GSSA
Geological Society of South Africa

# geobulletin

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Student chapter WC SEG-SGA
Platinum in Zimbabwe
Short course on Diamonds

news

MSA
THE MSA GROUP

**COVER PHOTO:**

The +20 m terrace on De Kalk 37, adjacent to the Orange River. Dwyka sediment is overlain by alluvial gravel and capped by calcrete. S 29.47762° E 23.91736°.
Photograph: Jurie Viljoen

**CENTREFOLD**

**"Movement of the ancient sand"** showing Matthew Huber on a visit to the Zion National Park in Utah. The photograph, taken by Elizaveta Kovelava, won her this year's EGU photo contest.

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GSSA Geological Society of South Africa

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# from the editor's desk

Chris Hatton

*Was a great big sign that said,*
*"Private Property,"*
*But on the other side, it didn't say nothing,*
*That side was made for you and me.*

Setting aside for the moment the tragedy of the commons, the sad fact that if the land belongs to everyone no one is going to strain to look after it, the you and me that Woody Guthrie was referring to were the European latecomers, railing against the White Anglo Saxon Protestants who had arrived earlier and claimed all the juicy bits. To the subsequent embarrassment of Pete Seegers, Woody Guthrie didn't spare a though for the North American Indians who had arrived even earlier. When Sloss politely attempted to decolonise North American geology in 1963 with his recognition of unconformity bounded surfaces and their associated sequences, he had the good sense to name them after indigenous North American tribes. The Sauk sequence begins in the late Precambrian, ignores the Cambrian and Ordovician boundaries, and finishes within the Ordovican. Similarly the Tippecanoe sequence ignores the Silurian and Devonian boundaries to finish in the upper Devonian. The Kaskasia sequence finishes within the Carboniferous and the Absaroka sequence ranges through the Permian and the Triassic to the beginning of the Jurassic. The Zuni begins in the Jurassic, encompasses the Cretaceous, and ends in the Paleocene. The sixth sequence, the Tejas ends with the major regression that is currently underway.

Sloss's six sequences over some six hundred million years provided the initial framework for what would later become the first order sequence. Subdivision of Sloss's sequences led to the second order sequence, with typical times scales between ten and a hundred million years. His errant student, Peter Vail established third order cycles, but instead of the exposed sediments of the cratonic interior, Vail and his colleagues turned the focus to the seismic profiles of oil exploration companies. Adherents of Vail's new sequence stratigraphy entirely rejected the ups and downs of the cratons as the driving mechanism for third order cycles. All was explained in the new paradigm of sea level rise and fall. Sloss remained unconvinced;

'I persist in the claim that cratons, their margins, and their interior basins "do not just lie there" passively waiting to be encroached upon by rising sea levels' he wrote in 1988.

The new sequence stratigraphy ploughed on regardless, calling on the melting of glaciers as the driving mechanism for sea level change. Because tectonism in continental basins such as the Karoo is considered to be independent of global sea level changes, a firm prediction of the new sequence stratigraphy is that continental fluvial sediments cannot be directly related to the Vail charts established in the marine realm. The 1:50 000 mapping programme that is currently underway at the CGS will reveal the fine scale necessary to test this prediction. Whether or not this prediction is correct, the North American precedent of naming sequences after the oldest inhabitants of the land would suggest that appropriate names for new South African units would be of Khoekhoe origin, in recognition of the oldest branch of the human family.

When Pete Seegers apologised to the North American Indians with the addition of the lines,

*You pushed our Nations to the reservations;*
*This land was stole by you from me.*

for good measure he widened his compass to embrace all living things, even little microbes,

*Fin, fur, and feather, we're all here together,*
*This land was made for you and me.*

Perhaps the inclusion of microbes is a little too accommodating. Yes, there was a time when we

eukaryotes were just small, and some microbes are our fellow eukaryotes, but most microbes are prokaryotes, with molecular machinery that is quite inferior to ours. Nonetheless, the once controversial idea that we eukaryotes arose from a union between two prokaryote branches is now orthodox. A firm prediction of the prokaryotes before eukaryotes hypothesis is that eukaryotes only appeared two or at most three billion years ago. The 1 : 50 000 mapping programme will be looking at rocks older than three billion years in the Barberton greenstone belt. Already there are signs that fossils in these rocks are unexpectedly large. If more evidence of fossils that are too large to be classified as prokaryotes emerges, the prokaryotes before eukaryotes hypothesis may finally expire.

Clearly South Africa is a great place to examine some serious questions in geology. Add to this the record of ape to human evolution in Maropeng and the SKA peering back to the beginnings of the observable universe and you have a grand destination for science tourism. This land is our land. Please visit.

**Chris Hatton**



# executive managers corner

Craig Smith

The key development since the June issue of Geobulletin was published concerns the effect the pronouncements of the Department of Mineral Resources (DMR) is likely to have on our membership as well as the earth science professions in South Africa. To recap, in mid-June the DMR gazetted the amended mining charter, which was quickly challenged by the Chamber of Mines (COM) on legal grounds. In apparent response to the COM challenge, the DMR gazetted another missive in mid-July proposing the freezing of mining and exploration rights with comment invited by August 4. The GSSA commented to the DMR in line with our policy of responding when deemed necessary. As it happened, the DMR withdrew the proposal on the day comment was due, and whether it was in response to negative comment already received or legal challenge by the COM is unknown.

The entire sorry saga is an indictment of the way the DMR operates, and is detrimental to investment in the resource sector – which in turn is negative for job preservation, much less job creation. In essence, investment disincentives have become disinvestment incentives. As an optimist, I do not believe the status quo can prevail. But if it does, there are a number of questions that need to be addressed. Is there a fundamental reason for implementing policies seemingly custom-made to cripple the resource industries? Do these policies contribute to premature closure of projects? What is the effect on the oil and gas sector – which will have to raise a quarter of a billion dollars or thereabouts to get to a 'no' or a

'maybe' as regards shale gas or off-shore hydrocarbon potential? Are South Africa's universities producing too many geologists? Do graduates have the right skills and attitudes to navigate this uncertainty? Are the metrics used to define success in higher education correct, or aligned between universities and government departments? At a time when industry is facing significant headwinds on a variety of fronts, we need to be modelling a number of future scenarios for South African earth science – across a range of different stakeholders. The current uncertainty is not benefitting anyone – except other countries that are more investor friendly and are reaping the benefits despite having less potential.

It's the time of year when the GSSA begins to plot its course through 2018, in a number of portfolios. In

Communications, sponsorship is being sought to assist with re-printing the textbook Geology of South Africa. The Meetings portfolio is planning the events calendar, and better use of technology for events is being investigated. The GSSA has received a positive response for staging Geocongress 2018 sometime around mid-year; and we will need committed sponsors for this. We will have more detail in the next month or so. The formalizing of a Geoheritage Division is happening. In the Finance portfolio, the fees model for 2018, as well as a budget 'roadmap' will be finalized by the time this issue this issue of Geobulletin goes to print.

As regards 2018 membership we will strive to keep increases as low as possible, and we will continue the early bird reduced fees specials. Expect your 2018 dues notices to arrive sometime in December. There are still a number of outstanding debtors for 2017, and we urge you to settle your account before the 2018 invoice arrives.

There are a number of members who are two years in arrears, and as per policy these individuals no longer have member privileges. One last effort to contact will be made before striking off permanently.

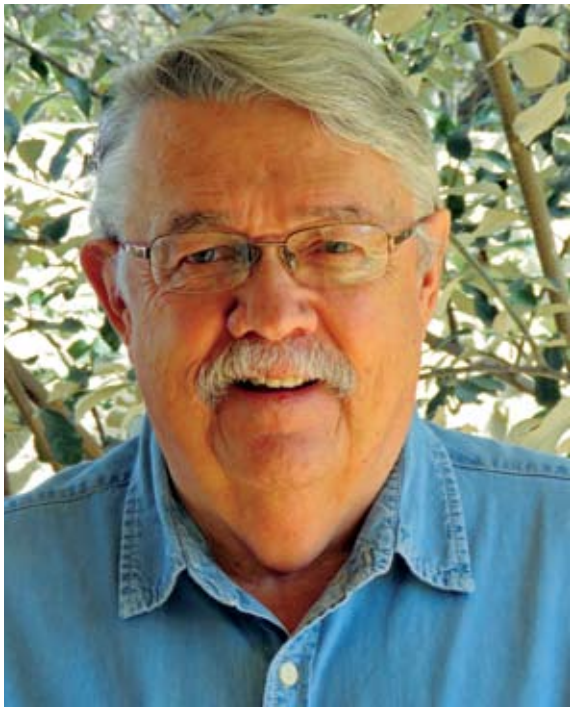
The GSSA is in the process of re-constituting the Complaints and Ethics Committees, as per the three year mandate for the committees. The majority of committee members have agreed to serve a second term, but there are now a few vacancies. Any Fellow of the GSSA interested in serving on one of the committees is welcome to contact me for information. Maintaining disciplinary procedures is important in maintaining RPO status for international resource reporting status, as well as a requirement to retain status as the Volunteer Association for earth science and geology within SACNASP. In the last few years the committees have resolved nine complaints; two more are in process.

Congratulations are extended to Mr. Mosa Mabuza, a Fellow of the GSSA, for his recent appointment as CEO of the Council for Geoscience. Mosa has been in the leadership role as acting head for several months, and we look forward to a number of new initiatives from the CGS. One of the more exciting projects planned is the geological mapping of key parts of South Africa at a scale of 1:50,000.

**Craig Smith**

# president's column

Ed Swindell



**A look at the forthcoming year for the GSSA**

I would like to commence this presidential year with a note of thanks to Jeannette for her wonderful service to the members of the GSSA over the last two years. Without her outstanding leadership I am convinced that the 35th IGC would not have been the success it turned out to be. I wish her well and great fortune as she continues her remarkable career.

On a personal note I would like to thank the Council for their vote of confidence in me with this appointment as President and would like to assure you all of my commitment to the task in hand and look forward to all the challenges of the forthcoming year. My association with the GSSA goes back to 1975, my honours year when I joined, as did the rest of my honours class, in order to attend Geocongress 75. Since that time the

GSSA has been my constant career long companion through a 42 year long career path, aiding and assisting my career in so many ways. I am very happy to step up and serve at this time.

