Geological Society of South Africa

geobulletin

QUARTERLY NEWS BULLETIN ~ JUNE 2016

VOLUME 59 NO. 2

35TH INTERNATIONAL GEOLOGICAL CONGRESS

IGC is here!

XXXV GEOLOGORUM CONVENTUS · CAPE TOWN · 2016 · SOUTH AFRICA · MENTE ET MALLEO

news

35TH INTERNATIONAL GEOLOGICAL CONGRESS

27 AUGUST - 4 SEPTEMBER 2016 | CAPE TOWN, SOUTH AFRICA

The International Geological Congress (IGC) is the principal event of the International Union of Geological Sciences (IUGS), one of the largest and most active non-governmental scientific organizations in the world. The IUGS promotes and encourages the study of geological phenomena, especially those of worldwide significance, and supports and facilitates international and interdisciplinary cooperation in the earth sciences.

The event will be a Pan African experience with the support of the major African geoscientific societies and related organisations. A large number of African delegates are expected to attend and field trips are planned to all parts of the African continent.

The Congress will have a very extensive technical programme, featuring papers, posters, short courses and workshops. Principal themes are: Geoscience in Society, Geoscience in the Economy and Fundamental Geoscience. Your contribution to this program is crucial.

Please contact Prof Laurence Robb at Laurence.Robb@earth.ox.ac.uk for more information.

giya ngomhlaba
dance with earth

www.35igc.org

IUGS International Union of Geological Sciences | GSSA Geological Society of South Africa | Council for Geoscience | UNESCO United Nations Educational, Scientific and Cultural Organization — Under the patronage of UNESCO

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Geological Society of South Africa

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Contributions for the next issue should be submitted by:
12th August, 2016.

Geobulletin is provided free to members of the GSSA. Non-member subscriptions per four issue volume are R350.00 for South Africa. Overseas and rest of Africa, R350 plus postage. Surface mail, R200.00. Airmail, R300.00. The views expressed in this magazine are not necessarily those of the GSSA, its editor or the publishers.

ADVERTISING RATES (Excl. VAT & Agency Commission): Geobulletin is published by the Geological Society of South Africa (GSSA) and appears quarterly during March, June, September and December each year.

2016 RATES: Jann Otto 082 568 0432

For detailed prices, mechanical and digital submission requirements, please contact the GB advertising co-ordinator, editor (see Contents Page for contact information) to obtain an up-to-date Rates Card or other information.

DEADLINES FOR COPY AND ADVERTISING MATERIAL are 15th February (March 2016 issue), 14th May (June 2016 issue), 12th August (September 2016 issue) and 10th November (December 2016 issue).

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from the editor's desk

Chris Hatton

The 35th International Geological Congress is taking place at a time when the importance of geology to other disciplines is on the rise. At one end of the time scale, the formation of the earth appears to have influenced the composition of the sun. Other stars show similar effects so geology is moving into the main stream of astronomy. At the other end of the time scale climate cycles, rooted in fundamental geological processes, directly influence events that are recorded in archaeology, mythology, history and indeed, are visible in our daily lives – as a striking example see the image on p. 31 of Hayley Cawthra's article, and have some sympathy, if you will, for those KZN coast dwellers who can expect their stroll to the seaside to be uncomfortably abbreviated every couple of decades or so. The widening influence of geology is recognised in the arrangement of the Scientific Programme of the IGC into three topical themes, one of which, Geoscience and Society directly addresses the increasing impact of geology on all aspects of modern life.

A great stream of data creates the flow that drives modern geology. In this issue the Universities of Stellenbosch and Johannesburg report on mass spectrometers they have recently acquired. In addition to providing the necessary geochronological framework from the dating of radiogenic isotopes in zircon and monazite, these instruments also explore the frontiers of science that analysis of stable isotopes is revealing. At the University of Stellenbosch trace element analysis will extend beyond the traditional rock matrix to other matrices, facilitating the expansion of geology into other disciplines.

The co-operation between the University of Johannesburg and the University of the Witwatersrand, begun with the establishment of CIMERA, continues with the building at Wits of the clean lab to prepare the samples for subsequent analysis at UJ.

On the global stage the analysis of meteorites continues to yield insights into the early evolution of the earth. Closer to home, while diamonds and their inclusions provide natural probes into the bowels of the earth (see the ad for the upcoming 11th IKC on p. 8), it is the extraordinary record preserved in the crust that yields the fundamental clues to the evolution of life and earth. As Spike McCarthy and Bruce Rubidge have documented in their ground-breaking book, nowhere in the world is this co-evolution better recorded than in South Africa. The record begins in the Barberton Mountain Land where the Viljoen twins' discovery of komatiite triggered the ongoing investigations which have revealed such extraordinary evidence of processes on the Early Earth that this area is likely to become a World Heritage Site, as Tony Ferrar tells us on pp.34-36 of this issue. One of the issues that Tony highlights is the question of how the earliest continents grew – plate tectonics generates subduction, considered be to the factory where continental crust in generated, but in Barberton there is also evidence for other mechanisms of continental generation. The research to understand how the early earth works falls within the core topic of the IGC – Fundamental Geoscience. The efforts to simultaneously preserve the geosites and to make their message accessible in a World Heritage site epitomise the focus of the core topic, Geology and Society. Gold has been mined for over a hundred years in Barberton so the area is also relevant to third core topic of the IGC, Geoscience in the Economy. The Barberton Mountain Land thus perfectly exemplifies the three core themes of the 35th IGC.

Of course Barberton is not the only site of superlative South African Geology. To mark the occasion of the 35th International Geological Congress the South African Post Office will be releasing the set of 10 stamps conceptualised by Pieter Bosch and illustrated by Rachel-Mari Ackermann (see p. 7). In addition to Barberton, the stamps depict the Karoo Supergroup, the Table Mountain World Heritage site, the Griqualand West Supergroup, a kimberlite pipe, the Witwatersrand Supergroup, the Phalaborwa Complex, the Vredefort impact site and the Cradle of Humankind World Heritage Site. Each of these sites have rich narratives similar to Barberton (and there are other sites which could have been added to this list). The stamps are a compact and complementary enhancement of the commitment of the Local Organising Committee to spread geology beyond the narrow confines of the professional geoscientist. In a hundred years the sharp distinctions of modern science may have dissolved as the global brain that is the internet become accessible to all. Although it will probably not be possible to precisely mark the time when these boundaries disappeared, the Local Organising Committee will have been justly rewarded if those looking back say "Yes, it was sometime round about the 35th International Geological Congress that geology moved into the mainstream."

Chris Hatton

executive managers corner

Craig Smith

Organization of the 35th International Geological Congress in Cape Town at the CTICC (August 27 to September 4) is proceeding. See www.35igc.org for the latest information. The abstract submission date is now closed, with over 5000 abstracts from 93 countries having been received and adjudicated. The detailed technical program will appear in early June, and readers are reminded that the meeting will represent a superb opportunity to see some great earth science from around the globe, as well as to network with the global community, without having to incur international travel expenses. Industry participants are welcome, and for those of you who may not be able to make the full week, day registrations are available. The Workshops and Field Trips are seeing steady bookings, and over the next month or so the organizing committee will decide on which go forward and which need to be cancelled. Some of the field trips are over booked, and some have been cancelled due to lack of interest to this point in time. For the field trips in particular it is important to book early because the go – no go decision points are coming very soon; conversely some trips are already full.

There are still sponsorship and advertising opportunities available, as well as some exhibition space. Exposure at the conference need not break the bank, and interested parties are encouraged to visit http://www.35igc.org/Verso/45/Sponsors. Straight advertising opportunities are also available; see http://www.35igc.org/Verso/44/Exhibitors-Advertisers#advertisers.

The GSSA will have a large stand in the Exhibition Hall, manned by Lully, Sally, myself, two student volunteers, and the President and Vice Presidents at varying times. There will be a coffee machine (!) and a networking space, so come visit and have a chat during the conference.

In April, members were reminded via the monthly newsletter that the request for comment on the proposed amendments to the Mining Charter had been issued by the Department of Mineral Resources, and some of you presumably have responded in your personal capacity. The GSSA management committee (Manco) formulated and submitted a GSSA comment, and that has been posted on the website.

In late 2015, the GSSA ran an experiment with the Technical Library, a newly established and independent information centre based in the Chamber of Mines. The long disused Chamber library has been revamped and rehabilitated, and the Technical Library is a potential resource for use by companies or consultants that do not have the financial capacity to sustain in-house information centres. The experiment in 2015 indicated there was a need for this service, and the GSSA will pay a small monthly fee so that GSSA members will pay a reduced fee. See http://www.techlibrary.co.za/Home/ for more information. The special rates for GSSA members will commence on July 1. The office will be sending out information messages during June.

The Annual General Meeting is scheduled for July 7 at the Johannesburg Country Club (Auckland Park) and will immediately follow the 'geophysics for geologists' short course being staged in collaboration with SAGA. As in past years, the AGM will take the format of a reasonably short business meeting followed by a light meal with networking. This is a great opportunity to catch up with friends and colleagues, as well as engage office bearers of the GSSA.

The GSSA extends its congratulations to Professor Lew Ashwal for being selected as a finalist of the National Science and Technology Forum (NSTF) award program, in the Lifetime Award category. Congratulations also to Umvoto Africa (Ms. Rowena Hay) for being a finalist in the Research Leading to Innovation SMME category. Those of you in the Cape Town region will know Umvoto as one of the expert consultancies operating particularly in the Cape region, with a focus on geohydrology.

Craig Smith

Notification to our Members

As most of you will be aware, the GSSA communicates with its members and other interested parties using a number of media, including Geobulletin, the monthly digital newsletter, the Facebook page, the website, and electronic mail drops. Because of slow and unreliable delivery we seldom use post, except for Geobulletin and the SAJG.

The GSSA has two problems that only members can assist with resolving. First, we receive numerous returns of undelivered copies of SAJG and Geobulletin. This is expensive, environmentally unfriendly, and also wasteful – particularly so for the weightier SAJG. If you do not want the print copy of the Journal and wish to access on-line through the website portal, please notify the office accordingly. Alternatively, if you do wish to receive a physical copy of the journal please ensure that your mailing address in your member profile is correct. For the near future at least we will continue to deliver SAJG and Geobulletin by post, but please also note that it is available in digital format on the website.

The second problem we face is bounced email notices. The GSSA uses a bulk mailer to advise members of upcoming events or important notices, as well as to distribute the end month newsletter. On average, you should be receiving three to five messages per week, and we promise not to bombard you with endlessly repeated notifications or spam. While there is precedent for some cost recovery for distribution of paid messages, this is seldom used and the office is very cognizant of not allowing naked product advertisements. The GSSA does not on-sell its database.

The office currently receives notice of 225 bounced emails per mail drop, which does not include members who choose to unsubscribe. If you are not receiving regular notices but would like to, you need to check that the email address we have for you is correct in your membership profile.

With the best will in the world, the office staff is not skilled at mind-reading from afar – at least most of the time. If you change your contact details you need to update your profile, and it won't hurt to notify the office at info@gssa.org.za.

Craig Smith (Executive Manager)

president's column

Jeannette McGill

And seemingly without blinking it is already the middle of the year!

Just this morning I received the very sad and unfortunate news of a Fellow (Jeremy Hawksworth), who unfortunately passed away after suffering a heart attack at the combined GSSA/SAIMM Samcodes conference. Our profound condolences go to his family and friends. This together with my mother suffering a small heart attack over in Australia has really made me stop and consider the fragility of live and how quickly things can change. Inevitable, I do realize – but sobering never the less. Being a part-time mountaineer I've also been glued to social media this week "watching" numerous Everest summits. After nearly 2 months of patient acclimatization rotations teams now made their final summit push. And here too achievements by many have also been marred in sadness due to the unfortunate deaths and disappearances of others.

However I don't want to cloud this Geobulletin with sombre happenings. I would rather focus on mindfully observing and experiencing what life is throwing our way. While we often think life is so busy we can gain from slowing down. For me two things spring to mind immediately:

The first is "our" very own International Geological Congress (IGC) that will be held from 28 August till 4 September. I was reading a paper summarizing the activities of the IGC held previously in 1929. On comparing how vastly different these two offerings are, what is quite astounding is the progress of time and the impact of modernization on an event of this calibre. The Local Organizing Committee has worked so very hard over the past 4 years to take this idea to a full sized conference. From the superb technical program, to the wide and varied geological fieldtrips, to the workshops and accompanying persons program we believe that all delegates arriving in Cape Town will

be proud of their geological heritage. I really do encourage anyone who has a spare few days over this time to come to Cape Town and become part of this conference. It is not easy putting on such an international conference during a significant slump in commodities markets. Garnering financial support has proven exceptionally difficult but yet I wish to thank all those parties that have provided support - we thank you.

The second was Hack Jozi – or more fully: the City of Johannesburg Hackathon. Hackathons are fast becoming exciting platforms for technology entrepreneurs to solve problems. While some observers berate the pace of the event which sometimes means that not sufficient answers can be provided, the Hack Jozi event has taken two months. During this time 400 hopefuls were whittled down to the final 10. Financial awards were made to the top three and the number one prize was R1 million. I was fortunate enough to join the judging panel for the final two rounds. This view into the broader sectors beyond mining, watching a younger generation at work was hugely optimistic. The top three provided tangible solutions in three areas that are significant pain points: public health care, access to education, and municipal work management. The solutions were bold and brave and coupled with immense enthusiasm.

It is sobering to remember how evitable life can be or how quickly circumstances can change. Ttaking a step back and reflecting on other happenings that will have a positive impact on our geological community and society at large is certainly one way of seeing the opportunity in the future.

Dr. Jeannette E. McGill

35th International Geological Congress, 27 August – 3 September 2016, Cape Town, South Africa

World class line-up of speakers include:

Prof Chris Hawkesworth,University Of Bristol • Ms Ruth Allington, GWP Consultants.
Prof Bob Scholes, University Of The Witwatersrand • Prof Michel Jebrak, University Of Quebec, Montreal
Dr John Anderson, Nelson Mandela Metropolitan University • Prof Joe Cartwright, University Of Oxford
Prof Thomas Graedel, Yale University • Prof. Mustapha Meghraoui, Strasburg University

Abstracts: With almost 5000 abstracts received to date for the congress, abstract submissions are now officially closed. Thank you for all your submissions.

