

geobulletin

QUARTERLY NEWS BULLETIN ~ JUNE 2017

Cu-Ni-PGE Mineralisation Workshop

The Antropocene – Geological Age of Humans

Daniëlskuil cave collapse

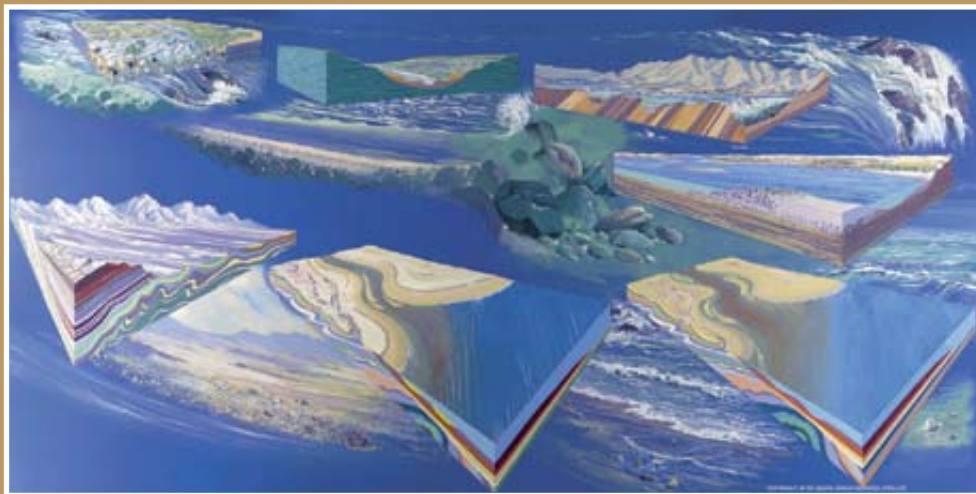
news



COVER PHOTO:

Karoo-aged feeder dykes to the Drakensberg lavas are generally poorly exposed. However, near Ficksburg, eastern Free State, they can be observed due to their metamorphic effects on the Clarens Formation sandstone. The dolerite dykes are typically 5 to 10 m wide, but (presumably) due to prolonged through-flow of magma they have produced significant metamorphism of 5 – 10 m on either side of the dyke. The resultant quartzite produces spectacular buttresses, whereas the softer dolerite forms the gully.

Photo and caption: Grant Cawthorn



CENTRE FOLD

Erosion of Kimberlite pipes from 90 million years ago to today

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Artist, Maggie Lambert-Newman.

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from the editor's desk

Chris Hatton



Stratigraphy used to be a relatively objective science. The geologist would look at a sequence of rocks that were deposited millions of years ago and define boundaries where the rock type changed. This straightforward description of past events becomes more difficult as the events become more recent. On pp. 16 to 18 of this issue Nicolaas Steenkamp describes the complexity that humans face in defining the Anthropocene, the Geological Age of Humans. The difficulties are not so much those associated with humans being both player and umpire but

rather the opposite; what are those signals that can be unambiguously related to human activity rather than to natural processes? The burning of coal produces fly ash, but coal fly ash has been found in Permian age Canadian sediments where it has been linked to the intrusion of the Siberian traps into coal and organic-rich sediments. More uniquely human signals may be the residues from atomic bomb test and the appearance of plastics in the 1950s. Building materials are likely to provide good stratigraphic markers but because they appear at different times in different parts of the world, they may not provide the precise age boundary that the Working Group on the Anthropocene is seeking. Whatever the final outcome, the underlying assumption is that the Anthropocene marks the time when humans influenced Earth systems on a global scale. To find another organism that has been implicated in a transition of similar magnitude one has to go back to the end of the Permian.

The prevailing theory is that the mass extinction at the end of the Permian was triggered by volcanic eruptions over a vast area of what is now Siberia. In a remarkable whodunit Daniel Rothman of the

Massachusetts Institute of Technology has argued that this is only part of the story. In 2014 he and his team presented a fascinating story in three parts. First, they showed that the increase in carbon levels during the end-Permian extinction event was far too rapid to be related to a geological process. Second, they re-estimated the time when the microbe *Methanosarcina* gained the ability to make methane from acetic acid and found that this time coincided with the end-Permian extinction. Then thirdly, they found that the concentration of nickel, an essential component of methane-making machinery, peaked in the end-Permian sediments. The Siberian traps were identified as the probable source of this nickel. The only weak link would appear to be the transport of non-volatile nickel from the Siberian traps into the sea. Recently Margaux le Vaillant and colleagues (including Stephen Barnes, co-presenter of the Cu-Ni-PGE Mineralisation Workshop, see pp. 13 to 14) showed that 'bubble riding' during degassing of the Siberian traps could allow nickel sulphides to disperse from the Noril'sk ore into the atmosphere and from there into the sea. Case closed, one might think.

A necessary requirement of a successful whodunit is that it be surprising, but not too surprising. The combination of a unique biological innovation and a unique nickel deposit is perhaps too surprising. Whodunits always obey common conventions and in the case of mass extinctions the usual suspects seem to be high temperature and high carbon dioxide contents. Evidence comes from experiments where humans influence Earth systems on a laboratory scale.

The ability of the 'living fossil' *Ginkgo* to survive drastic changes in carbon dioxide content provides the evidence for the estimates of carbon dioxide contents. *Ginkgo* saplings raised in nurseries reduce the number of stomata, the pores used to exchange gases, as the carbon dioxide increases. Estimating the

density of stomata in the ancestors of *Ginkgo* allowed Greg Retallack of Oregon State University to conclude that carbon dioxide rose from less a thousand ppmv before the end Permian extinction to more than six thousand ppmv during the extinction.

The change in oxygen isotopes of fish teeth from fish raised in aquariums at different temperature provides the temperature evidence. Fish are vigorous at low temperatures and don't discriminate as much between heavy and light oxygen as they do when they become hotter and lazier. Hot, lazy fish show a much stronger preference for light oxygen than do cold, vigorous fish. Transferring these results to conodonts in the type section of the end-Permian section at Meishan in China indicates a temperature increase of more than eight degrees over a geologically short interval. At the moment 'short interval' means less than sixty thousand years, but as zircon chronology improves and similar studies extend to other areas 'short interval' is likely to become even shorter.

On land oxygen isotopes are mainly controlled by rainfall patterns. As water moves to cold high mountains the proportion of heavy oxygen drops

off dramatically. This effect is not as pronounced in warm conditions so rain falling during the warmth of the end Permian extinction contained higher proportions of heavy oxygen than rain falling before the extinction. The tusks of the animals which died during the end Permian extinction in the Karoo Supergroup record this pattern. At the moment the precise position of the end Permian boundary in the Karoo Supergroup is uncertain. Fortunately, Mr Mosa Mabuza of the CGS is driving a campaign to resuscitate detailed mapping of South Africa so this situation is likely to improve. Consequently, one benefit of the rejuvenated mapping program will be that South Africa will become one of those areas where the duration of the end Permian extinction becomes ever more precisely defined. As the precision increases and the time scale narrows, a more objective comparison between the transition from the Permian to the Triassic and the transition from the Holocene to the 'Anthropocene' will become possible. Maybe we will even learn something useful from past patterns of the interconnection between carbon dioxide and temperature

Chris Hatton

executive managers

In May, South Africa lost two of its most influential geologists, Gerhard von Gruenewaldt and Rodney Maud. Both will be missed, and both contributed enormously to South African geology. The GSSA extends its condolences to the families of both. Formal obituaries are in preparation.

News reports of the past few days indicate that the Department of Mineral Resources is about to release the revised Mining Charter which was originally promised in March. The GSSA will likely comment, as we have done in the past on proposed or promulgated legislation. The overriding concern of GSSA Council is the health of the earth science professions in industry and academia, and the employment opportunities



corner

Craig Smith



that a favourable investment climate can stimulate. We are all aware that the political developments in South Africa over the last couple of years has inhibited inbound investment and consequent job creation, which is tragic for a country as endowed in resources and talented people as South Africa. Neighbouring regimes with less resource potential but with more transparent and efficient regulatory frameworks and investor friendly legislation have not suffered as much as South Africa during this depressed part of the resource cycle. South African based consulting companies are for the most part busy – but elsewhere in Africa. This is an indictment of the status quo in RSA.

In the last issue of *Geobulletin*, the European Union funded European Federation of Geologists (EFG) INTRAW project was featured in a six page article (International Cooperation on Raw Materials; see www.intraw.eu). This project addresses the need for access by countries to adequate supplies of raw materials, and is one of eight Horizon 2020 funded projects with links to earth science (for an overview of Horizon 2020 see <https://ec.europa.eu/programmes/horizon2020/>).

These projects have varying levels of South African involvement, are very well funded, and along with INTRAW will be of interest to earth scientists in industry, government and academia. Clearly the majority of these projects are of direct relevance to the Southern African scene, and local geologists need to be aware of the initiatives. The GSSA has representation in INTRAW, through its association with the EFG.

The other projects are:

KINDRA – Knowledge Inventory for Hydrogeology Research (<http://kindraproject.eu>)

MINATURA 2020 – Developing a Knowledge Framework for a European Minerals Deposit Framework (<http://minatura2020.eu/>)

VAMOS – Viable and Alternative Mine Operating System (<http://vamos-project.eu/>)

CHPM2030 – Combined Heat, Power and Metal Extraction from Ultradeep Ore Bodies (<http://www.chpm2030.eu/>)

UNEXMIN – Autonomous Underwater Explorer for

Flooded Mines (<http://www.unexmin.eu/>)

MICA – Mineral Intelligence Capacity Analysis (<http://www.mica-project.eu/>)

FORAM – Towards a World Forum on Raw Materials (<http://www.foramproject.net/>)

On the general topic of limits to the world's resources, there is always someone somewhere trying to sell the idea that the world is going to run out of this or that commodity. Usually sooner rather than later! Remember the 'Peak Oil' projections in the 1950's and 1960's; the production high point was projected to occur in the 1970's. But we know how that turned out. Advancing technology, favourable regulatory environments, new discoveries, and favourable economics combined with the rise of new clean energy sources are all conspiring to change the fossil fuel landscape. It is not inconceivable that the Middle East in particular may end up with stranded petroleum deposits.

The same arguments apply to resources in general. For a slightly different take on the projections we commonly see in the press, see <http://www.geochemicalperspectives.org/online/v6n1>. Anyone placing financial bets on various resources over the next couple of decades or so should peruse this contribution. (In some circles, by the way, financial bets are referred to as 'Investments'.)

However, one commodity that is now unquestionably in seriously short supply in the Western Cape is water. At the time of writing there seems to be no end in sight to the drought, with the rainy season being at least four weeks late. Those of us resident in Cape Town may have to resort exclusively to wine to survive. You can hear the waiters already – 'Sir, I recommend this wooded chardonnay with your bacon and eggs'. Filled swimming pools are adding to the market value of homes (three month supply of available water, though generally non-potable). If it is raining in the Cape by the time of publication, you will probably see images of dancing Capetonians on evening news broadcasts. Let's hope for such a spectacle.

Craig Smith

Geological Society of South Africa

president's column

Two years ahead always seems much further away than two years ago!

This will be my final written Presidential contribution, yet two years does feel like yesterday that I provided my support to the Society in this capacity. At the outset I wish to thank Craig Smith – Executive Manager for all his input, support and restraint. Without Craig the Society would definitely flounder. His enthusiasm and energy for the GSSA is significant. To run the society without full-time roles would simply not work. Lully Govender, Sally Nienaber and Marliese Olivier do an absolutely incredible job and have put in considerable effort over the past period especially with regards the IGC and the office move. Thank you ladies for your most appreciated contributions and support you have provided me. To my fellow Management Committee members: thank you for your involvement and individual leadership in each of your portfolios. Then to the broader Council members: your insights, experiences and ideas remain key to the society. Your ability to bring views representative of the broader communities you are part of are very important to ensure the society tackles the issues at hand.

To all the members of the Geological Society of South Africa: your society has served you well over the past few years. We have made some critical decisions in the professional landscape to support your broader vocation. There is significant posturing and rallying in various circles around the professional identity of all institutions. Be assured that the society puts your broader interests as central priority to all decision making. We have tackled numerous situations head on over the time period and I thank everyone for their input and rationale.

The International Geological Congress was a long time coming and seemed to go by in a blur of activity and interest. Here too the Society was ably represented by many members through the conference organization, speaking, posters, on committees, during the event and



Jeannette
McGill

on fieldtrips. I want to thank everyone who contributed in any way big or small. Sometimes we don't necessarily receive just thanks for our efforts but please know that everyone's contributions collectively ensured that we can be proud of the event. From me: Thank-you.

I know I've taken up enough space with my wordy thank yous but as the society moves ahead into the post IGC period I know that we are well positioned with very important members and nominated portfolio holders that we can see the society thrive. Challenges abound from all sides and the resources sector at large is still experiencing headwinds but the GSSA supports people whose focus is on the preservation of the geological community in South Africa through a variety of channels including meetings, training, geoheritage, fellows, membership, transformation etc. Various roles are up for renewal in the July AGM. I really do encourage everyone reading this to consider in what way they would like to support the Society. We have unfinished business in areas such as membership



conversion, relevance of the society to the student community, and greater transformation but I know that the society is well placed to continue pursuing these and address new areas for development too. To my successor I wish you all the support and well wishes. While the incoming President role remains pending on the AGM outcome I will note that the society takes balancing succession planning, exposure and leadership very seriously. We also have role-players who have provided remarkable leadership and guidance to the society over many many years. I can tell you within the current cohort of leaders, we are well placed to take the society forward.

When I returned to South Africa in 2010 after spending 5 years in the USA I had lost my network. On finding a safe harbour in the GSSA I developed networks, I rejuvenated friendships and I once again felt at home in a professional community. I have all of you to thank you for that. I think the Society can be its harshest critic sometimes. We tackled the IGC, we have represented the Society in a variety of public and private channels. We continue to do well and the Society remains a community of geoscientists that cares. Thank you Geological Society of South Africa.

"Life is about cherishing the past, facing the present, and moving ahead towards new milestones".

Unknown.

all the news fit to print

WITS

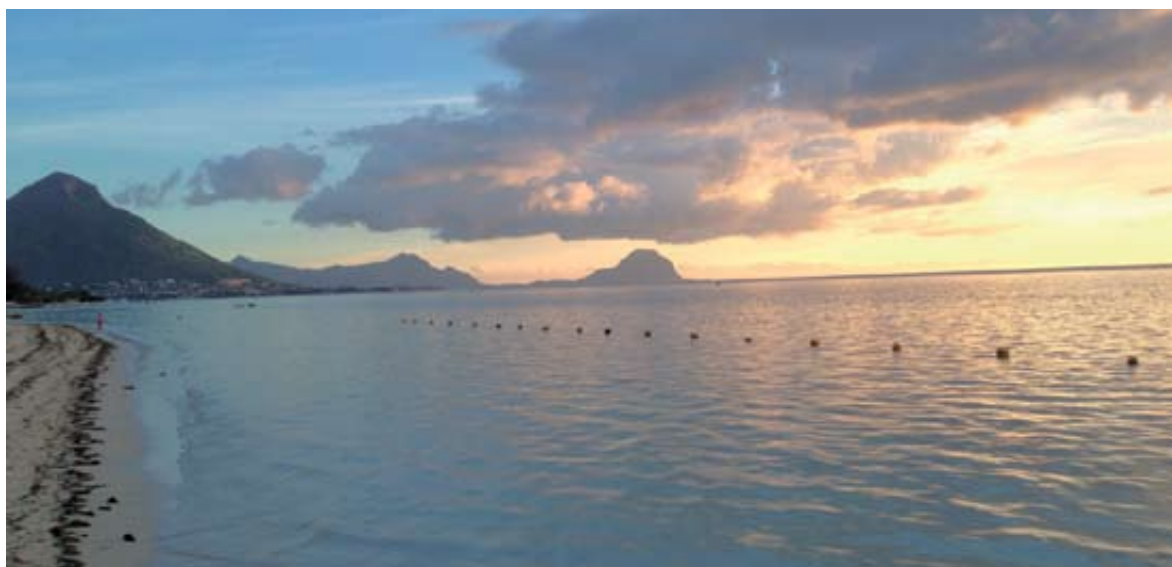
HIDDEN CONTINENTS

On 31 January, 2017, Prof. Lew Ashwal's paper (with Profs. Michael Wiedenbeck and Trond Torsvik) on the existence of a fragment of Archaean continental crust hidden beneath the young ocean-island volcano of Mauritius, was published in Nature Communications. This generated an immediate



and surprising frenzy of media attention, with coverage in hundreds of print and web-based articles (New York Times, Newsweek Cosmopolitan, to name a few), and dozens of TV and radio interviews. Public interest was probably sparked by an allusion to the discovery of a "lost continent", bringing to mind the Atlantis myth. The new results are based on the recovery of 2.5 – 3.0 Ga zircons in a 6 Ma Mauritian trachyte, suggesting that a sliver of ancient continent, stranded during Gondwana fragmentation, was fortuitously blanketed

A scenic beach on Mauritius.



by basalts representing the Miocene volcanic products of the presently-active Réunion deep-mantle plume. Lew and colleagues identified other possible continental fragments in the Indian Ocean, which they refer to collectively as the microcontinent “Mauritia”. This discovery allows more precise reconstructions of now-dispersed Indian Ocean continental entities, and implies that continental break-up processes are more complex than we thought. A 4-minute video, produced by the Wits University media department, in which Lew Ashwal explains the new work, can be viewed at <https://www.youtube.com/watch?v=o61P6ysKklM>. Cunningly caught on film is Lew’s rendition of Taylor Swift’s first hit single “Our Song”. He is still waiting for her call.