Now, here is a quick look at the path forward for the Society through the next year, in this post-IGC world. There is going to be a "Back to Basics" theme year with a continuing focus on our core businesses. The focus of Manco in the coming year is to focus on basics and build on all we do well. Manco believes that value for our members comes from doing just that. We are a membership based organisation reflecting the population of geologists who live and work in South Africa. Our Transformation effort lead by Dumisani Sibaya is largely a matter of capturing all those new geologists entering the field as members, and providing the service to keep them as members. The reason for the loss of members will be looked into and it is believed that by building the branches and developing a greater sense of community through social media we can retain and attract membership that will see the society properly reflect the population of geologists in the country.

122 years ago the GSSA started as a learned society of likeminded geologists unravelling the geology of SA. Since then the GSSA has focused on just that, and has continually tried to evolve as the needs and demands of its members evolved. It has never allowed a for-profit ethos and has always followed a more collegiate ethos. Fees have always been intended to cover arising expenses and ensure solvency and so it remains today. The GSSA has always been based upon a spirit of volunteering. Only in the 1980's did we find it necessary to appoint a full time paid office manager and supporting staff (we now have a fulltime staff of 4). But we remain reliant upon volunteers and all these people need very special mention. Against this background the GSSA has developed a core focus of networking through 3 core businesses namely;

1. Publications
2. Meetings and networking
3. Professional affairs

Some features for the forthcoming year:

**Publications**

We intend to continue to strengthen support for our editors and our content contributors. We need to specially mention the valiant and tireless efforts Steve McCourt, Lew Ashwal, Janis Otto, and Chris Hatton put in to ensure that these publications happen and remain of the highest standard. George Henry and our communications portfolio team know that we live in the digital age and have ensured our presence on a number of platforms. We need to support our Facebook champion Taryn Scharf, our Webpage champion Johan Krynauw, and ourLinkedIn champion Darren Tiddy, all of whom always need content. Here I wish to specially mention and note our champion Geobulletin Contributor Roger Scoon. Please keep it up Roger. I must also mention Lully Govender and her outstanding Newsletter. Please use this to get your meeting and event notices out, it really works and reaches all of the membership.

An item needing special mention is our Text book – We no longer have any print copies left and we urgently need to reprint 1000 copies. We don't have the funds and need sponsors. We need about R 400 000 and are looking for about 6 -8 sponsors. Please if anyone has any ideas we need to hear them.

**Meetings and Networking**

The Meetings portfolio has an exciting programme of events planned for the coming year including our now annual African Exploration Showcase, always a highlight of the year. Looking further we are exploring the possibility of a Geocongress in 2018. We are in the process of approaching the HOD's at the Universities in order to test their appetite for a mid-2018 Geocongress. Depending on their reaction we will commence planning for this. Further down the line we are in talks with the AAPG to participate in their forthcoming ICE meeting to be held in Cape Town in Nov 2018. Even further down the line we are exploring a concept meeting with the SEG in 2020. This is their 100th anniversary year and they have asked assistance with logistics for a few transect field trips in Southern Africa. The concept of holding a Geocongress in 2020 with joint SEG events is under consideration.

In the meetings space we are testing and searching for new business models. New concepts such as remote access options and webinars have to be looked at. We are evaluating how the financial risks associated with these concepts stack up versus the more traditional offerings.

Our main networking events have always been via the numerous meetings offered. With our move to the CSIR Mining Hub in Auckland Park we have an opportunity to provide a much more accessible home for far more regular meetings. By virtue of the nature of the venue meeting will be limited in size (48 max). There are benefits such as a more parking and a central location with office support on hand.

A critical element of our offering has always been Branches and divisions. We want to try to re-energise the branches this year. Some are successful and critically function on the back of key individuals, while others are essentially defunct. We think we should focus on Egoli and Western Cape and see where we CAN go from there. To do this we are going to have to draw heavily on Jo'burg and Cape Town Council members, so be warned. We are also trying to see what support can be offered to the branches, given our limited resources.

We have 2 very well operated and functioning divisions, namely the GWD and MINSA, and we are now trying to get the Geoheritage Division going. It involves lots of interest elements and is not simply a community of geologists. It is much more of a network concept and needs the development of a new model as to how such a unique division can be developed and run. This potential division has a Charter in place and now needs people.

**Professional Affairs**

Together with SACNASP we are actively trying to protect the profession from all the assaults on it, by ensuring we remain a loud voice wherever we may be heard. Our presence on the SACNASP Council in the person of Neale Baartjes, our constant activity on the various committees at SACNASP and our presence in the committees of the CGS all point to our on-going commitment to the professional status of our members. The existence of career building and internationally recognised tools like SAMREC are entirely a function of the effort and sacrifice made by GSSA members who, together with SAIMM members built the SAMCode system. Without the time and effort and money taken from your membership fees SAMREC would possibly not exist today. All of these activities and interventions will continue. I have stood down at the SSC in favour of Sifiso Siwelo and will continue to support the activities of our SAMREC / SAMVAL / SAMOG champions Ken Lomberg, Kelly Redman, Andy Clay and Tania Marshall at the SSC.

As regards SACNASP one particular body of work will hopefully be shortly finalised and that is the signing of the MOA regarding CPD. Just a few weeks ago Dr Rampersadh informed me that he has received the okay from the council to sign MOAs such as we proposed and that hopefully this matter can finally be progressed and settled. This means that our CPD system will be recognised by SACNASP and our members won't have to run 2 separate CPD logs on 2 separate systems.

As required by our Constitution the Fellows are in the process of re-establishing the C& D committees (they have a 3 year term) and I would like to thank the fellows led by Gordon Chunnett for an assiduously correct process of not only determining who should be honoured by the Society but also of managing the C&D process for the society.

On a personal note and having now had quite some experience of our Code of Ethics and its implementation I must comment that I do think we have a remarkably well drafted Code of Ethics that is standing up to the test of time very well. In our interactions with all sorts of people we are finding that it is stands up to international scrutiny and practice.

The ever on-going entrenchment of the code into our business will remain one of my priorities going forward.

**REI fund, Finance and Admin**

Reinie Meyer and his committee deserve special mention for the REI Fund work. We will work as always to ensure proper management and proper application of those funds. This fund continues to be a very useful resource for our members, assisting them in many endeavours.

Craig and Thomas Molelengoane will be working very hard this year on managing our finances and ensuring we remain above water and have a clean unqualified audit. In addition Craig will also be working to ensure that the GSSA has an on-going role in the management of the 35IGC Legacy Fund.

In conclusion I would like to thank you all and please be assured of my commitment and the commitment of the Council and Manco members to the society in this coming year.

**Ed Swindell**

Geological Society of South Africa

# all the news fit to print

UNIVERSITY NEWS

## University of the Free State

### Centenary celebrations

Geology as a subject has a long and proud history at the University of the Free State (UFS), having been taught from the inception of Grey University College, the predecessor of the UFS, in 1910. The Department of Geology will reach a milestone next year, as we celebrate the centenary of the establishment of our department under Prof WKM von Bonde, in 1918. To mark this momentous occasion, the Department of Geology will be hosting a 2-day mini-conference on 12 and 13 April 2018 that will take place on the University of the Free State Main Campus in Bloemfontein. We are currently in the process of approaching potential sponsors to assist with the costs of the conference and detailed arrangements including conference fees are likely to be communicated in November / December 2017. Interested parties are welcome to express their interest to attend by e-mail (roelofsef@ufs.ac.za) or online (http://whoozin.com/QTR-VGN-G3WE). Individuals, particularly our alumni, that would like to present their work at the conference or that would like to share with students their experiences as previous students of our department or aspects related to a career in the geosciences, should please send a proposed title for a 15 minute talk by e-mail. Slots are limited, so please act quickly to avoid disappointment.

### Departmental news

A total of 74 degrees were awarded by the Department over the course of 2016, with 27 students receiving BSc degrees, 28 honours degrees, 4 MSc degrees, and 15 Masters in Mineral Resource Management degrees. Several Geotalks were presented during the first semester of this year on a variety of topics including: i) medical geology as an emerging field of science (Hassina Mouri, UJ), ii) Pt in Uralian-Alaskan complexes (Giorgio Garuti, Montanuniversität Leoben), iii) chromitites and associated PGE in ophiolites (Federica Zaccarini, Montanuniversität Leoben) and iv) modern versus ancient controls on sedimentary systems (Poppe de Boer, Utrecht University).

The department is proud to announce that Photis Kalpakiotis was selected as the winner of the Haughton Award of the Geological Society of South Africa for the best honours thesis from a South African university for 2016, with a thesis entitled 'The Mapping and Structural Analysis of the Putsies Migmatite'. The study was conducted under the supervision of Wayne Colliston, who will be retiring in December this year.

A former honours student of the department, Tshiamo Legoale, was announced the FameLab International Champion at the Cheltenham Science Festival held in the UK over the period 6-11 June 2017, with her research on the use of wheat to harvest gold from

*Movement of the ancient sand (see Centrefold)*

mine dumps. Elizaveta Kovaleva and Matthew Huber (both post-doctoral research fellows in the department) attended the EGU General Assembly in Vienna (Austria) in April. The Department is delighted by the achievement of Elizaveta who won the EGU photo contest with a photo entitled "Movement of the ancient sand", showing Matthew Huber on a visit to the Zion National Park in Utah (see Centrefold).

The Department, after an exceptionally long wait, also received some good news from the NRF in November last year, when it was made public that Chris Gauert and Freddie Roelofse obtained C3 and Y2 ratings, respectively.

Until next time.
**Freddie Roelofse**

## Stellenbosch University

### Stellenbosch Students and Staff win accolades

Recent days have seen several Stellenbosch students and staff receive well-earned recognition for their academic achievements.

Prof. Gary Stevens has received recognition for his service to the country and the academic community, as SARChI Chair in Experimental Petrology. Gary was first appointed to a developmental Chair in 2008 and went on to be awarded a full Chair in 2012. His continuing success in producing high-profile research and graduation of MSc and PhD students has now earned him renewal of his Chair for a third 5-year cycle.

The Geological Society of South Africa has awarded the 2016 Corstorphine Medal to Ms Kelly Swana for her MSc thesis entitled "Application of hydrochemistry and residence time constraints to distinguish groundwater systems in the Karoo Basin prior to shale-gas exploration". The medal is awarded for a thesis that, in the opinion of the adjudicators, is of outstanding merit, reflecting international 'best standards'. Kelly, who was supervised by Dr Jodie Miller, was presented with her award (medal and cash prize) at the GSSA Annual General Meeting on July 6, at the Country Club Johannesburg.