Accommodation: August/September is peak tourist season in Cape Town and we encourage delegates to pre-book early to avoid disappointment. Take advantage of the negotiated rates for the congress.

Book online:
https://allevents.eventsair.com/trust/35igcaccom

Field trips: Bookings are now open, please visit the website for full itineraries and prices. http://www.35igc.org/Verso/173/Field-Trips

Registration: Take advantage of the Early Bird registration which closes 31 May – save and book now – https://allevents.eventsair.com/35igc/register35igc/Site/Register

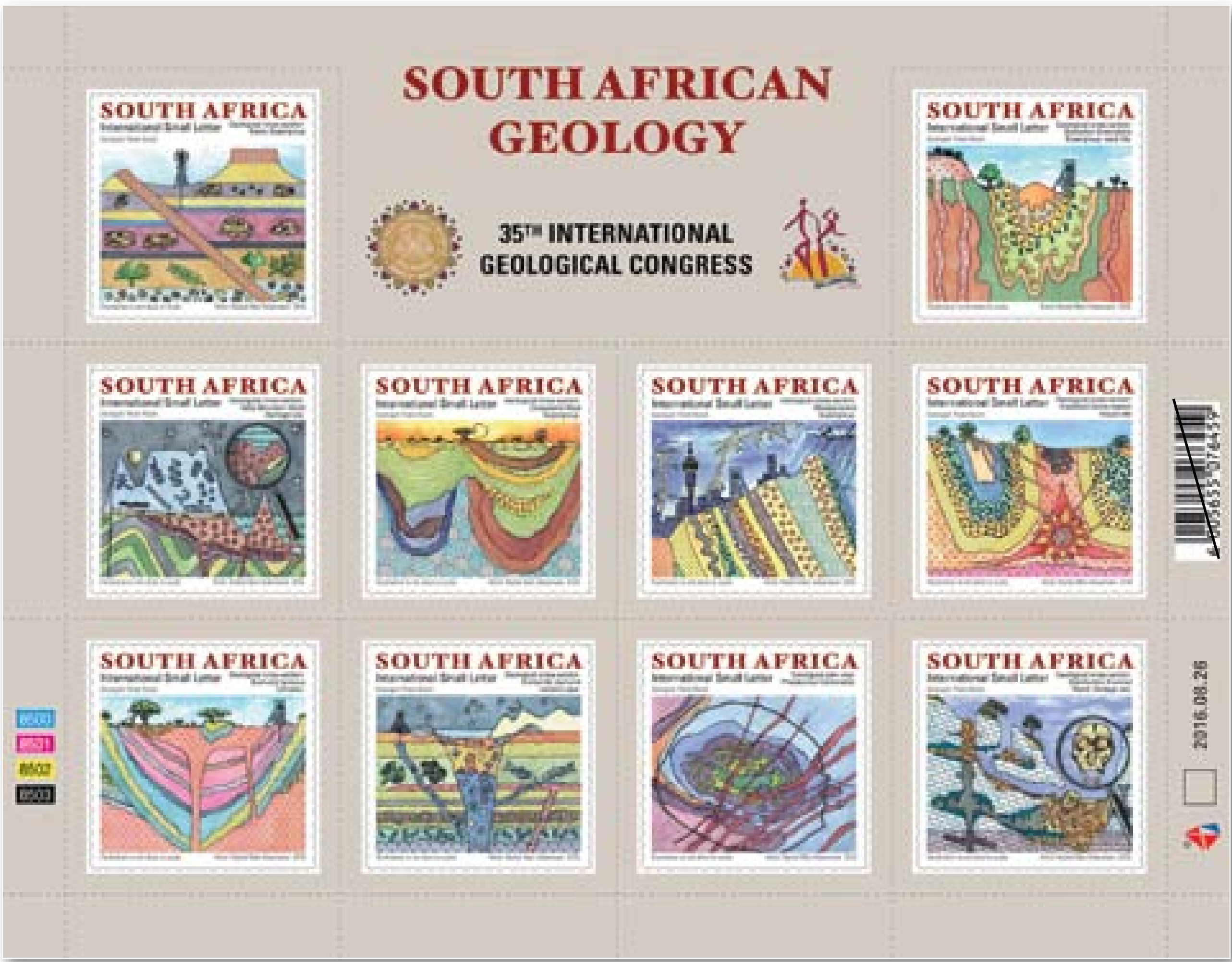
Workshops and short courses: –26 professional development workshops can be booked when you register - http://www.35igc.org/Verso/210/Professional-Development-Workshops-Short-Courses

SOUTH AFRICAN GEOLOGY STAMP ISSUE

35TH INTERNATIONAL GEOLOGICAL CONGRESS

The SA Post Office will issue a special commemorative stamp issue to celebrate the 35th International Geological Congress in Cape Town, South Africa. The SA Post Office worked in close collaboration with the steering committee for the congress and the Council for Geoscience (CGS) on this project. The concept designs for these stamps were researched and drawn by South African geologist, Pieter Bosch of the CGS and the artwork was illustrated by artist, Rachel-Mari Ackermann of Philatelic Services, a division of the SA Post Office. The stamps will display ten magnificent South African Geological Superlatives. The SA Post Office plans to launch the stamp issue at the congress on 26 August 2016. These products will surely add to the excitement of the momentous occasion!

AVAILABLE FROM 26 AUGUST 2016



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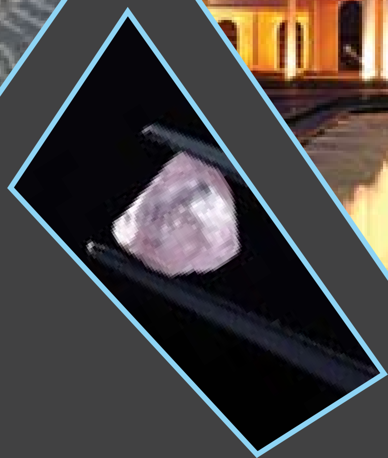
11th International Kimberlite Conference

Gaborone, Botswana

18-22 September 2017

50 Years Of Diamonds In Botswana



Conference Themes

- Emplacement and Economic Geology of Kimberlites and Related Magmas
- The Diamond Substrate – Petrology and Geochemistry of Earth's Mantle
- Geology and Gemmology of Diamond
- The Origin and Evolution of Kimberlites and Related Magmas
- Diamond Deposits – Exploration and Mining
- The Structure of Cratons

Field Trips

- Desert Gems – Botswana's Major Mines
- The First Gems – Kimberley and Surrounds, South Africa
- Highveld Gems – from the Pre-Cambrian to the Cretaceous, South Africa
- Highland Gems – Lesotho's Diamonds in the Sky
- Rivers that Sparkle – the Alluvial Deposits of Central South Africa
- Ocean Gems – the Marine Placers of Namibia
- Zimbabwe Gems – Murowa and the Enigmatic Marange Deposits
- Kalahari Gems – Botswana's Newest Mine
- Gaborone – Day Trips

Photo credits left to right: Orapa North Kimberlite, B Scott Smith; Zebra, S Smith; Orapa Mine, M Brook; 1.79ct Diamond, Lucara Diamond Corporation; Gaborone International Convention Centre;Diamond Trading Centre, U Mark.

www.11ikc.com

all the news fit to print

STELLENBOSCH

In this issue we concentrate on developments on the analytical side of things.

New Instruments

The ICP section of the CAF ICP-MS & XRF unit (housed in the Geology Building) recently installed two state-of the-art instruments, funded by the NRF. The Agilent 7900 quad ICP-MS is ultra-sensitive and has the capability of measuring sub-ppt levels (< 1 part in 10^{12} parts) of metals such as Cd, while simultaneously quantifying, for example, percent-level concentrations of Na. This ability minimizes the need for sample dilution and therefore errors in sample handling.

The instrument's fast acquisition times make it possible to detect and quantify single nanoparticles. The Agilent 8800 QQQ ICP-MS, the only one of its kind at a tertiary institution in South Africa, is unique in its capability of ultra-trace analysis in difficult matrices. It accomplishes this through its use of an octopole collision cell located between two quadrupole mass filters. This tandem mass spectrometer configuration provides two separate mass-selection steps, which provides full control over the ion/molecule chemistry within the cell. The first quadrupole allows only the ions of a given mass-to-charge ratio into the gas-pressurized octopole cell, rejecting all the ions at all other mass-to-charge ratios. The second quadrupole then selects only the ion of interest emerging from the cell, and rejects ions with all other mass-to-charge ratios. As usual, the facility undertakes both internal and external work, for a wide variety of academic and industry clients.

Our Element 2 SF ICP-MS and Resolution 193 nm laser-ablation system (on the left). These are used for U-Pb geochronology on minerals such as zircon and monazite.

This is our other Resolution 193 nm laser-ablation system connected to the Agilent 7700 ICP-MS and used for whole-rock trace-element analysis. The laser can also be connected to the Agilent 8800 QQQ ICP-MS for high-sensitivity trace-element or U-Pb isotope measurements.

This picture shows the large-format sample cell fitted to the laser. It can hold up to 15 round block mounts, as well as a combination of these and thin sections, to maximize sample throughput.

A Request for Assistance

One of our MSc students (Shane Doggart) is undertaking a study of the timing of emplacement and Nd-Sr isotope tracing of pegmatites from the Orange River Pegmatite Belt (N. Cape and S. Namibia). Part of his project involves U-Pb dating of columbite-tantalite ('coltan') by LA-ICP-MS.

We currently have coltan specimens from: Noumas; Jakalswater; the Homestead Mine (Tantalite Valley, Namibia); Riemvasmaak, Konkoonsies; and Mica Kop (Kenhardt area). However, we have found it difficult to obtain more material.

We are therefore asking whether any Geobulletin readers who may have columbite-tantalite specimens from the Orange River Pegmatite Belt, from known pegmatite mines/localities, might be willing to donate small amounts of material (mm^3 to cm^3 pieces) to assist with Shane's study. If you are willing to donate material, please contact either Shane (doggartshane@gmail.com) or his supervisors, Ian Buick (buick@sun.ac.za) or Dirk Frei (dirkfrei@sun.ac.za). In return, if it proves possible to date the your coltan we will let you know the age as well as acknowledge your donation in the resulting publication.

John Clemens

UJ

UNIVERSITY OF JOHANNESBURG

On the 1st June 2016, the laser ablation multi-collector ICPMS laboratory at the University of Johannesburg was officially opened, in the presence of representatives of various universities, government institutions and companies. The NRF-NEP-funded Nu Plasma MC-ICPMS with ASI Resonetics ArF Excimer laser is already proving to be a powerful tool for a range of analyses. Zircons from Antarctic rock samples have been dated in order to constrain tectonomagmatic events associated with the formation of Gondwana, while their Hf isotope composition sheds light on the crustal structure of the arc where magmatism took place. Another application is the laser ablation Sr isotope analysis of plagioclase from Bushveld drillcore, used to address the question whether the different lobes of the Complex are closely related to each other.

As with any piece of state-of-the-art analytical equipment, there have been the expected teething problems, which now seem to have been overcome. The official opening was the sign that the lab is 'open for business', with requests for its use already coming in from various users, including overseas universities. At the moment, the lab is mainly focusing on laser ablation analyses, as solution analyses can only be performed after purification of the element of interest in a clean

Jan Kramers about to cut the symbolic ribbon, held by Marlina Elburg and Henriette Ueckermann

lab environment. This lab is currently being built at the University of the Witwatersrand, and will hopefully become operational in August. This endeavour is indicative of the closer collaboration between UJ and Wits, as also shown by our association within the DST-NRF CIMERA Centre of Excellence, which has played an important role in the establishment of the UJ isotope facility.

In tandem with the opening of the lab, a workshop for more than 30 participants has been run, where the theory behind the instrument, as well as its applications was covered. The afternoon session saw a hands-on demonstration of the equipment and the associated computer programs that run it.

Anyone who is interested in doing isotope analysis by MC-ICPMS, or wants more information, can contact Marlina Elburg (marlinae@uj.ac.za) or Jan Kramers (jkramers@uj.ac.za) to find out what the requirements are.

Marlina Elburg

CORRECTION:
In the article "the age of the Earth and other stories", the caption to Figure 1 (C) erroneously states that a Cameca 1280 SIMS is shown. In fact it should read "C, Henriette Ueckermann (Instrument scientist), the RESOnetics installation engineer and Prof Marlina Elburg with the Nu Instruments multicollector ICP-MS and RESOnetics excimer laser ablation system recently installed at UJ".

Jan Kramers cutting the ribbon

Jan explaining the workings of the mass spectrometer to Chris Hatton, Geoff Grantham and Mike Knoper

WITS

Since the beginning of 2016, Wits Geosciences has been extremely busy. Firstly, it is with great pleasure to announce that Lew Ashwal has been selected as a finalist in the 2016 Lifetime achievement award from the National Science and Technology Forum. Lew was at RAU (now the University of Johannesburg) from 1990 – 2001 and has been at Wits since 2001,both teaching and producing high quality international research.

Lewis Ashwal

Congratulations are due to Susan Webb who received confirmation of her promotion to professor. Also, two of Sue's students graduated in March. Congratulations go to Tshepo Khoza and Stephanie Enslin who received their doctorate degrees.

In 2015, Tamiru Abiye successfully implemented an MSc in hydrogeology. The principal aim of this course is to train students to help tackle South Africa's water resource issues. Groundwater investigation into seeking fresh water resources to meet the needs of the country has increased in recent years, as the population has grown and awareness about long-term climate change has increased. In South Africa, only ~15% of groundwater resources have been accessed. During 2015, there were 4 full time students on the course. This year, course subscription increased to 5 full time and 4 part time students.

In addition, Tamiru is the principal investigator on a project entitled "Understanding recharge in the Limpopo River Basin", which is in collaboration with the International Water Management Institute in Pretoria. The aim of this project is to increase the capacity of young scientists as well as local and national authorities to assess groundwater recharge from applied field investigations. The project is funded ($300,000) by the Department of Science and Technology as well as the National Academy of Sciences (in the USA).

In March, Zubair Jinnah returned from fieldwork in Antarctica. Zubair is a part of a project that is on the hunt for dinosaur fossils from the end of the Cretaceous period.

