpose of fieldwork was paleomagnetic sampling of limestone and shale successions in the Meso- to Neoproterozoic Cuddapah Basin on the Dharwar Craton, as well as the Kolhan Basin of the Sighbhum Craton. These basins form part of what is named the "Purana Basins" in India. These basins provide a largely undeformed and voluminous (i.e., ~20% of Precambrian exposure in India) sedimentary record of shallow marine to slope-basin conditions spanning much of the Meso- to Neoproterozoic and the so-called "boring billion". This is a period in Earth history characterized by relatively unchanging ocean and atmospheric compositions, a stable climate, and evolutionary stasis. In terms of tectonics the period is anything but boring, as it spans the amalgamation and breakup of two Proterozoic supercontinents (i.e., Columbia and Rodinia). The boring billion represents a long delay in between the initial rise in atmospheric oxygen, the oldest eukaryotic body fossils and the appearance and diversification of complex life. Documenting the boring billion is critical to unravel the history of the co-evolution of life, global tectonics, and the near surface environment. **Ms Ingrit Malatji** will start working on characterization of some of the collected samples this year as part of her MSc research.

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

Quarry for slabs of "Cuddapah stone" or laminated black limestone and marl of the Kurnool Limestone near Banaganapalle, Andhra Pradesh, India.

Call for Industry Participation

BridgeTheGap
GeosciencesGuidanceProgram
EMPOWER || INSPIRE

Bridge the Gap Geosciences Guidance Program (BTG), is a student run organization at the University of the Witwatersrand, that focuses on mentorship between undergraduate and postgraduate students, as well as students and industry professionals. In addition to the mentorship program, BTG hosts a number of informative talks, workshops and field trips to expose prospective students and graduates to opportunities and expectations in the work environment.

BTG invites all geosciences/mining related companies and industry professionals to "bridge the gap" between students and industry, and to act as positive role models by joining the BTG program as a mentor, sponsor or motivational speaker.

If you are interested in getting involved please complete the Google form by clicking on the following link: https://forms.gle/6PXQwpWtBromVb4T9

For more information, please email bridgethegap.wits@gmail.com

Your influence can go a long way in encouraging and shaping aspiring geologists to become future leaders. We believe that each of us can inspire and empower students by being "the mentor you wish you had".

technology trends

Mining Technology Trends: 2020 and beyond

The mining industry has historically been one of the first uptakers of new technologies that have driven the preceding three industrial revolutions. The advent of the fourth industrial revolution has seen the mining industry stepping up again as one of the first sectors to embrace and utilise the new technologies and they have invested heavily in the development of applications. The main driver appears to be in reaction to the economic downturns over the last decade. Mining companies have embarked on programs to optimise operations by automating processes, reducing cost and increasing safety. The industry, however, needs to increase efforts related to expectation- and fear-management, as automation is seen as reducing jobs in poor communities. There also appears to be a slight degree of internal resistance to change and adopting new technology.

A review of popular searches associated with the mining industry and fourth industrial revolution-related technology terms gives an indication of the trends most likely to influence the industry in the coming decade. Here is a quick rundown of the trends for 2020 and beyond.

Internet of Things

The adoption of the Internet of Things (IoT) has been the most significant trend in the mining industry. The industry has seen the advantages of RF tagging and interconnectedness between systems. The main applications are related to the analyses of performance, trends and making performance predictions based on the data generated by the IoT. It allows both the manufacturers and the operators to react to problems or introduce timely remedial actions. It also allows manufacturers to run off-site diagnostics. The IoT is considered an integral part of some of the other trends considered here.

Artificial Intelligence

The proliferation of AI applications has entered virtually every sphere of mining. Mineral sorting to separate gold-bearing quartz from barren quartz directly from the conveyor belt and geochemical analyses on-the-fly to anticipate recovery are just some of the pilot projects being developed. In mineral exploration, AI is increasingly being used for target generation to constrain exploration efforts to the areas of highest probability. In the oil-and-gas sector, the use of AI to combine historic project data to model and predict the location of economical traps of hydrocarbons has yielded encouraging results. The success of the AI platforms, however, depends on the quality of the training data. A skilled professional will still need to validate the interpreted product.

Integrated Automation

The introduction of driverless vehicles is still years away in the urban areas, but is already a reality on some mines. Autonomous mining vehicles are monitored from a control centre, where GPS sensors indicate the location at any given time. An array of sensors also indicates to the operator if there are mechanical issues or when the vehicle is due for maintenance. Safety has also been increased due to fewer persons in operational areas, fewer operator mistakes and addressing the issue of operator/driver fatigue that is a leading cause of accidents on mines. Face-drilling rigs, with up to six booms, can now drill, flush and charge holes on the face, either by remote control or autonomously. All of this also increases productivity, as nearly continuous operations become possible.

Blockchain

Initially developed for cryptocurrencies, the application of blockchain technologies has increased exponentially in the last three years. Blockchain is seen as a secure means of executing international transactions. There has also been a strong drive from the precious metals and gems industry to develop blockchain platforms as

a means of ensuring and meeting the requirements of ethical sourcing. Blockchain is used to proof the provenance from sourcing to sale. In combination with IoT, blockchain platforms are also increasingly being used by procurement departments, where ordering of supplies is automatically done if the inventory indicates a product to be below certain volumes or quantities.

Cloud

The use of cloud-based systems for information sharing and collaboration platforms is increasingly introduced by multi-national companies, with a number of global operations, managed form a single hub. The cloud approach has proven to be useful for areas with less developed communication infrastructure, enabling workers to safely store data for offline usage. It has also allowed for significant savings as SME or even larger operations now do not need to purchase, install and maintain their own servers.

Drones

There has been a dramatic shift in the use of drones to conduct survey and security functions by mines. Previously, skilled contractors were used to conduct all or most of the drone-based activities, but there has been substantial in-house upskilling to licence mine staff as drone operators. The allure of a drone is the relatively short turn-around time, accuracy and reduction of labour cost. Drone data are only collected in the active areas of the mine and the metadata are incorporated into the live plans. There are, however, still limitations on the operational flight time, on-board storage and data download requirements and the influence of weather.

Earth Observation

The range of satellite applications available to the mining industry, from large commercial to new cube satellite entrants, is increasing. The next decade will see several satellite constellations being launched. Optical satellite imagery will increasingly be used for change monitoring throughout the life-of-mine and generation of digital elevation models. Secondary applications for vegetation and housing encroachment are set to increase in parallel. Synthetic Aperture Radar (SAR) applications are becoming increasingly popular for tailing storage facility and mining-induced subsidence monitoring.

Environment

Monitoring of extreme weather conditions is now also included in risk assessments. It is expected that the frequency and intensity of weather phenomena will continue to increase in the coming decade. An age-old problem in mining has been access to sufficient water for mining and processing applications, which is bound to worsen as mines and communities become increasingly dependent on the same source. Several mining operations have also been forced to suspend operations due to flooding or hurricanes, in areas that were not previously affected by such events.

Emission Control

The move towards green energy and minimising the environmental impact of mining has become more of a priority in the last couple of years. Electrical mining vehicles have been in operation at open pit mines for years. Now hydrogen fuel cell powered mining vehicles are being introduced to underground mines in an effort to reduce emissions. There has also been a marked increase in the number of photovoltaic solar installations at mines and the introduction of greywater systems.

Microgrids

In developing countries, mines have been self-sufficient in terms of power supply for decades, with infrastructure in most cases better than that of the host country. More mines are operating on an independent grid due to the increase in the cost of being supplied with electricity. The supply of electricity has become unreliable in some countries due to lack of maintenance of infrastructure and the phenomenon of loadshedding has had a negative impact on the industry, specifically smelters.

Circular Economy

Metallic scrap, such as iron and copper, used to dominate recycling. Recycling of electronic consumer goods is becoming more effective and economical. Historically, recycling was not considered to have a major impact on mining operations, but is now considered as a potential factor. Changes in the

geopolitical arena also have an influence, where scrap material that was previously considered uneconomical to recycle, has now become viable. In 2017, the recycling of REE magnets was not considered due to the monopoly, but steady supply to the market by China; now REE minerals have been weaponised in the global trade war. Recycling is also more energy efficient, for example only 5% of the energy is required to recycle the same volume of aluminium, relative to producing it from raw materials. The need to be able to recycle rechargeable batteries was recognised early on, with collection points and recycling centres already on the cards for when the currently produced batteries will reach the end of their serviceable lives and is expected to have reached the critical mass to make recycling economically viable.