Stellenbosch's resident sedimentologist and clandestine palaeontologist, Dr Ryan Tucker, has been awarded the Outstanding Recent Graduate Award from his alma mater, the South Dakota School of Mines (SDSM) in the United States. Ryan gained his MS in vertebrate palaeontology from SDSM in 2010 and his PhD in geology from James Cook University in Townsville, Australia, in 2014. He has a wide variety of on-going research projects both in South Africa and other countries.

### Stellenbosch PhD student to represent South Africa in Lecture Competition

Stellenbosch PhD student Matthew Mayne (supervised by Prof. Gary Stevens) competed in the 2017 Young Persons' Lecture Competition, organised by the South African Institute of Materials, Minerals and Mining (IOM$^3$). The aim of this competition is to provide an atmosphere of friendly competition for young scientists and engineers, so that they can hone their presentation skills while addressing a generalist but informed audience. The lectures are limited to 15 minutes' duration, have to contain the results of research and the lecturers need to answer questions from a panel of judges drawn from academia, industry and the IOM3. Regional heats were held at Nelson Mandela Metropolitan University on the 22nd of June and Witwatersrand University on the 23rd of June, with the top 3 presenters from each heat progressing to the national finals on the 27th of June at St George's Club in Port Elizabeth. Having won the regional heat, Matt

*Matt Mayne of Stellenbosch, Oscar Tarique of UP and Bridget Nomshado Zuma of WITS.*

went on to compete in the national event. The image above shows the three finalists in the South African competition, from the left, Matt Mayne of Stellenbosch, Oscar Tarique of UP and Bridget Nomshado Zuma of WITS. Matt won for his lecture entitled "How do rocks melt? - a question requiring both chemistry and thermodynamics", which described a cataclysmic world governed by simple laws. He also introduced a new software tool (https://tinyurl.com/Rcrust) that will assist geologists in investigating a variety of Earth processes. So, the IOM$^3$ will fly Matt out to Perth (Australia) in October, to represent South Africa in the worldwide competition.

**Our Formidable Public Interface Retires**

Yes, Loxie Conradie is retiring. After many many years of excellent service to the staff, students, visitors and clients of the Department of Earth Sciences, Loxie will leave us at the end of December. Loxie started out as the departmental librarian and gradually assumed more and more duties. She eventually became our Senior Departmental Officer, responsible for keeping us all doing what we are supposed to be doing and ensuring that our dealings with the University finance office go as smoothly as feasible. We all, staff present and past, as well as generations of students, owe her a considerable debt of gratitude for all she has done to help us and the Department. Tannie, we will surely miss you hugely but wish you all the best in your well-earned retirement.

**John Clemens**

**A Journey Through Time and Country: Stellenbosch University Honours Field School 2017**

Although text books and class-room lectures provide a solid grounding in the fundamentals of Earth Sciences, student learning is greatly enhanced by incorporating the hands-on practical experiences afforded by field schools. This is never more true than during the students' Honours year, when they have a wealth of prior knowledge that can be applied to interpreting and understanding the geology at various field sites.

The 2017 Stellenbosch University Honours tour was a 2500 km chronostratigraphic journey through Southern Africa's geology and mineral endowment. Our first stop, at the Vredefort Dome, took us right back to the Archean, where a major bolide impact and subsequent erosion provide a window into its granulite gneisses, cut by picturesque pseudotachylyte breccias at a number of dimension-stone quarries in the Parys area. Staying in the Archean, our next stop was at the Village Main Reef's Tau Lekoa gold mine just outside Orkney. For many of the students, this was their first experience of underground mining and they were all awed to finally see the world-renowned Wits gold mineralisation in situ. Diverting slightly from our chronostratigraphy but staying with gold, we stepped back in time to Harmony's Kalgold banded-iron-formation-hosted Au mineralisation in the Kraaipan Greenstone belt. Here we were afforded a comprehensive overview of its geology and mining operations, and were able to contrast their open-pit mining with the underground

mining technologies observed on the previous day. Students in our Environmental Geochemistry honours stream also welcomed the opportunity to interact with the SHEQ department and learn about the environmental implications of pit closures and methods of dealing with the artefacts associated with historical slimes dams. From here we headed west and up into the Neoarchaean-Palaeoproterozoic Transvaal succession and the economically-important BIFs in the Kuruman area. We were warmly hosted by Assmang's Khumani Mine who taught us about the importance of sink-hole structures in preserving high-grade Fe ore. This included a site visit to their King's pit where we enjoyed panoramic views of the operations and were able to compare massive, laminated and conglomeratic ore types.

After three mine visits, the students were ready for a break, and where better than at the Northern Cape's star attraction, Augrabies Falls. The river was running relatively low but this did not detract from the splendour of the Falls, and it produced good exposures of pot-holes in the gorge (by way of a subtle prelude to the diamondiferous potholes that we would later see in the lower reaches of the same river). A morning in the park was put to good use by allowing students to set up a geo-tourism route, instilling the viability of this option as an alternative career for an Earth Science graduate. Continuing across the many different terranes of the Palaeo-Mesoproterozoic Namaquan Province, we eventually reached the Aggenys-Gamsberg ore district, where Maties alumni hosted us with great enthusiasm at Vedanta's Black Mountain Mining operation. Half of the students had the opportunity to visit various underground faces with spectacular sulphide exposures, while the other half enjoyed visits to the processing plant and the core yard. The mine visit was concluded with a hike across a metamorphosed stratigraphic section in the Big Syncline area, including stretched conglomerates, amygdaloidal meta-basalts and gossan. The weekend was spent traversing both the exceptional exposures of the Richtersveld Terrane and the Lower Fish River-Onseepkans Thrust Zone, where we also swam in the geothermal springs of Ai Ais and in the Orange River. The Richterveld experience ended with a two-day visit to Trevali Mining's Rosh Pinah primary sulphide and Vedanta's supergene Skorpion oxide mines. In both instances our hosts afforded us excellent insights into the mining and exploration geology, as well as into the processing of ores.

*Students observing underground drilling operations at Vedanta's Black Mountain mine.*

Leaving the Precambrian, our return journey focussed on a variety of Cenozoic placer deposits along Southern Africa's west coast, hosting valuable minerals eroded from the traversed Southern Africa's hinterland. This started with a tour highlight – a traverse of Namdeb's diamond-mining operations from Sendelingsdrift to Oranjemund, complete with a cold swim and/or beverage where the river meets the sea. Back into South Africa, this was followed with our second-last mine visit, at Exxaro's extensive Namaqua Sands deposit. Here we learnt about how the topography and sea-level stands helped to concentrate this world-class heavy mineral deposit. After two weeks on the road, we squeezed in one last stop (on a Saturday – thanks Kropz!) at the nearby Elandsfontein phosphate deposit. Here we benefitted from a tour of both a box cut and their newly commissioned plant, where a novel reverse floatation method is used to concentrate the apatite ore.

Overall the trip was a superb learning experience for the students, providing first-hand exposure to Southern Africa's diverse geology, to a variety of open cast and underground mining techniques, and to the beneficiation and environmental considerations associated with exploiting ore bodies. The students further benefitted greatly from their interactions with the professional geologists, who provided insight into the roles of earth scientists in the post-university industrial environment. Stellenbosch University acknowledges the teams that so willingly hosted us (a large group of 29) at each of the mines mentioned above. The knowledge and insights that you shared with our students was exemplary, and for this we thank you sincerely.

**Bjorn von der Heyden and Martin Klausen**

*Stellenbosch honours students indicate 'Bolt-style' the imbrication of boulders along an alluvial bed inside a typical diamond pit.*

*Exposure of Namdeb's diamond exploration and mining activities along the Namibian side of the Orange River. Exploration Manager Gottfreid Grobbellaar instructs our Honours group from a vantage point.*

# student chapter

**The Western Cape Society of Economic Geologists–Society of Geology Applied to Mineral Deposits (WC SEG-SGA) student chapter**

With a member base of 50, the Western Cape Society of Economic Geologists–Society of Geology Applied to Mineral Deposits (WC SEG-SGA) student chapter is the 2nd chapter in South Africa and the 1st in the Western Cape, established in 2017. The student chapter is a joint venture among three South African universities in the Western Cape, namely Stellenbosch University (SU), University of the Western Cape (UWC), and the University of Cape Town (UCT). Most of the chapter's members are 3rd year and honours students, with each university having two members on the committee.

South Africa is renowned for its mineral resource wealth, very little of which is located in the Western Cape. It's easy to see why this could be deemed a bit of a challenge, but with a steer in the right direction from Mike Venter and Dr. Lynnette Greyling, our industry and academic advisors, respectively, we've come to quickly overcome this non-hurdle. This has been achieved by designing a program that embraces knowledge of the mining activities around the Western Cape, both historical and active, as well as a focus on industry talks.

The main aim of the chapter is to enhance the scope of Economic Geology that students are exposed to in university. Through engagements with various academics and industry professionals by hosting talks, we aim to establish a networking platform for our members, and hope that this will be a stepping stone for their future professional careers. In addition, our upcoming mine visits will provide a more practical aspect of Economic Geology, as well as enhance theoretical knowledge. This chapter believes it is imperative for members to be exposed to and to understand the mining and exploration processes that occur at various mines, mainly in the Western Cape, will open their view of the Industry and motivate research into further career opportunities that lie in that sector.

All this learning is great, but the chapter also promotes a social aspect to its activities, that do tie in with Economic Geology. This is through various social events, where members get the chance to interact with rock enthusiasts from the other universities and discuss their wacky and wonderful appreciation of disseminated pyrite and banded iron formations.

While the nitty-gritty of kicking off the chapter was not always smooth sailing, we believe the year will be a success and are hopeful this will be a continuing trend in the years to follow.