Musa Manzi went on research visits to both Princeton University and Penn State University, during April. Musa presented seminars on the research he is conducting here at Wits and joined colleagues at both institutions in discussions on forging long-term research collaborations.

In May AngloAmerican hosted the Wits Students Geophysics Society to a visit at the hanger at OR Tambo

Susan Webb with Dr David Khoza and Dr Stephanie Enslin

Fieldwork in Antarctica (photo by Zubair Jinnah).

airport. This facility hosts the world's most powerful EM exploration geophysics system, SPECTREM. The system is hosted on a modified DC-3 and hosts a proprietary EM system. Magnetic and radiometric data are also collected.

Musa during his stay at the Geoscience Department at Princeton University

Wits RocSoc organised a careers day event in May, which was well attended by many companies, with many speakers. Geologists from GSUP and UJ also attended.

Wits RocSoc is turning 40!! In celebration of this, RocSoc would like to invite all former RocSoc members, Alumni of Wits Geosciences, and friends to join us in a celebration of 40 years of students helping students!

The Wits geophysics team at the AngloAmerican hanger.

RocSoc celebrate a successful careers day event

RocSoc Ball invitation

This is a fundraiser and a networking event. We look forward to seeing you there!!

In April, Allan Wilson welcomed a delegation from the University of Ghana. The delegation spent a week at the Earth Lab to see how it is run as they prepare to set up their own lab back in Ghana.

In January, the school hosted the 11th annual AfricaArray meeting, which was attended by 80 participants from 23 countries. The meeting included a one-day training course for the operators of the 51 permanent geophysical observatories across 20 countries in sub-Saharan Africa. This was followed by a two-day scientific conference in which 40 oral and 20 poster presentations were delivered. Major themes of the presentations included the structure, tectonics and mineral resources of Africa as well as hazard assessment and mining-related seismicity. There was a mid-week trip to Sterkfontein Cave, a UNESCO world heritage site, where foreign delegates could enjoy some of the countryside. Four workshops were also held that were run by various visiting academics, including Ray Durrheim.

In April, Ray Durrheim, accompanied by his postdoc Ranto Raveloson and PhD students, attended the first assembly of the African Seismological Commission held at Luxor in Egypt. Several working groups were forming during the meeting with Ray Durrheim selected to coordinate the Structural Seismology and Hazard Risk groups. Following the meeting in Egypt, Ray attended the EGU meeting to promote the ICDP project, "Drilling into seismogenic zones of M2.0-M5.5 earthquakes in deep South African gold mines". Ray also presented a paper in the induced seismology session as well as co-presenting a poster during EGU.

Elsewhere, the school was recently granted R400 000 to install a series of items related to undergraduate and

Allan Wilson with the visiting delegation from the University of Ghana.

Participants from 23 countries at the 11th Annual AfricaArray Workshop.

postgraduate teaching. The school will be installing a new petrology teaching microscope camera, as well as various teaching improvements and lab improvements for future research. Also, work recently began on a new isotope preparation clean lab, which is being led by Grant Bybee. In January, the school contributed significantly to the Igneous and Metamorphic Studies Group meeting held in the Western Cape, with a large team attending to present both talks and posters.

Ben Hayes

Ray Durrheim with postdoc Ranto and PhD students, Tsitsi and Fenitra, in Egypt.

henno martin medal

Geological Society of Namibia – Henno Martin medal

The Henno Martin Medal commemorates and honours Henno Martin (1910-1998), the former Director of the Geological Survey of Namibia. At the beginning of the Second World War he and his colleague Hermann fled into the Namib desert near the Kuiseb Canyon to avoid possible internment by the South African authorities. Martin later compiled their two-year survival experience in different natural rock shelters into a book, the Sheltering Desert, the Afrikaans translation of which was for many years a setwork in South African schools.

View from the shelter (now easily accessible for visitors) above the Kuiseb Canyon

The four 2016 Henno Martin medals on one of the Gibeon meteorites (Geological Survey of Namibia).

Henno Martin became one of the most important and internationally acclaimed researchers on Namibian geology of the 20th century. Since 1999 the Geological Society of Namibia (geolsocnamibia.org) annually awards the prestigious Henno Martin to geoscientists working on and in Namibia for outstanding research contributions. This year the Henno Martin medal was jointly awarded to Anton Lombard, John Wilton, Hilton Philpot, and Louis Polomé for their work on the discovery and development of Otjikoto gold deposit in central Namibia. During his presentation John Wilton acknowledged the key role of the SABLE database in those early days of database development.

Chris Hatton and Ingrid Stengel

2016 award recipients Hilton Philpot, Louis Polomé and John Wilton (Anton Lombard not pictured), flanked by two former directors of the Namibian Geological Survey, Roy Miller (the first recipient of the award) and Gabi Schneider.

plaque replaced

Hout Bay Plaque Replaced

Replacement of vandalised Geological Society plaque at Hout Bay

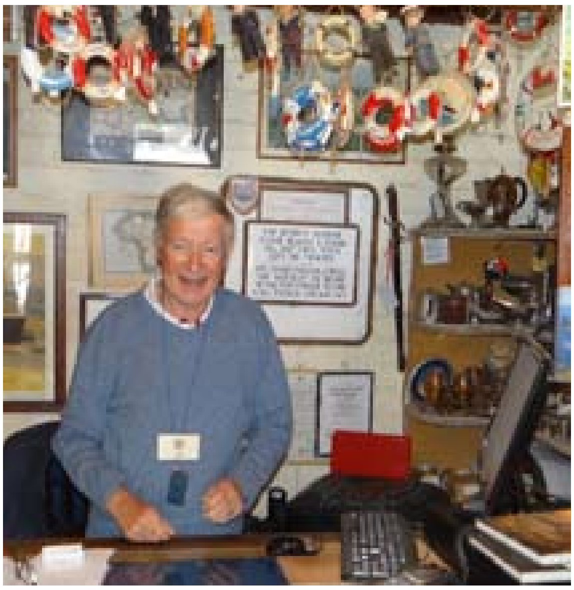
For several years, no damage was done to a Geological Society of South Africa (GSSA) plaque erected at the western end of the beach at Hout Bay to interpret the suite of manganese-ore adits along a subvertical plane above the zigzag of the firebreak below Constantiaberg. Sadly, the plaque disappeared from its granite plinth in 2015 and the GeoHeritage Subcommittee of the Western Cape Branch (WCB) decided to replace the plaque with a duplicate in its possession.

The replacement took place on 4th April, 2016 in the presence of John Rogers (JR) and Craig Smith, who lives in Hout Bay. The work was carried out by Warren Saville of the Hout Bay Boat Yard, who can be seen using JR's geological hammer to good effect to release the powerful sealant that was used, supplied by Coenie de Beer.

John Rogers

The replaced plaque with English and Afrikaans text, a map, geological cross-section and an interpreted view of the slopes of Constantiaberg.

John Hannah in his Shipwreck Shoppe, who plans to keep an eagle-eye on the plaque outside Mariner's Wharf.



Carl Theunissen of the Hout Bay Boat Yard and his workman, Warren Saville (with JR's geological hammer) and Craig Smith admiring the finished task outside Mariner's Wharf and the Shipwreck Shoppe (behind the ANTIQUES sign).

35TH INTERNATIONAL GEOLOGICAL CONGRESS

27 AUGUST - 4 SEPTEMBER 2016 | CAPE TOWN, SOUTH AFRICA

Dear Colleagues,

Arrangements for the 35th International Geological Congress (IGC) are progressing at a pace with 3 months left to register. This prestigious event as you know is to be held in Cape Town, one of the world's top conference and tourist destinations, from 27 August to 4 September 2016.
The congress has attracted worldwide interest with over 5000 abstracts having been received and with over 4000 delegates from 100 countries expected to attend. We have no doubt that your particular interest (s) will be more than adequately covered in one or more of the many technical sessions that are planned.
The main topics for the technical programme are:-

- Geoscience and Society
- Geoscience in the economy
- Fundamental Geoscience

Although international in scope, the conference will also highlight the geological and mineral superlatives of Africa and present a unique opportunity to learn more about the continent. The programme has been compiled under the able leadership of Prof. Laurence Robb and his team. See http://www.35igc.org/Verso/1Scientific-programme for more details on the programme.

The large selection of exciting field trips on offer will cover many of the geological wonders of South Africa and Namibia as well as east and west Africa and there are still some vacancies - see http://www.35igc.org/Verso/22/Field-Trips for details of the programme.

Two commemorative publications have been specially prepared for the congress. One of these highlights Africa's top geological sites while the other, a special publication of EPISODES, the IUGS journal, describes the great Minerals Fields of Africa. These unique publications will be made available exclusively to interested delegates.

The conference is an ideal opportunity to expose students and young professionals to the latest development in best practice and cutting edge developments in geoscience and represents a great opportunity for delegates to develop global networks.

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For more information on the 35th IGC, please visit the Congress website at http://ww.35igc.org/ or contact the Secretariat at Barnardo@geoscience.org.za , juanitaw@geoscience.org.za or gabotha@geoscience.org.za

The registration fee for the 35th IGC which has been kept as low as possible, is particularly favourable for overseas delegates as a consequence of currency exchange rates. Please see the registration fees and deadlines at the following link: http://www.35igc.org/Verso/60/Registratio and note that early bird registration closes on the 31st of May.

We would like to extend a special invitation to you and your colleagues to attend this unique, once in a lifetime event. We look forward to your support and to welcoming you in Cape Town.

Yours Sincerely,

Dr. Richard Viljoen
Co President
35IGC Local
Organizing Committee

Dr. Jeanette McGill
Co President
35IGC Local
Organizing Committee

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35th IGC TOPICS OF INTEREST IN THE TECHNICAL PROGRAM – THE BIG PICTURE

Organization of the 35th IGC is progressing well, with the technical program set during the first week in June, although the schedule of times and venues for presentations and posters will only be finalized by the first week in July. You can find a list of accepted presentations at http://www.35igc.org/Verso/1/Scientific-Programme; click on the core topics, followed by the theme of interest. From the theme page, a list of abstracts and authors is available.

As of this point, there are 4,824 accepted abstracts from over 5,200 submissions, of which 3087 are oral presentations and 1,737 are posters. These are divided between the three major topics, Geoscience in Society (31%), Geology in the Economy (24%) and Fundamental Geoscience (45%). There are 48 major themes, in most of which there are between three and fifteen major symposia or general sessions.

Throughout June and July, we will be highlighting what we regard as technical highlights to different interest groups, so watch for those communications.

There are nine plenary presentations, all of which are directed at themes of particular current relevance in the global earth sciences. See the website for more detail, but the plenaries broadly reflect the 'flavor' of the conference. Topics include:

- Formation of continental crust
- Science and the professions: service to society
- Climate and human evolution
- The mining industry and society
- Shale gas – the technical challenges
- Extraction technologies and the life cycle of metals
- Earthquakes in Africa
- Palaeobiology from fossil bones

Under the core theme, *Geoscience in Society*, there are a considerable number of geoheritage and geoconservation offerings, in line with the interest that the GSSA is seeing from the general public in geological topics. Climate change is a high interest topic (as predicted!). Communication to the public sector is addressed, as is mapping of Africa and the world. Geohazards, engineering

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geology and environmental geoscience all have strong support. Geoeducation at secondary and tertiary level is well represented. There is considerable interest in professionalism in the geosciences and geoethics. All of these topics are typically under-represented in conferences world-wide, and anyone interested in these subjects should definitely have a close look at this part of the program.

A very wide variety of topics directly related to *Geoscience in the Economy* are represented in the meeting, and coverage goes beyond the typical scope of pure economic geology. Of particular note is coverage of the geostatistical evaluation of mineral deposits as well as mineral economics, topics not normally covered in general geoscience meetings. Mineral exploration is well covered, and ore forming processes is a strong theme. In particular there are sessions on gold mineralizing systems as well as the crustal gold cycle. Energy resources fall into this stream, with four major themes being coal, petroleum systems, unconventional hydrocarbon sources, and energy in a carbon constrained world. Resourcing future generations is a current IUGS concern, and there is a theme dedicated to that. If you are an 'expert' in a specific aspect of mining and exploration geology, and would like to learn more about related fields, 35 IGC is the chance to do so.

The core topic *Fundamental Geoscience* covers a wide range of topics, particularly highlighting current efforts in geoscience research. Well covered themes include sedimentary processes, basin formation, magmatism, metamorphism, tectonics and the dynamic earth, marine geosciences, palaeontology, and Antarctic and Arctic geology. There are symposia devoted to Hadean, Archaean, Proterozoic and Phanerozoic geology and time scales.

35 IGC covers a multitude of earth science topics and is a reflection of the state of modern earth science. In recent years there is recognition that earth sciences impact significantly on society and on the global economy, as well as being fundamental to understanding the planet we inhabit. This meeting reflects this. And, in practice, it is nearly impossible to unequivocally categorize a specific subject or presentation into one core stream or another. There is lots of overlap. Spending a couple of hours on the website will be well rewarded.

We invite you and welcome you to IGC in Cape Town!

The Local Organizing Committee

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ADVERTORIAL

IGS Xplore.
De-risking Mineral Exploration

IGS Xplore is a new and innovative semantically-driven mineral prospectivity software service for automated targeting of up to 50 mineral deposit types. Developed by International Geoscience Services (IGS) Ltd., it has been designed specifically to provide automated mineral prospectivity analyses for early-stage mineral exploration, generating value-added mineral prospectivity maps for regions, countries or discrete geological terranes where base level geodata exists.

IGS understands that in the current downturn with declining commodity prices and rising discovery costs inhibiting early-stage investment and exploration activities, innovations in mineral exploration have never been more important and mineral explorers need new ways to take even more risk out of discovery. IGS Xplore Manager, Dr Aoife Brady, explains that "early-stage mineral exploration data is often patchy, disjointed and of varying quality, which leads to inadequate understanding of the data and ultimately poor decision-making and lost opportunities. The new IGS Xplore software service addresses such exploration challenges with advanced technology that provides meaning and context to base-level geodata. In IGS' unique knowledge-based application, IGS Xplore, prospectivity maps are produced in an automated, iterative process, which has been designed to reconcile discrepancies in geodata representational formats, correlate multi-source data, and reason upon it using geological rules in order to infer and visualise potentially prospective regions."