Virtual Reality

The uptakers of virtual reality (VR) or augmented reality have been limited to an extent to training and education institutions. Universities have started using VR to simulate underground conditions and conduct practical training on these platforms. Mines have tested proof-of-concepts were incident investigations are done by using laser survey scan point-cloud data to reconstruct events on the VR platform, limiting the need to access the area where an incident such as a fall-of-ground took place. EPCM companies have also realised the potential of using VR to offer clients project interaction. VR models are used to generate walk-through environments that depict milestone and anticipated final product appearance.

3D Modelling

Geologists have now become the new IT specialists, with the market being flooded with modelling software, and being highly skilled in software packages and programming is now a requirement for even the most junior of positions. Exploration remains the main vertical market for 3D-modelling, with the aim of integrating more information from less fieldwork and fewer analyses but producing more accurate models. 3D-modelling has also gained interest as a tool to anticipate risk areas and develop remedial scenarios. Ground truthing will, however, remain a critical function.

Cybersecurity

There is, however, a risk factor associated with the introduction of these technologies. The two main concerns queried relate to the cybersecurity risks of the shift to cloud-based storage and the "bring your own device" culture that is increasingly being adopted by companies. Company IT infrastructure could become vulnerable as it can increasingly be accessed from outside the company network, due employees with varying degrees of e-safety awareness. It also increases the risk of corporate espionage or sabotage by competitors.

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4IR Mining
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Diamonds – Source to Use — 2020 Conference

Innovation and Technology

9 June 2020 — A technical and economic guide to diamond process engineering workshop and Technical Visits

10 June 2020 — Conference

11 June 2020 — Conference and Site Visit

The Birchwood Hotel & OR Tambo Conference Centre, Johannesburg

BACKGROUND

The *Diamonds – Source to Use* conference series targets the full spectrum of the diamond pipeline, from exploration through to sales and marketing. The 2020 conference, the eighth in the series, will focus on advances in the mining and metallurgical aspects as well as many of the downstream and related industries

KEYNOTE SPEAKER
L. Hockaday, *Mintek – Renewable Energy Technology*

OBJECTIVE

The objective of the conference is to provide a forum for the dissemination of information relating to the latest tools and techniques applicable to all stages of the diamond industry, from exploration through mine design, processing, to cutting, marketing, and sales.

WHO SHOULD ATTEND

- Geologists
- Mineral (diamond) resource managers
- Mining engineers
- Process engineers
- Consultants
- Suppliers
- Sales/marketing
- Diamantaires
- Mine managers
- Mining companies
- Students

2 ECSA CPD points,
24 GSSA CPD points and
3 SACNASP CPD points
will be allocated to
all attending delegates

TOPICS

- Geology and exploration
- Mine expansion projects
- Mining, metallurgy, and processing technology
- Rough diamond sales and marketing
- Cutting, polishing, and retail
- Synthetic diamonds
- Financial services and industry analysis
- Industry governance, beneficiation, and legislation
- Mine-specific case-studies

Site visits

- **Epiroc South Africa**
- **Multotec South Africa**

For further information contact:
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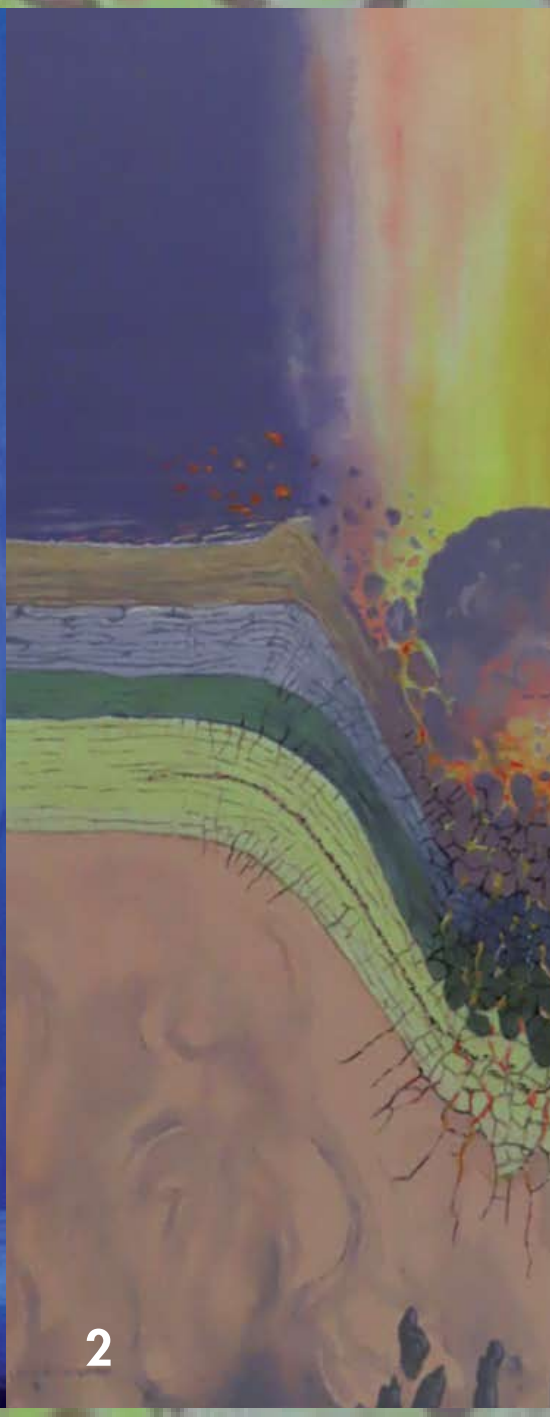

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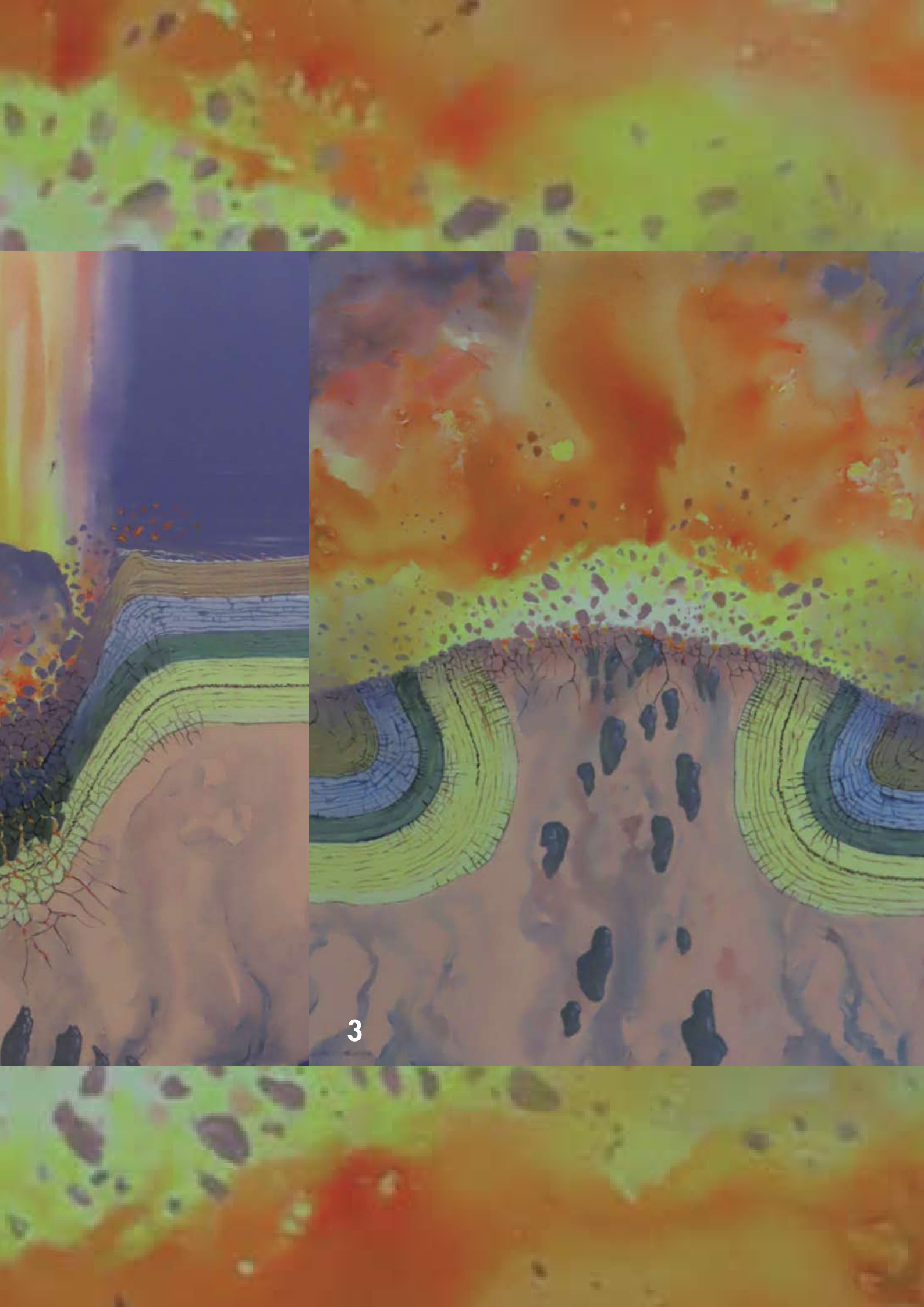
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geoheritage