CARDIFF VISIT

In March 2017, Profs. Lew Ashwal and Susan Webb made a 3 week visit to the School of Earth and Ocean Sciences, Cardiff University (U.K.), sponsored by a grant to Prof. Wolfgang Maier from the Cardiff International Seedcorn Fund. This Fund aims to foster international research collaboration between universities, and to

explore strategies to formalize academic linkages that could involve, for example, student exchange programmes. Lew and Sue each presented two lectures on their recent work- petrology & geophysics of layered mafic intrusions, dykes and shale gas potential of the Karoo, and “hidden continents”, and they were able to interact individually with many of the talented geoscientists working at Cardiff. In addition to Wolf Maier (magmatic ore deposits), Lew and Sue held research discussions with Tom Blenkinsop (structure & tectonics), Huw Davies (mantle geodynamics), Johan Lissenberg (mafic magma evolution, Iain MacDonald (PGE geochemistry), Chris MacLeod (ophiolite tectonics), Marc Millet (novel isotope systematics), and David Thompson (lithosphere structure). Opportunities were discussed to develop one or more collaborative research projects between Cardiff and Wits geoscientists, for example on the broad-scale origin and evolution of layered intrusions, and possible strategies to leverage funding from both European and South African research agencies. Lew and Sue’s visit culminated in their participation in Cardiff’s annual 10-day field excursion to Cyprus, during which 85 3rd-year students were introduced by 7 Cardiff staff members



Johan Lissenberg and Wolfgang Maier explaining the properties of the lower oceanic crust to Cardiff students at the Troodos ophiolite, Cyprus.



to the geology and ore deposits of the spectacularly-exposed Troodos ophiolite complex. This is a world-famous example of uplifted oceanic crust and upper mantle, where the sedimentary, magmatic, tectonic and metallogenic processes involved in formation of oceanic lithosphere can be witnessed directly. Lew and Sue feel that this would be an outstanding site for South African students and their mentors to visit.

The MSc by Coursework and Research Report in Hydrogeology is growing from strength to strength, with the 2 graduates from 2016 joined by a further six who have completed their research reports earlier this year.

It is with deep sorrow that we wish to inform you of the passing of Thuso Magonya, a third year student in Geology in the School of Geosciences. Sadly, Thuso passed away last Wednesday (March 29) in a freak swimming pool accident. Thuso was deeply involved in all aspects of the School of Geoscience. He was highly admired for his commitment to his studies and he recently received the award for the best marks for second year Geology. Although he qualified for his BSc in Geography, he elected to complete his Geology

degree as a second major. He repeatedly served as class representative and was elected to the committee of ROCSOC for several years, serving as the current chairperson. Thuso was instrumental in organizing last year's highly successful ROCSOC-Alumni function that enabled students to network with industry alumni and friends. His chocolates often featured at School events and were an expression of his entrepreneurial enthusiasm. We offer our heartfelt condolences to his family.

Deep Carbon Observatory International Science Meeting

At the end of March, Katie Smart travelled to Scotland to participate in the 3rd Deep Carbon Observatory International Science Meeting in St. Andrews, Scotland, where she gave a paper on the role of diamonds in the deep carbon cycle. Immediately before and after the conference, Katie visited John Craven at the University of Edinburgh NERC ion probe facility in order to conduct further research.

Dr. Katie Smart at the University of Edinburgh NERC ion probe facility in March.

Thuso Magonya





The installation of two Thermo Scientific Inductively Coupled Mass Spectrometers (ICPMS: Thermo Element XR sector field and iCAP quadrupole) has commenced on 17th May. The two instruments form part of a state-of-the-art Laser Ablation ICPMS facility at the School of Geosciences funded by the NRF. Installation will be completed this weekend and training will start 29th May. The laser is due to be installed in October. Main applications will include high-precision in-situ measurement of trace elements (both whole rocks and minerals) and U-Pb geochronology.

Susan Webb



The longest serving staff member in UJ's Geology Department (and the longest at UJ!) is Professor Nic Beukes. He has received numerous accolades during his academic career and recently (May 2017) can add another to the list. His most recent achievement is to be nominated as a finalist in the National Science and Technology Forum (NSTF) "Lifetime Contribution" category. Since taking the position of Director of the Department of Science and Technology (DST) / National Research Foundation (NRF) Centre of Excellence for Integrated Mineral and Energy Resource Analysis (CIMERA), Department of Geology, University of Johannesburg, Nic has continued his research excellence that began at RAU, now UJ, over 45 years ago.

From the CIMERA desk, Dr George Henry reports that The American Association of Petroleum Geologists (AAPG) Distinguished Lecture for 2017 was presented by Dr Tom Dunn on Tuesday evening 7th March 2017

at the University of Johannesburg Sol Kerzner School of Tourism and Hospitality. His talk was entitled *"The value of looking at rocks in the era of advanced instrumentation and computer modelling"*. The event was co-sponsored by DST-NRF CIMERA and about 60 guests enjoyed an interesting talk and a networking evening.

While on the subject of guest lecturers, Professor Poppe L. de Boer, who hails from Utrecht University in the Netherlands, gave a presentation on the 27th March in the department titled *"Modern versus ancient controls on sedimentary systems; the present is not always the key to the past"*. This was part of the 13th IAS (International Association of Sedimentologists) Special lecture tour 2016-2017 and de Boer, who is a Past President of the IAS, was the selected academic to undertake this important sedimentological tour, sponsored by the IAS.

The 5th DST-NRF CIMERA Steering Committee meeting was held at the University of Johannesburg on the 11th

Dr Craig Smith (GSSA) and Dr Tom Dunn, the AAPG Distinguished Lecturer, during question time after his talk held on the UJ Bunting Road campus



April 2017. Prof Nic Beukes (UJ) presented his Annual Director's Report for 2016 and Prof Judith Kinnaird (Wits) a short Co-Director's report to the Committee members. DST-NRF CIMERA had a very successful operational year for which thanks are due to all its research collaborators.

UJ has an academic category titled Distinguished Visiting Professor (DVP). This is a prestigious appointment and the DVP has to be hosted by a staff member in the relevant department. Professor Marlina Elburg is one such person and she regularly hosts DVP Professor Tom Andersen from Oslo University. He visited the Department during May, dividing his time between two contrasting South African projects, working in collaboration with Prof. Marlina Elburg: the Pilanesberg mineralogy, and South Africa's detrital zircon record. For the latter project, Prof Andersen has made good use of the NRF-CIMERA funded laser ablation MC-ICPMS, obtaining additional U-Pb and Lu-Hf analyses on zircon to augment his database on the Gariep and Nama Group. Importantly for the LA-MC-ICPMS facility, he is also continuing to improve the 'NuAge' U-Pb data reduction spreadsheet that he produced, focusing on the incorporation of monazite and apatite as datable phases. The Pilanesberg research, on the other hand, is focusing on the influence of the crystallisation conditions on the mineralogy of the Green Foyaite, which is the most peralkaline unit in the Pilanesberg Complex – and therefore host to some very unusual minerals. Some of them have never been recorded in South Africa before, while others may be

completely new to science! The results of both projects are now being prepared for publication.

On the Doctoral graduation front, the first half of 2017 has been a bumper year for UJ geology. Leading the charge was Professor Fanus Viljoen, currently the DST Research Chair in Geometallurgy. He supervised no fewer than four graduate PhD students, two of whom, Lauren Blignaut and Derek Rose, are both Lecturers in the department. The PhD topics of his students included "*A Petrographical and Geochemical Analysis of the Upper and Lower Manganese Ore Bodies from the Kalahari Manganese Deposit, Northern Cape, South Africa – Controls on Hydrothermal Metasomatism and Metal Upgrading*" (Lauren Blignaut), "*A geometallurgical investigation of the Merensky Reef and UG2 at the Two Rivers Platinum mine with emphasis on ore characterization*" (Derek Rose), "*A mineralogical and geochemical characterization of beryl from southern Africa*" (Jullieta Lum), and "*A Geometallurgical Investigation of the Main Mineralised Zone and the Peridotitic Chromitite Mineralised Zone at the Nkomati Mine, with a View on the Liberation and Recovery of Pentlandite and Chromite*" (Thomas Dzvinamurungu). And in addition, he had an MSc graduate in May, Buhle Mkhize, with a dissertation titled "The variability of particle size distribution measured in 2D vs 3D".

Axel Hofmann has been invited by the European Association for Geochemistry (EAG) and Geochemical Society (GS) to give a short course as part of their 2017 Outreach Program to Africa (<http://www.eag.eu.com/>



Prof Axel Hofmann presenting his short course at the University of Ghana.



[outreach/outreach-program](#)). The EAG-GS Outreach Program was established in 2012 with the directive of developing outreach activities in geochemistry in under-represented regions of the world. In the last week of April, Axel started his outreach activity with a visit of the Department of Earth Sciences of the University of Ghana. There he presented a 3-day short course entitled Early Earth Life and Mineral Systems. The course explored the relationship between surface processes, evolution and habitat of life and the formation of mineral deposits on the early Earth from its very beginning until two-billion-years ago. The course was attended by c. 50 undergraduate and postgraduate students as well as staff from the department. Besides promoting geochemistry in Africa, the course also showcased some of the analytical capabilities available in South Africa and was aimed at intensifying Pan-African collaboration. The outreach programme will continue with visits to other Earth Sciences departments in Africa in 2017. Short courses have so far been scheduled at universities in Nigeria and the University of Dar-es-Salaam in Tanzania.

In the latest batch of NRF ratings, Dr Jeremie Lehmann and Professor Sebastian Tappe were successful in their submissions for rating, the former achieving C2 and the latter B2. Prof Tappe is the youngest person to achieve a B2 rating. Prof Tappe has been appointed as an Editorial Board Member for 'Scientific Reports', which is a relatively new technical briefs format by the Nature Publishing Group London. It is multidisciplinary and with an Impact Factor just over 5 a relatively attractive journal to publish geological findings.

The Department has also welcomed some new international post-doctoral staff. Dr Malcolm Massuyeau from France will be working on thermodynamic modelling of the trace element distribution in mantle-derived melts with Prof Tappe and Prof Viljoen. Another post-doc from France, Dr Christophe Ballouard, has started work with Prof Elburg on the pegmatites of Namaqualand, in collaboration with Prof Buick from Stellenbosch University. Christophe has brought along reference materials to set up U-Pb dating on apatite, so

it is expected that this technique will soon be added to the ever-increasing repertoire of the UJ LA-MC-ICPMS laboratory. The arrival of Christophe has increased the number of French post-docs in the department to four, so French is now firmly entrenched as the second European language in the department!

Bruce Cairncross

Stellenbosch



Stellenbosch University is currently embarking a process of introspection and programme renewal, tackling issues such as how to teach the students of today and tomorrow, what to teach and how to address the student-flagged issue of decolonisation of curricula. That process will take some time.

Of more immediate impact, we want to report a recent success in obtaining research funding through the medium of crowdsourcing and the recruitment of members of the public to be 'citizen scientists'.

Three of our postgraduate students are trying to find out how sustainable South Africa's groundwater resources are. They will be collecting rainfall and groundwater samples from across the country, with the help of the public.

With the assistance of administrative structures within the University, the students embarked on this initiative, starting in late February, using the South African crowdfunding platform Thundafund. So far they have raised nearly R150,000, which goes a long way toward their ultimate target of R200,000, and allows the work to begin. The funding is being used, partly, to set up rainfall collectors and to sample groundwater from existing boreholes. Citizen scientists will receive sampling kits as well as funding to send samples back to Stellenbosch for analysis.

It is important to understand how regularly groundwater is recharged and whether it is a renewable resource. The

team will use Tritium (^3H) concentrations to determine when water that enters the groundwater system was last in contact with the atmosphere. Radioactive tritium is produced naturally in the stratosphere and is rained out at Earth's surface. Once it enters the groundwater system and becomes isolated from the atmosphere, it decays at a constant rate. So, the longer groundwater is isolated from the atmosphere, the lower the tritium concentration. Once the residence time of the groundwater is known the renewability of the resource can be modelled, and it will be possible to identify areas that have renewable groundwater resources for sustainable agricultural developments, as well as those where the water resources need to be protected.

You can visit Thundafund at www.thundafund.com/project/knownyourwater to support the campaign, follow the students' progress on their blog 'We Know Water', on Facebook (search for We Know Water) or on Twitter @we_know_water.

John Clemens



MSc student Jared van Rooyen and BSc honours students Yaa Agyare-Dwomoh and Zita Harilall, with their supervisor, Dr Jodie Miller.

mineralisation workshop



Delegates of the Cu-Ni-PGE Mineralisation Workshop, Steve Barnes seated with Rais Latypov standing directly behind (photograph courtesy of S. Chistyakova).

Cu-Ni-PGE Mineralisation Workshop

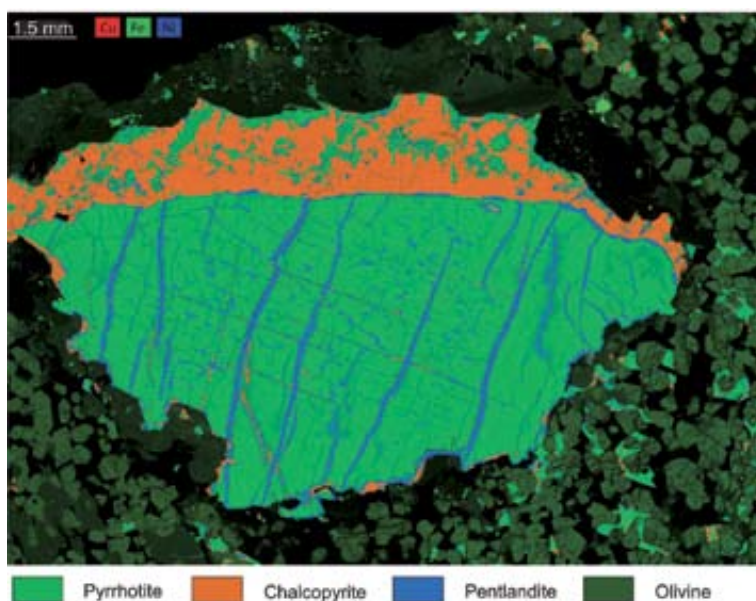
11-12 May, Glenhove Conference Centre

The GSSA hosted a well-attended workshop on magmatic sulphide and chromite ores presented by Prof Rais Latypov of Wits University and visiting Prof Steve Barnes from CSIRO, University of Western Australia. The objective of the workshop was to provide an account of the current understanding of magmatic Ni-Cu-PGE and chromite deposits and the magmatic processes involved in their formation, as well as some of the gaps in our understanding and areas of current research. The course expertly catered to attendees along the full

range of experience and knowledge, from present-day students to life-students, the eldest delegate being 88 years young (Figure 1). There were lively debates over magmatic processes and their timescales, geological models versus field observations, in particular the many enigmas and controversies of the Bushveld Complex.