IGS Xplore is fundamentally different to other mineral prospectivity software because rather than being GIS-based it uses proprietary, non-GIS, semantic technology (ST) to challenge traditional prospecting analysis. Broadly speaking, semantic technologies encode meaning into content and data to enable a computer system to possess human-like reasoning, and effectively allow them to "understand" the data they process. Interestingly, this type of technology or processing is already well-established in the pharmaceutical, genomics and financial sectors, notwithstanding its use by Google, LinkedIn and others.

Prospectivity analysis in the semantically-driven IGS Xplore system is essentially a two-stage process. The first stage consists of geodata modelling where data is converted from a GIS-based format to a Resource Description Framework (RDF) format, the standard data format of semantic technology. The unique process transforms the geodata using dedicated geological knowledge stores, called ontologies, which allows the IGS Xplore system to actually understand the information contained in geological databases and express it using knowledge from the ontologies. A crucial step in the geodata modelling stage is the process of geodata enrichment, the discovery of new and important relationships within the geodata. This is also performed using the proprietary IGS ontologies, which contain computer-readable definitions of geological terms, such as rock terminologies and geological features, as well as the relationships between them. While the relationships within the ontologies are often very complex, IGS Xplore's geodata enrichment process is performed automatically. Prospectivity analysis is implemented at the second stage by embedding geological knowledge in the system as a set of well-established, empirically based (non-probabilistic) geological rules. IGS Xplore employs up to 50 mineralization models described by peer-reviewed research and accepted by the mineral exploration community consensus to identify prospective areas. These rules, which represent important criteria indicative of mineral prospectivity, guide the process of prospectivity analysis and are compiled as geospatial queries that are fired against the enriched geodata for a given region to evaluate the likelihood of a mineral deposits existence; thus ensuring that generated prospectivity areas are based on actual geological conditions.

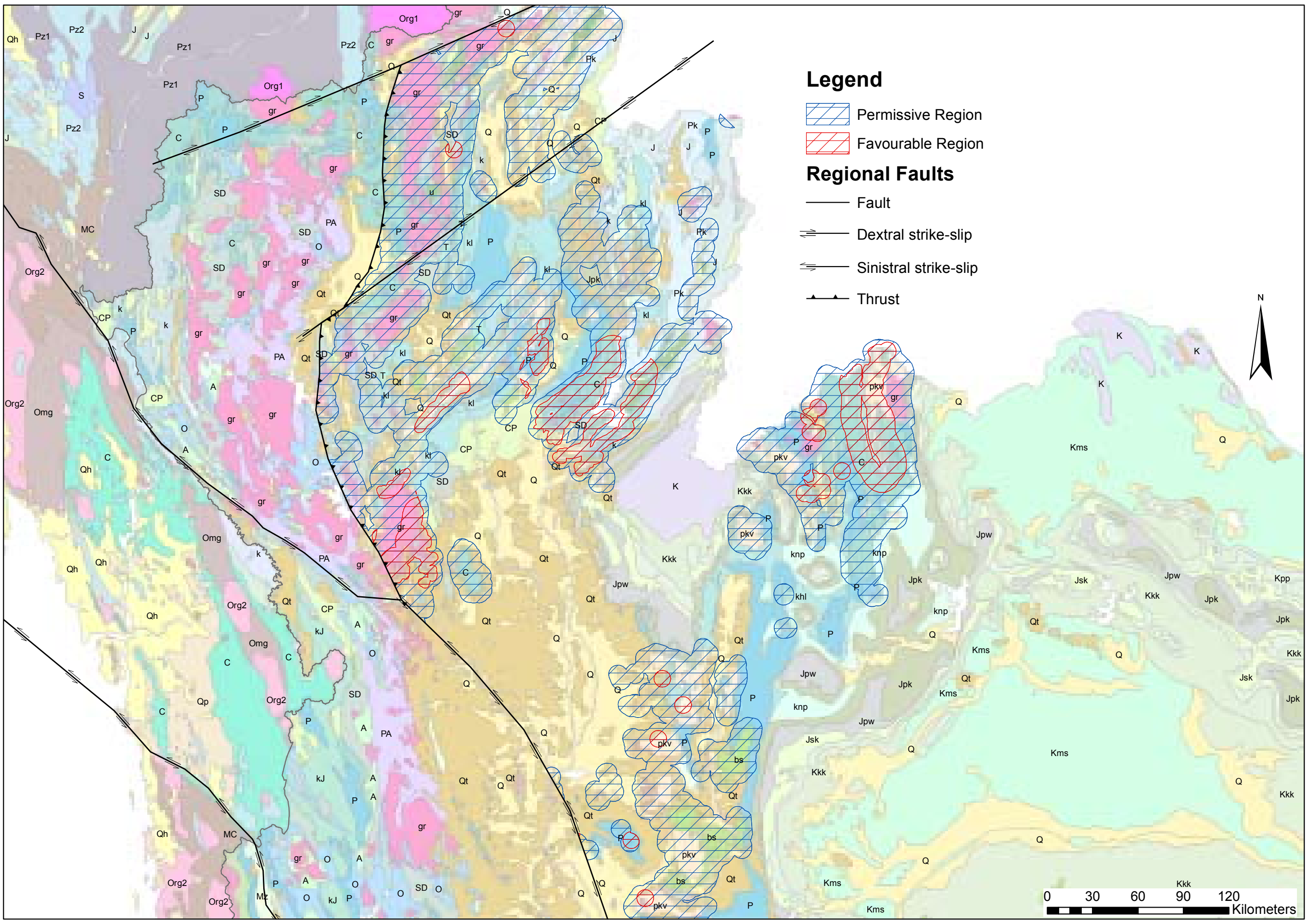
IGS Xplore is capable of rapidly testing the different types of geo-datasets that exist for a region or country, including geology, geochemistry, known mineral occurrences and other data sources against the geological rules, identifying early-stage targets and automatically generating a series of detailed prospectivity maps for a region / country and on a commodity basis. Although such maps do not place an 'X' of where a mineral deposit occurs, they can and quickly provide for a ranking or prioritization of regions that show potential for mineralization across a range of commodities. The methodology, being a novel, semantically-driven technology platform that is non-GIS based, tests base-level geodata for prospectivity, quickly and cost effectively, for regions or even entire countries where data exists. Integrating this information with tenement / cadastre data, for example, can then quickly show where prospective areas are available for licensing.

The IGS Xplore system addresses the challenges of 'Big Data' using an RDF data model that offers smarter, more efficient & flexible geodata processing & integration capabilities than traditional GIS-based technologies. Furthermore, IGS Xplore, being a knowledge-based system, offers complete transparency where the analytical processes are human-readable and their outcomes fully traceable. The mutable parameters and separation between the mineralisation models and prospectivity analysis allows for their seamless modification and extension, further differentiating IGS Xplore from statistical and machine-learning approaches.

IGS recognise the enormous value associated with geodata and its primary purpose with the IGS Xplore system is to maximise the meaning of the vast amounts of data generated by exploration. IGS Xplore produces customized and sophisticated early-stage exploration maps to guide mineral explorers and senior decision makers to make well-informed decisions regarding the selection of commodities and the identification of potential concession areas for exploration, as well as influencing the crucial decision-making process to raise investment. IGS recognise that a "hands on" experience is an integral part of evaluating the initial mineral prospectivity of a region and has initially launched IGS Xplore as a technological service to the mineral exploration sector. The service is designed to bring together IGS' mineral exploration experience and technological knowledge to deliver a prospectivity service customized to suit the client, providing objective and comprehensive assessment of geodata quality resulting in independent, reliable, value-adding prospectivity analyses.

igs Xplore

De-risking mineral exploration



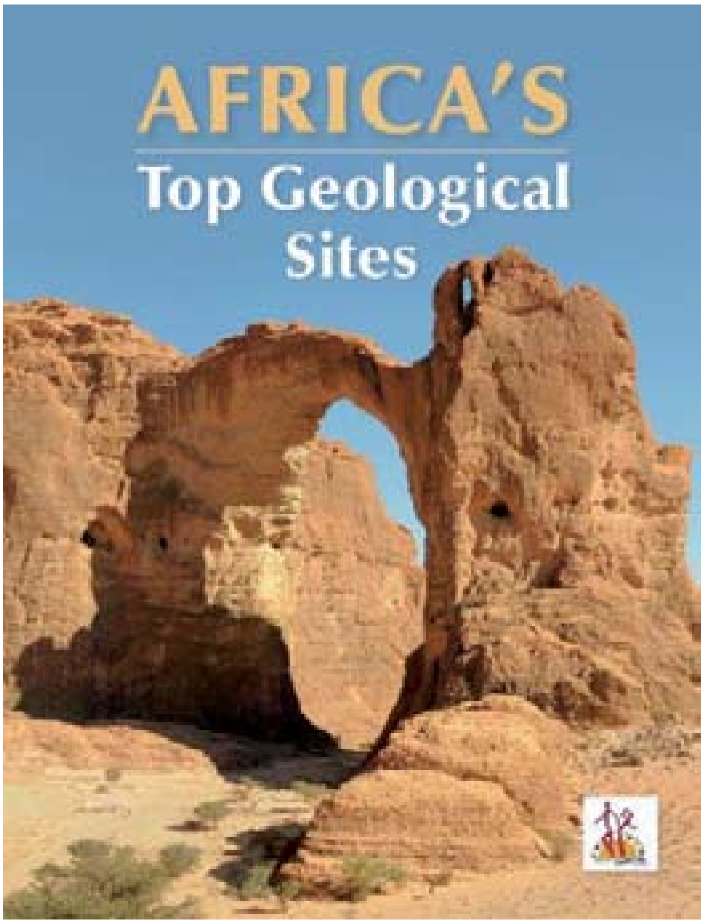
Snapshot from an IGS Xplore prospectivity map showing different levels for Cu-Au porphyry deposits

highlights
of the Scientific Programme

Geoscience for Society

One of the three core topics of the scientific programme, ''Geoscience for Society'', has attracted over one thousand abstracts. Some highlights of this core topic include Geoheritage, Geotourism and Geoconservation, all rapidly growing fields of the earth sciences. Taking cognisance of this, the geoheritage of Africa has been showcased in a special, 35 IGC commemorative publication "Africa's Top Geological Sites" which will be launched at the congress and made available to delegates at a special, reduced price.

The book contains forty four chapters and provides the backdrop to various papers to be presented at the congress. Many of the sites described are world heritage sites of great value with regard to geoheritage, conservation and geoparks of the future. The sites are also important locations for the promotion of geoscience education, public communication and the rapidly growing sector of geotourism. Some sites have established geotrails, while similar features are planned at a number of others. Many of the sites documented in the book will be visited as part of various field trips related to the Congress.



Cover of the 35 IGC commemorative volume, ''Africa's Top Geological Sites''. Photograph shows a sandstone arch, the second highest in the world, in the Ennedi plateau of the Sahara desert.

Of increasing importance is how geoscience can benefit low income countries, with buy- in by rural communities, particularly in Africa, and this will be discussed at the congress. In addition to sessions on natural hazards such as earthquakes and volcanic eruptions, sessions on environmental geoscience, climate change, groundwater, soil science, and the history of geology, the programme will provide delegates with a unique opportunity of gaining insights into some exciting possibilities of developing a variety of earth science initiatives in Africa for the benefit of society. "Africa's Top Geological Sites" provides excellent background information for the launching of such initiatives and we are sure that you well enjoy reading the book and find attendance at the congress a stimulating and valuable experience.

For further information on the scientific programme see: http://www.35igc.org/Verso/1/Scientific-Programme and click on core topics, followed by the theme of interest and list of accepted authors and abstracts.

Geoscience in the Economy

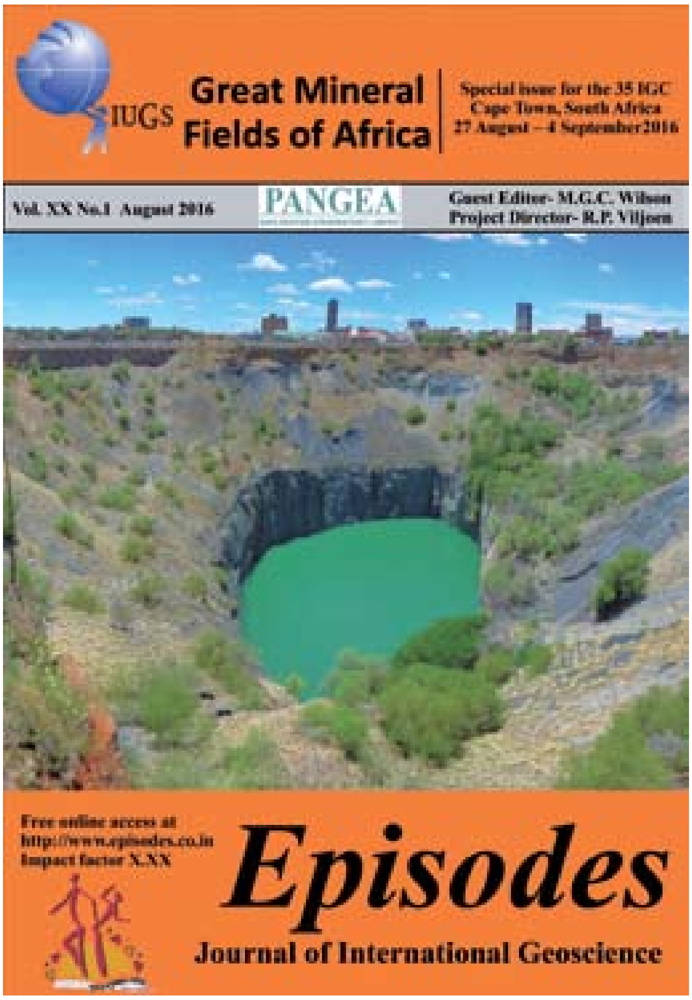
The core topic of "Geoscience in the Economy" has attracted over 1100 abstracts, a third of which fall under the broad theme of "Mineral Deposits and Ore Forming Processes". The African continent is host to a number of iconic mineral fields, including the great Witwatersrand and West African gold fields, the vast platinum, chromium and vanadium deposits of the Bushveld Complex and Great Dyke, as well as the Central African Copper Belt. In addition, the continent is host to major deposits of diamonds, manganese, iron ore, nickel, uranium, tin, coal oil, gas, and rare earth elements and many of these will also be highlighted at the congress.