Exhibition opens up the geological mystery of the Vredefort Dome

After months of planning and extensive hard work, a complete and scientific visual display of the Vredefort Dome now forms part of the Parys Museum.

It will help tourists understand the force and impact of the meteorite that struck the earth some 2,000 million years ago. The crater it formed is considered to be the biggest and oldest clearly visible impact structure on earth. The exhibition will make this geological wonder even more understandable for the many national and international tourists who visit the area annually.

It was officially opened in October 2019, with Nicky Oppenheimer, the son of Harry Oppenheimer, and his wife, Strilli's, visit to Parys. Duncan Macfadyen (ecologist) and selected guests, attended the function. Jan Fourie took them on a tour, visiting important viewing points in the Dome. They also enjoyed lunch at the historic mining town of Venterskroon.

Some of the displays from the new Vredefort Dome exhibition at the Parys Museum.

The Geological Society of South Africa, sponsorship from the Oppenheimer Trust and various other sponsors made the Dome Room with the exhibition possible.

About the exhibition

Together with the twin brothers professors Morris and Richard Viljoen, the well-known geo-artist, Maggie Lambert-Newman, put together various photos, maps, diagrams, rock samples and artwork. Unesco declared the Vredefort Dome a World Heritage Site in 2005.

Originally it was supposed to have an exhibition at the Vredefort Impact Centre to benefit tourism in the Free State. Unfortunately, it is now only a R24-million white elephant alongside the Parys/Vredefort road. The Centre never opened after completion in 2008. As a result of its poor construction, it was regarded as too unsafe. Since then, neither the national nor provincial governments have accepted responsibility for this shameful waste.

When the talented geo-artist, Maggie Lambert-Newman, moved to Parys two years ago, she was surprised to find very little information available to tourists, either in Vredefort or Parys. Although tours of the area are recommended, these are necessarily lengthy and impractical for visitors who are just passing through or who are only here for a day.

She found that tour guides were generally in favour of having more information available. They felt this would actually encourage people to take a tour or, if there was no time, to return to Parys another time to do so.

The first problem was to find somewhere suitable to house an information display and, after several fruitless attempts, Maggie learnt that Iris Andrew had re-opened the Parys Museum. Iris and Maggie then discussed a plan to incorporate a "Dome Room" into the museum and set to work on the project together. The next problem was how to produce an attractive, easily understood display from a subject with complicated geological information and, to the layman, incomprehensible scientific jargon. The Vredefort Dome being unique in the world in both its age and size, enjoys much international and local attention from geologists and students. Their interests, therefore, had to be catered for. Fortunately, Maggie had experience in working with geologists and had come to understand the basics of this fascinating, but occasionally daunting, subject.

Nicky and Strilli Oppenheimer, who attended the opening function.

From left are Maggie Lambert-Newman, the twin brothers Morris and Richard Viljoen, Ephraime Mosibi and Renee Hartslief.

She contacted the Viljoen brothers with whom she had worked many times before. They were able to explain the history and structure of the Dome to her. They discussed how this information could be translated into terms understandable to those not familiar with the complexities of geology. Morris and Richard had supplied a great many photographs, diagrams and maps for Maggie to choose from. She added artwork and more photos to add colour and drama where it was needed.

"Foremost in setting up the new exhibits were the new museum curator, Iris's daughter Diane, the knowledgeable and extraordinarily versatile Warrin Flores, and David Mkhwanazi, whose reliable and practical support has been indispensable. Jan Fourie's knowledge of the area and tourism experience was of great value. He also donated several specimens for the display. Karen Addison took Morris, another geologist colleague, and myself on our first tour of the Dome."

"I'd like to thank Tinus Pieterse of It's Ink for his untiring help and patience with the printing and layout of labelling. There are many more who have given their time and talents. On behalf of the museum team and myself, I'd like to thank you all wholeheartedly for helping us achieve what I hope will be the first of many new projects for Parys Museum," says Maggie. And now the plan is to get the museum open on certain days. If you have time on your hands, have an interest in history, or just a willingness to help – please contact Diane on 071 388 0446.

Special thanks to Jean-Marie van den Bergh, Selma Kok, John Mampa, Renee Hartslief, Kira Eikmeier, Julia Holterman, Tim, and Julian Gisi, Warren Floris, David Mkhwanazi, Jan Fourie, Iris Andrews, DV Glas and Jaco from Parys Nutsman who have helped in the past, or worked non-stop the past 3 weeks to get the museum clean and ready for the opening of the exhibition.

Author: **Liezl Scheepers**
Photos: **Renee Hartslief**
Reprinted with permission from the **Parys Gazette**, 17 October 2019

Guests on a guided tour at selected viewpoints in the Vredefort Dome. On the left are Nicky and Strilli Oppenheimer, with Maggie Lambert-Newman in the middle and Richard Viljoen on the right hand side.

escarpment mines

Drakensberg Escarpment Mines

Geotravellers heading east on the N4 and willing to take a small detour and armed with sturdy boots can get a glimpse of the gold mining and related activities on the escarpment at the turn of the previous century. The small sites of Slaaihoek and Ngondwana are worth a quick stop. These are two of the lesser known mining areas of the old Eastern Transvaal.

Slaaihoek and Mamre gold mines

Slaaihoek and Mamre gold mines were established during the time prospectors were looking for the next Pilgrim's Rest in the 1880s. The town of Slaaihoek essentially consisted of a street of corrugated iron homes. Like most of the other mesothermal gold mines along the escarpment, Mamre and Slaaihoek mines closed due to poor quality and erratic distribution of gold ore. Other contributing factors to the permanent closure of the mines were complications with broken ground, underground water and refractory ore. The town of Slaaihoek was almost completely demolished after the mines closed, but the swimming pool behind the old clubhouse can still be found. Anecdotal sources have indicated that small gold nuggets are still periodically found in the Gladdespruit.

In 1929, the Mineral Rights on Slaaihoek were purchased by ETC, an Anglovaal subsidiary, to mine gold at the old Mamre and Slaaihoek mines. In the early 1970s, an Anglo American/INCO joint venture began exploring Uitkomst for nickel. In 1990, Anglo American (AAC) completed a feasibility study on an open-pit operation exploiting the large disseminated sulphide resource of the Uitkomst Complex (ARM, 2017). Today these mines are located on the Nkomati Mine lease area. In 2010, Slaaihoek gold mine made the news when 14 zama-zamas were arrested there. The Slaaihoek pass is a cul-de-sac road that ends at the Nkomati Nickel mine. The pass is 24.5 km long and descends 600 m, on a road that has 95 corners, bends and curves, engineered to have a constant radius, making it one of the best motorcycle routes in the country.