**WC SEG-SGA Student Chapter**


*Opening function at the University of Cape Town pub.*

# platinum in zimbabwe

**A Short History of the Discovery of Platinum in Zimbabwe**

The Main Sulphide Zone (MSZ) of the Great Dyke contains the world's second largest PGE resource after the Bushveld Complex. The first reference to the MSZ was made in 1918. The first recognition of Platinum Group Elements (PGE) within the MSZ was in 1925 in the Makwiro area near Selous (Lightfoot, 1926, 1927). Following this discovery, the MSZ was soon traced throughout most areas of the Great Dyke in the Darwendale, Sebakwe, Selukwe and Wedza sub-chambers. Initial interest focused on the near surface, oxidised zone but later shifted to the deeper sulphide ore.

The first major attempt at producing platinum from the MSZ was by the Grainger brothers at Wedza Mine near Mimosa during the period early 1926 to late 1928. A relatively sophisticated reduction plant with 600 ton per month capacity was erected. PGE grades were estimated at 4.5 g/t over one meter. The concentrates produced from the plant were sent to the United Kingdom for refining. The eventual failure of this operation was largely due to low plant recoveries at less than 50% of head grade and a fall in platinum price below £7 per ounce in 1928 (Bowen, 1994). It became apparent that the fine-grained platinum minerals could not be economically recovered from the oxidised-ore with the existing wet gravity or froth flotation methods (Wagner, 1929).

During a site visit to Mimosa Platinum Mine a couple of years ago, the original adit developed by the Grainger brothers were visited. The adit is developed in the area that is now referred to as North Hill. The oxidized horizon outcrops and sub-outcrops on the lower part of the hill. The adit entrance has been covered by the Mine, but the evidence of their activity is still visible.

*Granger Brothers Adit Entrance*

*North Hill*

*Old Shallow open cast operation with recent bulk sample location*

*Norite autogenous milling stones*

Just outside the adit entrance, the shallow open cast operation in the outcropping oxidised material can still be seen along with recent bulk sampling location and the disturbed old rock dump. In the surrounding bush, rounded norite cobble stones used in the autogenous mill can still be found.

The next major phase of activity was in the 1950's. Between 1951 and 1953, the Great Dyke Wedza Syndicate investigated the oxidised ore in the Wedza area (Morrison, 1974) and established that the PGE could be economically recovered in ferro-nickel by smelting the ore in an electric arc furnace. Despite this metallurgical success, nothing came out of this project. It was, however,

*Disturbed old rock dump*

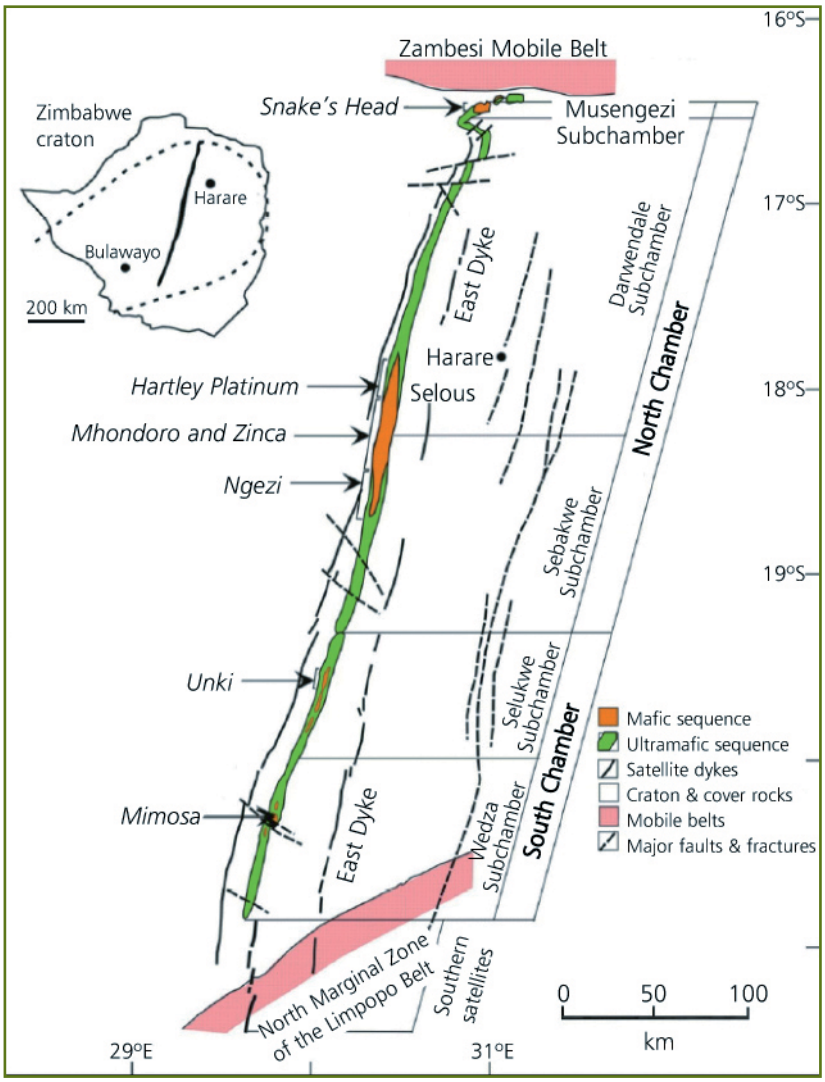
realised that the high cost of electric smelting could partly be offset by cheap surface mining and by savings in crushing the relatively soft friable ore without the need for subsequent grinding (Prendergast, 1988a).

Seven years later in 1960, Ben G. Worst compiled Geological Survey Bulletin No. 47: "The Great Dyke of Southern Rhodesia" which revived interest on the MSZ. Several mining companies, notably Anglo American Corporation, Union Carbide and Rio Tinto began serious exploration on the Great Dyke. Although the initial interest was on chrome it soon changed to focus on the MSZ. Between 1960 and 1983, these three companies independently conducted deep diamond drilling which proved a huge tonnage of potential ore in a widely persistent MSZ up to 1,8m thick beneath the remnants of the upper mafic sequence of the Great Dyke. The main target areas established were: Wedza - Mimosa in the Wedza sub-chamber (Union Carbide), Middleridge in the Selukwe sub-chamber (Anglo American), Zinca in the Sebakwe sub-chamber (Rio Tinto), and Selous in the Darwendale sub-chamber (Union Carbide). Union Carbide and Rio Tinto set up trial mining and plant-scale metallurgical extraction projects at their respective targets while Anglo American sunk an exploration shaft at Unki in the Middleridge area. All these pilot projects investigated and proved the technical feasibility of appropriate mining schemes and extraction processes. Despite these successes in exploration and evaluation efforts, a producing mine could not be developed, and by 1984, all the Great Dyke platinum projects had become dormant.

The main reasons for this disappointing result have been listed by Prendergast (1988b) as follows:

1. The relatively marginal grade which could only be offset by cost-efficient mining and extraction, and by higher metal prices than prevailed at the time;
2. The high capital investment required to develop a mine of the optimum economic size, and
3. The poor market perception of the local investment climate.

Other contributory technical problems are the poor ground conditions encountered at Selous and Zinca, and the lack of distinct petrographic markers for miners to follow. Dilution was, and remains, the critical problem to successful mining (Prendergast, 1988b).




*Great Dyke of Zimbabwe, after Kinnaird 2011*

ZIMASCO took over Mimosa in 1992. The pilot plant was refurbished, and mining recommenced in 1994, gradually building up to a rate of just less than 30,000 tonnes of ore per month. Although small, the operation was highly successful, and began to attract the attention of the South African PGM producers. A proposed acquisition by Anglo American collapsed in 2000, but the following year Impala Platinum acquired a 35% stake in the mine. In 2002 Impala took a further 15%, with Aquarius Platinum taking the remaining 50% of the company. Full commissioning of 4,050 tpd plant took place in 2003.

Geological Setting

The Great Dyke is a 2.59 Ga old, linear shaped layered intrusion, striking over 550 km NNE, with widths varying from 4 km to a maximum of ~11 km. At present levels of erosion the Great Dyke comprises a slightly curved, locally faulted line of 5 layered ultramafic to mafic

complexes. The intrusion cuts Archaean granites and Greenstone belts of the Zimbabwe Craton. Parallel to the intrusion are a number of satellite dykes comprising of gabbro and quartz-gabbro.

The lower portion of the Great Dyke consists of ultramafic rocks (dunite, harzburgite, olivine bronzitite and pyroxenite) and contains narrow layers of chromitite. The upper Mafic Sequence consists of plagioclase-rich rocks (norite, gabbro-norite and olivine-gabbro). Up to 14 cyclic units are recognised in the ultramafic succession. The origin of these cyclic units is interpreted as due to repeated injections of primary magma followed by fractionation and differentiation.

Economic PGE mineralisation occurs some metres below the transition from the Ultramafic to Mafic sequence within the MSZ. The mineralisation is hosted in the P1 pyroxenite and can be several meters thick. Although overall this zone is slightly discordant to the major layering (Prendergast, 1990), it is extremely persistent and occurs in all sub-chambers of the Great Dyke (Coghill and Wilson, 1993). According to Prendergast (1990), volatile fluids played a part in the genesis of the MSZ, as a result of which hydro-silicate alteration is a prominent feature of this PGE-enriched zone. The MSZ shows a lateral facies change from a narrow, high-grade layer near the margin, to a thicker, lower-grade layer towards the central axis. Hydro-silicate alteration is also more pervasive near the margin of the Great Dyke (Evans and Buchanan, 1991; Prendergast, 1990).

**Dr Nicolaas C. Steenkamp**

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# Environmental and Natural Sciences

## Short Course: Diamond Exploration and their Primary and Secondary Sources

**24 - 27 October 2017**

University of Pretoria (UP), Pretoria, South Africa

Course leaders: Mike de Wit and John Bristow

Topics covered from 24 - 26 October 2017:

1. **Exploration:** History of diamonds, World diamond markets, Origin of diamonds, Kimberlites/Lamproites and cratons, Structural geology and diamond exploration, Modern exploration techniques, Geophysics and diamonds, Mantle structure and diamond genesis, Indicator minerals chemistry *(Mike de Wit, John Bristow, Fanus Viljoen, Hielke Jelsma, Gavin Selfe, Hilde Conwright, Katie Small).*

2. **Primary and Secondary Sources of Diamonds:** Classification of primary sources of diamonds including Kimberlites/Lamproites, Characteristics and settings of secondary (alluvial) diamond deposits in South Africa (Orange, Vaal River, NW Province), Africa and India, Marine diamond deposits *(Johan Stiefenhofer, Lyndon De Meillon, Tania Marshall, John Ward, Mike de Wit).*

3. **Evaluation and Economic Valuation of Diamond Deposits:** Due diligence and geological requirements, Diamond valuation (rough and polished), Size frequency studies, Mining methods, Evaluation of alluvial deposits, Financial valuation models *(John Bristow, Alex Holder, Derek Lahee, Grant Ziegler, Tania Marshall).*

The 27th October 2017:

4. **Mine visit to Cullinan Mine, Pretoria**

This unique course in diamond exploration and evaluation is presented at the University of Pretoria by international experts, and presents the latest developments and new technological applications in exploration methods, geophysics as applied to diamond exploration, mining methods, the origin of diamonds, mineral chemistry, petrography, settings of kimberlites/lamproites including cratons, secondary diamond deposits, and mining, processing and treatment, and recovery methods. It has been several decades since the last major diamond mine discovery, and markets will be looking for additional natural diamond production in the future.