Prof Barnes provided the framework for understanding magmatic processes and mineralising systems, with the minimum of Spider Diagrams possible (i.e. none). The current emphasis at CSIRO in terms of research into magmatic sulphide systems is on flow dynamics, physical processes and the relative timing and effect of each of these in deciding which are important at





Multi-element microbeam XRF image of a differentiated sulphide liquid globule from Noril'sk, Russia. The globule represents a bubble wherein residual liquid and sulphides are concentrated. The upper zone of Cu-rich sulphide is the crystallisation product of a residual liquid, whereas the lower pyrrhotite-pentlandite exsolutions were originally formed as a monosulphide solid solution (Fe,Ni)S cumulus phase (Barnes et al 2017, Elements 13(2)).

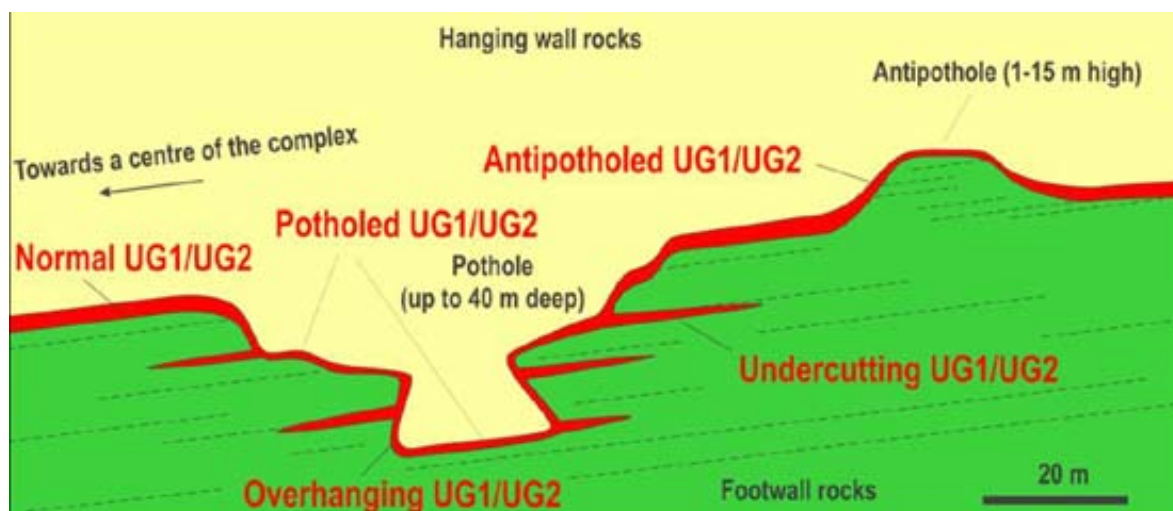
Prof Latypov led the discussion on current controversies and new thinking on crystallisation and layering in large layered intrusions, such as the Bushveld Complex. The significance of

different scales, using komatiite-hosted deposits as a backdrop to explain and understand these. Previous thoughts on the formation of sulphide accumulations in magmatic flows were that they concentrated in pre-existing traps; however 3D tomographic studies and multi-element microbeam XRF imaging suggest that thermal and chemical erosion of the footwall by a very hot, very runny sulphide liquid plays an important role in creating its own traps, and that percolation is responsible for many of the textures observed in sulphide deposits.

Generalised stratigraphic section illustrating different facies of chromite ore with respect to potholes and antipotholes, highlighting the existing controversy in the model of formation (from course notes Latypov, 2017).

different observed ore facies, in particular with respect to potholes and antipotholes, was raised as important to constraining processes such as the mechanisms of magma emplacement, the nature of replenishing magmas, interaction with floor rocks and mineralisation. The development of chromitite draped over complex topologies and even over-hanging surfaces challenges a classical gravity settling model and makes a strong case for in situ crystallisation, but as is often the case, no one model is able to explain all the observations. With ideas (and a few rocks) thrown around, it was clear that even after nearly 90 years of mining in the Bushveld Complex, much of our knowledge is incomplete, but by considering processes at different time and spatial scales we continuously move closer to answers.

JP Hunt




WORKSHOP



AAPG

Africa Region



EXPLORATION AND DEVELOPMENT OF UNCONVENTIONAL HYDROCARBONS: UNDERSTANDING AND MITIGATING GEOTECHNICAL CHALLENGES THROUGH CONVENTIONAL WISDOM

CAPE TOWN, SOUTH AFRICA • 20-23 JUNE 2017

The objective of the workshop is to update the attendees on latest development and best practices on unconventional resource exploration and development. The workshop will review various approaches of what worked and what did not work in the field implementation of technologies. Also, the workshop will aim at identifying the knowledge and technology gaps that require further investigation and development. The workshop will attract experts from various disciplines to talk about their experience and share their knowledge and the learning curve from actual projects. Participants will be able to exchange views and ideas with the other professionals in the industry.

The majority of the presentations will be in the form of case studies, highlighting engineering achievements, and lessons learnt. In order to stimulate frank discussion, no proceedings are published and the press is not invited to attend. The workshop will be followed by a field visit to

Karoo to understand depositional environment of White hill shale and Dwyka Fm, stratigraphy, and environmental issues.

Benefits of Attending

This workshop provides the opportunity to learn and discuss the latest knowledge, techniques & technologies applied to unconventional reservoirs which can be utilized to explore for and develop these reservoirs. The workshop will provide a set-up for networking, interacting & sharing expertise with fellow petroleum scientists interested in developing and producing unconventional hydrocarbon resources

Who Should Attend?

Geologists, Geophysicists, Reservoir Modelers, Sedimentologists, Petrophysicists, Reservoir Engineers, Team Leads and Managers.

SPONSORSHIP OPPORTUNITIES

<http://www.aapg.org/career/training>

the antropocene

The Antropocene – Geological Age of Humans

The 'Anthropocene' is a term that has gained popularity since it was first coined by Paul Crutzen and Eugene Stoermer in 2000. The term is used to designate the current period of Earth's history during which humans have a clearly marked and lasting recordable influence on the Earth systems. What makes the Antropocene significantly different for all the other recorded geological ages is that it took only centuries or decades depending on how it is perceived, to manifest versus millennia that the previous ages took to establish.

The 'Anthropocene' has not been formally defined as a geological unit within the Geological Time Scale. A proposal to formalise the 'Anthropocene' is being developed by the Working Group on the Anthropocene, established in 2009, for consideration by the International Commission on Stratigraphy. The Working Group met in August 2016 in Cape Town at the

35th International Geological Conference. Here thirty of the thirty five delegates voted in favour of designating this new epoch on the geological stratigraphic unit.

The start of this new epoch could be defined by referencing it to a particular point within a strata section. This is called a Global Stratigraphic Section and Point (GSSP) or is colloquially known as a 'golden spike'. It could alternatively be a designated time boundary, called a Global Standard Stratigraphic Age. This boundary would have to be found across the globe and have similar signal characteristics. The advent of the 'Anthropocene' has previously been suggested to have started around the year 1800, the time of the Industrial Revolution in Europe. This event pushed the CO₂ levels from the previous 12,000 year average of 280 ppm to 400 ppm in the present day. It has however been argued that the increase of carbon particle deposits due to burning of coal was not decisive enough to differentiate from natural processes. More pronounced

Wundergrotte stalagmite



time boundaries have been suggested where the global impact can be more empirically measured. The most compelling argument is the 1950's, marking the start of the atomic and plastic age.

The closest comparable event would be the K/Pg boundary, the transition from the Cretaceous to the Paleogene periods about 66 million years ago. This layer was formerly known as the Cretaceous-Tertiary or K/T boundary. The characteristics of this layer would suggest a global catastrophic event, indicated to be related to a massive meteorite impact. The key marker elements of the K/Pg boundary are; increased iridium levels presence in the layer, iridium is very rare on the crust of the Earth and more generally found in metallic meteorites; tiny balls of clay and glass referred to as spherules, derived from cooling of molten droplets of impact rock in the atmosphere; shocked quartz grains; evidence of tsunamis; species extinction marking the end of the age of dinosaurs and fossil turnover.

The advent of the 'Anthropocene' would be marked in the geological record across the globe by a number of phenomena, referred to as signals. The signals are likely to be defined by the presence of elevated levels

of radioactive elements dispersed across the planet by nuclear bomb tests. A range of other signals include: the prolific change in soil chemistry worldwide due to the use of fertilisers, resulting in a spike of nitrogen and phosphate, and the distribution of plastic pollution, with the slow degrading micro-particles being preserved as part of the sedimentary record. Plastic has even been found to be incorporated into modern lava flows. The presence of concrete and other building materials such as glass and aluminium, along with the physical movement, excavation and re-deposition of soils have led to the development of the geotechnical term of describing a soil horizon as being an Anthropogenic soil.

The tough, unburned carbon spheres, emitted as soot from power stations are deposited world-wide and are recorded in ice drill core from the Polar Regions. The sharp increase in the CO₂ levels are also recorded in bubbles in these Polar ice layers. The hunting and migration patterns of humans over the last couple of millennia have also been linked to the extinction of a significant portion of the mega-fauna. The extinction of the major mega-fauna of the America's and Australia has been suggested to be directly linked to



Anthropogenic Soil



Soil profile





Ice Core

the migration of humans into these regions following the end of the last Ice Age approximately 12,500 to 10,000 years ago. The movement of livestock has also led to the global proliferation of especially domestic chickens and cattle and the resultant deposition and preservation of their bones in landfills and other natural

accumulation spots. Farming has also resulted in mass de-forestation in favour of planting of grains.

The Working Group on the Anthropocene now has two to three years to decide on the most pronounced signals globally that will be used and the reference location that will be used to define the start of the new epoch. The location would have to have an annual or near annual deposition of material that could record the signal(s) referred to previously. It can take the form of boundary between two layers of ice taken from the Polar region, similar to the ice core currently used to determine the start of the Holocene Age. They are also investigating the possibility of using mud sediments regularly deposited each year; in southern Africa it would be locations such as the St. Lucia estuary or Oranjemund. An alternative could include stalactites and stalagmites which accrete annual rings. Deep marine or lake sediments, corals, tree rings and even layers of non-degradable waste in landfill sites are also being considered. The declaration and proclamation of the Anthropocene is however expected to still be a couple of years in the making.

St Lucia estuary



Dr. Nicolaas C. Steenkamp

employment

Quarries create employment for surrounding communities

The value of well-run quarries in our cities and towns was recently underscored by research suggesting that every job in the quarrying industry creates a further five jobs in downstream operations.

These figures therefore suggest that quarries are major contributors to regional job creation efforts; and as an industry is a major driver of the national economy accounting for substantial revenues and the creation of many thousands of direct and indirect jobs.

Aspasa director, Nico Pienaar, says these job creation figures are yet another compelling reason for communities to be excited about the proclamation of a new quarry. "A registered legal quarry, especially one belonging to Aspasa should be an asset to a community by creating jobs and allowing for the construction of houses and infrastructure to be developed within the surrounding areas.

"The research done in the USA by the Phoenix Centre for Advanced Legal and Economic Public Policy Studies shows that quarries are not only beneficial

to the development of physical infrastructure, but are also major contributors to the building of strong local economies. Furthermore, it showed that the benefits lasted for an extended period of time ranging from 20 years to longer.

"This effectively means that people can be employed within the supply chain of a quarry for a lifetime. That means that everyone from the quarry manager, to the machine operators, transport providers, financial services, surrounding store owners and a host of other beneficiaries can build long term plans and rely on the quarry as a constant source of income.

"Given today's requirement for strict health and safety requirements, and with tight legislation guarding all environmental aspects of a quarry, perhaps the time has now come for communities to change their misconceptions about quarries and to start viewing them as enablers of strong communities with solid infrastructure that is sourced locally with lifelong benefits for the entire community," concludes Nico.

Aspasa, Nico Pienaar

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Email: nico@aspasa.co.za, Web: www.aspasa.co.za



daniëlskuil cave collapse

Daniëlskuil cave collapse - excitement around the R31 sinkhole

Following heavy rains during the first week of January 2017, a sinkhole opened up alongside the R31 road between Kuruman and Daniëlskuil in the Northern Cape. The fissure-like sinkhole was initially 100 m long and appeared to be up to 30 m deep in places. A week later, on the 12th of January 2017, a second heavy down pour opened up the sinkhole further to an extent to 300 m in length and a second depression was noted close to the road, prompting the Department of Roads & Public Works to close the R31. A gravel road detour has since been built around the affected portion of the road. The sight however still attracts the interest of passers-by and motorists who stop to walk along the side and take photos. Were it not for the publicity and the new gravel road around the extended sinkholes the depth and extent thereof would not have been known to most travellers along the road. A photo of the area shows that it is now fenced off and only a few fresh ground mounds indicates some disturbance in the area.



The newly exposed caverns immediately attracted the interest of spelunkers from around South Africa. The first couple of spelunkers entered the caverns on the 25th of January 2017. Upon closer investigation the

cavities between the dolomite pinnacles are apparent and the depth makes you want to step back a bit, just in case it can still give way. The cavern system is much more extensive than the portion exposed due to the collapse on surface. The sidewalls of the cavern consist



of smooth dolomitic rock with pockets of secondary calcite crystals. The cave system is generally very narrow, with the deeper passages only accessible to explorers of slender build. The passage underneath the road is approximately 4 m high and 3 m wide. The passage then flattens out, becoming 1 m high and 10 m wide and ends approximately 30 m on the other side of the road. No standing water is observed in the passages, suggesting it is connected at depth with further underground caverns and fissures.

A local geological company has been appointed to determine the extent of the associated caverns and passages. Holes are drilled up to a depth of 40 m and several cavities have been intersected. A Johannesburg based geotechnical company has been appointed to consult on the filling of the sinkhole and stabilising the road surface. A survey company has also been appointed to survey the area and delineate the extent of surface depressions. Temporary remedial measures have been put in place to divert more water from entering the system. The area has now stabilized after the rains and does not appear to be growing in size.

The Daniëlskuil area is renowned for the caves and sinkholes found there. At the Wonderwerk cave, the oldest traces of the use of fire by early man were discovered in 2013. The cave hosts a number of San



Parallel view of the fissure

paintings and the remaining foundations of the first house constructed by Boer pioneer family in the area. On the Mount Carmel farm the Boesmansgat sinkhole



Side view of the fissure



Passage entrance

is found and is ranked as the sixth deepest sinkhole in the World. It is a popular diving spot, where a number of diving records has been set, but has also claimed its fair share of lives over the years. The Eye of Kuruman, a fresh water spring hosted in dolomite, also made the settlement of the town possible. Kuruman was also the home to Robert Moffat where he set up his mission station. The legendary David Livingston recovered from his wounds at the Moffat mission home after a lion attack, and there met and proposed to his wife, Mary Moffat.

For scientists familiar with the sinkholes in the Cradle of Humankind area, the question arises: is there potential for paleontological discoveries such as animal, human or hominid bones preserved in the area? Much of the area remains unexplored due to the sparseness of known human activity in the area and lack of a recent wet climate that could create sinkholes in the area.

Nicolaas C. Steenkamp

Stephan A.B. Laubscher

Gravel road

law & geology:

How the African Mining Legislation Atlas Transforms Access to Data

Laws (and access to them) directly impact the work of geologists involved in African exploration and mining: mineral development fundamentally involves geological and geophysical activities. Consequently, when mining legislation is formulated, revised or assessed,

the perspective of geologists can tangibly contribute to achieving a more responsive legal framework. It is based on this reasoning that the African Mining Legislation Atlas (AMLA) Project sought experts from a variety of scientific backgrounds, including geologists from the University of Witwatersrand and the Nigerian Geological Survey, to finalize the Project's latest knowledge product, the Guiding Template. But

prior to describing this new tool, it would be best to contextualize the tool within the entirety of the AMLA Project, a freely accessible database which as, noted by Craig Smith of Geobulletin in the March 2017 edition, “saves...weeks of research and attendant costs at the touch of a button and it’s free!”

As global commodity prices continue to fluctuate, proper governance of Africa’s mining sector remains critical to optimize the sector’s contribution to African economies. Complete and transparent access to a country’s framework of laws, policies and regulations is an essential piece of this governance structure. Ideally, any person looking for the laws and policies governing issues such as the licence application process at different stages of mining, or who owns geological data, should be able to find this information for any African country quickly and easily.

In spite of this need, access to the legislation of many African countries remains difficult, more so, as numerous countries have recently adopted or revised their mining codes. These laws are already public documents but are difficult to locate partly due to a lack of institutional capacity as well as a shortage of platforms for dissemination.