The Slaaihoek and Mamre gold deposits are associated with the Uitkomst Complex (Boer *et al.*, 1995), a Bushveld Complex satellite intrusion that is developed on the contact between the Transvaal chemical and clastic sediments. The Slaaihoek and Mamre lode is hosted in shale of the Timeball Hill Formation (Steenkamp, 2012). Fluid inclusion and stable isotope data suggest that the vein deposits were formed from saline fluids with variable enrichment in CO_2 at temperatures of 300 to 350°C and supra-lithostatic pressures of 2.2 to 2.5 kbar (Boer et al., 1995). The data are consistent with either a magmatic or metamorphic source for the fluids and exclude involvement of substantial amounts of meteoric water (Boer *et al.*, 1995).

Ngondwana Lime Kilns

Prior to the use of cyanide, burnt lime was used to extract gold from ore. The Grootgeluk lime mine supplied lime to the gold mines on the Witwatersrand and Barberton. The operations consisted of gunpowder blasting and digging by hand. The miners simply followed the thick white seams in the mountainside. This lime was taken from cavities in the dolomite, of which the greater part has again been filled by dripstone formations (National Monuments Council, 1980). Mule-drawn coco pans brought the lime to the surface, in some cases a distance of almost 4 km, and to the kilns (Artefacts, s.a.). The burnt lime was railed to the goldfields on the then newly completed ZASM Railway. The pure lime produced at Ngondwana, with a calcium carbonate content of up to 97%, was preferred over "blue lime" for metallurgical purposes (National Monuments Council pamphlet, 1980).

The first three kilns were constructed of brick, round stone and wet lime (Artefacts, s.a.). This was later followed by the construction of the 18.3 - high, round kilns near the old farmhouse above the Sappi Mill. The stonework was reinforced with steel straps with adjustable buckles and the chimneys were made of hardened steel plates imported from Germany (Artefacts, s.a.). The mine closed in 1899, declared insolvent and all the machinery sold. The site was later used as a citrus-packing plant, before being taken over by Sappi.

The three kilns were prominent roadside landmarks, until they were obscured from sight by the Ngondwana paper and pulp factory. The three kilns were declared national monuments in 1980 (National Monuments Council pamphlet, 1980). The old mine shaft and the inverted kiln site has been fenced off, but care should still be taken when visiting the site.

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The old Ngondwana lime kilns

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For more information, visit the conference website!

http://allevents.co.za/geocongress/

mineral scene

Diopside

The featured mineral this issue is diopside, $CaMgSi_2O_6$, which according to Mindat.org "is a member of the Pyroxene Group - Clinopyroxene Subgroup. Diopside is one of the most common members of the pyroxene group. It often occurs in metamorphosed limestones (marbles) as generally pale greenish to greyish green crystals, masses and blebs/grains associated with humite-group minerals, spinel, phlogopite, tremolite and grossular. Diopside can also be pure white and not distinguishable from the enclosing carbonate. Often fluorescent bright powder blue". It is monoclinic, with a vitreous to dull luster and a hardness on the Mohs' scale of 3.22 to 3.38.

The two featured specimens are the typical green colour of most diopside, but with different characteristics and mineral associations. One comes from the Palabora Igneous Complex in South Africa, the other is a gem variety from East Africa.

The Palabora Igneous Complex is an elliptical-shaped, zoned alkaline intrusion that has been mined for copper and associated minerals (du Toit, 1931; Hanekom, 1965; Heinrich, 1975). Regarding the latter, the deposit has been transected by younger dykes that have been associated with a suite of secondary minerals described by Gliddon and Braithwaite (1991) and Southwood and Cairncross (2017). These are varied and include amongst others, an interesting array of zeolites. The Palabora diopside is typically vibrant green and associated with biotite/phlogopite, as is the one shown here. There were reports from the mine that some diopside crystals were over one metre in length, although these tended to be cleavage fragments.

The other diopside specimen is markedly different and comes from the Karo mine, Merelani Hills in Tanzania (Wilson et al., 2009). The diopside from this area is

Cleaved green diopside crystals in a phlogopite/biotite(?) matrix from Palabora mine. 11.5 cm specimen. Bruce Cairncross collection and photo.

Gem-quality green chromian diopside on large, well-formed graphite crystals. Karo Mine, Merelani Hills, Lelatema Mountains, Manyara Region, Tanzania. Field of view is 3 cm.
Philip Hitge specimen, Bruce Cairncross photo

highly prized by collectors and gem cutters of rare and unusual gemstones. The vibrant green colour is caused by the presence of chromium (hence chromian diopside) and some crystals are transparent and hence qualify as gemstones (Cairncross, 2019). Some of the most prized specimens are like the one shown here, being associated with what is considered the finest known crystalline graphite, producing stunning specimens contrasting the two green and black minerals (Jaszczak and Trinchillo, 2013).

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obituary

Trevor Richardson †

6th October 1974 to December 31st 2019

Trevor Leonard Richardson, or "Mr. T" and "Big Trev" as we knew him, with his most engaging smile and chuckle, passed away terribly suddenly following a tragic accident. He will live on, as Trevor believed in organ donation, three people will gain a lease on their lives in the sad passing of our friend.

Before Trevor graduated in 1999 from Laurentian University (Sudbury, Ontario) with a BSc in Geosciences, he had already begun working in mineral exploration in the Sudbury area. After only a short time working in Canada, he saw a posting for an MSc opportunity in South Africa. Trevor was accepted and in 1999 moved to South Africa. This change in his life was more than just for the education, Trevor sought out adventure and was excited to experience something different to his Canadian home. He found South Africa welcoming and made this country his own. Seeing an opportunity to grow a geological consulting business in South Africa, he partnered with his Canadian friend Scott Jobin-Bevans and together they created Caracle Creek International Consulting (CCIC) in 2001.

From the top of mountains to the most inaccessible valley, Trevor made the work of his profession, Geology, fun, and showed how to excel in it. Initially, he worked for Anglo Platinum in the Eastern Limb of the Bushveld Complex, where he successfully managed the Driekop and Der Brochen projects. With his colleagues, he built a company of professionals around himself in the South African arena, and led a tight knit that team to be a well-respected professional outfit with a particular strength in the Bushveld Complex. Many young South African geologists owed Trevor their first taste of real exploration work.

Trevor "left" South Africa, returning to Canada, and developed many other business interests over the past ten or so years, displaying his entrepreneurial talents and geological senses for projects that held good economic potential. He was in the middle of raising funds for the latest of these ventures with his new business partner Laurie Meloche when tragedy struck and ended the life of a young man with still so much to do.

There is an African phrase of "ubuntu" that translates roughly as "a person is a person because of other people" and Trevor was one of those people whose contribution contributed to the Ubuntu of many communities. Through his company, CCIC he sponsored many occasions of the Geological Society of South Africa and other social events in the geological and mining fraternity. From the academic work that he did as part of his M.Sc. and research at the University of the Witwatersrand, to the economic impact that he had on the rural communities where he spent so much time exploring the bush and identifying potential deposits, Trevor interacted positively and proactively engaged with both work colleagues and friends. In fact, his outgoing and engaging nature is probably the reason that many of his work colleagues became close, personal friends within a short period of time. And Trevor was a loyal friend, always willing to help. It is this friendship that we would like to remember and someone who was great in stature and equally great in spirit. As they would say in Zulu – my friend, "Hamba Kahle" – travel safely.

Trevor leaves behind his loving wife Wendy Robidoux and his stepson Logan. Trevor will be dearly missed by his parents George Richardson (Wanda) and Gail Watson, his brother Derek and stepsisters, Kareen and Rana. He will remain forever in their hearts.

To Wendy and Logan and to Trevor's family we just want to say how saddened we are in this way too early and devastating loss. We all have fond memories of our friend.

To his friends, he believed in organ donation and it is never too late to sign up for the privilege of being an organ donor.

Written by **Friends of Trevor**

CCIC Caracle Creek International Consulting (Pty) Ltd
Geological Consultants - Project Management

ABOUT THE SYMPOSIUM

The South African Diamond Producers Organisation (SADPO) is pleased to announce that the 2020 Kimberley Diamond Symposium & Trade Show will take place in Kimberley, Northern Cape Province, RSA, in early September 2020. New technologies and geological interpretations have revived activity in mid-size and small-scale diamond mining in the Northern Cape and North West Provinces, and exciting technology advances are driving greater recoveries of large and exceptional diamonds in mines across Southern Africa and other parts of the world, and transforming the industry in its entirety.