The Course fee is US$550 (ZAR7 000) per person which includes refreshments, comprehensive course notes, and visit to a world class underground diamond mine. Funds raised from the Course are allocated to assist Honours students and support a post-graduate fund for junior lecturers in the Geology Department at the University.

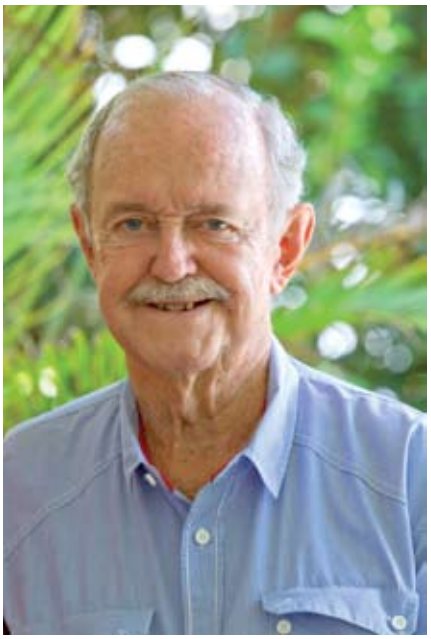
For details contact Mike De Wit at dewit@icon.co.za, John Bristow at jwbdia@mweb.co.za or Vusani Mathada below. Some places are reserved for the 2017 Geology honours students so early registration is recommended.

***Registration and enquiries:***
**Vusani Mathada**
**Tel: +27 (012) 420 2281; Email: Vusani.mathada@up.ac.za**

# obituary:

## Rodney Richard Morgan Maud †

**RODNEY RICHARD MORGAN MAUD**
**(1935 - 2017)**



It is with great sadness and a sense of immense loss that we mourn the passing of Dr Rodney Richard Morgan Maud on 12th May 2017, after a year of declining health.

**ACADEMIC ACHIEVEMENTS**

Once asked why geology, when he could have been anything he set his mind on he said his passion for geology was kindled as a young boy around the hills of Hillary, south of Durban, collecting rock samples and hoarding them in his mother's cupboards.

Armed with this passion, and having matriculated from Durban High School (DHS), he went on to read for a Bachelor of Science degree in Geology and Chemistry at the then University of Natal, Durban, graduating in 1954.

He took up a post as geologist and soil scientist at the South African Sugar Association or SASA from 1955 to 1966, but was able continue his tertiary studies obtaining his Bachelor of Science (Honours) degree (cum laude) in 1957 and his Doctorate of Philosophy in Science, Geology, in 1962.

It must be said here that his doctoral thesis was not well received by the then Professor of Geology, Lester King, who had his own theory on the geological structure of Natal, referred to as the Natal Monocline. Rodney's research advanced a different but more universally accepted explanation, that of a faulted block margin. This apparently led to Prof King referring to Rodney as *'his most misguided student'* and almost failed him were it not for the external examiners.

He was awarded the Selby Research Fellowship by the Australian Academy of Science and spent 1964/65 at the CSIRO in Adelaide, as a research scientist.

**CONSULTING GEOLOGIST CAREER**

In1967 he joined the consulting firm Kantey, Templer and Web as a consulting Engineering Geologist but then in 1969 moved to D L Web and Associates as a senior associate. This association lasted until early 1975 when he and his then colleague Dr John Drennan decided to go it alone. This departure from D L Web was however far from amicable.

*The story told by Rodney is that they resigned early in February 1975, to leave at the end of March. However, Dr Web was having nothing of that and had them immediately booted out together with all their belongings packed into tea boxes.*

Out of the tea leaves rose Drennan Maud and Partners on 1st of April 1975. The practice flourished and grew into what it is today. Drennan Maud celebrate 'Tea Box Day' on the 14th February each year.

He retired from the practice in 2001 but continued as a consultant right up to his passing, ever happy to assist or share his immense experience and knowledge.

**ASSOCIATION WITH ACADEMIA**

Rodney remained in close contact with his *alma mater*, the then University of Natal, Durban (UND), after receiving his PhD.

In 1968 he was invited back as an Honorary Lecturer in Engineering Geology and as an external examiner. This continued until 1978 when he was made Honorary Senior Lecturer.

In acknowledgment of his 20 years of selfless contribution to academia, UND appointed him as Honorary Professor in1988, a position he held until he retired from the institution in 2010. He carried the title with immense pride.

He has seen hundreds of students pass through his early morning lectures to the refrain *'Students change, the syllabus doesn't'*.

Between 1996 and 2006 he also held the position of Honorary Research Associate at the Natal Museum, in Pietermaritzburg.

During his busy life he found time to author no less than 32 publications, locally and internationally, and a further 39 in collaboration with close colleagues, Professors Tim Partridge and Fred Bell, and others, predominantly in the fields of engineering geology, quaternary geology, geomorphology and hydrogeology.

**WORK EXPERIENCE**

During his time at SASA he mapped, farm by farm, some 500 000 hectares of the entire South African Sugar Industry as it was then.

Between 1967 and up to his passing he was directly or indirectly engaged in an estimated 8 000 Engineering Geological appointments, working on many of KZN's flagship projects of the day. *He would regularly tell the staff they need to keep more than one ball in the air at any time if they wanted to work for him.*

He carried out numerous hydrological studies and was appointed as the project co-ordinator of the KwaZulu-Natal Hydrological Characterization and Mapping Project for DWAF in 1993, completed in 1995.

Rodney's association with agriculture and the soil sciences, both locally and internationally, remained an integral part of his professional life from his days at SASA right up to his passing.

Together with his close friend and colleague, Oscar Ashton, as well as MBB Agricultural Engineers and many other clients, he has crisscrossed the length and breadth of this continent on many agriculture related projects.

**AWARDS**

In 1989 he was recognized for his contribution to geology and awarded the Jubilee Medal of the Geological Society of South Africa (together with Prof Tim Partridge).

Rodney joined SAIEG as a Member in 1984 and was made a Fellow in 1993. In 2003, SAIEG awarded him the Gold Medal for his significant contribution, lifelong service and loyalty to Engineering Geology in South Africa, having also served as a Council member for many years (at his own cost), President between 1989 and 1990 and IAEG's Vice-President for Africa from 1999 to 2002. .

He also served as President and Honorary Treasurer of the South African Society for Quaternary Research.

**ONE LINERS**

A tribute to this exceptional man would just not be complete without quoting a few of his one-liners;

His opinion of other people;
..... *trust no-one!*

His opinion of drillers and contractors;
..... *drillers are liars, contractors are thieves and consultants are saints!*

His opinion on personal exercise;
..... *I lie down when I get the urge to exercise until the feeling goes away.*

He will be long remembered and sorely missed for his larger than life character, wicked sense of humour and prolific academic and professional achievements and contributions, made to both the Sciences and Engineering in South Africa over some 60 years.

REST IN PEACE DOC

**Michel Benet**

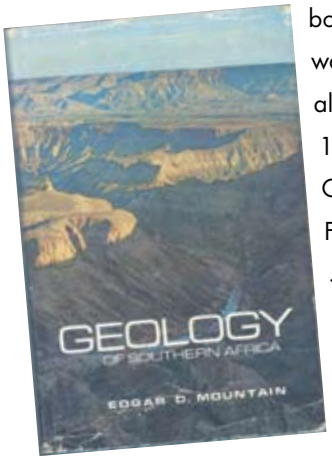
# mineral scene

## Mountainite from the Bultfontein Diamond mine, Kimberley, South Africa

**Bruce Cairncross**
**Department of Geology, University of Johannesburg**

It seems wholly appropriate that a mineral should be named after a geologist whose surname is Mountain. Edgar Donald Mountain (1901-1985), had this honour bestowed on him in 1957 (Gard *et al*, 1957) for a new mineral discovered at the Bultfontein diamond mine in Kimberley. Mountain was employed in the Geology Department at Rhodes University from 1926 until his retirement in 1969. During his tenure, he was Head of Department for 40 years, from 1929 until he retired (https://www.ru.ac.za/geology/geology/rhodesgeologydepartment). Prior to joining Rhodes University, he worked as an assistant in the Department of Mineralogy at the Natural History Museum in London. He worked there for four years before leaving for South Africa. He was an accomplished field geologist and mapped extensively in the Eastern Cape Province but he also had an interest in mineralogy, publishing articles on some of southern Africa's rare minerals (Mountain 1935, 1957, 1962). In 1968 he published a book on the geology of South Africa. Mountain was not only an acclaimed geologist but also an Olympic athlete. He competed as a 19 year old in the 1920 Antwerp Olympic Games, coming fourth in the 800 m final. Furthermore, he set a world record for the 500 m in Stockholm in 1921 and competed in a second Olympic Games in Paris in 1924 (http://www.sports-reference.com/olympics/athletes/mo/edgar-mountain-1.html accessed May 2017).

*Edgar Donald Mountain. Photograph courtesy of Rhodes University Department of Geology.*




*Copy of the cover of the book written by Edgar Mountain.*

Mountainite is a hydrated monoclinic phyllosilicate $CaNa_2K_2)_2Si_4O_{10}\cdot 3H_2O$. It was found, together with rhodesite, another type-species discovered at the Bultfontein diamond mine that Mountain (1957) described as a new species. Specimens were sent to him at Rhodes University from the McGregor Museum in Kimberley. Due to their habit, color and morphology, mountainite, rhodesite and the third Bultfontein mine type-species afwillite, were all thought to be natrolite until analyses revealed them to be three new species all originating from the Bultfontein kimberlite.