As a contribution to the "Resourcing Future Generations" theme, an initiative of the IUGS, we are extremely proud to confirm that a unique publication on ''The Great Mineral Fields of Africa'' will be available for delegates at the conference as a special issue of '' Episodes'', the geoscientific journal of the IUGS. The publication showcases many of the continents remarkable and often unique mineral heritage and includes updated reviews of the geology, resource base and origin of various deposits across the continent, together with mineralisation models, exploration methodologies and comments on possible extensions.

Not only will many of the authors to chapters of this publication be presenting reviews of their contributions, but there will also be focussed sessions on specific topics such as the world famous Witwatersrand goldfield and the Bushveld Complex. At the same time a broad range of presentations on many aspects of economic geology will be a feature of this core topic. Additional sessions include Mineral Exploration, Mineral Resource Evaluation, Petroleum Systems and Exploration, Coal, Unconventional Hydrocarbons, Gold Mineralising Systems, Critical Metals, Applied Mineralogy and Geometallurgy, as well as Resourcing Future Generations.

The 35th IGC should be a must attend event for geologists and others interested in learning more about aspects of the geology, exploration and many other geoscientific issues related to the diverse mineral endowment of the continent as well as mineral deposits elsewhere. Your support will add considerably to the success of this special event and we look forward to you joining us in Cape Town.

For further information on the scientific programme see http://www.35igc.org/Verso/1/Scientific programme



264 million years ago, in the late Middle Permian, the south-western Karoo Basin of South Africa was a temperate but semi-arid floodplain, traversed by primarily seasonal rivers bordered by riparian bush. During the rains vegetation would have flourished, providing nourishment for a diverse ecosystem of early therapsids, a group of animals including the ancestors of modern mammals. At this time, the dominant large herbivores and carnivores were the dinocephalians. *Tapinocephalus* was one of the largest herbivorous kinds and may have lived in herds. Here some male *Tapinocephalus* (1) present a fearsome barrier between their young and two carnivorous *Glanosuchus*, (2) which were relatively large predatory members of another therapsid group, Therocephalia. The *Glanosuchus* are, however, more interested in easier prey, in the form the the dicynodont *Robertia* (3). This little herbivore was a member of a therapsid group, Dicynodontia, that would become much more diverse and reach much large sizes later in the Permian. Nearby a *Bradysaurus*, (4) part of an extinct group of early reptiles called pareiasaurs, browses on some ferns fronds, while in a small isolated pool left by receding flood waters a temnospondyl amphibian, *Rhinosuchus*, (5) contemplates the future of its home. The earliest known ancestor of tortoises and turtles, *Eunotosaurus*, (6) basks on a branch. 260 million years ago a mass extinction event wiped out the dinocephalians, such as *Tapinocephalus* and its kin, as well as *Bradysaurus* and *Robertia*. Other groups suffered a loss of species and for some time the Karoo was populated by far fewer species.

Although the animal life of the Middle Permian has been well-studied the associated floras are comparatively poorly understood. What is knownis that these ecosystems were dominated by the typical Gondwanan Permian plant, *Glossopteris* as we see in the forests of the far distance in this scene (7). *Glossopteris* no doubt also exploited other niches, with some species adopting a more shrubby habit, as in the dense scrub along the river banks in the foreground (8). *Sphenophytes* (horsetail ferns), are the most commonly encountered fossil plant in the southern Karoo Basin at this time, as their tough, silica-rich stems were resistant to decay and mechanical abrasion. These spore-producing plants with their unmistakable jointed, longitudinally striated axes, thrived in floodplain settings throughout the Permian and into the Triassic Period. Here we see the horsetails *Phyllotheca australis* and *Schizoneura africana* growing in dense mixed stands in a marshy setting in the middle distance (9), with a close-up of *Schizoneura africana* in the foreground on the right (10). *Schizoneura* species are unusual in having their long, narrow leaves fused into broader lobes at each node.

Painting: **Maggie Newman,** Karoo Life in the Middle Permian

Caption: **Mike Day** and **Rose Prevec**.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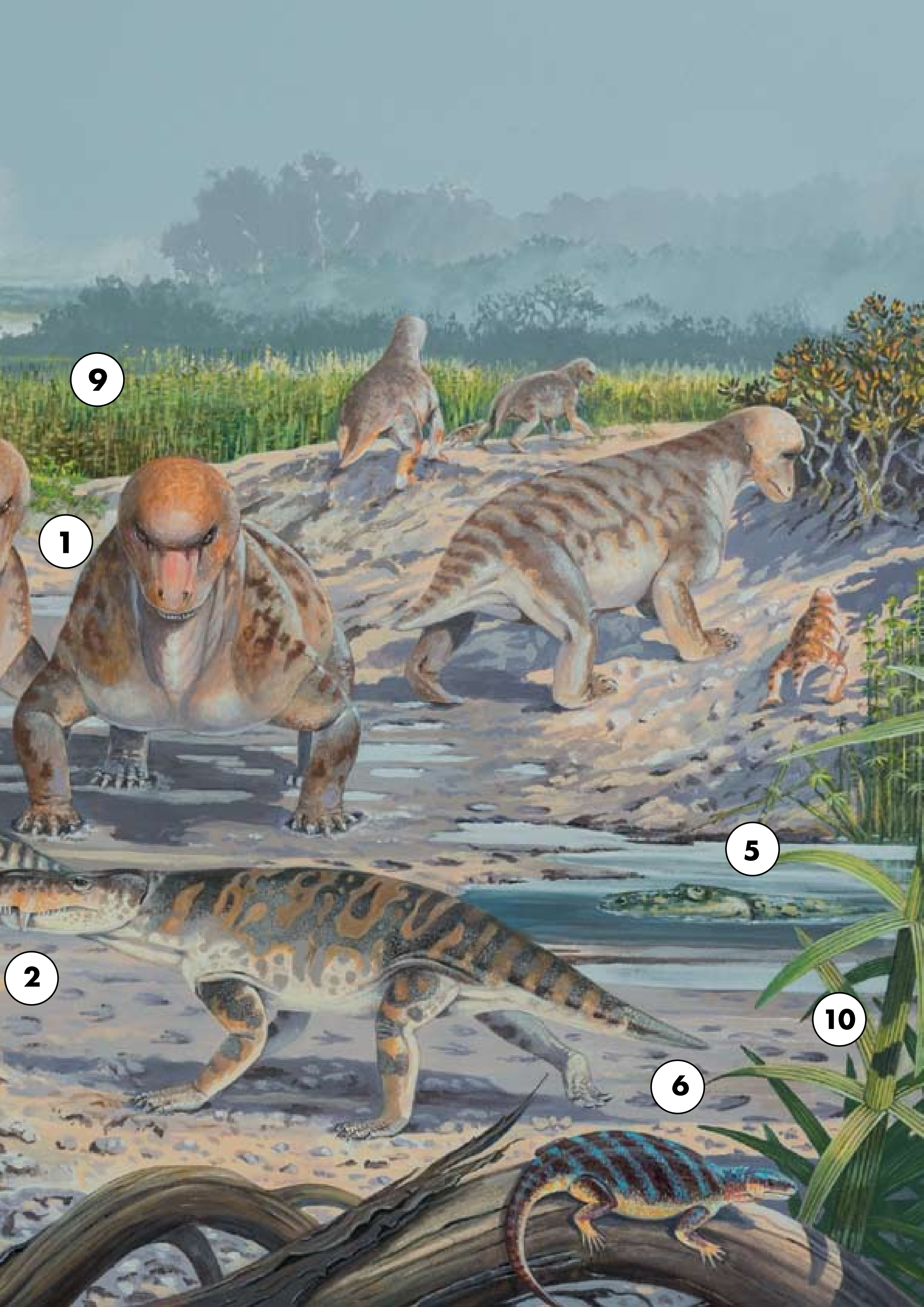
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ARTICLES

interglacial period

The implications of being in an interglacial period in South Africa

Introduction: Background to sea-level cycles

Sea-level rise is a definite consequence of global warming. Ice-age cycles of the past million years have seen sea level fluctuations between 130 m below and 10 m above the present level, mainly associated with the growth and retreat of continental ice sheets in 100 ka cycles (Figure 1). Presently, melt-back of all remaining ice on earth would create about 65 m of sea-level rise (Raymo and Mitrovica, 2012). To quantify these past fluctuations, near-continuous coral elevation data have produced well-constrained sea level reconstructions since the Last Glacial Maximum (LGM) at 21 ka (Clark et al., 2009; Lambeck et al., 2014). Beyond the LGM, however, sea-level estimates from corals are discontinuous and have rather large age uncertainties. Several techniques have been developed to generate longer continuous sea level reconstructions from marine sediment core data, but each of these is subject to assumptions and regional influences (Spratt and Lisiecki, 2016). Some of these coastal sea-level proxies include organic proxies such as peat bogs and shell beds, and geological formations such as beachrock.

Southern Africa has generally been considered one of the more reliable regions to study palaeo sea-level as it is said to be situated beyond the area influenced by glacio-isostatic effects (Fleming et al., 1998), but more recently these effects and distance to the ice sheets are being thoroughly investigated. The depositional record and Late Quaternary sea-level curves for South Africa show that since Marine Isotope Stage (MIS) 11 (~440 ka), four glacial/interglacial cycles are identified from sedimentological and biological proxies. Maximum Quaternary sea levels reported at +11 m and +8 m were attained during MIS 11 and the Last Interglacial (MIS 5e), respectively, at times of ~420 and ~125 ka (Carr et al., 2010; Roberts et al., 2012). Between 90 and 21 ka, sea level dropped beyond the shelf break before rapidly rising from this eustatic low (the LGM, at 130 m below present). The Holocene Transgression extensively eroded the pre-existing shelf and coastal plain sediments until stabilising at its present elevation between 7 and 6 ka (Ramsay, 1995; Compton, 2001, 2006). There is good evidence from the South African West- and South coasts for a mid-Holocene highstand from ~7.3 - 5.9 ka on the order of ~3 m above present MSL. Sea level therefore reached its present elevation at approximately 5.5 ka and now continues to rise.

Sea level and the coast

Sea level estimates for warm interglacials at ~420 and 125 ka are of specific interest as potential analogues for future sea-level rise. Local sea-level changes, however, differ from global mean sea-level change due to geological background processes; atmosphere-ocean dynamics and the gravitational and elastic effects of ice and ocean mass redistribution (Kopp et al., 2015).

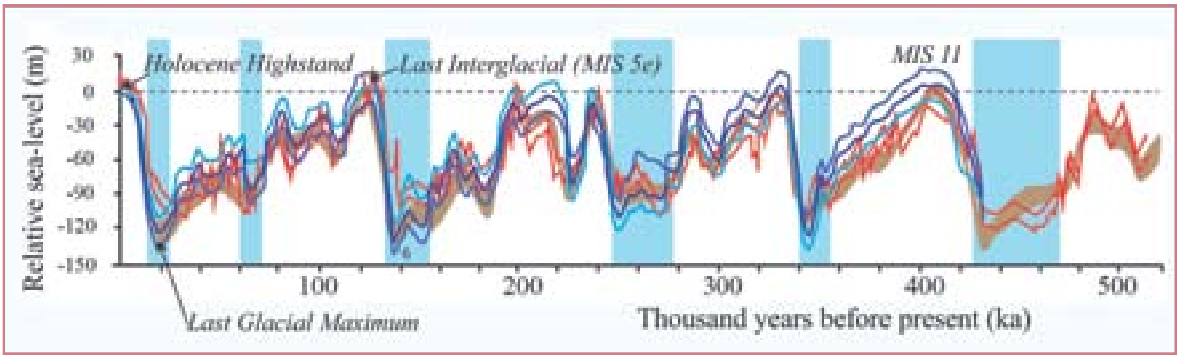

Figure 1. Global glacio-eustatic sea level curves from the middle Pleistocene to the Recent. For most of this time, sea level has been significantly lower than at present. From Cawthra (2014). References therein.

Modern society is vulnerable to subtle changes in sea level, as some 600 million people currently live within 10 m of present-day sea level, in an area that generates 10% of the world's total GDP (McGranahan et al., 2007). An assessment of 136 of the world's largest harbour cities estimated that by the 2070s, the population exposed to flooding risk may grow by more than a factor of three as a result of the combined effects of sea-level rise, land subsidence, population growth and urbanization. A sea-level rise of up to 2 m may displace almost 2.5% of the global population (Nicholls et al., 2011). Therefore, understanding the past is extremely important to predict future scenarios.

During ice-age cycles, continental ice volume generally maintained pace with slow, multi-millennial scale changes in climate. Today, rapid greenhouse gas increases have outpaced ice-volume responses, possibly committing us to between 0.9 and 1.8 m of sea-level rise by 2100 and 2.7 and 5 m of sea-level rise by 2200 (Rohling et al., 2013). This modern change is considered rapid by past interglacial standards but lies within the range of 'normal' processes (Rohling et al., 2013). Components of the climate system, such as deep ocean temperature and ice volume, respond slowly due to their large inertia. Most information on rates of sea-level rise is obtained from deglaciations, when ice ages terminated and sea level rose by up to 120–130 m at average rates of about 1 m per century (Jouzel et al., 2007), but with steps of rapid rise between. During these 'Meltwater Pulses' (MWP) or steps in sea-level rise, rates reached 4–5 m per century for several centuries (Jouzel et al., 2007). The worst case scenario trajectory proposed by Rohling et al. (2013) requires that sea-level rise rates develop toward an eventual value of 4.3 m per century, roughly similar to MWP-1A, even though today's global ice volume is only about a third of that at the onset of the last deglaciation when this occurred. Rates such as those of MWP-1A would require unprecedented ice-loss mechanisms, such as destruction of a major ice sheet (e.g., the largely marine-based West Antarctic Ice Sheet) (Rohling et al., 2013). Thus far, anthropogenic forcing has remained close to the range of expectations based on well-known natural interglacial patterns and sea level may be expected to rise to an elevation as high as MIS 11 or 5e, but over several thousands of years.