Technical Presentations and Panel Sessions – will focus on large-stone diamond populations and their origin, recovery, and provenance (in the case of alluvial deposits), developments in local and international diamond exploration and mining, the unique alluvial diamond deposits of the Northern Cape (including the marine placers of the West Coast) and North West Provinces, new technology developments that are reshaping all facets of the diamond industry, synthetic or laboratory-grown diamonds, and the future of the international diamond industry.

There will be sessions on new geological and technological applications enhancing delineation and exploitation of ultra-low-grade alluvial deposits, back-to-basics geological modelling that has restated the origin and diamond resources of alluvial deposits in North West Province, RSA.

TRADE SHOW

This will accompany the Symposium at the same venue and provide delegates with a cross section of enhanced earth moving equipment, new approaches in design of diamond processing plant, and advanced recovery technologies, including single particle sorting developments. New entrants to the mining industry will be on hand to display their equipment ranges.

THE GEOTRAVELLER

By Roger N Scoon[1]

Antiquities and Historical Sites in the Peloponnese, Greece: Ancient Cultures and Active Tectonism

The narrow entrance to Navarinou Bay, southwestern Peloponnese, the site of famous naval battles in both ancient and modern Greek history, is guarded by two islands, Sfaktira (right) and Pylos (left). The bay occurs within soft sediments (Neogene) associated with the Kalamata Graben; the islands consist of resistant limestone (Upper Cretaceous) on the western flanks of the graben

The Peloponnese is a mountainous part of southern Greece with a deeply indented coastline. The coastline includes deep bays, many of which constitute secure harbours. The region is well known for antiquities and historical sites that are visited by large numbers of tourists. The archaeological sites encompass a broad range of civilizations covering several millennia. During the Classical Greece and Hellenistic periods, the Peloponnese was subdivided into seven districts, each of which is associated with well known, ancient civilizations (e.g., the Spartans). The ancient civilizations occupied marine terraces and valleys where fertile alluvium and abundant supplies of subterranean water from the juxtaposed limestone mountains supported agricultural methods originally developed in Asia Minor.

The physiography of the Peloponnese is consistent with historical descriptions of the peninsular as the "Islands of Pelops" (derived from a mythical king). The Peloponnese is constrained on four sides by parts of the Mediterranean Sea. The peninsula is surrounded by the Ionian Sea (west), the Gulfs of Corinth and Patras (north), the Saronic Gulf (northeast), and the Aegean Sea (southeast). Most settlements, including the major city of Patras and regional centres such as Corinth, Kalamata, and Nafplio, are located on narrow coastal terraces. Some regional towns, such as Tripoli and Sparta, occur in broad valleys that dissect the mountainous interior.

The coastal areas were settled by many of the earliest European civilizations. Archaeological evidence covers the Neolithic Age (7000–3000 BC) and the Early/Middle Bronze Age (3000–1600 BC). Evidence of the Late Bronze Age Mycenaean civilization (1600–1100 BC) is found in many parts of the Peloponnese. The Mycenaean was superseded by the Archaic, Classical Greece, and

Location map showing antiquities and historical sites of the Peloponnese. The Corinth Canal transects the Isthmus of Corinth. Source: Satellite Image of Europe based on NASA MODIS data, courtesy of Planetary Visions/DLR

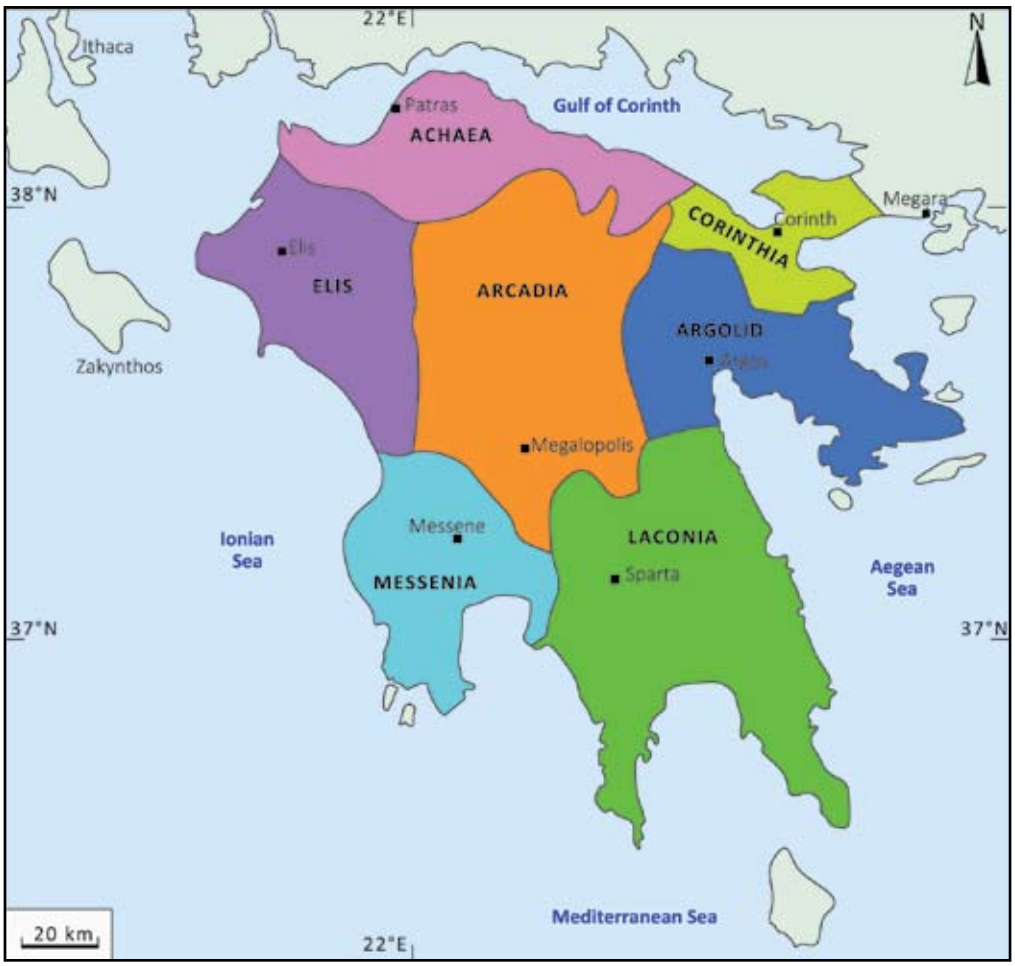
Hellenistic periods. These periods were followed by the Roman and Byzantine Empires, as well as by the Norman and Venetian invaders.

The seven classical districts of the Peloponnese are as follows: the Argolid (Argolida) and Corinthia (Korinthia) in the northeast; Achaea (Achaia) in the north; Elis (Ilia) in the northwest; Arcadia in the interior; and Laconia (Lakonia) and Messenia (Messinia) in the southeast and southwest, respectively. These subdivisions correlate reasonably well with modern districts although there is little consistency in spelling of geographic localities (arising from problems translating the Greek alphabet). Antiquities and historical sites are described from each district with the exception of Corinthia (Geotraveller, March 2018).