During a visit to Rhodes University in April 2017, courtesy of Emeritus Professor Gooney Marsh, we found the original specimens that Mountain had received from the museum and from which the type-species was named. The specimen is still in its original box and the label bears the mineral's names together with a description of its composition. Just below the specimen, the word "Bultfontein" can be seen. An internet search (Mindat.org, accessed May, 2017) revealed that mountainite remains a rare species worldwide, with only five localities, including Bultfontein, listed. The photos of bultfonteinite on the Mindat website are all from the Yubileinaya pegmatite, Kola Peninsula in Russia and are micromineral species. Therefore, the specimen housed at Rhodes University is important as it would appear to be the largest, and richest sample known.


*A large 3.5 cm sample of mountainite in its original box. Rhodes University, Department of Geology collection. Bruce Cairncross photograph, April 2017.*

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# media monitor



## MINING AND EXPLORATION NEWS

### Diamonds

Alrosa has partnered with Angolan national diamond company Endiama to develop the Luele kimberlite. Alrosa will be involved in the project through Catoca Mining, which operates Angola's largest diamond mine and in which Alrosa and Endiama each have a 32.8% stake. Catoca will obtain a 50.5% stake in the Luele project, with Alrosa proposing to buy an additional 8%. The Luele pipe is claimed to be the largest kimberlite discovered worldwide in the past 60 years, with a total commercial value assessed at over US$35 billion.

Botswana Diamonds announced the recovery of 223 microdiamonds from 160 kg of kimberlite drill core from the Frischgewaagt Project near Mokopane, in South Africa's Limpopo Province. These results were modelled to an estimated grade range of 20 to 270 carats per hundred tons (cpht) at a bottom cut-off of 0.6 mm. The wide range in the estimated grade reflects the small sample size. Frischgewaagt is on a 6 km kimberlite dyke/pipe complex averaging 1.34 m in width. The project is 2 km along strike from the historical Marsfontein mine, which produced 1.9 million carats with an average grade of 172 cpht and diamond value of $128 per carat from a kimberlite 'blow' 0.4 ha in size. The mine, which was operated by a De Beers / SouthernEra joint venture, achieved a return on the $25 million investment in just four days.

Debmarine Namibia, a 50/50 joint venture between the government of Namibia and De Beers Group, has inaugurated the world's largest and most advanced marine diamond exploration and sampling vessel following five months of successful sea trials. The US$157 million SS Nujoma, constructed by Kleven Verft in Norway and named after Namibia's founding president, Dr Sam Shafiishuna Nujoma, is 113 m long and 22 m wide, has a displacement of 12 000 t, and will accommodate a crew of 80. It has a helicopter deck suitable for Sikorsky S61s. This is the sixth mining vessel in Debmarine's fleet, which mines in the 6000 km$^2$ offshore mining licence area off the southern coast of Namibia at water depths of up to 140 m.

### Gold

Australian-listed Amani Gold Limited reported a maiden mineral resource of 2.3 million gold ounces (48.7 Mt at 1.5 g/t Au, Indicated plus Inferred) at the Kebigada deposit on its Giro project in the Kilo-Moto greenstone belt, Democratic Republic of Congo. The resource is defined over a strike length of 1.3 km. Three deep diamond drill-holes have confirmed that the high-grade mineralisation extends to a depth of at least 250 m, indicating the potential to develop an underground project. Amani is currently planning an infill diamond and RC drilling programme to define a Measured mineral resource for inclusion in pre-feasibility studies. A selection of diamond drill cores as well as bulk samples from the lateritic and saprolitic lithological

profiles will also be submitted for detailed metallurgical testwork. The Kilo-Moto belt hosts Randgold Resources' 17million ounce Kibali group of deposits, which lies within 30 km of Giro. Kibali produced 585 946 ounces of gold in 2016, and is targeting production of 610 000 ounces for 2017.

## Platinum Group Elements

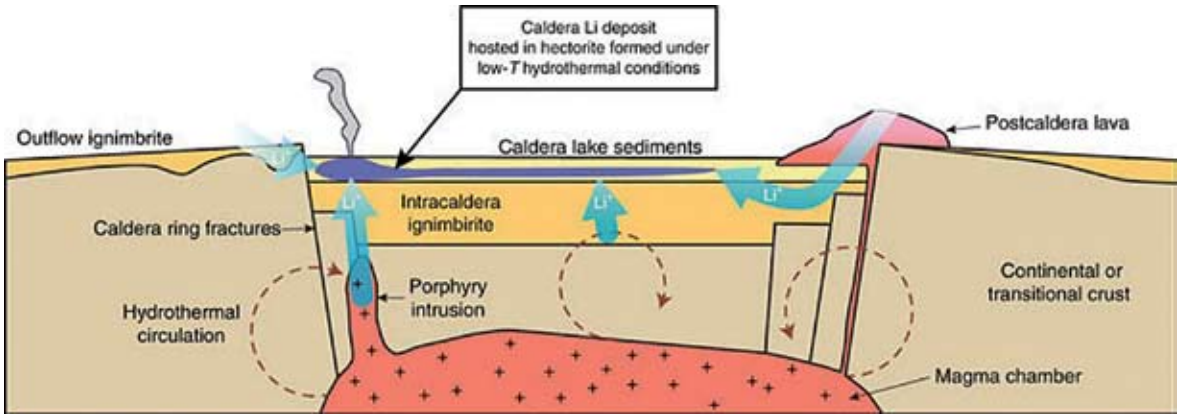
Ivanhoe Mines released positive results of an independent definitive feasibility study for the planned first phase of its Platreef project on the northern limb of the Bushveld Complex. The US$1.5 billion first phase of development envisages a mechanized underground mine and concentrator with an annual throughput rate of 4 Mt/a, producing 476 000 ounces of platinum, palladium, rhodium, and gold, plus 21 million pounds of nickel and 13 million pounds of copper per annum, based on Probable Mineral Reserves of 125 Mt at 4.40 g/t 3PE + Au. Initial concentrate production is expected by early 2022. There is potential for relatively quick and capital-efficient expansion to 6 and 8 Mt/a and beyond, using start-up infrastructure. The Platreef mine is projected to be the world's lowest-cost, and in time the largest single primary producer of platinum group metals, with a cash cost of US$351 per ounce of 3PE+Au, net of by-products, and including sustaining capital costs. Even at today's spot metal prices, the project would generate an operating margin in excess of 40%.

Platinum Group Metals Ltd. has begun definitive feasibility study engineering work on the Waterberg Project, including infill drilling, resource modelling, mine plan optimization, and infrastructure engineering. Engineering and design work to reduce and improve underground development and optimize the project scale and return will be part of the DFS. Detailed drilling targeting the higher grade, thicker portions of the deposit is in progress with the objective of moving portions of the deposit into the Measured Resource category and to investigate the best grade portions for inclusion in early mine planning. The work is at present wholly funded by 28.35% joint venture partner JOGMEC (the Japan Oil, Gas and Metals National Corporation) through an exploration earn-in commitment.

Atlatsa Resources is to place the loss-making Bokoni mine on the eastern limb of the Bushveld Complex, which it operates under a joint venture with Anglo American Platinum (AAP), on care and maintenance. AAP has agreed to fund all once-off costs associated with placing the mine on care and maintenance, as well as ongoing costs until 31 December 2019. Atlatsa has accepted a conditional offer from AAP to acquire the Central Block and Kwanda North prospecting rights, which adjoin AAP's Mogalakwena mining right on the northern limb of the Complex, for R300 million in cash.

## Other Geoscience News

Geoscientists at Stanford University and the US Geological Survey have shown that lacustrine sediments preserved within large intracontinental rhyolitic calderas have the potential to host large lithium-rich clay deposits. The study, which was published in *Nature Communications* [doi: 10.1038/s41467-017-00234-y], represents an important step toward diversifying the global supply of this energy-critical strategic resource. To identify the most promising targets for lithium exploration, the team analysed quartz-hosted melt inclusions from a range of tectonic settings, including the Kings Valley deposit in the McDermitt volcanic field on the Nevada-Oregon border, using the SHRIMP-RG ion microprobe at Stanford Earth. They found that that moderate to extreme lithium enrichment occurs in magmas that incorporate a significant proportion of felsic continental crust. Importantly, Li concentrations in melt inclusions show positive correlations with incompatible elements such as rubidium, and negative correlation with zirconium; hence the easily analysed trace elements can be used as a proxy for the original lithium concentration. Lithium leached from the rhyolitic lavas and ignimbrites by meteoric and hydrothermal waters can become concentrated in clays in caldera lake sediments to potentially economically extractable levels. A considerable amount of Li is also supplied by




eruption of post-caldera rhyolitic lavas and degassing of magma remaining in an underlying shallow magma chamber. Owing to the volumes of magma erupted, large calderas that preserve hydrothermally altered lake sediments have the potential to host high-tonnage Li clay resources similar to the McDermitt/Kings Valley deposit, which contains a resource of about 2 Mt of lithium carbonate equivalent.