Considering local changes, most of the world's coastlines are eroding, and soft coastlines' erosion rates vary from 0.3 m to 1.0 m per year (Pilkey and Cooper, 2004). A recent case study considering increased storminess and coastal erosion in Kwa-Zulu Natal was published by Smith et al. (2010), describing factors which during 2006 and 2007 led to several large swell events. The largest swell (of 8.5 m) struck the coast on the March equinox and observations made before, during and after the event recorded excessive coastal erosion, with shoreline recession of up to 40 m and considerable damage to property and infrastructure (Figure 2). Although the styles of erosion during the various large swell events were markedly different in the cause, Smith et al. noted that these events cannot be treated

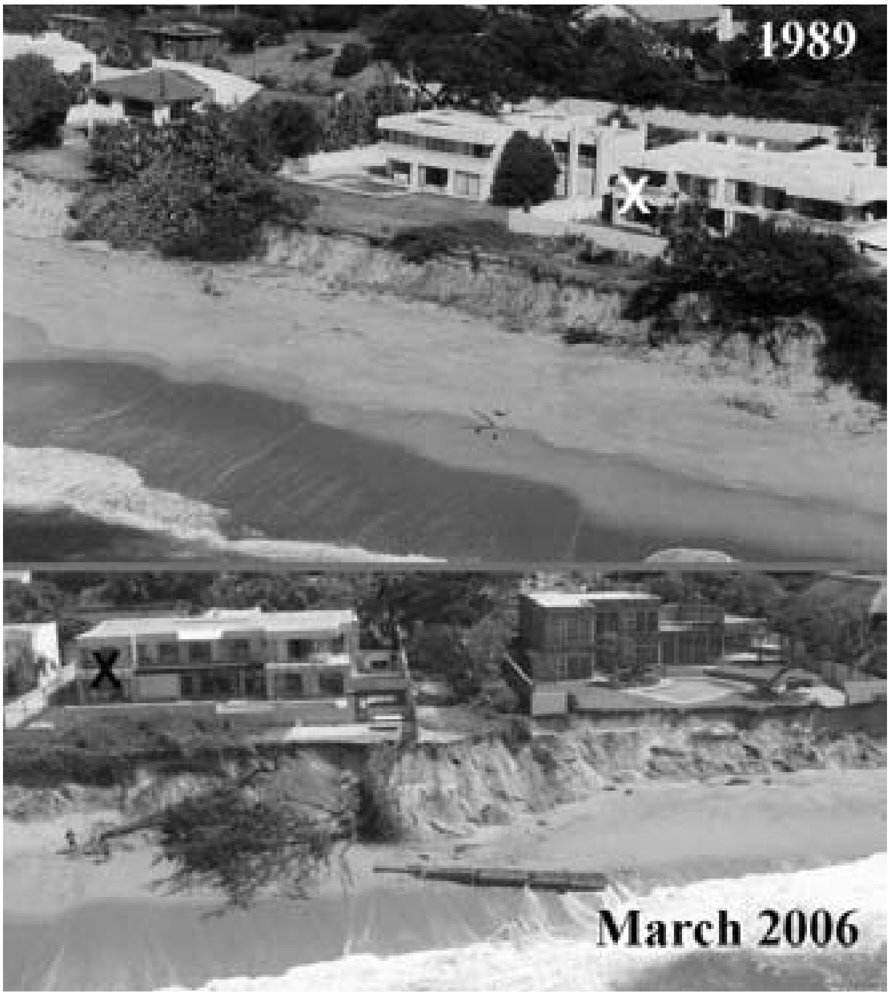

Figure 2. Coastal erosion in KwaZulu Natal: Eastmoor Crescent, Durban. The photographs were taken in 1989 (top) and 2006 (bottom). From Smith et al. (2010).

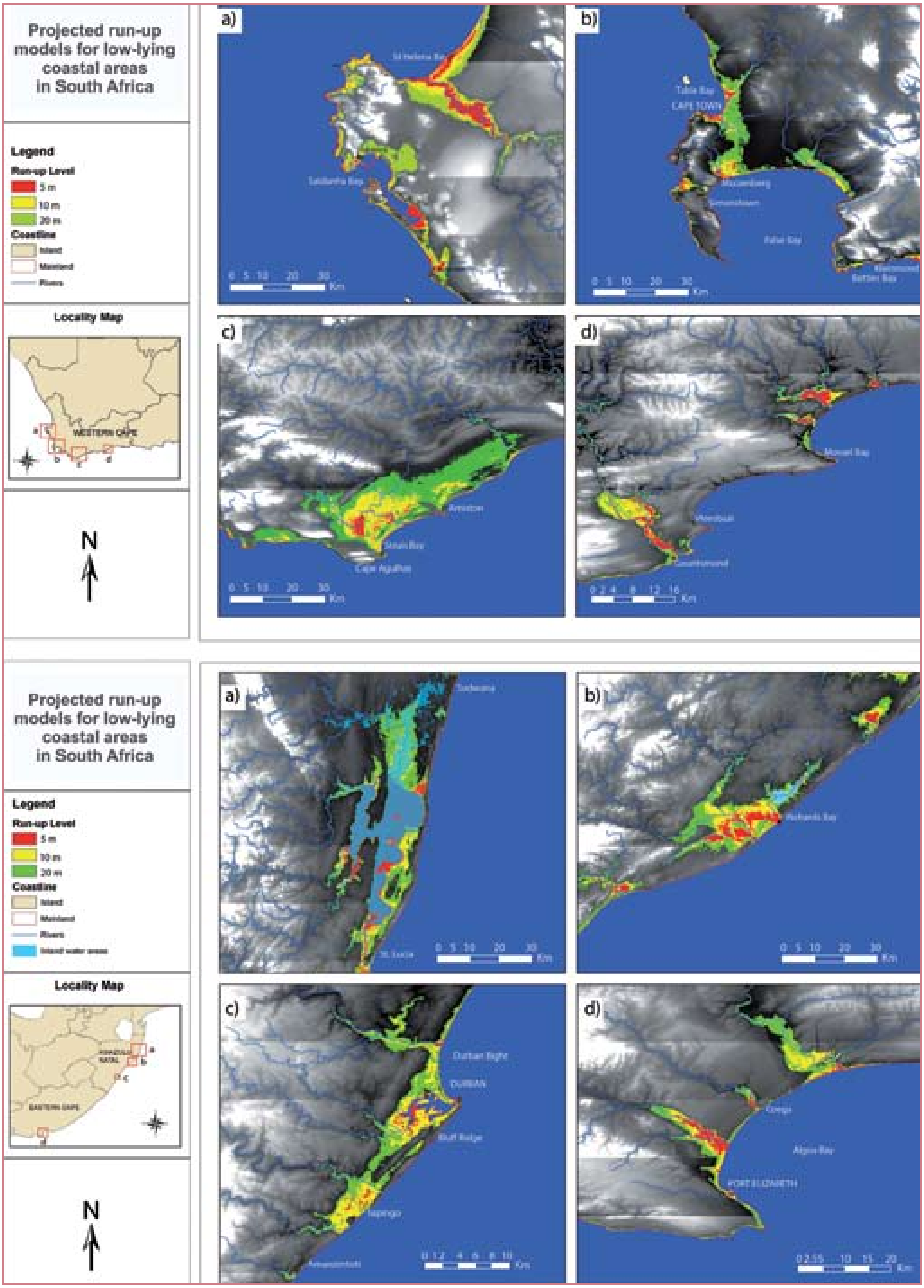

Figure 3. In the upper panel, examples of projected run-up models for the Western Cape of South Africa are presented. The lower figure provides examples of projected run-up models for the Eastern Cape and KwaZulu-Natal Provinces. From Cawthra and van Zyl (2015).

in isolation, and that observations can provide insight into the overall coastal morphodynamics which require a deeper level of understanding to aid prediction and/or mitigation of damage. Although some evidence suggests that erosional events are cyclic on this coast, with the rising sea levels and stronger winds forecast for global warming and interglacial periods, events such as this are likely to increase.

Coastal areas most likely to be impacted by interglacial conditions in South Africa

In a study aimed to provide an overview of areas susceptible to tsunami inundation in South Africa, Cawthra and van Zyl (2015) identified the low-lying coastal areas in South Africa most susceptible to the impact of a water level rise (Figure 3). Whether considering more immediate effects such as tsunami inundation, or slower sea-level rise, or increased storms as a function of latent heat in the atmosphere, areas most adversely affected all lie in low-gradient coastal regions. The inundation distance can be relatively short, as a result of a steep onshore gradient, or over a longer distance along rivers or coastal embayments.

Another paper that produced a coastal vulnerability index for South Africa (Musekiwa et al., 2015) addressed factors including elevation to chart datum, beach width, tidal range, wave height, geology, geomorphology, anthropogenic activities, distance to the 20 m isobath and relative sea level change to rank coastal vulnerability on a scale of 1 (low) to 5 (high) (Figure 4). The necessity of assessment of the vulnerability of coastal areas to sea-level rise has been recognised globally. In general, the results showed that the vulnerability is lowest on the northwest coast, south of the Orange River. This increases to medium values through St Helena Bay which is characterised by mixed rocky and sandy beaches and a low coastal gradient. Near the southern extent of St Helena Bay where Cape Granites are exposed at the coast, the vulnerability index indicates that the region between Saldanha Bay and St Helena Bay is relatively resistant to coastal erosion. Towards the city of Cape Town, a variable range in values is interpreted to reflect the variation in coastal geology and complex anthropogenic infrastructure. These values range from medium to high, the latter linked to the sandy beaches of Table Bay and False Bay. The continuity of the southern Cape coast from Port Elizabeth in the east to Cape Agulhas in the west is broken by a series of zeta bays, creating variations in geomorphic expression. Resistant lithologies bounding the south coast log-spiral embayments tend to form rocky headlands of steep sea cliffs which inhibit the development of sandy beaches and hence, coastal dune systems. This geological signature is closely mirrored in the coastal vulnerability index, which ranges intermittently between the medium and high ranges. The presence of steep, resistant Msikaba Formation sandstones along the shoreline from East London to Port Edward separate locally developed sandy embayments and are significantly dissected by rivers. Although the resistant lithologies exhibit a medium index on the river mouths, a narrow shelf and steep shoreline account for scattered very high indices. Metamorphic rocks along the KwaZulu-Natal south coast, extending from Port Edward to Umkomaas, produce medium index values. North of Durban, vast sandy beaches dominate the coast as a function of a broad coastal plain underlain by erodible Cretaceous strata of the Thekwini and Zululand Basins. These stretches of coast are generally classified as highly vulnerable and the Smith et al. (2010) study also attests to this. For regions in central kwaZulu-Natal, however, with Karoo Supergroup deposits outcropping at the shoreline, the vulnerability index suggests a decrease in susceptibility to erosion to medium values.

Summary

Two broad themes have been discussed here. The slower overall rise in sea level, linked to natural interglacial conditions, as well as the more 'immediate' consequences in coastal areas. The latter includes the susceptibility to storms and resultant coastal erosion. The implication of being in an interglacial period in South Africa, a 'far-field' site relative to the polar regions, highlights the potential impact of a higher water level and large waves likely to affect coastal areas. Sea level all over the globe continues to rise, as a function of natural processes and a certain consequence of global warming, but the rate of rise is arguably slightly

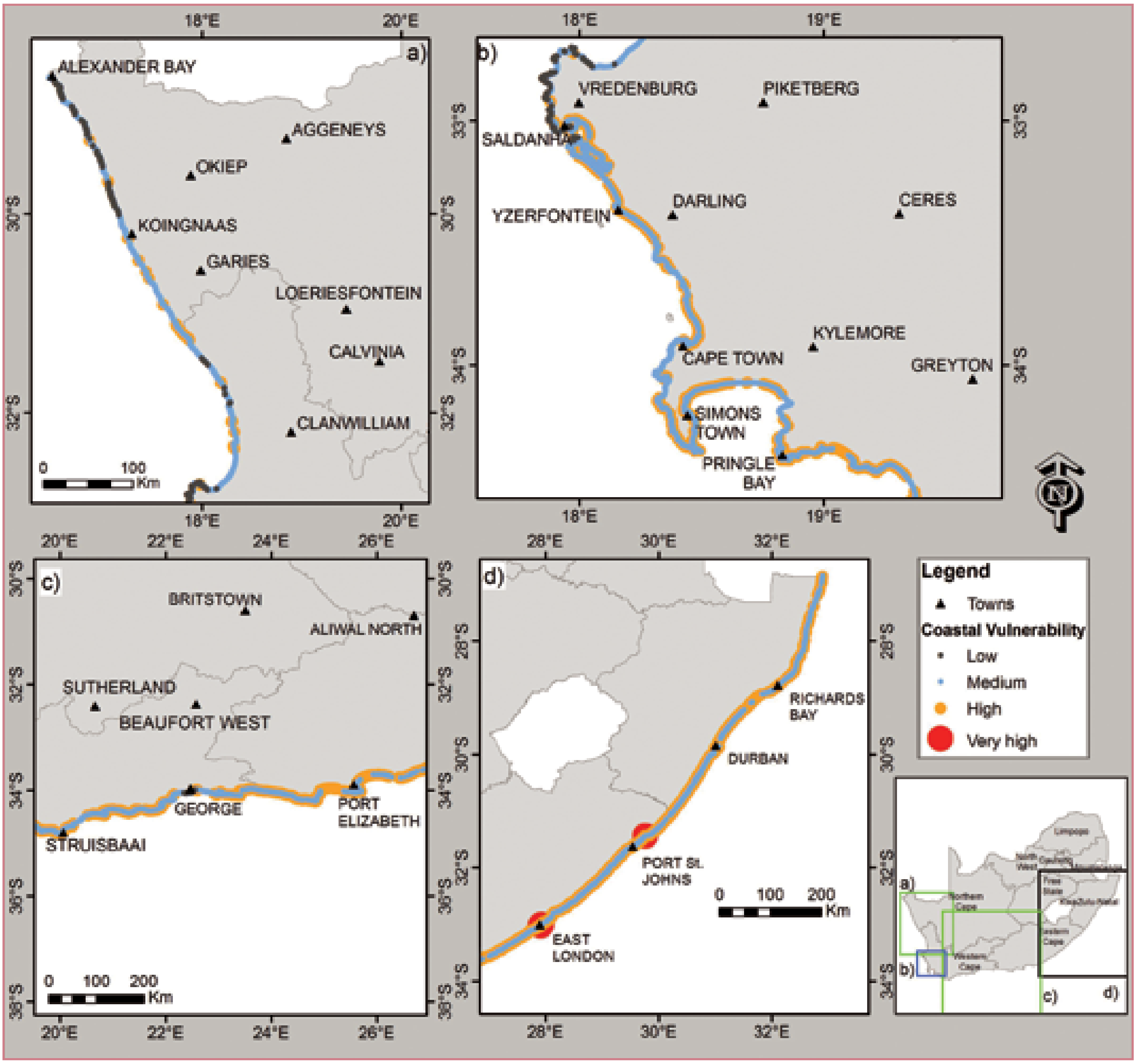

Figure 4. The regional Coastal Vulnerability Index for the South African coastline based on a combination of all parameters. From Musekiwa et al. (2015).

exacerbated by anthropogenic activities. Atmospheric warming will likely have an impact on available latent heat in the system to drive more powerful storms, as we have already observed in the past decades. With vast improvements in technology and monitoring systems (for example, tide gauges installed in harbours and an Indian Ocean tsunami warning system in place) and access to higher resolution satellite altimetry data, gaining an understanding of these interglacial patterns is increasingly possible. Cities situated at the coast continue to develop preventative solutions for the impact of a rising sea level, or measures to better withstand large storm waves, but the sea level rise is inevitable: perhaps within the next two centuries as much as 0.9 - 1.8 by the year 2100 and 2.7 - 5 m by the year 2200 (numbers calculated by Rohling et al., 2013).