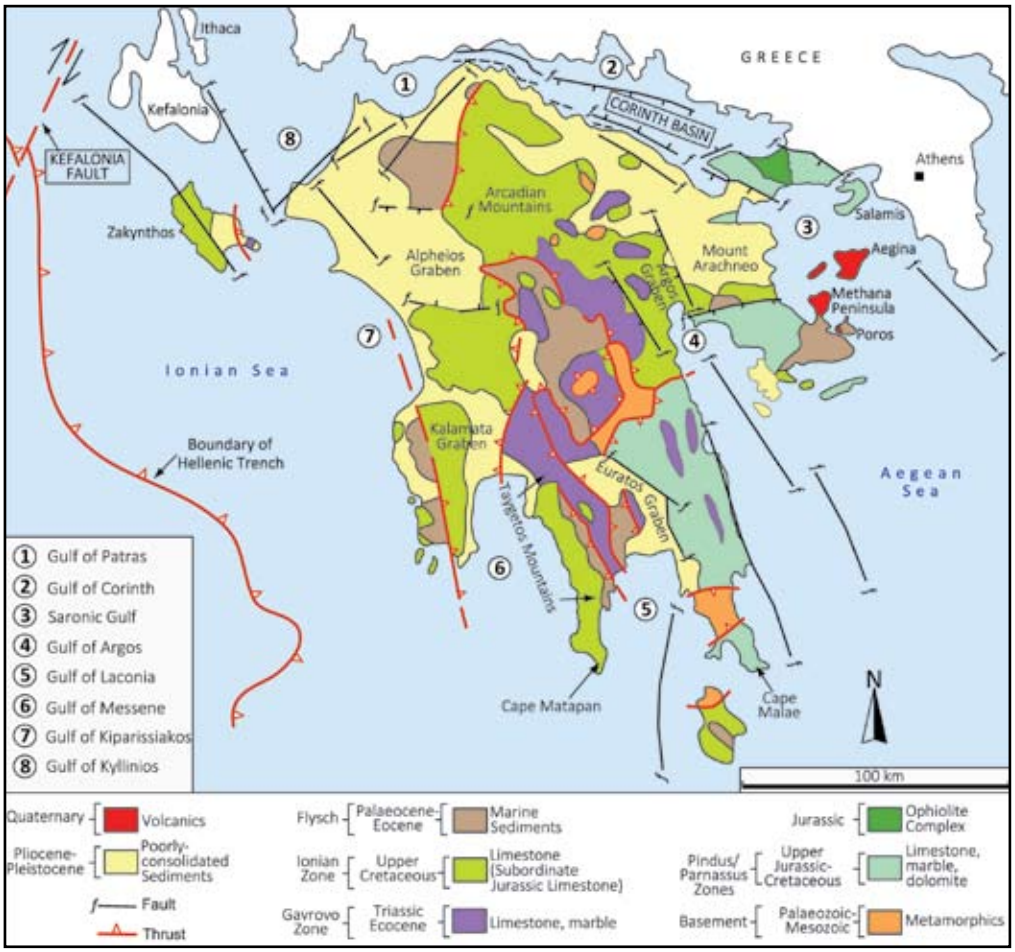
The Eastern Mediterranean is a tectonically active region influenced by the waning stages of the long drawn-out Alpine Orogeny (65.5-2.6 Ma). The orogeny is driven by ongoing collision of the African and Eurasian Plates (King et al., 1993; Robertson and Mountrakis, 2006). The peak of the orogeny probably occurred in the Oligocene and Miocene. The Hellenic Trench is part of an active subduction zone. The curvilinear nature of the trench has resulted in formation of microplates, together with the Kefalonia Fault. Movement on the Hellenic Trench is responsible for major seismic events, which can severely impact the Peloponnese (e.g., Hasiotis et al., 2002). The Gulfs of Corinth and Patras are highly susceptible to tsunamis (Papadopoulos, 2003; Ambrasey and Synolakis, 2010).

Metamorphic rocks in the Peloponnese occur in the Palaeozoic basement and the NW–SE-trending Alpine tectonic zones. Four tectonic zones are indentified: Ionian and Gavrovo Zones (western and southern parts), Pindus Zone (Arcadian Mountains), and Parnassus Zone (northeastern part). Tectonic zones may be separated by thrusts. The Ionian Zone is dominated by Upper Cretaceous limestone (with some Jurassic limestone). The Gavrovo Zone is comprises Triassic–Eocene limestone and marble. The Pindus Zone contains Upper Jurassic–Cretaceous limestone, marble, and dolomite. The Parnassus Zone is similar to the Pindus Zone but may include ophiolite complexes (Jurassic). Parts of

Ancient districts and capitals of the Peloponnese during the Archaic and Classical Greece times



Simplified geological map of the Peloponnese showing the NW–SE Alpine trend of the different tectonic zones and the NNW–SSE- and W–E-trending Neogene–Quaternary basins and grabens. Source: Geological Map of Europe (https://geoviewer.bgr.de) and articles referenced in the main text



the Peloponnese are underlain by Palaeocene–Eocene marine sediments (flysch), with modest levels of metamorphism.

The compressional regime was displaced during the middle of the Cenozoic by extensional tectonism. Rifting and normal faulting resulted in development of basins and grabens. These features are responsible for the highly irregular nature of the coastline. Basins in the northern part are associated with the W–E-trending Central Hellenic Shear Zone, a regional suture that separates the Eurasian Plate (northwest Greece) and the Hellenic Microplate (Peloponnese and Aegean Basin). The W–E-trending Patras Basin is aligned with the Gulf of Patras. The WNW–ESE-trending Corinth Basin is aligned with the Gulf of Corinth and the Saronic Gulf. Grabens in other parts of the Peloponnese are generally aligned NNW–SSE, e.g., Alpheios Graben, Argos Graben, Eurotas Graben, Kalamata Graben; they may reflect reactivation of older Alpine structures. Most basins and grabens are partially infilled by Neogene–Quaternary sediments. Quaternary volcanics (Hellenic Volcanic Arc) occur in the Methana Peninsula and several islands of the Saronic Gulf.

*The **Argolid District** is divided by Mount Arachneo (1,199 m) into an eastern region (coast of the Saronic Gulf and the broad Argolid Peninsula) and a western region (Argive Plain). The Argolid occurs in the Parnassus Tectonic Zone. Mount Arachneo and the Saronic coast consist of Upper Jurassic–Cretaceous limestone, marble, and dolomite. The Argolid Peninsula is dominated by flysch deposits (Palaeocene–Eocene), whereas the Argive Plain is part of the NNW–SSE-trending Argos Graben, which persists into the Gulf of Argos. The Argos Graben is one of the most fertile parts of the Peloponnese as large sections are infilled by alluvium (Quaternary). The shoreline of the Gulf of Argos has changed considerably since historical times, e.g., the position of Lake Lerna, a historical site featuring in Greek mythology, was part of a lagoon prior to 5,000 BP (Higgins and Higgins, 1996).*

The most important antiquity in the Argolid is the ancient city of Mycenae (1600–1100 BC), located on the western flanks of the Argive Plain, between Nafplio and Corinth. In 1876, the German archaeologist Heinrich Schliemann discovered numerous gold artefacts (masks, vessels, and ornaments) in shafts and ornamental tombs. These finds suggested the city may be the capitol of the Mycenaean civilization. The citadel at Mycenae is a complex of buildings located on low hills composed of limestone (Triassic–Jurassic). The limestone bedrock provided a secure location and minimized the potential of earthquake damage (Higgins and Higgins, 1996). The limestone provided a local source of building material and was used in constructions such as the Lion Gate.

Lion Gate, Mycenae. Source: Andreas Trepte (Own work, CC BY-SA 2.5, https://commons.wikimedia.org/w/index)

The three-level museum in the citadel accesses some of the shafts and burial tombs excavated by Schliemann. The main part of the city occurs on a lower-lying site associated with marls and conglomerate within the graben.

The Mycenaeans were probably colonisers who migrated from Asia Minor, displacing and integrating with the Early/Middle Bronze Age inhabitants throughout the Balkan Peninsula. It is the Mycenaeans that the Greek poet Homer, who probably lived in the 8thC BC, described in the Iliad and the Odyssey (Homer described Mycenae as "Rich in Gold"). There is ongoing debate as to the ages of the artefacts at Mycenae, as well as to the historical accuracy of the Iliad. Some of the most well known treasures, e.g., the "Mask of Agamemnon" (Agamemnon led the Greek forces that laid siege to Troy) and "Nestor's Cup" are displayed in the National Museum of Athens. The source of the gold at Mycenae remains a mystery (Egypt or Macedonia?), but the organized nature of the society, which included paved roads to access harbours on the Gulf of Argos and a strong bureaucracy (evidenced by stone tablets with the Linear B script), could have supported a significant trading empire.

The route that follows the coastal region of the Argolid is immortalised in mythology by the six labours that Theseus faced on his epic journey from Troezen (his birthplace) to Athens. Troezen is an extensive archaeological site, spread over several square kilometres, near the modern village of Trizina. The rock that Theseus was required to lift as the first of his tasks can be observed here. Marble slabs showing multiple stages of calcite veins, some of which reveal ptygmatic or sinuous folding, an indication of plastic deformation in which the vein has a greater competency than the host rock, were used for some constructions. The hills at Troezen are associated with flysch deposits, with some of the higher mountains, such as at the "Devils' Bridge", a natural spur of limestone spanning a narrow gorge, associated with older and more competent limestone and marble. The gorge has developed on the contact between limestone–marble and a thin schist belt. Large boudins of marble can be observed in the less competent schist.