*Schematic model for the formation of caldera-hosted Li clay deposits. Li is leached from ignimbrite and caldera-related lavas by meteoric and hydrothermal fluids and deposited in hectorite clays formed within ash-rich caldera lake sediments. Post-caldera magmatism contributes additional Li via lavas and outgassing of intrusions; it also generates hydrothermal systems focused along caldera ring fractures (Benson, T.R. et al., Nature Communications 8).*

**Antony Cowey**

Uganda

# THE GEOTRAVELLER

**By Roger Scoon**

## THE VICTORIA NILE, MURCHISON FALLS AND LAKE ALBERT, UGANDA:
*Rifting and River Capture*

*The western branch (Albertine Rift) of the East African Rift System (EARS) is a remarkable area of geomorphological and ecological diversity. The rapid and unusual diversification of species for which this region is renowned (Danley et al., 2012) can be ascribed to the unique geology, which in turn has created considerable climatic variability. The Albertine Rift is named after Lake Albert the largest lake in the Ugandan section of the rift. Lake Albert was once part of the giant palaeolake Obweruka which infilled large tracts of the Albertine Rift during the Late Miocene and Early Pliocene. The southern and western parts of Uganda have considerable potential for geotourism. The capture of the Victoria Nile, the Murchison Falls, and Lake Albert is described here.*

*Lake Albert is fed largely by the Semliki River, which flows northward from Lake Edward and includes streams draining the Ruwenzori Mountains. The Semliki River was the principal channel for the upper part of the Albert Nile during the Pliocene and Pleistocene, but recent tectonic activity has created an entirely new channel, the Victoria Nile. This section of the Nile exits Lake Victoria at Jinja and flows via Lake Kyoga into the rift over the Murchison Falls prior to entering the northern extremity of Lake Albert in a broad delta. These areas, together with some of the other well known national parks and reserves are located on a satellite image.*

*The geology of southern and western Uganda is dominated by the crystalline basement (Archaean and Proterozoic), the Gondwana-related uplift and erosion of basement terranes, and the faulting, volcanism, and lacustrine basins associated with the Albertine Rift (Miocene-Holocene).*

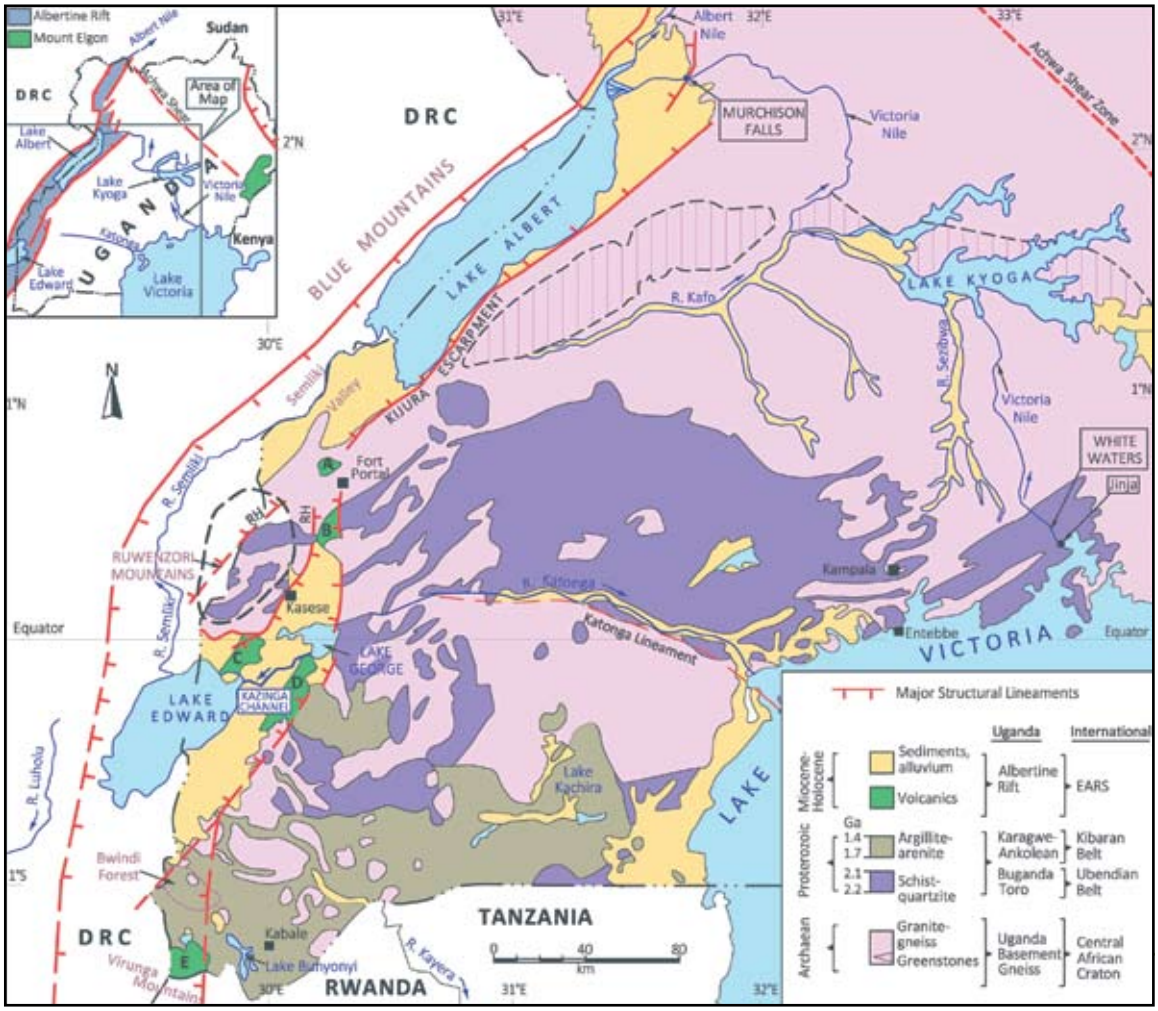
*The Archaean rocks in Uganda are divided into two broad groups, Ugandan Gneiss Complex and Nyanzian Greenstones. They are part of the Central African Craton, linking the older Tanzania and Congo cratonic nuclei (Dirks et al., 2015). The estimated age is between 2.75 and 2.55 Ga. The gneiss complex is dominated by granite-gneiss, typically found on regional plateaus covered by sandy soils or thick lateritic profiles. The greenstones include metavolcanics, cherts, shales, and banded iron formations, often cropping out in rugged hills. The greenstone hills have shaped some of the unusual drainage patterns of southern and western Uganda, e.g., the River Kafo east of Lake Albert.*

*Two Proterozoic terranes are recognized in southern and western Uganda: the Buganda-Toro (2.2-2.1 Ga) and Karagwe-Ankolean (1.7-1.4 Ga) Systems. The former is correlated with the high-grade Ubendian Belt (Dirks et al., 2015). This is comprised of thick sequences of argillite, schist, and quartzite, with lenses of amphibolite occurring in the lowermost part. The latter is correlated with the low-grade Kibaran Belt (Dirks et al., 2015). These rift-related sequences consist of sandstone, conglomerate, and shale in the lower part with molasse-like, coarse clastics in the upper part. Both of these metamorphic terranes may be associated with areas of high relief, including linear hills.*

*The regional plateaus that characterize large areas of east and southern Africa developed in response to uplift associated with the break-up of the supercontinent of Gondwana (approximately 180-35 Ma). The paucity (or absence) of Palaeozoic and Mesozoic strata, with the exception of small inliers of Karroo Supergroup on the shores of Lake Victoria can be ascribed to either their non-development or the cycles of erosion which accompanied uplift.*

*The EARS is causing the African Plate to potentially separate into two plates, a western or Nubian Plate and an eastern or Somalian Microplate (Ebinger, 2005).*


*Google Earth image of part of Uganda. Lakes Albert and Edward in the Albertine Rift, demarcate the western boundary with the DRC. The Victoria Nile exits Lake Victoria at Jinja and flows northwest into Lake Albert via the sinuous Lake Kyoga.*




*Geological map of part of Uganda simplified from the 1:1.500.000 scale map compiled by R. MacDonald and published by the Department of Geological Survey and Mines, Uganda (1966).*

*The major structural lineaments, including the Ruwenzori Horst (RH) are greatly simplified. The volcanic terranes in the Albertine Rift (A-E) are younger than the Mount Elgon Volcanics on the Kenyan boundary.*

*Large areas of the Basement terranes in Uganda are covered by thick lateritic profiles and recently deposited gravels and alluvium, such as in this quarry near Mbarara.*

*Faulting and volcanism associated with the Albertine Rift can be related to a deep-seated magma plume which spread southward from the Ethiopian segment of the EARS, during the Oligocene at approximately 30 Ma. The main phase of rifting probably commenced in both the Albertine Rift (Uganda; DRC) and Gregory Rift (Kenya) in the Late Miocene at approximately 12 Ma (Morley et al., 1999). The Albertine Rift differs from the Gregory Rift in that it has a much lower volcanic output and hosts a chain of giant, deep, freshwater lakes in comparison to the small, mostly alkaline lakes found in the latter.*

*Formation of the Albertine Rift persisted from the Late Miocene through the Pliocene-Pleistocene epochs with development of major boundary faults. Some of these are associated with regional escarpments. To the west of Lake Albert, situated at an altitude of 615 m, is the Blue Mountains (heights of almost 2.000 m), and to the east is the Kijura Escarpment. Large sections of the Albertine Rift, however, are structurally segmented into half-grabens; the sequence of boundary faults alternates between the eastern and western boundaries.*

*This unusual geometry has been impacted by basement highs. The most prominent of the basement highs located wholly within the rift is the Ruwenzori Horst. This uplifted block is comprised partly of the Uganda Gneiss Complex, and partly of the Buganda-Toro System. The 120-km long Ruwenzori Mountains, formerly known as the Mountains of the Moon, includes Mount Stanley (5.109 m), the third highest peak in Africa.*

*Despite the Holocene being a relative quiet epoch with modest seismic activity and volcanism, there have been*

*View looking southwest along the Kijura Escarpment, eastern boundary of the Albertine Rift, near the Kibiro Geothermal field.*

*several large earthquakes in the Albertine Rift of western Uganda. A magnitude 7 event in 1966 resulted in 157 fatalities in the Semliki Valley and a magnitude 6 event in 1995, caused a 20 km long crack to appear in the Fort Portal region (Roberts, 2007). Most earthquakes are deep-seated (27-40 km) and the rift has a higher than average heat flow. The Semliki Valley has revealed some important archaeological finds, including evidence of Plio-Pleistocene hominins.*

*The EARS has severely impacted drainage patterns within the heart of the African continent (Beadle, 1981). The Albertine Rift captured the upper parts of the Nile River (the Victoria Nile). The course of the Congo River, which may originally flowed eastward, was also affected (Stankiewicz and De Wit, 2006). Prior to the main phase of rifting at 12 Ma, the Kafo, Katonga, and Kagera rivers were part of the westward drainage towards the Atlantic Ocean. The linear basin that opened east of the upper reaches of the present-day Congo River – the initial manifestation of the Albertine Rift - changed this pattern, forming an area of internal drainage with extensive swamps. As uplift on the western escarpment persisted, the westward-flowing rivers were trapped, enabling formation of the giant (550-km long) palaeolake Obweruka (estimated age of 8-3 Ma). This palaeolake may have originally linked all of the large lakes in the northern part of the Albertine Rift, including Tanganyika, Kivu, Edward, and Albert.*