The AMLA Project

In 2014 the World Bank Group (WBG), in partnership with the African Legal Support Facility, the African

Union Commission and several African Universities, launched the African Mining Legislation Atlas (AMLA) Project to begin addressing this gap in data access. The AMLA Project catalyzes the discussion around the sustainable development of Africa’s mining sector through three avenues:

- The AMLA Platform, a free online one-stop resource for Africa’s mining legal framework (mining codes, regulations and related legislation);
- The AMLA Training Program, focused on strengthening the capacity of Africa’s next generation of legal experts; and
- The Guiding Template, an annotated document offering a menu of legislative options, designed to assist users in the assessment, preparation or revision of mining laws.

To date, the online AMLA Platform, available in English, French and Portuguese, contains all 53 existing African mining codes in searchable format, as well as a comparison feature that allows users to compare the legislative provisions of 45 countries (and counting) across 98 commonly addressed topics in a mining law.

Users can access the primary mining law and existing primary regulations of each African country in addition to related legislation (where available). This can be helpful, for example, when ascertaining a country’s licence acquisition process during the different stages of the mining process, as well as license holder rights and responsibilities. The comparison feature allows for



Laptop displaying the AMLA website





Group picture taken during the 2016 AMLA Workshop, Accra, Ghana

a deeper look into specific legislative provisions. Users can select one topic to compare against two countries at a time, a useful tool particularly for those who work in or plan to work in several different African countries.

Users can also utilize the feedback button available on the AMLA Platform homepage to provide comments or ask questions to the Project's team and they have done so extensively. Through this useful feature the Project team has recorded positive feedback from a diverse group of African users who commended the AMLA Platform as a brilliant and useful initiative that concretely helps them with their work whether it is in the private or public sector.

Training the Next Generation

To address issues of capacity and skills availability, the Project has also trained 70 young African law students, 36 men and 34 women, from 18 countries. Starting with an intensive, ten-day training, pre-selected students attend sessions on a diverse range of topics impacting the mining sector, from fiscal regimes, licensing and local content to community development, environmental protection and health and safety. Students are introduced to the AMLA platform that is populated with the primary mining codes, regulations and related legislation of all African countries.

Each year the best students from training are invited to join the Legal Research Team responsible for populating and updating the AMLA platform. Each member is assigned the analysis of a minimum of two countries' mining legislation against a common taxonomy of



topics, to encourage comparative analysis, and to give each member the mission to also gather related legislation. You can learn more about current and past members of the Legal Research Team [here](#).

Members rely on each other to answer questions of legislative interpretation and formatting, engaging with one another weekly and often daily via a World Bank Group's Communication platform. A group of experts in the field are also present on the communication platform, to guide the students in their research assignments when needed.

"The objective of this aspect of the Project is to create and highlight a continental cadre of lawyers who are well versed in mining law at the early stages of their career, who have the technological dexterity to utilize the AMLA platform, having fully contributed to its development and who also belong to a cross border legal fellowship that they can rely on for collaborations to provide both national and regional legal services for the mining sector," explained Nneoma Veronica Nwogu, a Senior Counsel at the World Bank who leads the AMLA Project.

The Guiding Template

The Guiding Template is the latest knowledge product launched by the project and, like the Platform, it is available online for free. The Guiding Template, however, substantially differs from the AMLA Platform in its level of depth and complexity as well as in the process through which it was created.

The online tool addresses over 200 commonly addressed topics in a mining law from traditional licensing to the licensing and beneficiation of industrial minerals. It focuses on twice as many topics as those available for legislation comparisons on the AMLA Platform, identifying among those additional topics some that are specifically responsive to African realities.

While developing the Guiding Template, it was determined that a large gap existed as far as research

addressing the industrial minerals, or development minerals sector. To better address this need, the Project and its partners organized what it termed a book sprint-style symposium in October 2016. Contributors came from all disciplines produced research for the development of sections of the Guiding Template, and participated in dialogues on the contents of the tool, including comments on the work of legal drafters who were concurrently drafting sample provisions to reflect agreed outcomes.

"Innovative practices such as this book sprint-style symposium which brought together lawyers, geologists, and other African sectors experts to co-generate a technology-based tool that enhances the responsiveness of the mining legal framework in Africa is the sort of creative solution needed to really improve both the business and governance of Africa's mining sector," Nwogu noted.

Representing the Southern African region, Professor Nelli Mutemeri as well as graduate students Paskalia Neingo and Pontsho Ledwaba from the University of Witwatersrand provided critical perspectives on salt and sand mining in South Africa as well as the geological impact of artisanal and small scale mining throughout the region. The AMLA Project is currently working with the ACP-EU Development Minerals Programme to publish a volume of these presented papers later this year.

The Guiding Template was launched at the 2017 Mining Indaba and received positive feedback from the audience. H.E. Lebohang Thotanyana, Lesotho's Minister of Mines, who is currently leading the review process to revise Lesotho's mining law, said: "I think this is the tool the African Continent has needed for quite some time". The former Commissioner for Trade and Industry with the African Union Commission, H.E. Fatima Haram Acyl, added: "Africa needs tools that respond to and are aligned with the principles of the Africa Mining Vision and aspirations of the Agenda 2063. The African Mining Legislation Atlas is [...] the only one of such tools [...] that responds to the needs



of having comprehensive mineral resources laws and regulatory frameworks.”

Looking to the Future

From the beginning, the Project’s goal has been to identify an Africa-based entity that would take over ownership, ensuring that the AMLA Project’s commitment to the co-generation of knowledge continues to occur grounded in the realities of Africa’s mining sector. At the beginning of 2017, maintenance of the AMLA Platform and coordination of the AMLA Training Program began its transfer to an AMLA Secretariat established within the African Legal Support Facility of the African Development Bank.

Overall, the last three years of work under the Project have shown that there and continue to be many opportunities to maximize the continent’s mineral wealth, provided that an interdisciplinary commitment remains to find innovative, creative ways to increase access to information and continue cultivating cross-continental expertise for this generation and the ones to come.

Want to learn more about the AMLA Project? Please visit www.a-mla.org where you can also check out this brief video about the Project and its plans for the future. Questions or comments about the accuracy of the data? The Project welcomes feedback which can be sent to feedback@a-mla.org.

book review:

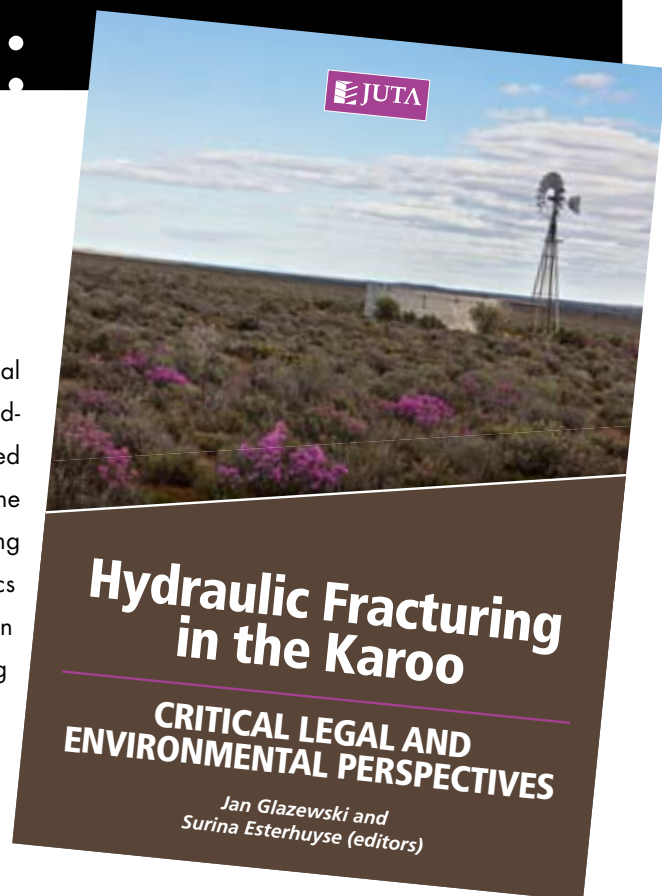
Hydraulic Fracturing in the Karoo.

CRITICAL LEGAL AND ENVIRONMENTAL PERSPECTIVES.

Jan Glazewski and Surina Esterhuyse (editors)

“Hydraulic Fracturing in the Karoo: Critical Legal and Environmental Perspectives” explores a broad-ranging set of questions related to the proposed hydraulic fracturing or ‘fracking’ in the Karoo. The book is multidisciplinary, with contributors including natural scientists, social scientists, and academics from the humanities, all concerned with the ways in which scientific facts and debates about fracking have been framed and given meaning. ”

Hydraulic Fracturing of carbonaceous shale in the Karoo is a sensitive though important topic and the production of this 494 page “heavyweight” book is therefore timely as questions need to be answered which require extensive dialogue and research. Soon after possible fracturing, a sensible term for “fracking” due to negative linguistic connotations, in the Karoo became public due to the possibility of huge reserves of shale-gas in the Karoo Supergroup; a debate ensued between lobbyist for and against it.



Lobbyist’s fears and concerns against gas and oil drilling and shale-gas fracturing were driven by environmental, groundwater, farming and the Karoo, as a “sense of place”, concerns. Public fear and awareness of the possibility of disasters related to gas and oil drilling were also inter-alia driven by international blockbuster


Hollywood movies like *Deepwater Horizon*. This is a fictional drama based on the real life events that started on 20 April 2010 at the BP Deepwater Horizon sea gas and oil drilling rig which lead to the wellhead blowout and the explosion and fire on the rig. This lead to a loss of life of 11 people and 17 injured and the biggest current recorded oil petroleum pollution with huge damage to wildlife, the fishing and tourism industry along the Gulf of Mexico. In addition there are reports of blowouts associated with the formation of craters and subsequent burning of wells that had a huge impact on surrounding environments as well as reports and documentaries from the United States of America of pollution of ground-water as well as enhanced seismic activity. These reports lead to the banning of or strict control of hydraulic fracturing in many countries and some states of the USA. Although strict mitigation steps to prevent such disasters were taken and although there have been great advances in drilling gas and oil exploitation technology to significantly reduce the risk of environmental disasters, the events that caused the Deepwater Horizon Oil Spill during modern times should alarm authorities that human errors due to financial pressures and mechanical failure might still pose a risk.

Hydraulic Fracturing of shale-gas on the other hand might have substantial advantages economically and socially in parts of the Karoo and benefit the country as a whole. Communities living in or adjacent to areas where gas exploitation may occur, might be exposed to new direct job or "spin-off" business opportunities and improved social services like schools, hospitals and service delivery. South Africans might benefit due to reduced costs of fuel, expansion of the electricity grid and more energy available to the industry. In a growing economy there is high pressure to supply energy to industries and to the population as the standard of living improves. With the demands for a growing economy and the need for energy, including clean energy which does not contribute to global warming, pressures are rising to use methane gas as an alternative energy resource, which is perceived

to be relatively cleaner than coal, but according to the authors fugitive methane may potentially be much more effective to increase the effects of global warming. The availability of gas might relate to reduced imports of oil and reduced dependence on coal to generate electricity. Gas is perceived as a possible saviour of the economy and a relatively cleaner source of energy which may be used directly or converted into liquid fuel. The reviewer experienced first-hand the intricacies of gas-and oil drilling and some of the financial and social benefits and also evidence of environmental degeneration during an intensive period of training and work as a well-site geologist in Mozambique in 2007 during the drilling of 11 successful exploration and production wells.

For a while this topic appears to have been placed on the "backburners" in the media in South Africa and some developers apparently lost interest but it is very likely to be strongly pursued again after the High Court in Cape Town's decision to put the Development of Nuclear Energy on hold for now due to perceived illegal procurement processes. For the average person or scientist hydraulic fracturing might at first hand appear straightforward, but to achieve balanced objectivity and scientific integrity on this issue it is well advised that persons of interest should obtain more background information regarding the multitude of multidisciplinary issues at stake. The about-change that may be made when more information becomes available was aptly displayed by the late Professor van Tonder attached to the Institute for Groundwater Studies at the University of the Free State, nicknamed the "U-turn Professor", who changed his point of view regarding the possible pollution of groundwater. The authors dedicated this book to Professor Gerrit van Tonder (1953 to 2014).

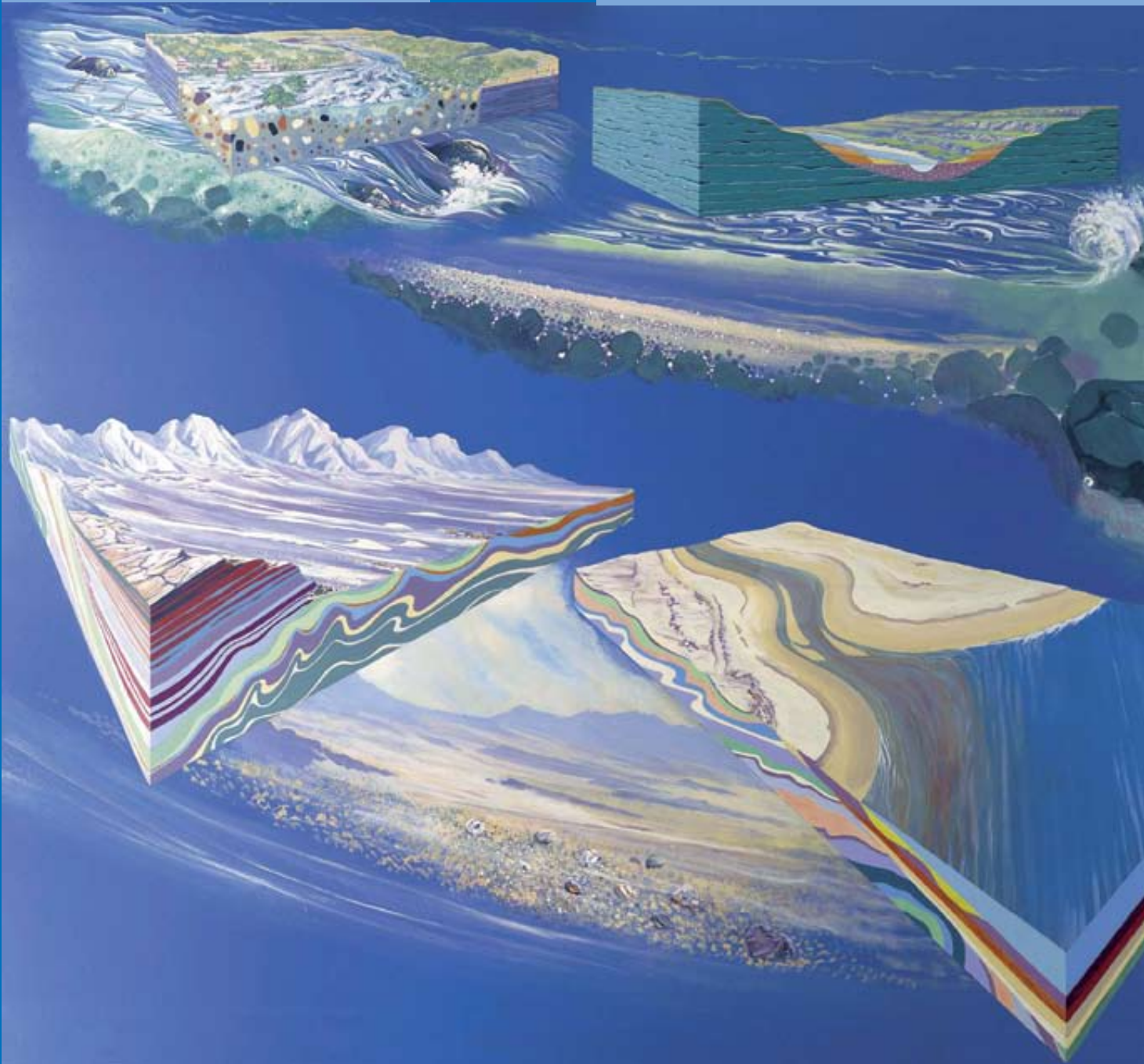
The book thoroughly discusses the various legalities, agreements and statutes at local, provincial, national and international level. It emphasizes the roles of various different Government departments and parastatals and Non-Governmental Organizations and Institutes of research and learning. The need for

Continued on p 30 

Erosion of Kimberlite pipes from

Large rivers cut and erode the pipe.

Diamonds and other heavy mantle minerals are carried by rivers and accumulate in between pebbles and boulders in alluvial gravels.