The Asklepieion at Epidaurus is situated in the foothills of Mount Arachneo (Triassic–Jurassic limestone) and includes one of the best preserved theatres (340–330 BC) in Greece from the Hellenistic period. The site offers both a commanding position and provides a source of building material. The theatre is constructed of limestone breccia (probably cave deposits), which contain clasts of red and grey limestone. Extensive deposits of Triassic volcanic ash occur; this distinctive green, water-lain tuff can be observed in the foundations of some of the subordinate buildings (Higgins and Higgins, 1996).

The limestone rock that Theseus was required to lift prior to commencing his epic journey to Athens can be examined at Troezen

Marble slab at Troezen showing ptygmatic calcite veins

The antiquity of Epidaurus is situated on the eastern slopes of Mount Arachneo (Triassic–Jurassic limestone) and includes one of the best preserved theatres of the Hellenistic period

Franchti Cave on the Argolid Peninsula has yielded evidence of the earliest inhabitants of the Argolid. The cave is located in Triassic–Jurassic limestone and has a depth of 150 m and a 30 m-wide entrance. The cave was used by Homo neanderthalensis (40,000 BP) and some of the earliest Homo sapiens (30,000 BP). Neolithic and Early Bronze Age cultures used the cave until approximately 3,600 BP. The "Dolines of Didyma" are two circular sink holes (locally known as "craters") that occur in the limestone a few kilometres north of the Franchti Cave. One sink hole was occupied by people

(a) The antiquity of Olympia is situated in the Alpheios Graben, which is enclosed by hills and ridges (Lower Pliocene marine sediments); (b) The stadium is situated in an old, alluvium-filled river channel (Quaternary), overlooked by the Hill of Kronos (Upper Pleistocene terrestrial sediments)

during the Neolithic Age and the other is sufficiently large to contain two small Byzantine churches.

The interior mountains of the Elis District are dominated by limestone of the Ionian Tectonic Zone (Upper Cretaceous), but substantial areas are underlain by flysch (Palaeocene–Eocene). Several Neogene–Quaternary grabens are identified in Elis, aligned either NNW–SSE (i.e., parallel with the narrow strait between the Peloponnese and Zakynthos) or W–E (i.e., parallel with the Central Hellenic Shear Zone (Higgins and Higgins, 1996; Papanikolaou et al., 2007). The most widely visited antiquity is Olympia. The popularity of the site has resulted in development of the modern town of Olympia, accessed by either road or rail from the regional town of Pyrgos. Olympia is situated in a broad, fertile valley associated with the W–E-trending Alpheios Graben. By the Upper Pliocene–Pleistocene, sedimentation exceeded subsidence and the westward-flowing rivers deposited thick sequences of poorly consolidated sediments. Near the coast, wide marine terraces (Neogene) developed, e.g., at Pyrgos, or poorly-consolidated sands and gravels (Quaternary), e.g., at Katakolon, a harbour used by cruise ships include a visit to Olympia. Pyrgos is located close to the current exit of the Alpheios River, but in historical times the river flowed into the Ionian Sea north of Katakolon. Pyrgos was subjected to a major earthquake in 1993, ascribed to movement on the graben faults (Koukouvelas et al., 1996).

Olympia is primarily a Hellenic site that was first occupied in 3,000 BC. Between 776 BC and 393 AD a four-yearly sporting event that initially included all of the Greece city-states, and then the Roman Empire, took place. The Olympic events were terminated in 393 AD by Theodosius I, the first of the Christian Roman Emperors. The site was largely destroyed in 425 AD by Theodosius II. Despite Olympia being located in a region where earthquakes are considerably less frequent than in the districts of Corinthia and Achaea, major seismic events in 522 AD and 551 AD caused catastrophic damage. The antiquity was subsequently affected by floods and landslides (Higgins and Higgins, 1996). Many of the monumental buildings at Olympia are built of shelly limestone (Lower Pliocene), quarried from hills south of the Alpheios River. The most famous component is the 5thC BC, oval-shaped stadium (interior length of 150 m), surrounded by grassy banks, which includes a monumental entrance at the western end. The stadium may originally have been part of a natural channel of the River Alpheios. Other features are the Temples of Hera (constructed in 650 BC) and Zeus (constructed in 465 BC). The Temple of Zeus originally contained the colossal gold and ivory Statue of Zeus, one of the Seven Wonders of the Ancient World. Columns of the Temple of Zeus probably lie where they collapsed in the 6thC AD earthquakes. Some of the tiles and sculptures at Olympia consist of imported marble, either Parian or Pentelic in origin.

The mountainous western part of the Arcadia District is associated with two tectonic zones, the Gavrovo Zone, dominated by limestone and marble (Triassic–Eocene), and the Pindus Zone, which includes limestone, marble, and dolomite (Upper Jurassic–Cretaceous). Alpine thrusts expose sections of the older basement in Arcadia. This region is drained by the River Alpheios, which flows westward into the district of Elis. There are a number of scenic areas catering for tourists. The 15 km-long gorge associated with the Lousios River, a tributary of the Alpheios, is protected as an archaeological site as it contains numerous churches. The wetlands and swamps of Lake Ladon are associated with springs at the base of the Arcadian Mountains. The springs are the primary source of the River Alpheios. The abundance of subterranean water in the limestone hills and fertile interior valleys may explain why the ancient civilizations flourished in this part of of the Peloponnese. The eastern part of Arcadia includes broad valleys and plains associated with several grabens. The regional town of Tripoli is located in one such structure, as are the antiquities of Megalopolis ("Big City"), which contains the ruins of the largest theatre in Greece, and Tegea, the latter being the most important of the Arcadian cities of the Archaic and Classical Greece periods. Tegea is famous for a high-quality, sparkling grey-white marble, derived from the slopes of Mount Parnon (Higgins and Higgins, 1996).

To the east of the N–S-trending Taygetos Mountains in the southern Peloponnese is the Laconia District. The Taygetos Mountains rise to a height of 2,300 m (the highest range in the peninsula) and are comprised of limestone and marble (Triassic–Eocene) associated with the Gavrovo Tectonic Zone. Steep, dry gorges, typical of karstic landforms, can be viewed from a winding mountain road with tunnels and overhangs, which links the regional towns of Sparti (Laconia) and Kalamata (Messenia). Modern Sparti occupies the fertile valley of the Eurotas River, part of a large NNW–SSE-trending

The road linking Kalamata and Sparti crosses the Taygetos Mountains which are composed of resistant limestone and marble (Triassic–Eocene)

graben. The eastern side of the graben extends to the Parnonas Range which consists of similar rocks to those within the Taygetos Mountains. The Eurotas Graben is partially infilled by alluvium (Quaternary) but also includes inliers of somewhat more resistant marls and clays (Plio–Pleistocene).

The Mycenaean palace of Menelaus and Helen (the Menalaion) is situated south of modern Sparti in the broad valley associated with the Eurotas Graben. The antiquity is constructed on a bluff of marls and clays (Plio-Pleistocene) that rises 50 m above the valley (Higgins and Higgins, 1996). The stepped topography (or cuesta landform) of the valley is characteristic of an area underlain by gently-dipping sedimentary strata. Ancient Sparta is joined to the northern side of the modern town. Sparta was possibly the most iconic of the city-states in the Archaic, Classical Greece, and Hellenistic periods.

Ancient Sparta is situated on a low knoll (right) consisting of marl and clay (Plio-Pleistocene). Part of modern Sparti and the western edge of the Eurotas Graben visible in the background

Similar building styles to other localities of this period were used, with building stones, primarily limestone and grey marble, derived from quarries on the Taygetos Mountains. The antiquity occupies a low mound of marls and clays (Plio-Pleistocene), similar to the Menalaion, and which would have provided a defensive position (Higgins and Higgins, 1996). Ancient Sparta was largely destroyed by an earthquake in 466 BC that created a 10–12 m–high scarp on the western graben fault (i.e., at the base of the Taygetos Mountains). Sparta was resettled and extended by the Romans; information boards at the antiquity provide details of the different phases of occupation. The historical site of Mystras is located 5 km east of Sparti on the steep slopes of Kastro Hill, a resistant block of dolomite (Triassic–Jurassic). Mystras is a popular tourist destination as the extensive remains of Byzantine (13–15thC AD) and Venetian (16–17thC AD) buildings straggle up the hillside.