*At approximately 3 Ma, a further phase of rifting caused escarpments to develop along the eastern side of the Albertine Rift. Reactivation of horst blocks within the rift caused the palaeolake to divide into several compartments. Lakes Edward and Kivu were divided by the active volcanism of the Virunga Mountains. Lakes Albert and Edward were split by the Ruwenzori Horst and overflowed into the Semliki Valley to create a new (temporary) westward-flowing river that exploited the Beni Gap in the DRC.*

*Lake Victoria with an area of 68.800 km$^2$ is unusual for the African Great Lakes in that it occurs in a shallow warp located between the Albertine and Gregory Rifts. The relatively shallow depth (<100 m) and rectangular outline contrasts with the deep finger lakes of the Albertine Rift. A maximum age of 1.6 Ma is estimated from sediments exposed on the shores of the Kavirondo Gulf, Kenya (Kent, 1944). As rifting progressed, however, the basin tilted eastward to expose sediments in the Kagera Valley, Uganda (at an altitude of 150 m) with an age of 0.8 Ma (Doornkamp and Temple, 1966). The lake is underlain by a 60 m-thick sediments, consistent with approximately 40.000 years of deposition.*

*Lake Victoria was initially filled from rivers (headwaters of the Katonga and Kagera) blocked by the rise of the eastern side of the Albertine Rift. Renewed episodes of uplift on the western side closed the Beni Gap, such that rivers in the Albertine Rift drained northward into the Albert Nile. During this phase of activity, the main outflow from Lake Victoria was by the Katonga River into Lakes Edward and George. This system subsequently fed into Lake Albert and the Albert Nile via the Semliki Valley. At this time, the Kafo River flowed westward directly into Lake Albert.*

*Development of a gentle upwarp part way between the Albertine Rift and Lake Victoria, at approximately 30.000 BP, resulted in further changes to drainage patterns. The flow of the Kafo River was reversed and a closed system, including the sinuous Lake Kyoga developed. The connection between Lakes Edward and Victoria was terminated and the River Katonga began flowing eastward. The rise in water entering Lake Victoria caused a new outlet to form, at Jinja, and the Victoria Nile was borne. The connection of the Victoria Nile with the Lake Kyoga-River Kafo system is estimated to have occurred at approximately 13.000 BP (Talbot and Williams, 2009).*

*Numerous desiccation events, mostly associated with the Late Pleistocene Ice Ages (0.68 Ma-12.000 BP) have been identified in East Africa. During some of these events, Lake Victoria dried entirely. The rivers currently observed are estimated to have flowed only since the end of the Ice Ages. Lake Victoria is fed by numerous rivers, all of which can be envisaged as headwaters of the Nile River. Some researchers place the source of the Nile with the River Kabega and one of its tributaries, either the Ruvyironda, which rises in Burundi, or the Nyabaronga in Rwanda.*

*The exit of the Victoria Nile from Lake Victoria at Jinja includes a memorial commemorating the "discovery" by John Hanning Speke (Speke, 1863). This was considered a major achievement in Europe at the time as the ancient*

*The Owens Dam on the Victoria Nile with views of the regional plateau capped by resistant metamorphic rocks of the Buganda-Toro System*

*The Wildwaters Lodge, Kangulumira is located on an island in a fast-flowing, yet wide section of the Victoria Nile. The swimming pool is rimmed by pink coloured granite-gneiss of the Uganda Gneiss Complex.*

*Greek and Roman travellers didn't penetrate the swamps of the Sudd. The disputes and counterclaims by Richard Burton (Burton, 1860), who was more widely travelled and a more successful explorer except in this one arena, make for interesting reading. The exit from Lake Victoria has changed due to construction of the Owens Dam (in 1954) which submerged the narrow ravine and Ripon Falls. The upper section of the Victoria Nile has carved a shallow channel through the metamorphic rocks of the Buganda-Toro System. There are few deposits of silt or alluvium, indicative of the youthfulness of the channel.*

*North of the Owens Dam, the Victoria Nile has cut a shallow gorge that includes the Bujagali and Kyabirwa Falls. This section of the river is used for white-water rafting. The luxury resort of Wildwaters is located in the riverine forest of Kalagala Island, an equatorial setting (00°35'N; 33°81E) near Kangulumira. The river here is over 1 km in width and includes numerous rapids as well as the Ithanda Falls. Kalagala Island is dominated by pink granite-gneiss of the Uganda Gneiss Complex. The falls and rapids may have developed where the river channel has changed from the softer amphibolite of the Buganda-Toro System onto the harder rocks of the Uganda Gneiss Complex.*

*The granite-gneiss of the Uganda Gneiss Complex is intruded by dark amphibolite dykes of the Buganda-Toro System, Wildwaters Lodge.*

*The most impressive site on the Victoria Nile between Lakes Kyoga and Albert is the Murchison Falls. Discovered by explorers Samuel and Florence Baker but named after Roderick Murchison, president of the Royal Geographical Society. Some 300 $m^3$/second of water are forced over a height of 43 m from the wide river above the falls into a narrow gorge. There is some debate as to whether the Bakers observed the Murchison or the Uhuru Falls, the latter related to a secondary channel north of the main falls which was dry for many years but flooded during the anomalously heavy rains of 1962. The 1962 flood also destroyed a small bridge (known as Churchill's Ten*

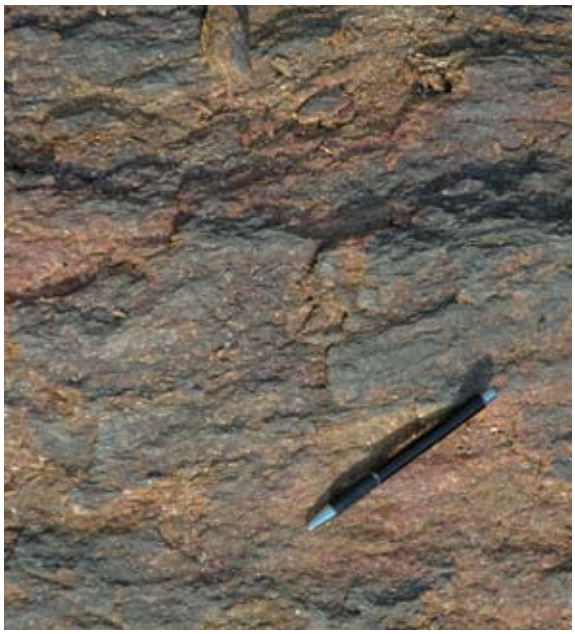
*The Victoria Nile is constricted from a wide channel into a narrow ravine at the Murchison Falls.*

*Pound Bridge after comments he made during a visit in 1902) which was built to access a view site in 1960, at which time the northern channel was dry.*

*The Murchison-Uhuru Falls are located near the eastern edge of the Albertine Rift, demarcated by several small faults including the Bunyoro Escarpment. Proximal to the falls the escarpment forms a small step in comparison to the larger escarpment further north. The falls have developed on the contact between the resistant granite-gneiss of the Uganda Gneiss Complex of the regional plateau and the softer rift-related sediments of the Lake Albert basin.*

*The southern entrance to the Murchison Falls National Park (which covers an area of 3.840 km$^2$) is via a car ferry at the Paraa crossing where the 2-km wide river is far more sluggish and has formed a deep, alluvium-filled channel in the rift-related sediments. The banks of the Victoria Nile in this area are rimmed by riverine forest. A well known site is the "African Queen", a tourist boat commemorating the usage of this area for scenes in the 1951 film of C.S. Foresters book (which was based in Burundi and Lake Tanganyika). Boat trips can be taken upriver to the gorge and to the delta where the river enters Lake Albert. The river provides unsurpassed opportunities for bird watching, including nesting colonies*

*The Victoria Nile has carved a narrow gorge in the resistant rocks of the Uganda Gneiss Complex at the Murchison Falls, beneath which it forms a wide channel within the softer sediments of the Albertine basin.*



*The Uganda Gneiss Complex at Murchison Falls is intensely sheared.*

*The lower reaches of the Victoria Nile in the Murchison Falls National Park are fringed by riverine forest with hardwoods, including African mahogany, and borassus palms.*

*of kingfishers and bee eaters and one of the few sites where the endangered shoebill stork can be readily observed. The delta includes low-lying islands and a myriad of channels associated with infilling of the rift by relatively young sands and gravels. Some islands may have formed due to papyrus grasses and floating masses of water hyacinth capturing river silt. Villagers may be observed fishing from canoes in the delta, but this area is hardly touched by tourism and few boats are observed on the lake.*

*Lake Albert lies in an area where the base of the Albertine Rift is estimated to have sunk some 4.000 m during the past 12 Ma. This is the northernmost of the African Great Lakes with a surface area of 53.000 km$^2$, length of 150 km and width of 35 km. The lake is fresh water and has a maximum depth of 58 m. The main inflow is the Semliki River. The water of the Victoria Nile (notably less saline than the lake) enters so close to the outlet that even during floods the ingress has barely any influence. The location between two major escarpments, as noted above, makes the lake susceptible to strong winds. Catastrophic storms are common, such as occurred in December 2016 when a large number of people lost their lives when a ferry capsized.*

*The Lake Albert basin includes the Kibiro Geothermal*

*The Lake Albert delta of the Victoria Nile includes a myriad of channels and small islands. The water hyacinths (introduced from South America) have survived the passage from Lake Victoria where this floating weed is a major ecological problem.*


*Aerial view looking south along the Albertine Rift with Lake Albert (foreground) constrained between the Blue Mountains, DRC (right) and Kijura Escarpment, Uganda (left). The triangular-shaped delta of the Victoria Nile (left) and outflow of the Albert Nile (left centre) are visible in the immediate foreground. Background includes a compressed view of the Semliki Valley, Ruwenzori Mountains, and Lake Edward. Just visible in the distance is Lake Kivu, Rwanda/DRC. (http://earth.imagico.de/views/rift_new4_large.jpg).*

*field, located on the eastern shores at the foot of the 300-m high Kijura Escarpment (Natukunda, 2010). The escarpment includes outcrops of the Uganda Gneiss Complex, but the valley floor is dominated by rift-related, mostly lacustrine sediments with a total thickness of more than 1.200 m. The area includes several hot springs and petroleum seepages, the latter having initiated extensive prospecting in recent years.*

*Photographs by the author except where referenced*

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