Hayley C. Cawthra

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ARTICLES

lifting the curtain...

Continents are a planetary oddity, when you think about it. We know of no other planet that sports any similar features. The same applies to life. Can these two peculiarities be related, so vastly different in scales of both time and space? The search for answers takes us to the origin of both processes, deep within the basement of the Earth's first continent: the Kaapvaal craton, as exposed in the Barberton Mountain Land.

Continents, those semi-permanent platforms floating in the Earth's crust, require the separation of an originally homogenous mass, into lighter and denser materials. This can only be achieved through steady and repeated partial melting of huge volumes of rock by a reliable long-term heat source, such as found in the Earth's mantle. Subduction and convection combine to force cooler solid material into deeper, hotter zones. Subduction zones are recognized as the continent factories. Lighter material rises within the magma chambers above subduction zones, and is eventually exposed to the gases and liquids at the surface, while denser material sinks back into the mantle. Once exposed, the gradients achieved in the 'solid' surface materials (mountains) ensure that weathered continental rocks are transported to the oceans in both particulate and dissolved form, giving rise to immense clastic and chemical sedimentary deposits, along with endless pore spaces, dissolved nutrients and shallow-water (wet and dry) tidal environments. Simply add sunlight and wait 3 billion years (3 Ga).

There is, however, no need to invoke *plate* (or lateral) tectonics for this process. If the planet's interior was too hot, subduction would not succeed because the surface material will be too hot and too buoyant to sink. Nevertheless, the earliest continents may have formed through the vertical rise of hot mantle material in discrete cells with the corresponding sagging of material in between, a process not unlike that in a lava lamp – an old idea that has recently come back into fashion. The Barberton Greenstone Belt (BGB) is one of the few regions worldwide that shows evidence of this particular style of *vertical* tectonics, a relic of a younger, hotter Earth.

Faurea growing in the high hill-slopes of the Barberton Mountain Land.

Northward view toward the Lebombo mountains

Recognising these attributes, the BGB was proposed as deserving World Heritage Site (WHS) status by Carl Anhaeusser in the 1980s, a relatively lonely voice until about a decade ago. Slowly, even until today, awareness of the value of geoheritage is growing. Official planning for WHS recognition began around 2006, and in WHS status followed in 2009, but after one year of work, the project ran out of funds and was placed on hold. Planning is now back on track and the Barberton Mountain Land is first in the queue of South Africa's upcoming WHS applications. The plan is to have the Nomination Dossier tabled at UNESCO during the current year's cycle of acceptance.

Credit for staying in touch with the process must go to the Barberton Chamber of Business whose belief in the merits of the case has never faltered. They created a project management agency named BATOBIC (Barberton Tourism and Biodiversity Corridor) responsible for funding and managing the project. BATOBIC also oversaw the planning and construction of the Barberton Makhonjwa Geotrail, now two years old and warmly reviewed by geologists and tourists alike. The team of professionals doing the WHS work is basically the same as in 2009, brought together by geologist, Dr. Dion Brandt.

The area to be included within the WHS has been the subject of much debate. The Tentative Listed site included only nature reserves; but important geosites extend way beyond their boundaries. Outcrops in overgrazed cattle country are not necessarily at greater risk of damage than those in nature reserves, and are often easier to find. Trackless mountain wilderness, with long grass, thorny thickets and forested river lines, makes for delightful geological fieldwork. But biodiversity protection is not a pre-requisite for geosite protection, although in some circumstances it helps at a landscape scale. Having little commercial value, these outcrops are low-risk, low-maintenance assets. So where should the WHS boundaries be located?

1st signs of life visible to the naked eye

Current planning indicates that a multi-owner, multi-land-use core area will be proposed. Management and administrative complexities will result, but they will be offset by the relative simplicity of protecting *geodiversity*, as compared to protecting *biodiversity*. Scientifically important (rare) geosites can be conserved easily because rocks are largely self-protecting. There is not much to be asked of a land-owner with an important geosite on his land: "Please don't damage, excavate or bury the rocks," and, "Please allow visitors to examine them". Registered

Zebra stripes near the Lochiel T-junction

outcrops, and there are about 300 of them, are not likely to wander off or get shot like rhinos do.

As a matter of fact, the biggest threat to these valuable outcrops, both within nature reserves and outside, is the ill-discipline of rock collectors: including, geologists, students and researchers, with their ever-ready geopicks and core drills. With WHS proclamation this 'entitled' behaviour will have to become more disciplined and considerate.

If museums could display continents and microbes side by side, confined by walls and glass, the significance of the link would probably be lost to visitors as they walk out the door. To really gain insight about the continent factory, and why singled-celled organisms had to make a 2.5 Ga investment to make the planet clean enough to support multi-cellular life, you have to get into those impossibly ancient green hills of the Makhonjwa Mountain Range. These most ancient strata, never subducted, have lain lightly and coolly buried and protected for 3.3 billion years. Their study lifts the curtain on the Earth's earliest beginnings and shows the vital link between continents, and the evolution of life as we know it.

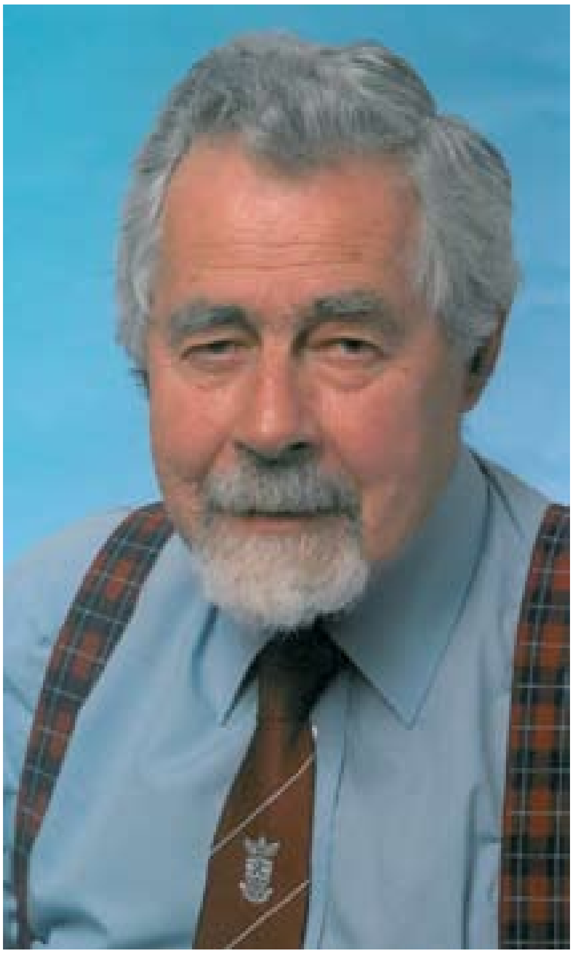
At the side of a tarred road along the Geotrail you can see, by simply stepping out of your car, the earliest signs of life visible to the naked eye. A few graceful curves further, and you will see all sorts of evidence of our planet's first proto-continent. The relationships are there, clearly explained for all to see. In truth, the Barberton Mountains stand as the planet's pre-eminent natural monument to Earth's early history. There is nowhere else quite like it anywhere on Earth – nor on any other planet.

Tony Ferrar, Barberton;
with unreasonable amounts of help from his wife Sandy, and Christoph Heubeck in Jena, Germany.

Tidal foresets

obituary:

Joseph Lurie †



Prof Jos Lurie

Jos Lurie, a Fellow of the GSSA and an Honorary Life Fellow of the SAIMM, passed away on Monday 27th April 2015 at the age of 86 after his fight with cancer.

From his early childhood in Maclear, in East Griqualand, he showed his leadership qualities in the Scouts and through independent camping adventures. His youthful experiences are recorded in an unpublished book he wrote in the last full year of his life titled "An Exciting Life" by Jos Lurie.

Jos was a relative late-comer to Geology, having had at least ten years working experience, mainly as a Land Surveyor, before enrolling at Rhodes University in his late twenties to study Geology. It was perhaps his exposure to the world of work before enrolling at Rhodes, which directed his eventual passion for vocational education which he assiduously pursued all of his professional life.

His first employment was as a filing clerk in Cape Town, after which he became a trainee draftsman, qualifying in 1947. He progressed to the Department of Trigonometrical Survey in Mowbray, and obtained his Surveying qualification with distinction. His subsequent work for the Trig Survey involved surveying many of the trig beacons, located on some of the highest peaks in Natal and the Cape Province.

In 1954 Jos obtained employment as an Engineering Surveyor in Kenya to set up irrigation schemes. During this 4 year period he learned to fly small aircraft and had the opportunity to climb Mount Kilimanjaro accompanied by only one friend. He was always an adventurer!

Jos met and married Brenda (his wife of 57 years) in 1958. Brenda was an English nursing sister from Surrey, who was on contract in Kenya at that time. Their honeymoon took them on an adventure in a Land Rover through Central Africa during turbulent political times. Thereafter they decided to return to SA, whereupon Jos enrolled at Rhodes, graduating with his B.Sc. (Hons) in Geology (with distinction) in 1961.

In 1963 Jos joined the then Witwatersrand College for Advanced Technical Education (located opposite Johannesburg Station) as a lecturer in Geology and Surveying and soon became the head of the Geology Department. He became Head of the School of Mines in 1980, by which time the Engineering departments had been moved to the new Doornfontein Campus and the name of the institution had been changed to Technikon Witwatersrand. It was during his tenure at the Doornfontein campus that Jos built up his enduring legacy of vocational education in the Minerals

Industry, which included Mining, Surveying, Extraction and Engineering Metallurgy and Geology. He was very well respected across the mining industry and occupied a position which can truly be termed "iconic". Generations of past students including many Mine Managers in South Africa and abroad will remember him fondly. Such was his passion for vocational training that he would not be deterred from his desire to include Geology as part of the suite of courses following this model. In 1972, while still on the Eloff Street Campus the first students were enrolled for the newly created Geology Diploma. Despite this course being curtailed after only one year, Jos was not to be deterred and resurrected it in 1982 as the Diploma and Higher Diploma in Economic Geology, which was to continue being presented (undergoing both a name and curriculum change) for more than 20 years, after which it was discontinued as a result of the merger between the Technikon and RAU. During the time of its existence the Geology Diploma course provided many valuable graduates to the Minerals Industry, many of which are today working as Geologists worldwide.

Although Jos worked tirelessly and long hours for the cause of Technikon education, he did not neglect his interest in Geology. He authored what is undoubtedly the one textbook on Geology in South Africa which has the distinction of being the longest in publication and used by more students than any other textbook of its kind in South Africa. South African Geology for Mining, Metallurgical, Hydrological and Civil Engineering was first published in 1977 and has been through 11 editions, and is still used by current students. It has been the standard Geology reference work for thousands of Mining Industry students for almost forty years. In 1974 Jos was awarded his Doctorate in Geology by Rhodes University for his thesis on the Geology and Geochemistry of the Pilanesberg Complex, on which he became an authority.

His interest in history led to the publication of two books; one on the history of Mining and Metallurgy at the Technikon Witwatersrand and the other a history of the Technikon Witwatersrand. He also became a Fellow of the Gemmological Association, by obtaining a qualification in Gemmology (FGA). After retiring from the School of Mines in 1994, Jos maintained an office in the School as he was busy with many projects, including his books on the history of the Technikon, and in developing an archive housing material of historical importance to the Technikon. In retirement he also made good use of his Gemmology qualification in teaching the subject to the Jewellery Design students and built up an impressive centre of Gemmology teaching. Jos had always been interested in crystallography and in his later years extended this to an interest in polyhedra, a subject on which he also published.

Jos was an accomplished raconteur, and those who worked with him at the Technikon will recall the many hours during field trips and in the staff room at tea and lunch, when Jos so enjoyed recounting anecdotes of his earlier adventures as a student under Edgar Mountain at Rhodes, a young surveyor scaling the highest peaks of the Cape Province with a theodolite, his time in East Africa and the years spent mapping in the isolation of the Pilanesberg prior to it being declared a National Park and after it had been vacated by the farmers.

A number of us got to know Jos well over the last few years at the geologist's retiree's lunches at the Wanderers Club. On these occasions Jos's passion for the Pilanesberg together with crystallography and survey always emerged with many an absorbing tale over a few beers. Shortly before his death Jos was involved in the preparation of a paper on the Pilanesberg for the Geoheritage volume to be published for the 35th IGC.

Many interesting anecdotes relating to his long association with and passion for this remarkable alkaline ring structure emerged over lunch, and as part of the preparation for the Pilanesberg paper, Jos handed Morris and Richard Viljoen on an old grey suitcase containing a range of superb colourful polished slabs of Pilanesberg alkaline rock specimens, together with number of manuscripts. These will now be well curated, for the benefit of future generations and as a lasting memory of Jos.