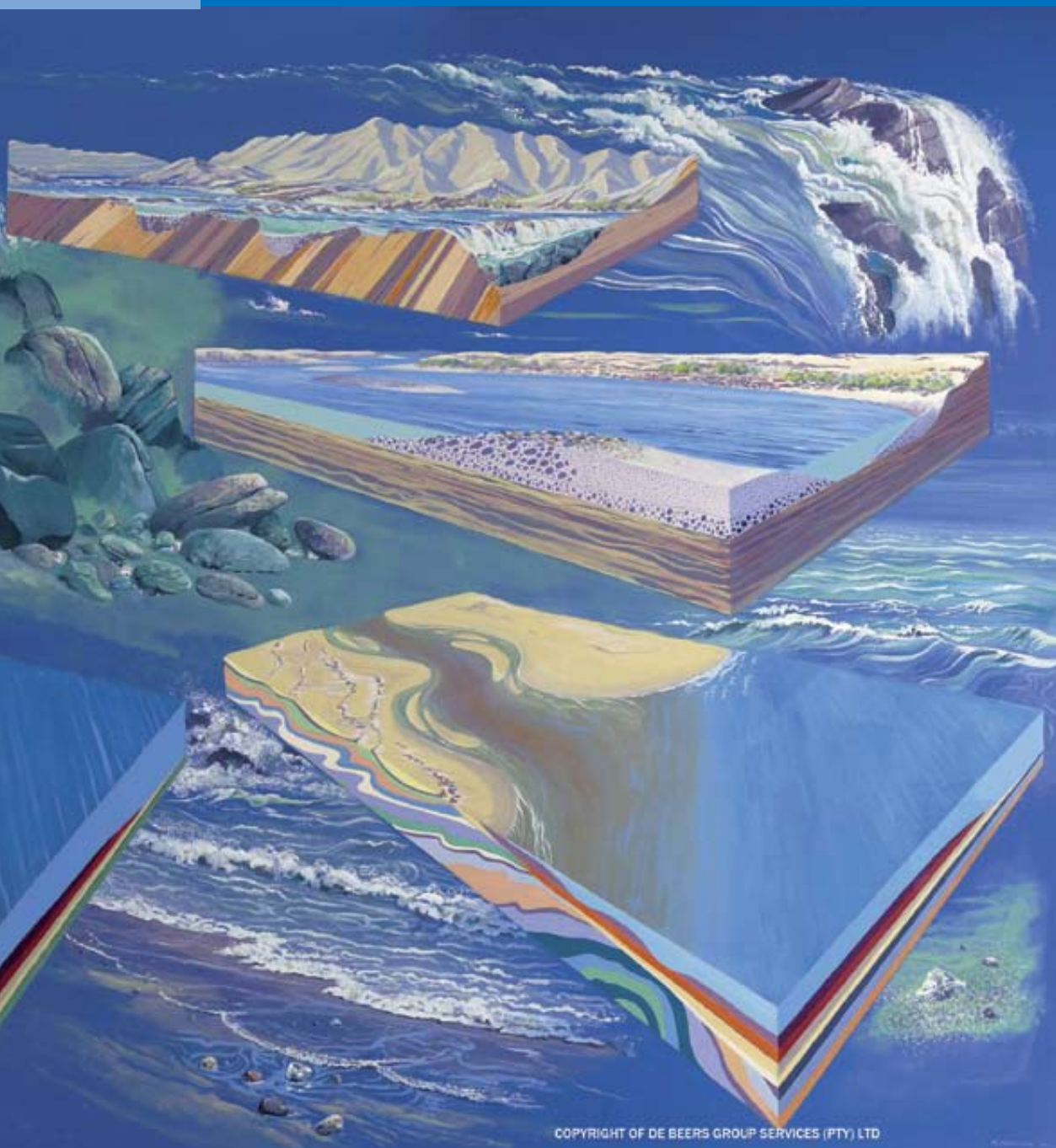


After travelling hundreds to thousands of kilometres in rivers diamonds are deposited as alluvial gravels and produce the onshore and offshore diamondiferous marine deposits of the west coast of South Africa.

Because only diamonds free of imperfections survive this long journey, alluvial and marine diamonds are of high quality.

From 90 million years ago to today

dispersed into
boulders to form



Alluvial gravels become stranded at progressively higher levels as the active river cuts into the landscape. Diamonds are more frequently trapped in coarser gravels.

marine gravels on beaches. Changes in relative sea level changes South Africa and Namibia.

the diamonds are generally of higher quality than diamonds in kimberlite.

inter-departmental collaboration and multidisciplinary work is emphasized while the current possible pitfalls in terms of the weight that each of these department's rules and regulations might carry is discussed. Concerns are expressed that the overlap of disciplines, scope of work and levels of authority at some departments might lead to an unbalanced point of view. The possible effects of changes in society, possible forms of aerial and sub-aerial pollution and disturbances to fauna and flora, some critically endangered to the various biomes of the Karoo are also discussed, while possible mitigating steps are offered to address these issues. Areas and/or disciplines with a lack of research are indicated. This book is therefore a timely publication that introduces the readers to the magnitude of legal, social and environmental issues related to hydraulic fracturing within the context of one book.

The work comprises four parts: Part 1 provides an international, legal, energy, economic, and revenue overview of the topic. Part 2 has a physiogeographic theme, with chapters on the inter-related aspects of water, geology, geo-hydrology, seismicity and biodiversity, as well as archaeological and paleontological considerations. Part 3 focuses on public health, and sociological and humanities-related aspects, and Part 4 addresses the relevant laws, emphasising their implementation and the role of governance. A list of Abbreviations is presented near the front of the book to help the reader with the many abbreviations used throughout the chapters in the book as well as a list of figures, maps and tables which are used to explain discussions in the text. Another deviation from normal books of this format is that the list of bibliography is also near the front of the book to afford easy access to the multitude of publications that was used and referred to and possibly also to draw attention to the importance of a multidisciplinary approach taken in this book. An index of 48 pages at the back of the book facilitates referencing of key words and topics in the book.

PART 1:

Introduction – law, regulation and governance

- Introduction – Jan Glazewski & Surina Esterhuyse
- Experiences from other jurisdictions – Louise du Toit
- The constitutional and legal framework – Jan Glazewski
- Regulating petroleum extraction: the provisions of the Mineral and Petroleum Resources Development Act 28 of 2002 – Lisa Plit
- Environmental assessment of shale gas development in South Africa – Tracy Humby
- The governance of hydraulic fracturing in the Karoo: a local government perspective – Anél du Plessis

PART 2:

Energy, economic and revenue aspects

- The South African energy context - Jeremy Wakeford
- The economics of shale gas fracking in the Karoo: what can the American Experience teach us – Saliem Fakir & Ellen Davies
- Revenue and tax policy considerations – Lee-Ann Steenkamp & Jan Glazewski

PART 3:

Geohydrology, water, biodiversity and archaeology and palaeontology

- Potential impact of unconventional oil and gas extraction on Karoo aquifers – Surina Esterhuyse, Fanie de Lange & Jan Glazewski
- Potential impact of unconventional gas mining on surface water systems of the Karoo – Marinda Avenant, Marie Watson, Surina Esterhuyse & Maitland Seaman
- Water quality, fracking fluids and legal disclosure - Alison Lewis, Luke McMichael & Jan Glazewski
- Hydraulic fracturing, wastewater pumping and seismicity – Andrzej Kijko, Beth Kahle, Ansie Smit, Surina Esterhuyse & Jan Glazewski
- The potential impacts of fracking on biodiversity of the Karoo Basin, South Africa – Simon W. Todd, M. Timm Hoffmann, Joh R. Henschel, Anabelle W. Cardoso, Michael Brooks & Leslie G. Underhill
- The internationally significant Karoo archaeology

and palaeontology record: short-term threats and long-term responsibilities – David Morris, Bruce Rubidge & Jan Glazewski

PART 4:

Public health, sociology and humanities perspectives

- Hydraulic fracturing in shale gas extraction: public health challenges for South Africa – Leslie London & Mieke Willems
- Effects on communities: the social fabric, local livelihoods and the social psyche – Nola Redelinghuys
- What does it mean to require 'evidence-based research' in decision-making on hydraulic fracturing? – Lesley Green
- The scripto-visual rhetoric of 'fracking' in South Africa – Ian-Malcolm Rijdsdijk
- Making legal sense of a 'sense of place' in the Karoo – Loretta Feris
- Planning perspectives: values, ethics and responsibilities – Tania Katzschner.

PART 5:

Conclusion

- Conclusion: looking forward – Jan Glazewski.

This book is a massive achievement considering that it was written and published within a period of two years with contributions from local and international researchers. In general the authors suggest that the principle of careful precaution should be followed and that the process should proceed with the drilling of an exploration well from where further information should be carefully considered. This is especially important in the light of the fact that the presence of economically exploitable shale gas has yet to be proven.

"The underlying theme of Hydraulic Fracturing in the Karoo: Critical Legal and Environmental Perspectives is one of caution. The book emphasises the need for collaboration between the natural and social sciences and the responsibilities of those charged with the implementation and governance of the fracking enterprise if South Africa hopes to effectively manage fracking at all."

Pieter Bosch

obituary

HUGH CLIFFORD DAVID JENNER-CLARKE

8th December 1929 (Sutton, Surrey, UK) – 31st March 2016 (Cape Town, South Africa)

Born as the eldest son of George and Vera Jenner-Clarke, Hugh and his younger brother, also named David, grew up in a home called "Roselea". George was a general dealer who sold groceries and fresh produce from a typical "English corner shop" in High Street, Sutton.

Hugh attended a local Grammar School where he obtained his A-Levels. His BSc degree in geology followed four years of study at the Chelsea Polytechnic, a Division of London University.

Hugh Jenner-Clarke †



Wedding day,
20 February, 1981



His career in geology commenced soon afterwards, with his appointment as junior geologist with Anglo-American Corporation of South Africa, seconded to the Consolidated Diamond Mines of South West Africa (CDM, currently known as NAMDEB) at Oranjemund. At the age of 24 he boarded the RMS Pretoria Castle in Southampton, arriving in Cape Town in September 1954 and proceeding almost immediately to Oranjemund. The contrast between the green fields of his hometown and the SW tip of the Namib Desert, must have astounded him.



Sutton
(Google Earth,
2017)

Oranjemund
(Google Earth,
2017)



It is certainly true to say that most people exposed for the first time - especially during those early days - to this isolated region of South-western Africa with its dramatic desert mountain scenery would depart greatly impressed and awed. The young son of the shopkeeper of Sutton was no exception and it left an indelible impression on his mind.

At CDM Hugh worked under two of the stalwarts of the West Coast diamond industry, viz. Darryl Hallam and the 2-i-c, Dr Charles Stocken.

During October 1954, soon after his initial introduction to CDM's style of diamond exploration at Oranjemund (mostly at the so called G Area), Hugh was attached to a geological mapping programme – the first since before 1914 – covering the barren, very isolated area east and north of Oranjemund up to the Sperrgebiet boundary.

This area included the infamous Obib Dune Field, part of the area that was later on named "The Namib Sand Sea" by geographers. This programme did not last long as the geologist in charge was beginning to show signs of a nervous breakdown, and told Management at Oranjemund: "There are troublesome lions in the area and I'm not going back to work there again!". In later years it became well known that the deep umph-umph! sounds made by a male ostrich patrolling his territory at night, are almost identical to those made by a male lion patrolling his territory.

Unperturbed by the challenges offered by this harsh part of the world, Hugh steadily became more attached to its natural beauty and unique features.

The mapping programme having been shut down, Hugh was spared from enduring endless months of fruitless work and returned to Oranjemund. His duties were to map and record the geology of the prospecting trenches at Kerbehuk and Affenrucken. He remained working on raised beach deposits until March 1956 when he was seconded to an exploration programme for uranium in the southern interior of South West Africa (now Namibia). This programme soon developed into a search for kimberlites, targeting the drainage areas of the Konkiep and southern Fish Rivers. Hugh enjoyed this period immensely; while the work was largely stereotyped and sterile he was in the company of several young and enthusiastic, lively colleagues living a rugged but carefree camp life, so much different from the claustrophobic, rigidly confined and overly regulated Diamond Area No. 1.

However his marine alluvial capabilities were needed at Oranjemund where he returned at the end of June that year. This time he was given charge of prospecting the high level beach deposits at Kerbehuk north of the main (at that time) mining blocks of G-Area, Uubvley and Mittag. Here at least, CDM provided well-made though small transportable living quarters for its field staff. Hugh spent a considerable period of time there, largely in the company of his fondly remembered and

devoted Ovambo personal servant and cook, Festus. Weekends were spent at Oranjemund, providing social stimulus as well as geological discussions and collaborations with colleagues at base. Hugh was reserved and a reluctant party-goer, and so he remained throughout his life.

Having lived and worked in remote areas myself, I know the value of good friendships under trying and challenging conditions. Hugh was blessed with two such friendships that started in those early days in Oranjemund, and continued to support him for the rest of his life. R Baxter-Brown arrived in Oranjemund early in 1956 after graduating from Rhodes University in Grahamstown the previous year. Their friendship was immediate and empathy of personal interests developed. In my mind it was a case of two complete strangers meeting, but both of them true gentlemen and acute earth scientists and the bonding of a lifelong friendship was inevitable. They discussed theories of diamond transportation and concentration and visualised a time when they would be free and able to launch their own diamond exploration ideas. In the comfort of their secure surroundings it all seemed so effortless and geologically obvious, but many years were yet to pass before it would materialize.

More or less the same time Hugh met Cynthia Laubscher, described by Baxter-Brown as "a remarkable outgoing and lively personality, an original thinker and teacher as well as a talented artist". A lifelong platonic friendship developed.

In April 1957 Hugh was transferred to the De Beers Kleinzee Mine at the mouth of the Buffels River, accompanied by a mining engineer, Gary Browne and his wife, both friends of Hugh's. Not long afterwards Baxter was transferred to Lichtenburg to prospect the farm Pypklip for De Beers, Kimberley, and the two thereafter kept in touch with the occasional letter.

At Kleinzee Hugh began to plan his departure from

De Beers in order to seek out a financial "backer" to grubstake his plans to "discover the source of the Kleinzee diamonds in the headwaters of the Buffels River". The Bushmanland plateau was the obvious starting point for testing the theory and Hugh consumed all the then known literature documenting the earlier exploration work done on the plateau, in particular that of Dr E Reuning in the 1920's. Hugh's field research was initially hampered by the ban on diamond exploration on State Land in Namaqualand during 1927 to 1963.

During 1958 Hugh bade the town of Kleinzee and De Beers goodbye and paid a brief visit to his family in England. Returning to Namaqualand he based himself in Springbok and soon thereafter met the remarkable Gertjie Niemoller of Pofadder, a multi-millionaire sillimanite miner and very successful farmer. Hugh convinced Gertjie of the merits of kimberlite exploration in the Bushmanland and a deal was struck that gave Hugh a minimal budget, sufficient for obtaining option agreements from farm owners (in those days, the property owner still had the first right to apply for an exploration/mining authorisation on his property, which right became the basis of an agreement with the mining companies). The agreement with Gertjie Niemoller also provided Hugh with the funds to run a small exploration team.

With the aid of aerial photographs and meticulous field mapping, Hugh soon recognised upwards of 200 meta-kimberlite pipes in the Bushmanland. Those were the days before Clifford's Rule and the seminal work done on kimberlite mineralogy by John Gurney and others, and a flurry of excitement filled the Bushmanland air. The mining companies did not want to be left behind, and the "Bushmanland kimberlite" race was on. Alwyn Cornelissen (Newmont's O'okiep Copper Company), Roderick Baker and others (De Beers) and Keith Whitelock (Rand Mines) were the main players. The confidence in the Bushmanland Project combined with the enthusiasm of Hugh Jenner-Clarke and Niemoller, paved the way for the recruitment of Baxter-Brown to the project. Baxter had



then just completed the prospecting of Pypklip and its proclamation as an Alluvial Diggings for the benefit of the local digger community, and resigned from De Beers with the intention of further studies at Imperial College in London. Before leaving South Africa he agreed to join Hugh and Niemoller on his return from London.

Baxter returned via an unconventional route that took him through Egypt, the Red Sea, overland from Mombasa to Kitwe, then Salisbury and home in the Eastern Cape. In the meantime Hugh had been frantically trying in vain to reach him to say that he should not return here, since it has been shown that the two "diamonds" found in one of the Bushmanland pipes turned out to be highly resorbed crystals of clear, brilliant yellow zircon.