The Matapan Peninsula is an extension of the Taygetos Mountains in which the limestones at Cape Tanairo (the southernmost part of the Balkan Peninsula) contain a sea cave, the mythological home of the Greek God of the seas, Poseidon. The Matapan and Malae Peninsulas are affected by a turbulent wave pattern derived from interaction of the Aegean and Ionian Seas (which have significantly different depths and salinities) (thus the mythology underpinning Poseidon). The extremity of the Malae Peninsula includes scenic landforms protected in the Kavomalias (Cape Malias or Malae) Geopark. The Malae Peninsula was the source of red, green, and grey marbles (Upper Jurassic–Cretaceous) used for local antiquities and exported for monumental buildings in Rome (Cooper, 1981). Some ancient quarries, including the Rosso Antico Quarries (a red to purple marble, the coloration linked to specks of hematite), are protected sites. The historical town of Monemvasia is located on the steep southern slopes of a rocky outcrop east of the Malae Peninsula. The Triassic-age dolomite here is extremely resistant to erosion. Monemvasia is accessed by a narrow peninsula and was an important and relatively easily defended locality in historical times.

(a) The historical site of Mystras is constructed on Kastro Hill, a resistant block of dolomite (Triassic-Jurassic);

(b) The view from Mystras (with the dolomite visible in the foreground) overlooks the Eurotas Graben with Sparti visible in the background

The historical town of Monemvasia is constructed on the steep southern slopes of a rocky outcrop consisting of resistant dolomite (Triassic)

The town was established in the 6thC AD by Laconians (fleeing Slavic invasions), and remained an important trading centre throughout Medieval times and beyond. The exposure to the prevailing Meltemi winds, which blow almost all summer in this part of Aegean Sea, yield a healthy climate (disease was a major problem in the Eastern Mediterranean during Medieval times).

The Matapan and Malae Peninsulas are separated by the Gulf of Laconia, an extension of the Eurotas Graben. The town of Gythion, located at the head of the gulf, was the main harbour for Ancient Sparta. The small island of Kranae is linked to Gythion by a causeway, and it is here where the Iliad describes Paris and Helen as spending their first night on their way to Troy. The island is constructed of resistant, pale grey marble (a Triassic horst), whereas the town is built on softer sediments (Pliocene) within the graben. The island of Kranae was possibly a more dominant feature in historical times (geomorphological changes may have affected the coastline).

The Kalamata Graben (aligned parallel to the Eurotas Graben) is the principal geological feature of the Messenia District. Kalamata is situated on marls, sandstones, and conglomerates (Pliocene), close to the eastern side of the graben. Kalamata was subjected to a major earthquake in 1986 (magnitude of 5.8), located on the eastern graben fault at a depth of only 4 km. Historical sites can be observed in the regional town of Kalamata (famous for Kalamata olives) and at Korone and Methoni. The latter includes a Venetian castle that forms a prominent landmark on a headland at the entrance to the Gulf of Messene (or Messiniakos). Coastlines in this area, as well as in the proximity of Pylos and Navarinou Bay on the west coast of Messenia, have changed considerably since historical times (Kraft et al., 1980; Higgins and Higgins, 1996). The scenic road that links Kalamata and Pylos accesses Neda Gorge, known for remarkable variations in flow rate and depth, probably arising from the underground source of much of the water in the Upper Cretaceous limestone. Navarinou Bay is the largest and safest natural harbour in Greece, protected on the outer (western) side by two islands, the large, elongate Sfaktira Island (Spacteria in historical references) and the considerably smaller Pylos Island. The islands consist of resistant limestone and contain sea caves and arches. The modern town of Pylos is situated at the southern end of the bay, in part of a subsidiary graben (measuring 10 by 4 km and with a depth of up to 60 m). The western graben fault is aligned with the outer coast of the two islands. The northern part of Navarinou Bay includes a large lagoon with small entrances into the main bay. The western part of the lagoon abuts limestone cliffs that contain two historical sites, Nestor's Cave and a historical castle ("Palaiokastro"). A crescent-shaped bay on the west side of the lagoon, Voidokoila Bay (or Bouphrus Bay), includes a remote, scenic beach connected to the Ionian Sea. The lagoon is fringed by an extensive dune field.

Sea-level changes have had a pronounced effect on the extent of Navarinou Bay and the shoreline is estimated to

The Venetian Castle of Methoni at the entrance to the Gulf of Messene stands on a prominent wave-cut platform consisting of limestone (Upper Cretaceous)

Pylos Island at the entrance to Navarinou Bay includes sea caves and arches cut into limestone (Upper Cretaceous)

have been several kilometres farther inland in the Early-Middle Holocene (Kraft et al., 1980). In historical times, the geomorphology was influenced by sedimentation patterns. The shoreline of both the southern and northern parts of the bay differed substantially to that currently observed. Moreover, the dune field associated with the lagoon was formerly far more extensive: thus the description by Homer of "Sandy Pylos" was both accurate and indicated the historical location of the town was at the northern end of the bay (Kraft et al., 1980). Navarinou Bay is famous for two great battles. During the Peloponnesian Wars, the Athenians attacked a Spartan army based on Sfaktira (Battle of Spacteria, 425 BC). In 1827, a large, combined British, French and Russian navy, under the control of Admiral Codrington, defeated an even larger (but less modern) fleet assembled by the Ottoman Empire and Egypt. The battle was unusual as this was the last sea battle fought entirely between sailing ships, although most remained at anchor (the bay has only one navigable main entrance). Some of the sunken ships can be observed in the placid waters of the bay. Memorials have been constructed on some islands, as well as in Pyrgos, and are commemorated by a local public holiday as the battle led to the independence of the modern state of Greece.

The plateau to the northeast of Navarinou Bay is an erosion surface, known as the "Kampos". The Kampos is underlain by Neogene sediments and was uplifted by approximately 400 m during the Pleistocene (Higgins and Higgins, 1996). The Palace of Nestor is located on the plateau 17 km north of Pylos. This is a Mycenaean archaeological site with an estimated age of 1300 BC. The ancient walls and foundation are viewed from raised platforms and the view west over the rolling hills towards Navarinou Bay fits historical descriptions, as does the location, which catches the cooling sea-breezes during the summer heat.

All photographs unless otherwise referenced by the author.

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The Mycenaean walls (13thC BC) of the Palace of Nestor are protected by a roof in an archaeological site that overlooks a broad plateau situated above Navarinou Bay

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GSSA events 2020

GSSA Events from January 2020 – November 2020 **VP Meetings – Noleen Pauls: info@gssa.org.za or noleen@fastmail.fm**

Date	Event	Venue
19 – 21 February	Drilling Methods in Johannesburg	Mandela Mining Precinct, JHB
25 - 26 February	SAMCODES Conference	Birchwood Hotel, JHB
18 March	SAMOG Code in JHB	Mandela Mining Precinct, JHB
15 April	CPD Workshop	Mandela Mining Precinct, JHB
30 April	Bushveld PGE Day	Glenhove Conference Centre, JHB
21 May	Hydrothermal and alteration systems short course	Glenhove Conference Centre, JHB
19 June	Geoskills "pop-up" event	TBC
29 June – 1 July	Geocongress 2020	Stellenbosch
16 July	Mineral Rights in Southern Africa: the current state of affairs	JHB
16 July	AGM	Johannesburg Country Club Auckland Park, JHB
14 – 16 August	Advanced structural geology field trip	KZN
20 August	3-D Geological modelling	Glenhove Conference Centre, JHB
September	Diamond Conference	Kimberley
16 – 18 September	Drilling Methods	Avianto, Muldersdrift
8 October	CPD Workshop	Mandela Mining Precinct, JHB
16 October	REI colloquium	JHB
22 October	Project Management for geologists	JHB
6 November	Geoskills "pop-up" event	TBC
11 November	Fellows Dinner	Johannesburg Country Club Woodmead
12 -13 November	Technology Day African Exploration Showcase	Glenhove Conference Centre, JHB

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