Hugh then continued his Bushmanland work on a reduced scale and Baxter was given the task of exploring the lower Sout River north of Vanrhynsdorp. Diamonds of excellent quality were found, but small and after a while Niemoller quit diamond exploration.

Soon thereafter Hugh and Baxter decided to become diamond consultants with emphasis on alluvial exploration. Thus the company Asam Minerals was born, headquartered in Springbok. Building a client base was a slow and difficult process but consultancies took them to many exploration sites in Namaqualand, the Kimberley region, the Middle Orange (where they found the first diamonds on Niewejaarskraal between the historical diggings of Saxendrift and the town of Prieska), Botswana and even as far afield as Brazil.

*At daughter's 21st,
Jan 2004*



While writing this obituary, I was lying awake early one morning. Suddenly I was in another place, at another time. I saw nothing, but I heard Hugh saying: "Having ignored You for most of my life, it dawned upon me that it was futile living without You, but I dare not die without You. I have nothing to offer, I can only plead for mercy" and a quiet, authoritative voice replied: "Mercy is what My plan of Salvation is built upon. Because I knew that no one will ever be able to earn it, I made it a gift of unmerited favour. In the parable of the servants hired at different times of the day I made it clear that it does not matter at what time of the day you accept My Gift, as long as you do it before the end of your day".

Shalom Hugh, we'll meet again!

Assie Van der Westhuizen

Bethuel Solomon 'Ray' Molaka

19 February 1959 – 5 November 2016

It is with great sadness that we report the death of Bethuel Solomon 'Ray' Maloka. Ray passed away after a short illness, at hospital, with his wife by his side. He was 57 years old.

Bethuel Solomon 'Ray' Molaka †

Ray was a member of the GSSA for 25 years and was a Fellow of the GSSA. He passed away while still a member in service of the GSSA Council.

Ray has also worked at various positions at SACNASP, including most recently he was the Chairperson of the Professional Advisory Committee for Geological



Science. He also sat on the SACNASP Council from 2009 to 2015. The majority of Geological and Earth Science members of SACNASP approved members across South Africa over the last decade would have been scrutinised, assessed and many approved directly by Ray. Ray was registered with SACNASP for the last 20 years.

Matriculating from Herman Thebe High School near Swartruggens, North West, Ray went on to work as a vacation student with Anglocoal Arnot and Landau collieries. He took up his first permanent position, at New Denmark Colliery still with Anglocoal in 1988. This was a year after completing his undergraduate degree at the University of Zululand. In 1992 he returned to the same university to complete his Honours in Geohydrology and soon thereafter took up a post in 1993 with WLP (Watermeyer, Legge, Piesold and Uhlman). This was a company involved in Consulting Engineering.

He completed a Postgraduate Diploma in Mineral Resources at the University of the Free State. In the geoscience arena Ray has worked with various

commodities, as well as production and exploration operations. He positioned himself in challenging positions at a time when the industry was under pressure and he has seen the good times and tough times so well known in the South African mining sector. He was an exploration geologist for Anglovaal in 1995, where he worked at the Target Exploration Project, today the Target Mine, in Allandridge Free State. He also worked for Matla Coal, and reached the position of Chief Geologist, and later as Resource Manager at Eyesizwe. Ray worked for Eskom, the DMR, the Atomic Energy Corporation and the state mining company at various stages of his career. He was versatile and it showed in the assignments he was entrusted with.

Ray valued lifelong learning and many people identify him by his firmness and fairness. His legacy is not just the quality of his contribution to the companies he worked for, the geologists he has mentored who today work in South Africa and around the world, but he was also the standard for ongoing professionalism of the geoscience profession in South Africa. Ray will be missed by his colleagues that he has worked with over the many mines and exploration projects across South Africa.

He will also be sadly missed by the GSSA where he made a significant contribution over the years. At SACNASP he will be remembered for his contributing role to the science profession and the attention to detail as he monitored and enhanced professional standards over the years.

Our thoughts are with his wife, Prisiella, and his two children, Tumelo and Refilwe. Ray is also survived by his mother Rachel Maloka and two sisters Shila and Dora.

Neale Baartjes & Tumelo Maloka

mineral scene

Erythrite from Kruisrivier cobalt mine, Bushveld Complex, South Africa

Bruce Cairncross¹ and Maria Atanasova²

¹Department of Geology, University of Johannesburg

²Council for Geoscience, Pretoria

The Kruisrivier cobalt mine is situated in the Groblersdal district north of Loskop Dam, approximately 180 km northeast of Johannesburg and has been known for over 100 years (Beck, 1907; Mellor, 1907). Although a few, small cobalt deposits exist in South Africa, Kruisrivier was the only one to be commercially exploited, albeit some time ago. The mine was operated in the early 1870s although this was sporadic and ceased in 1931 (Reeks, 1996). Hammerbeck (1976) further states that in the early mining days (1886) 143 tons of hand-cobbed

ore averaging 15.34% cobalt and 68 grams per ton gold was exported from Kruisrivier.

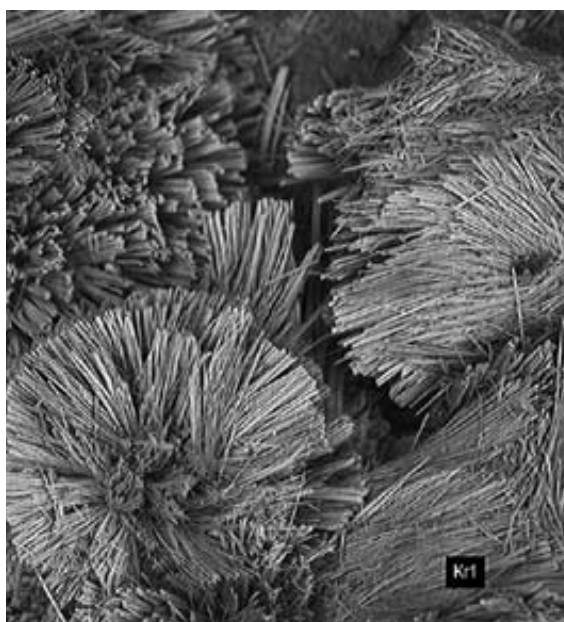
From a geological standpoint, the host rocks to the cobalt mineralization occur in the Upper Zone of the Rustenburg Layered Suite. Early workers described the country rock variably as felsite, norite, quartz-feldspathic sandstone and gabbro, and the geographic closeness of the Rooiberg Group felsite and Pretoria Group quartzite might explain this confusion. The mineralisation consists of thin veins containing ore minerals that run parallel to the contact between norite and quartzite (Hammerbeck, 1976).

From a mineralogical standpoint, primary sulphides and secondary mineral phases exist at Kruisrivier, most as microminerals (Atanasova et al., 2016). The main cobalt-bearing minerals are cobaltite, heterogenite, safflorite, skutterudite and erythrite. It is the latter species that is the feature of this Mineral Scene. Specimens of

A cluster of stellate erythrite crystals on matrix, Kruisrivier cobalt mine. The field of view is 10 mm. Bruce Cairncross collection and photograph.



erythrite can still be collected from the old mine dumps today and although they are mainly small specimens, they are nonetheless spectacularly photogenic. Where prismatic habits are found, and these are rare, they occur as flattened monoclinic prismatic crystals either aligned in parallel rows or radiating out as stellate groups several centimetres in diameter. However, it is the radiating “puff balls” of erythrite that form the most attractive specimens. These occur as either isolated aggregates on the matrix or can be clustered together into groups. The three dimensionality of the Kruisrivier erythrite combined with the very attractive bright pink colour, produce one of the most iconic South African microminerals.



SEM image of Kruisrivier erythrite. Bar scale is 20 microns. Maria Atanasova image.

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Erythrite crystals from Kruisrivier. Wolf Windsich specimen and photograph. The field of view is 3.10 mm.

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excursion:

One Day Pre IGC Excursion to the Central Witwatersrand

Excursion, Leader Morris Viljoen assisted by Alison Blackhurst

The discovery of gold on the Witwatersrand had an enormous influence on South African history, leading in part to the Anglo Boer War and the emergence of the city of Johannesburg from a mining camp to the major economic hub of the African continent. The excursion was aimed at providing an holistic overview of the geological origins, history, mining, entrepreneurs, labour and environmental issues of the world's greatest goldfield. The following is a brief description of some sights visited as well as information presented.

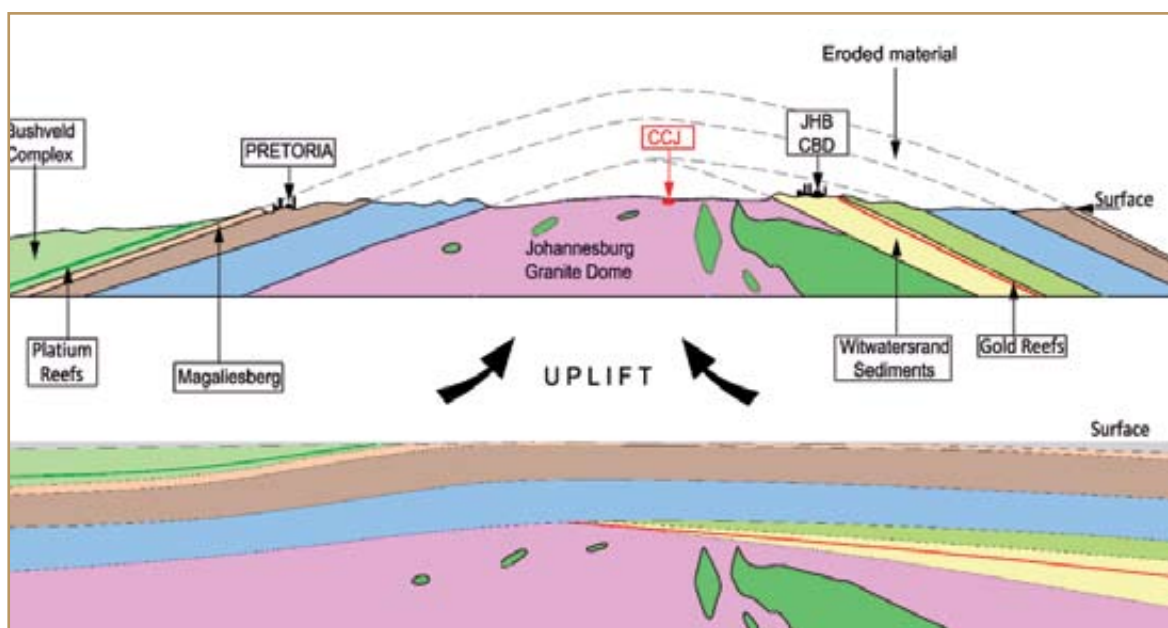
With the aid of a colour coded digital terrain image together with a simplified geological map and cross section, the setting of the unique Witwatersrand plateau correlating with the outcrop of the resistant strata of the northern part of Witwatersrand basin, was explained.



Herbert Baker mansion, Northward



Colour coded digital terrain image



Simplified geological map and cross section





Contorted bed

This took place from the northern scarp edge of the plateau formed by the Orange Grove quartzite at the classical Herbert Baker mansion, Northward, built in 1904 as a residence for Randlord John Dale Lace and his flamboyant wife Jose. A brief history of Northward and the Dale Lace family was given by the curator of the house, Neil Viljoen.

A stop was made on the Contorted Bed banded iron formation with its folded layers of white chert red jasper

and dark grey iron oxide, the magnetic nature of which is always impressive when demonstrated by means of a swing magnet. The Contorted bed and other magnetite layers played a key role in tracing the Witwatersrand strata below younger cover rocks to the southwest, leading to the discovery of the west Wits Goldfield. The resistant contorted bed forms a sub continental watershed in the area, between the Indian and Atlantic Ocean drainages.





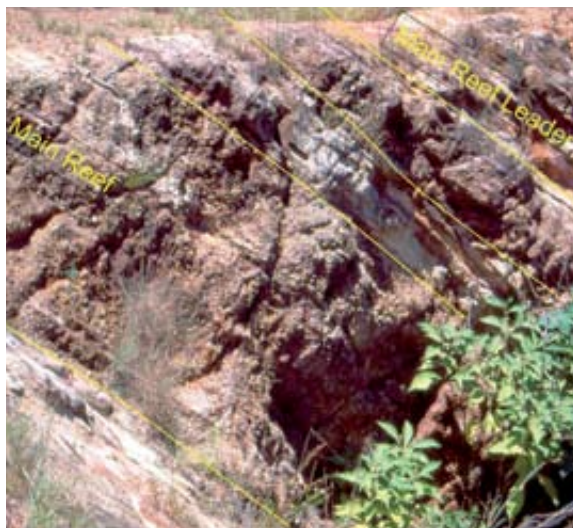
After viewing a number of classical historical buildings in downtown Johannesburg such as Consolidated Building of J.C.1, the old Standard Bank Building and the Rand Club, the excursion headed for the new Standard Bank centre at 5 Simmonds Street. Here in a basement museum the original Ferreira stope on the Main Reef Leader was viewed together with brown oxidised pyritic layers and stringers of the underlying Main Reef.

A well-known landmark south of Johannesburg was the old Park Central tailings dump and the Top Star drive-in cinema that existed on the top. The iconic sand dump, one of the oldest in Johannesburg, ran at 0.75g/t gold and although there was strong resistance, the dump was finally reprocessed, leaving behind a footprint on which paddocks were developed to retain Acid Mine Drainage runoff. From the top of the preserved east flank of the dump, the story of



Mondeor conglomerates





earliest Johannesburg's mining history as it unfolded on mines such as Ferreira and Robinson Deep was told. In addition, the environmental impacts of mining, particularly those of Acid Mine Drainage and dust pollution, were also recounted.

Another stop was made on the well exposed large-pebble Mondeor conglomerates forming the Southern extent of the Witwatersrand plateau to the south of Moffat Park. A superb view to the south is obtained across the valley along which the N12 (Southern Bypass) runs. South of this is the Klipriviersberg range formed

of Ventersdorp lava which overlies the Witwatersrand strata. At the base of the Klipriviersberg range is the red roof of the historical Victorian / Wilhelmien style mansion (Klipriviersberg) that belonged to Johannes Petrus Meyer (after whom Johannesburg and Meyerton were named) and built in 1893. Unfortunately at this stop, one of the participants lost his footing on the loose rounded quartz pebbles weathered out of the Mondeor conglomerate, fell and cut his head badly on the hard quartzite. This led to quite a drama and delayed the excursion.

A stop was also made at George Harrison Park, discovery site of the Main Reef and Main Reef Leader and now overrun by a large Zama Zama (illegal miner) operation. After receiving assurances from the bossman (the only person with a hard hat) that his miners would not interfere with our overseas guests and that we were only interested in the geology and not in their activities, we proceeded to examine the historic exposure. We watched the Zama day shift emerge from the decline and the night shift preparing to go underground. They put on what appeared to be white baby's nappies made of a hard plastic material and then proceeded to slide down the smooth concrete decline on their behinds at high speed into the dark with only with a lamp attached, to a cloth on their heads. Excursion participants watched the whole operation in wide eyed amazement if not amusement as I told them that this is how we mine gold on the Witwatersrand today.

At the congress opening reception I met up with the delegate who had cut his head and although with a number of stitches in he had recovered fully and was in high spirits.

The multi faceted nature of the excursion proved to be so successful that we are currently investigating the feasibility of establishing a similar style of excursion as a general tourist offering.

Morris Viljoen

media monitor

Mining and Exploration News

Gold

Copper

Ivanhoe Mines has intersected a relatively shallow, westerly extension of the Kakula copper discovery at the Kamoa-Kakula project in the DRC. The step-out borehole, located 3.8 km west of the current limit of Kakula drilling and 5.4 km from the boundary of Kakula's current Inferred Resources, was sited at the intersection of the axis of the interpreted Kakula trend with a SW-NE -trending antiform, and intercepted 16.3 m of 'visually moderate-strong' chalcocite mineralisation similar to that found in the core of the Kakula deposit, beginning at 410 m below surface. The discovery essentially doubles the potential strike length of the Kakula mineralisation to more than 10 km.

Acacia Mining announced a maiden NI 43-101-compliant Inferred Mineral Resource of 1.31 million ounces at 12.1 g/t for the Acacia prospect at its West Kenya Project. The mineralisation is associated with shear zones ranging in width from 0.5 m to 10 m hosted by a mafic volcanic sequence. The strike lengths of the explored sections of the main mineralised zones vary between 200 m and 600 m, and the resource is currently defined to a vertical depth of 750 m with the structures open down-plunge. There is additional known mineralisation at the Bushiangala prospect, 1 km to the west, with a further three prospective lodes in early-stage testing. Acacia plans to spend US\$12 million on exploration on the West Kenya project in 2017, the majority of which will be for 45 000 m of drilling, targeting a resource increase to over 2 million ounces in the second half of 2017. A scoping study on a potential underground operation is scheduled to begin towards the end of the year.

Diamonds

Botswana Diamonds completed the first phase of drilling at its flagship Vutomi project at Frischgewaagt, 280 km north of Johannesburg. 34 percussion and 9 diamond drill holes were completed along a 1.5 km strike length on the 6 km kimberlite dyke system. From petrographic analysis of the samples, the dyke has been classified as a Group 2 olivine phlogopite-rich magmatic kimberlite with blows of volcanoclastic kimberlite. The drilling programme recovered high-interest olivines along with G10 and G9 garnets, which are important diamond indicators. Samples have been submitted for microdiamond analysis, and results are expected within two months. Frischgewaagt is east of, and on strike with, the former Marsfontein Mine operated by De Beers and SouthernEra in the late 1990s, where the economics allowed the entire capital cost to be recouped in under four days.

Newmont Mining plans to build a new underground mine at its Ahafo operations in Ghana and expand plant capacity by more than 50%. The Subika underground mine is expected to produce 1.8 million gold ounces over an 11-year mine life, with ore grades of 4.7 g/t supporting production through at least 2029. The project will add between 200 000 and 300 000 ounces per annum to Ahafo's production, increasing the total average annual production to between 550 000 and 650 000 ounces.

Australian company OreCorp completed a positive prefeasibility study for the Nyanzaga gold project in Tanzania. The project is expected to deliver an average gold production of 213 000 ounces per annum over a



12-year mine life, totalling approximately 2.56 million ounces, from concurrent open pit and underground operations, at an all-in cost of US\$858 per ounce. Pre-production capital costs are estimated at US\$287 million.

Australian-listed Stonewall Resources completed a scoping study of the Rietfontein and Beta projects, situated in the historical Pilgrims Rest goldfield in South Africa's Mpumalanga Province. The study indicates that, based on a staged development whereby the capital cost of Beta will be funded through cash flow from Rietfontein, the combined projects could produce up to 100 000 ounces per annum over 7½ years of full production, for a total capital cost of US\$64.9 million and operating costs of US\$495 per ounce. The ore would be processed at the existing TGME carbon-in-leach plant at Pilgrims Rest (owned by Stonewall) following an upgrade and refurbishment.

Mineral Sands

Savannah Resources has defined an Inferred JORC Mineral Resource estimate of 900 Mt at 4.1% total heavy minerals (THM) at its Ravene deposit, situated approximately 40 km south of Inhambane in Mozambique. The Ravene resource includes a high-grade portion of 92 Mt at 6.2% THM, which will be a primary focus in the scoping study currently being conducted. Ravene forms part of the Mutamba Mineral Sands Project, being developed by Savannah and Rio Tinto, where the global mineral resource estimate (combined Jangamo, Dongane, and Ravene deposits) now stands at 4.4 Gt at 3.9% THM, comprising both Indicated and Inferred category materials.

Platinum Group Elements

Northam Platinum has agreed to purchase the Eland Platinum mine, on the southeastern limit of the western limb of the Bushveld Complex, from Glencore for R175 million in cash. The assets consist of two mining rights with a resource estimated at 21.3 million 4E ounces at an average in-situ grade of 4.4 g/t, two

decline systems, a 250 kt/month concentrator, and a chrome spiral recovery plant. The mine was placed on care and maintenance in September 2015. The proposed transaction includes the takeover of Eland's environmental obligations and responsibilities, and is supplemented by an exclusive chrome marketing agreement with Glencore International to market and sell chromite produced at Northam's PGM operations.

Zinc

Canadian company Trevali Mining Corporation has entered into definitive agreements with Glencore to acquire an 80% interest in the Rosh Pinah mine in Namibia (including an effective 39% of the nearby Gergarub exploration project), and a 90% interest in the Perkoa mine in Burkina Faso for approximately US\$400 million in cash and shares. The deal will more than double Trevali's zinc production to approximately 410 million pounds per annum, and position the Company among the top ten global zinc producers. Glencore, which has a long-standing strategic relationship with Trevali, will become a cornerstone investor with a 25% stake in the company. Trevali currently has two commercially producing zinc-lead-silver operations – the Santander mine in Peru and the Caribou mine in the Bathurst mining camp of northern New Brunswick.

Orion Gold completed its acquisition of a 73% interest in the historical Prieska zinc-copper mine in South Africa's Northern Cape Province, as well as the nearby Marydale gold-copper project. Prieska is regarded as one of the world's 30 largest volcanogenic massive sulphide base metal deposits, based on historical production of 0.43 Mt of copper and 1 Mt of zinc from 46.8 Mt of sulphide ore, and extensive drilling and geophysical work has confirmed the potential for unmined dip and strike extensions to the mineralisation. Orion expects to complete a maiden mineral resource estimate for the open pit target in the June quarter. The company is also planning a major drilling programme from surface to test the depth extensions to the mineralisation that was mined historically.

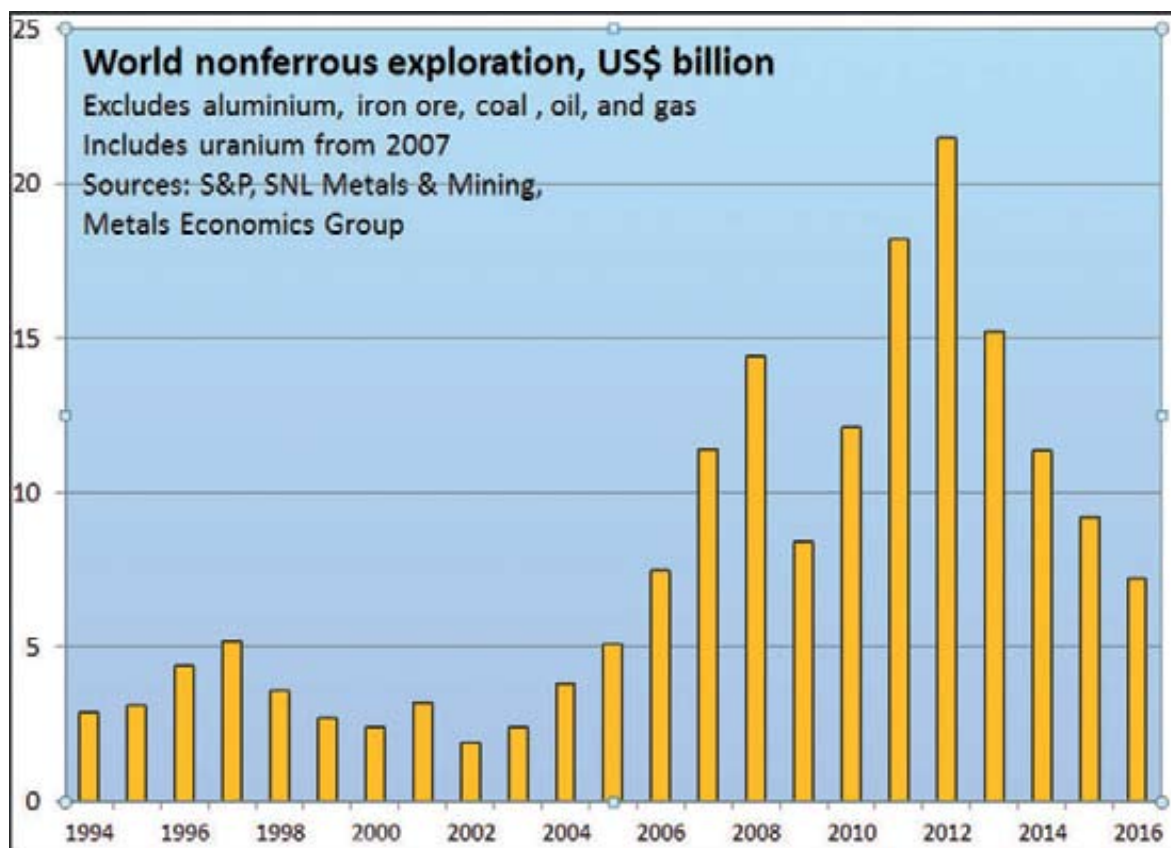
EXPLORATION TRENDS

2016 marked the fourth consecutive year of declining exploration spending, with budgets slashed to barely one-third of the record high of US\$21.5 billion allocated in 2012, according to the S&P (formerly SNL Metals & Mining) report on Worldwide Mining Exploration Trends for the 2017 PDAC International Convention. Total expenditure on nonferrous exploration is estimated at US\$7.2 billion, \$2 billion less than in 2015. Junior companies accounted for 39% of the decrease, and majors for 36%, with intermediate and government/other companies accounting for the remainder. Although all geographical regions had lower allocations, Latin America remained the most popular exploration destination, with 28% of the global total, followed by North America (21%) and Australasia and Africa (13% each). Gold was still the top-explored commodity, accounting for 48% of the total spending (up 3%), although declining in dollar terms to US\$3.30 billion, the lowest level since 2006. Base metals were second, at US\$2.21 billion. Diamond and uranium exploration each accounted for 4%, and

platinum group elements only 1%, with 'other' targets at 12% of the total. S&P expects corporate exploration budgets to show little change in 2017.

OTHER GEOSCIENCE NEWS

A study by geoscientists from the GEOMAR Helmholtz Centre of Ocean Research Kiel and Canadian research institutes has revealed a new mechanism for the genesis of the gold and uranium mineralisation in the Carbon Leader Reef of the Witwatersrand Basin. The study, which was published in the May issue of Precambrian Research. [DOI: 10.1016/j.precamres.2017.03.007], indicates that crude oil and hydrothermal fluids played a major role. High-resolution scanning- and transmission-electron microscopy of pyrobitumen-hosted uraninite showed that the uraninite grains are highly porous aggregates of nanocrystals, with native gold filling many of the pores. The gold grains, in turn, contain small pores occupied by former oil droplets that were converted to pyrobitumen during burial and metamorphism. The pyrobitumen contains in-situ-formed uraninite nanocrystals. The proposed mineralization



Exploration trends
1994-2016



model involves the interaction of uranium-bearing hydrocarbon liquids and auriferous hydrothermal fluids to form micro-emulsions. Uraninite nanocrystals precipitated from the hydrocarbon liquids and flocculated to form porous uraninite aggregates. Gold precipitated as native metal around the oil droplets owing to a reduction in oxygen fugacity, which destabilised the bisulphide species. Commonly, this process occurred together with the flocculation of the uraninite nanocrystals, trapping the native gold in the pores of the uraninite aggregates. The hydrocarbon liquid that occurred as droplets in the gold was transformed to pyrobitumen, resulting in the formation of a thin pyrobitumen seam containing uraninite nanocrystals along the inner walls of the pores in the native gold.

Australian paleontologists have published the first detailed description of what is probably the world's most extensive and diverse collection of dinosaur footprints. The findings were reported in the *Journal of Vertebrate Paleontology* [DOI: 10.1080/02724634.2016.1269539]. The track, which are found at multiple sites spread over more than 200 km of coastline along the Dampier Peninsula in Western Australia, represent at least 11 and possibly up to 21 distinct species, including five different types of theropod (bipedal carnivore) tracks, at least six types of sauropod (herbivorous quadrupeds) four types of ornithopod (bipedal herbivores), and six types of thyreophora (armoured dinosaurs). The tracks appear to have been left during intervals between periodic sheet floods on a large, tidally influenced delta during the Early Cretaceous. The investigation

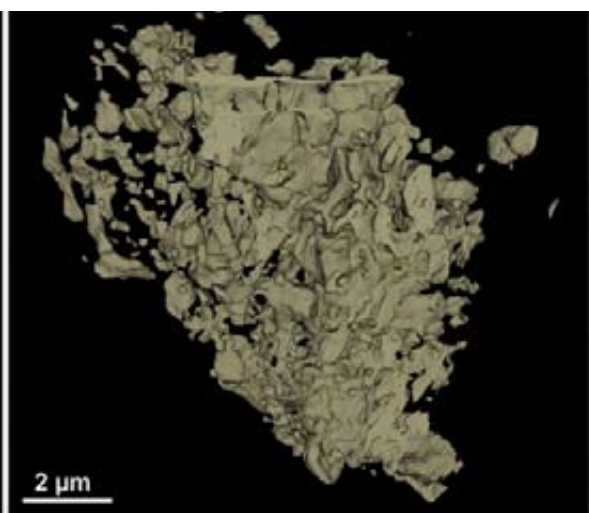
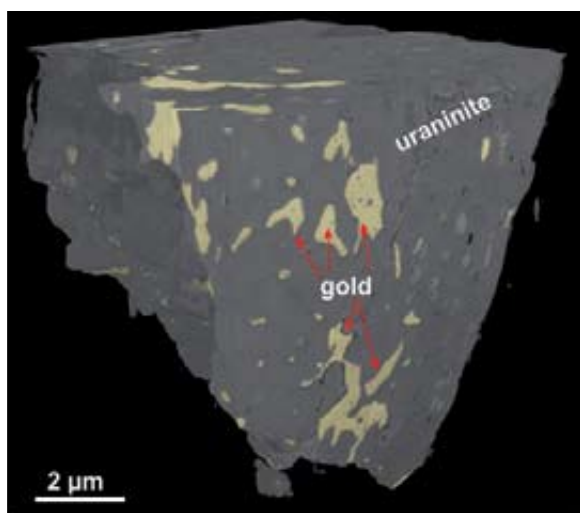
was carried out at the request of the area's traditional custodians, the Goolarabooloo people, after the region was selected as the site for a liquefied natural gas processing precinct. The tracks form an important part of the cultural heritage of the indigenous people of the Dampier Peninsula, who relate them to the 'Dreamtime', when the land was inhabited by supernatural ancestral figures who created and named sacred sites and other features, as well the animals, plants, and peoples.

A sauropod footprint below, 1.7 m in length, indicating an animal around 5.3–5.5 m high at the hip (photograph: Damian Kelly/University/University of Queensland/EPA).

Antony Cowey



CLR mineralisation. The left micrograph shows a uraninite grain containing gold. In the right image, the uraninite has been removed digitally, illustrating the large amount of gold occluded by the uraninite (photographs: Sebastian Fuchs, GEOMAR).



*Mount Elgon,
Uganda &
Kenya*



THE GEOTRAVELLER

By Roger Scoon

GEOLOGY OF MOUNT ELGON, UGANDA AND KENYA:

A Giant Pre-rift Volcano



The saddle leading to Wagagai Peak (4.321 m) on the Ugandan side of Mount Elgon separates the caldera (left), from the outer slopes (right).

The free-standing Mount Elgon Volcano is located north of Lake Victoria and cuts across the international boundary between Uganda and Kenya. The dome-shaped profile with a gentle slope of only 4° is typical of a deeply eroded shield volcano. Mount Elgon is the only example of the pre-rift volcanism associated with the Gregory Rift, the eastern branch of the East African Rift System (EARS), which has a sufficiently large cone to justify being protected in a park or reserve. Two national parks are recognised, one in Uganda, which this contribution is largely based on, and one in Kenya. The parks offer extensive treks, with three or four days required to reach the summit plateau. An unusual feature

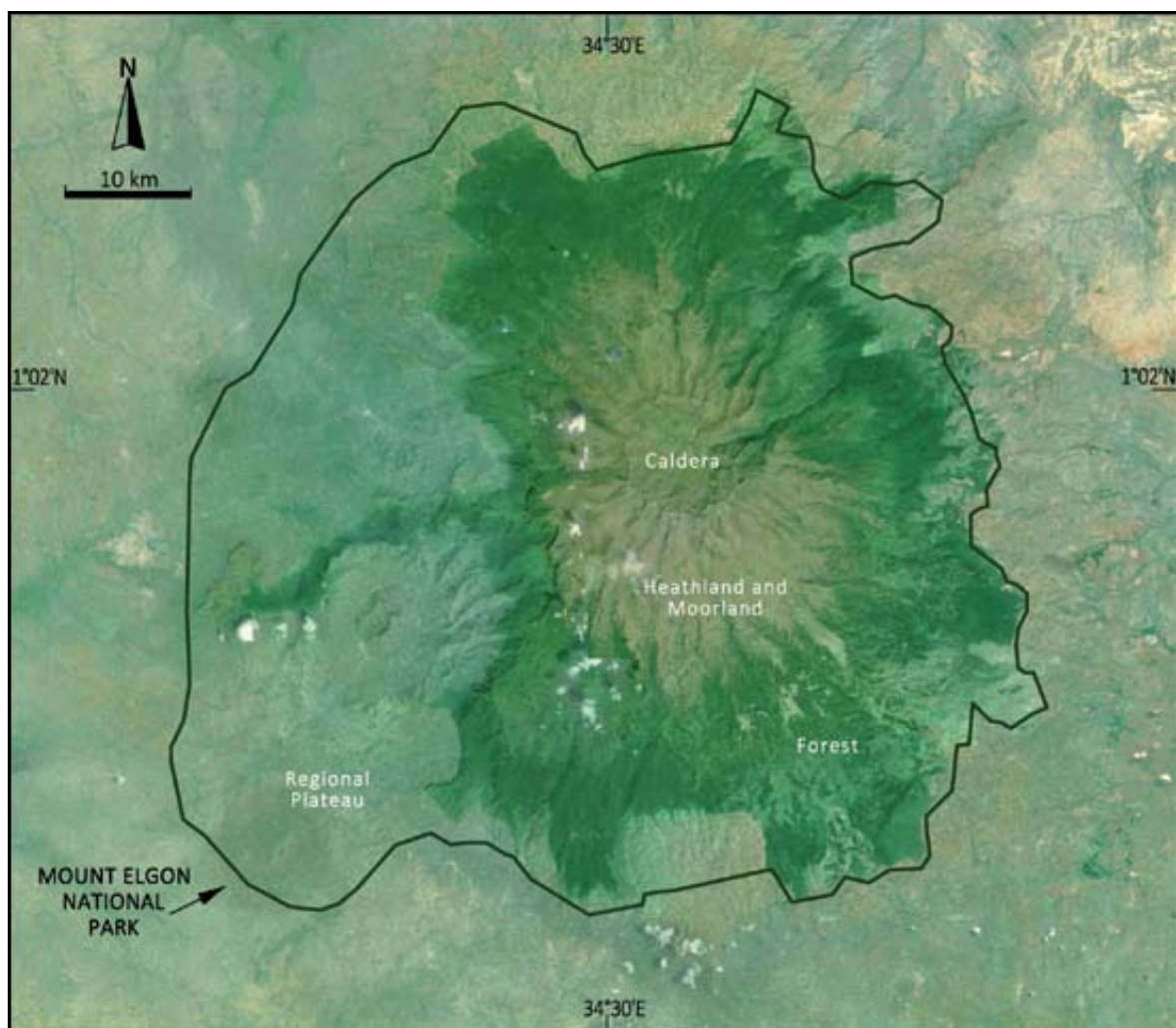
of the mountain is the occurrence of several large caves which are regularly visited by large mammals, including elephant to access the mineral salts.

Areas around the base of the mountain are densely populated with rural communities farming the nutrient-rich volcanic soils. Mount Elgon is deeply weathered and severe landslides are a major hazard on some of the lower slopes.

With a diameter of 80 km, surface area of over 3.000 km² and rising almost 3.000 m above the regional plateau, Elgon is one of the largest volcanic centres in East Africa.



Google-Earth image of Mount Elgon reveals the extensiveness of the montane forests (dark green) and the central depression (probably a caldera) in the summit plateau.



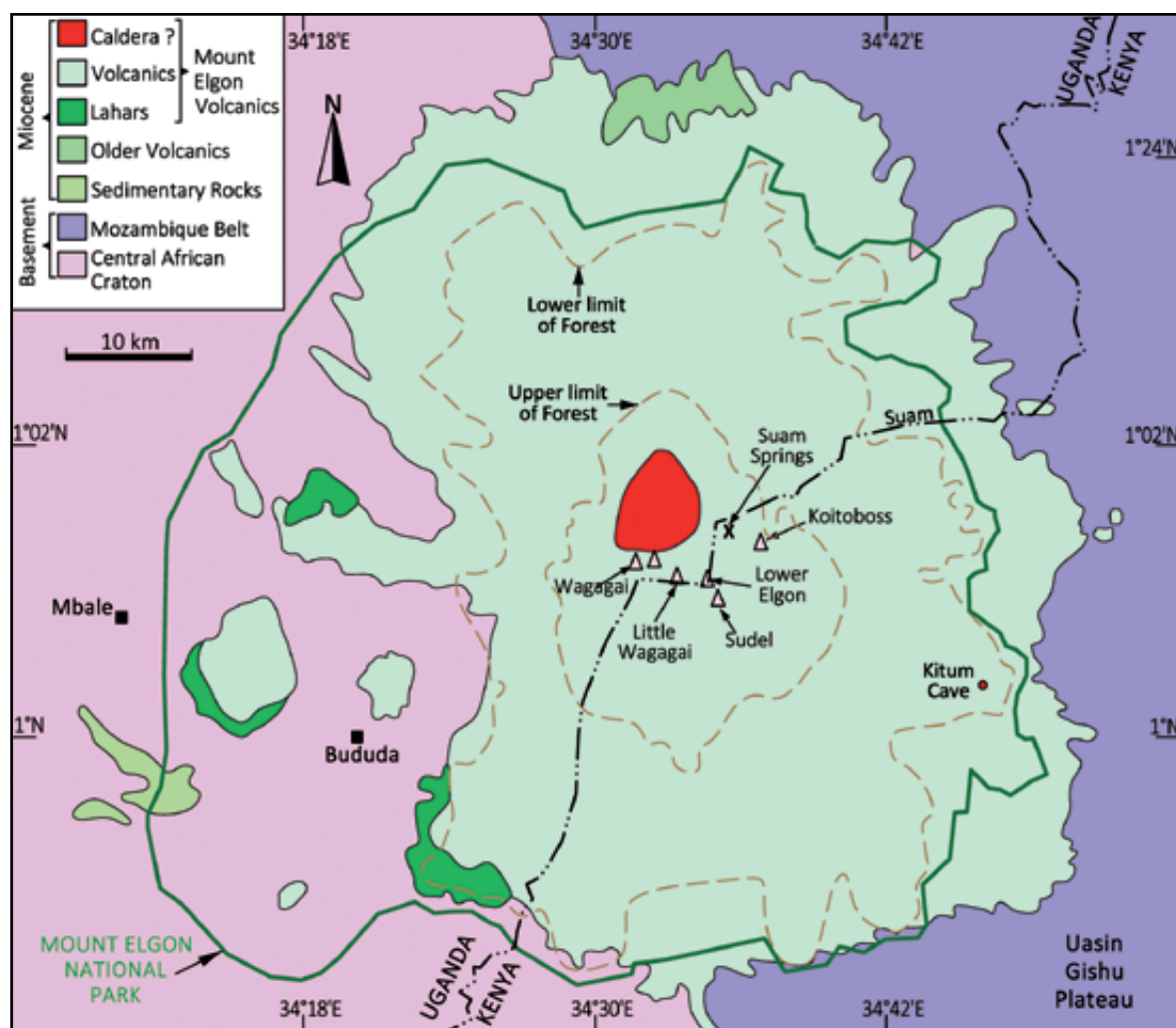
The highest peak of Wagagai (4.321 m) is situated on the rim of a partially-collapsed caldera, part of an extensive summit plateau. The mountain is an important water resource for the region. The Suam River drains northward into Lake Turkana whilst the Nzoia and Lwakhakha Rivers flow southward into Lake Victoria. The central slopes of the mountain are thickly forested with the upper slopes reporting extensive heath and moorlands. The Elgon National Park in Uganda is generally approached from the regional town of Mbale. The 3-4 day hike to the Wagagai Peak via the Budaderi gate provides an opportunity to examine the various botanical zones as well as some important cliff sections and outcrops on the summit plateau. The trek along the Suam Gorge on the Kenyan side reveals some spectacular scenery.

The volcanism is related to the pre-rift stage of the EARS which included the initial development of the Kenya-Tanzanian Dome. Doming and volcanism related to a deep-seated magma plume spread southward from the Ethiopian segment of the EARS at approximately 30 Ma. The location of Elgon is significant because as rifting developed to the half-graben and full graben stages, volcanism in the Gregory Rift shifted both southward and eastward.

An unusual feature of the Elgon Volcano is that it is built directly upon Basement terranes, as determined by the earliest mapping (Davies, 1952). In comparison, most volcanic cones associated with the Gregory Rift are constructed on earlier generations of rift-related volcanics. The western sector of Elgon overlies granite-gneiss of the Central African Craton, part of a more-or-less contiguous Archaean terrane between western Kenya and the



Mount Elgon is located to the west of the Gregory Rift and with an Early Miocene age, is one of the oldest volcanoes



Geological map of Mount Elgon simplified from various sources including Woolley (2001). The Miocene age volcano, an example of the pre-Rift volcanism associated with the EARS, is located on the eastern edge of the Central African Craton.

Albertine Rift in western Uganda. The eastern sector is located on the metasediments of the Mozambique Belt (Neoproterozoic). Magma may have been fed through a central conduit that exploited a structural weakness on the edge of the craton.

The region around Mount Elgon includes a number of pre-Elgon intrusive bodies, including, for example, the Bududa Hill carbonatite (King et al., 1972; Woolley, 2001). There are also basins dominated by Miocene age sedimentary rocks. A unique cache of Miocene fossils, including mammals, aquatic reptiles, birds, and crabs, has been discovered in a basin near Butwa on the northeastern slopes of Mount Elgon (Bishop et al., 1969).

The Mount Elgon volcanism is dominated by nephelinitic tephra and agglomerates (Davies, 1952), typical

of a group of magmas defined by Baker (1987) as characterising the pre-rift activity of the Gregory Rift. Agglomerates, which can be readily observed on the higher slopes, include clasts which are typically <10 cm in size. Locally blocks of nephelinite and phonolite up to 1 m in size occur. Well-bedded tuffs are a subordinate feature. Lavas (nephelinite and minor phonolite and trachyte) are estimated to contribute less than one per cent by volume of the volcanic pile. The dominance of tephra is consistent with a high explosive index, typical of much of the pre-rift volcanism of the Gregory Rift.

Radiometric dating based on nephelinite lava has yielded an age of approximately 22 Ma (Bishop et al., 1969; Simonetti and Bell, 1995), but whether this is representative of the far more voluminous tephra is uncertain. Small intrusive bodies (plugs, dykes, and sills) of alkaline composition are widely dispersed on the



volcano. Some of these contain deposits of apatite and zircon, and possibly rare-earth elements, although they have not been found in economic quantities (Woolley, 2001).

The Elgon summit plateau with a diameter of 8 by 6 km includes an interior depression interpreted by Ödman (1931) as a caldera. Faults were not mapped by Davies (1952) on the perimeter of the depression, but the satellite image suggests evidence of linear structures. Five peaks of over 4,000 m occur on the summit plateau. These include, in addition to Wagagai and Little Wagagai (4,298 m) in Uganda, the peaks of Lower Elgon (4,301 m), Sudek (4,176 m) and Koitoboss (4,187 m) on the Kenyan side. Large moraines, indicative of Late Pleistocene glaciation have been reported from the summit plateau.

There are several hot springs on Mount Elgon, most of which occur on the eastern slopes, including the Suam Gorge. Mount Elgon is well known for the occurrence of caves up to 250 m in length. They occur in pyroclastic rocks and contain sodium-rich salt deposits sought by large wildlife. Elephants regularly enter caves to gouge

the walls. The “elephant caves” as they are known were first described by Thomson (1880) and they may have provided inspiration for part of Rider Haggard’s novel *King Solomon’s Mines*.

The Kitum Cave (Kenya) is internationally known after a publication by Richard Preston in 1994 disclosed that two visitors died after contracting the rare Marburg Virus. There has been debate as to whether the caves are dissolution features or zoogeomorphic. Some reports suggest they are lava tubes but this is unlikely in the light of the composition of the volcano (predominance of tephra). Lundberg and McFarlane (2006) concluded that the caves are Holocene features and formed by processes induced by erosion of incompetent beds of agglomerate, initiated by waterfalls in surface streams. There is no evidence of water flowing in the caves, or of dissolution. Initial undercuts are enlarged by roof collapse, as well as by humans and elephants.

Mount Elgon is particularly well known for botanical zones that include a large array of trees and plants, a number of which are endemic to the mountain (Williams

The giant, dome-shaped mass of Mount Elgon rises above the forested lower slopes of the regional plateau on the Uganda side.





Heathlands and moorlands occupy the high slopes of Mount Elgon, near the rim of the caldera, Uganda.

et al., 1967). The montane forest is extensive, as is the bamboo belt that fringes the upper heath and moorlands. A profusion of wild flowers occur within these zones. The summit plateau is part of the heath and moorlands, as proximity to the Equator and relatively modest height are such that the Alpine deserts and icefields that characterise Mount Kenya and Kilimanjaro are not developed. The area within the summit depression has the appearance of a "Lost World" as it includes stands of giant groundsel (*Senecio barbatipes*) and lobelia (*Lobelia elgonensis*).

The western slopes on the Ugandan side of Mount Elgon are intensively settled and provide subsistence farming and cash crops, the latter including good quality coffee. The local people have long depended on the forested slopes for part of their livelihood and this has resulted in some conflict with the national park. In recent years there has been a relaxation of rules in some sections, and harvesting of resources such as bamboo poles and bamboo shoots (a local delicacy) is now allowed.

A series of devastating landslides have occurred on the Ugandan side of Mount Elgon in recent years. In 2010,

an estimated 350 people lost their lives in the Bududa District after a number of landslides, and on June 25th 2012, after several days of torrential rain, landslides buried parts of villages on the western slopes of Elgon with considerable loss of life. Landslides have also occurred on some pre-Elgon intrusive bodies, including carbonatites where fertile soils have encouraged intensive farming on steep slopes.

A study to understand land use changes including the possibility of landslides on critical slopes, found that since 1933 a considerable loss of woodland and forest cover had occurred, particularly on steep slopes (National Environmental Management Authority of Uganda, 2010). Encroachment, attributed to unacceptable population growth in the report, induced a series of shallow and deep landslides that caused significant loss of life. Encroachment into the park in Uganda has another unfortunate consequence: most of the large fauna has migrated to the Kenyan side, with a potentially deleterious effect on tourist revenues. Finally, there has been little or no research on the volcanism of Elgon for many years and the upper slope, including the caldera



*Cliffs of nephelinite
ashes (pale grey) can
be observed on the
lower slopes of Mount
Elgon, Uganda.*



*yield outcrops which may be sufficient to enable a more
detailed study to be undertaken.*

Photographs by the author except where referenced



*Heathlands with giant
groundsel and lobelia
occur in the central
caldera of Mount
Elgon, Uganda.*



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Nepheline agglomerate with medium and small clasts, Mount Elgon, Uganda.

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Lower western slopes of Mount Elgon, Uganda, are intensively farmed in an area of high rainfall and nutrient-rich volcanic soils.



Landslide in the Bududa District, Uganda, on the lower slopes of Mount Elgon (Source: National Environmental Management Authority of Uganda, 2010).



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GSSA Events from January 2017 – November 2017

DATE	EVENT
15th-18th January	IMSG (Igneous and Metamorphic Studies Group – GSSA supported event)
17 February	Excursion to Hartebeeshoek Radio Astronomy Observatory (to be confirmed)
22 – 24 February	Drilling Methods in Johannesburg
13-14 March	AAPG Distinguished Lecturer (in association with AAPG; March 13 Cape Town and March 14 Johannesburg)
31 March	Gold Day
5 May	Valuation of Mineral Properties
2 June	Advanced Structural Geology (to be confirmed)
23 June	Compliance and Reporting for Competent Persons
27 - 29 July	Geological Skills for the Young Professional
18 August	Geometallurgy
1 September	Geoheritage Strategy (to be confirmed)
27 - 29 September	Drilling Methods in Johannesburg
20 October	Ore-forming Process and Mineralisation Systems
27 October	REI Colloquium
9 November	Fellows Dinner
8 - 9 November	Technology Day and African Exploration Showcase