Harry Brown
Peter Knottenbelt
With contributions from **Richard** and **Morris Viljoen** and **Gerry Levine**

media monitor

MINING AND EXPLORATION NEWS

Copper

Freeport McMoran has agreed to sell its 56% interest in the Tenke Fungurume mine in the DRC to China Molybdenum Co. (CMOC) for US$2.65 billion in cash plus a contingent consideration of up to $120 million. The transaction is subject to the right of first offer held by Lundin Mining Corporation (24% interest) – the remaining 20% stake is held by La Générale des Carriéres et des Mines (Gécamines), which is wholly owned by the DRC government. Tenke Fungurume, which has consolidated recoverable reserves totalling 7.2 billion pounds of copper and 874 million pounds of cobalt, produced 467 million pounds of copper and 35 million pounds of cobalt in 2015. Freeport will also negotiate exclusively with CMOC for the sale of its interests in the Kokkola cobalt refinery in Finland and the Kisanfu feasibility-stage exploration project in the DRC.

Ivanhoe Mines released an independent pre-feasibility study for the first phase of its Kamoa copper joint venture with Zijin Mining in the DRC. The first phase of mining would be based on shallow underground resources, with an annual run-of-mine production of 3 Mt to produce approximately 100 kt of copper in concentrate per annum over a 24-year mine life at a mine-site cash cost of US$0.75 per pound. The capital cost of development is estimated at US$ 1.2 billion. The planned second phase would entail a major expansion of the mine and plant, and construction of a smelter to produce blister copper. Kamoa currently has a Probable Reserve of 71.9 Mt at 3.86% Cu, contained within Indicated Resources of 752 Mt at 2.76% Cu.

Gold

Armadale Capital announced the preliminary results of a feasibility study for the Mpokoto gold project in the Katanga Province of the DRC. The initial phase of mining will focus on the shallow oxide portion of the orebody, producing an average of 24 900 gold ounces per annum over four years. Capital cost is estimated at US$25.15 million, with operating costs of US$792 per ounce. Open pit mining will be carried out in conjunction with the continued development of the deeper unweathered ore designated for phase 2. The company is undertaking an initial 2000 m auger drilling programme to be followed by a 2500 m diamond drilling programme to test prospective targets identified in late 2015 that indicate possible strike extensions of the known high-grade gold mineralisation. Mpokoto has a current total mineral resource of 14.58 Mt at 1.45 g/t Au for 678 000 gold ounces.

Endeavour Mining sold its Youga gold mine in Burkina Faso to privately owned Turkish company MNG Gold for US$25.3 million. Youga, which has a remaining life of 2 years, is close to MNG's high-grade Balogo project, which will enable the operation to be extended. Endeavour subsequently agreed to acquire True Gold Mining, which has a 90% interest in the Karma gold mine in Burkina Faso, for C$82.6 million. The acquisition will increase Endeavour's gold reserves by 19% to 10.2 million ounces, and boost the company's forecast annual gold production by about 110 000–120 000 ounces with a mine life of 8.5 years.

Randgold Resources has entered into two new exploration joint ventures in the northeastern DRC. The first is with Canadian company Loncor Resources, which has exploration permits covering 2077 km2 of the Ngayu Archaean greenstone belt, and which Randgold will manage and fund to completion of a pre-feasibility study. The second joint venture is with state-owned mining company Société Minière de Kilo-Moto SA (SOKIMO) and Moku Goldmines for the Moku-Beverendi exploration project, along the same greenstone belt that hosts the Kibali mine, owned by Randgold and AngloGold Ashanti. Randgold can earn in a minimum 51% stake in the project by funding and conducting exploration and completing a pre-feasibility study.

Industrial minerals

Australian company Black Mountain Resources has agreed to acquire the Namakera vermiculite mine and Busumbu phosphate project in eastern Uganda from African Phosphate. Namakera, a former Rio Tinto asset, is considered to be the world's largest vermiculite deposit with a JORC Code Inferred Resource of 57.4 Mt at 26.7% vermiculite announced by previous owner Gulf Industrials in 2009. Vermiculite production began on a small scale in 2002, and the operation was re-commissioned and expanded by Gulf in 2010, producing 42 kt of vermiculite between 2011 and 2013. Black Mountain plans to conduct further feasibility work with the aim of expanding production to 30 kt/a, and ultimately to 80 kt/a. At the Busumbu phosphate project, which is located on the existing Namakera mining lease, drilling has confirmed mineralisation to a depth of up to 60 m with grades of up to 30.5% P2O5. Black Mountain aims to complete a pre-feasibility study late in 2016.

Avenira Limited has started operations at the Baobab phosphate project in Senegal, with commercial production scheduled for the second half of 2016. The company's strategy is based on an initial operation producing 500 000 t/a of phosphate concentrate, with expansions to follow. The total capital expenditure to production is USS15 million.

Black Rock Mining announced the completion of an independent scoping study for the production of 52 kt/a graphite concentrate at its Mahenge project in Tanzania. The company has now begun a pre-feasibility study, together with more detailed metallurgical test work and a final drilling programme. Mahenge contains a current global resource of 131.1 Mt at 7.9% total graphitic carbon (TGC), making it the third largest JORC-compliant flake graphite resource in Africa, with 40% of the resource tons in the Indicated category. The scoping study utilised 12.5 Mt of the highest grade near-surface tonnage with an average grade of 10.5% TGC.

Platinum group elements

Ivanhoe Mines reported a substantial increase in the mineral resources at its Platreef project on the northern limb of the Bushveld Complex. The Indicate Resources now contain an estimated 42.0 million ounces of 3PGE+Au (346 Mt at a grade of 3.77 g/t 3PGE+Au, 0.32% nickel, and 0.16% copper at a cut-off of 2.0 g/t PGE+Au) – an increase of 45% over the previous estimate in 2013. The new estimate, which is based on 97 737 m of detailed infill and exploration drilling, encompasses the Turfspruit Cyclic Unit (TCU), which hosts the majority of the resources, as well as two additional zones of mineralisation that occur in close proximity to the TCU. Following the changeover of shaft-sinking equipment from the pre-sinking phase, the main sinking work on Shaft 1 is scheduled to begin in early June 2016. This shaft, which will provide early development access into the deposit and will be utilised to fast-track production during the first phase of the project, is expected to reach the deposit at a depth of 777 m below surface during the third quarter of 2017.

Vanadium

Bushveld Minerals will pay the Evraz Group US$17.2 million for its 78.8% stake in Strategic Minerals Corporation, which owns the producing Vametco vanadium mine and processing plant in South Africa's North West Province. Vametco, which is located adjacent to Bushveld's recently acquired Brits greenfield exploration project, has a current annual capacity of 2750 t of vanadium in Nitrovan (a patented vanadium nitride product used in the steel industry) and V2O3, with scope to expand to 3340 t/a through limited capital expenditure. The ore reserves of 27 Mt, with some of the highest in-magnetite vanadium pentoxide (V2O5) grades in the world, averaging 2.55%, are sufficient to support the operation for 24 years at current production levels.

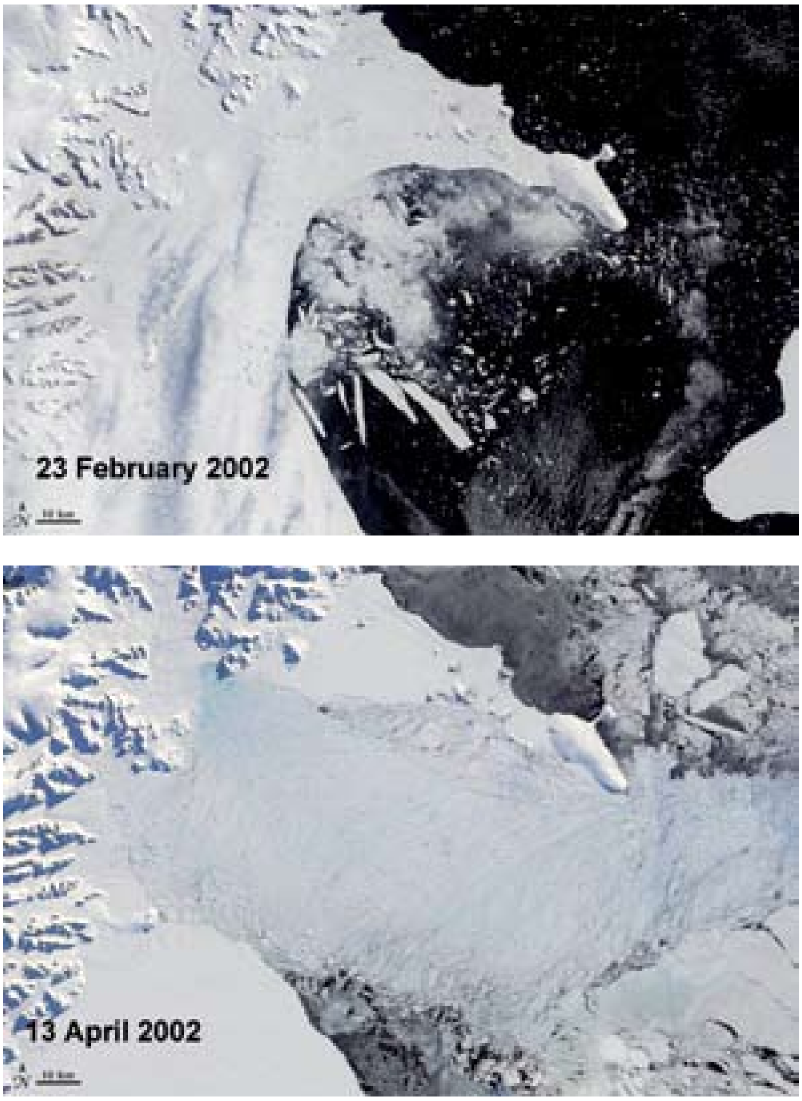
Zinc

Ivanhoe Mines announced the results of an independent, preliminary economic assessment for the planned redevelopment the high-grade, Kipushi zinc-copper mine in the DRC. The study covers the redevelopment of Kipushi as an underground mine, producing an average of 530 kt of zinc concentrate containing 53% Zn annually over a 10-year mine life, at a total cash cost, including copper by-product credits, of approximately US$0.54 per pound of zinc. Mining would focus on Kipushi's Big Zinc Zone, which has a currently estimated 10.2 Mt of Measured and Indicated resources at 34.9% zinc, a grade that is more than twice as high as the Measured and Indicated resources of the world's next-highest-grade zinc project. Historical mining at Kipushi was carried out to approximately 1220 m below surface, and with most of the underground development and surface facilities already in place the project is of low capital intensity, with a total capital cost of US$528 million.

Other Geoscience News

Climate change is affecting the way that the Earth wobbles about its polar axis, a new study by NASA has found. As ice sheets melt and aquifers are drained, the planet's distribution of mass is changing—and with it the position of the spin axis. The spin axis does not always coincide with the geographic poles, but drifts slowly. The furthest away it has moved since observations began in 1899 is 12 m – not enough to affect daily life but which needs to be taken into account to get accurate results from GPS, Earth-observing satellites, and ground-based observatories. Before about 2000, the north pole of rotation was moving towards Canada, but since then it has shifted eastward towards the Greenwich Meridian and is now moving almost twice as fast as previously, at a rate of almost 17 cm a year. In a paper published in Science Advances (doi: 10.1126/sciadv.1501693), Surendra Adhikari and Erik Ivins of NASA's Jet Propulsion Laboratory use satellite geodetic and gravimetric data to demonstrate that almost the entire amplitude and directional shift of the observed motion can be ascribed to changes in the Earth's distribution of mass as a result of changes in water storage. However, the massive losses from the ice sheets in Greenland and West Antarctica are not enough to explain the entire shift. Calculations show that the bulk of the answer is a water deficit in the Indian subcontinent and the Caspian Sea area. Although the water mass lost due to depletion of aquifers and drought is nowhere near as great as the change in the ice sheets, it has a disproportional effect because the spin axis is very sensitive to changes occurring around 45° latitude, both north and south. Changes in continental water storage, in particular, appear to match closely with the so-called decadal oscillation, in which the spin axis moves 0.5–1.5 m eastwards or westwards of its general direction of drift every six to 14 years. This newly discovered link between polar motion and global-scale variability in water storage has broad implications for the study of past and future climate.

Antony Cowey



The collapse of the 3250 km2 Larsen B Ice Shelf in Antarctica in 2002 is just one example of shrinking glaciers around the world, a process that is changing the planet's mass distribution. (Photographs by NASA Earth Observatory)

MEDIA MONITOR

Aberdare & Mount Kenya

THE GEOTRAVELLER

By Roger Scoon

Volcanic Terranes adjacent to the Gregory Rift, Kenya

High slopes of Mount Kenya include heathland where lavas with near-horizontal bedding are exposed.

The Aberdare Range and Mount Kenya are located within the Central Highlands, Kenya, and include well known national parks visited by hikers and wildlife enthusiasts. The Aberdare is an extensive, faulted volcanic terrane derived from numerous fissures and small cones. Mount Kenya is a giant volcanic edifice built around a central conduit. Several intrusive plugs of nepheline syenite, the largest of which blocked the conduit and triggered considerable parasitic activity are a feature of the Mount Kenya volcanism. The volcanic origin and presence of ice sheets on Mount Kenya was first observed by Joseph Thomson, in 1883, but was only accepted in scientific circles when John Walter Gregory, after whom the eastern branch of the Rift Valley is named, reached the Lewis Glacier at a height of 5,000 m in 1893. The jagged peaks that cap Mount Kenya were first climbed by H J Mackinder, in 1899, who ascertained they are part of a large plug of nepheline syenite.

The bulk of the Aberdare Range is protected in a National Park established in 1950. The park was made famous from visits by the British royalty to the unique Treetops Lodge. The Mount Kenya National Park, established in 1949, is a World Heritage Site. Both parks occur east of the Gregory Rift Valley and are served by regional towns that include Nyeri and Naro Moru. The climate is temperate due to the high altitude, despite the equatorial setting. The Aberdare Range includes plateaus with altitudes of over 3,500 m. Mount Satima (4,001 m), the third highest peak in Kenya, is a rocky knoll that can be reached within a day's hike. In comparison, the dome-shaped massif of Mount Kenya has a diameter of over 100 km and the highest point accessible to trekkers, Point Lenana (4,985 m) requires a 2-4 day hike. The most popular route is the Naro Moru track via the Teleki Valley with overnights at the Met Station and Mackinder Huts. The two highest summits, Batian (5,199 m) and

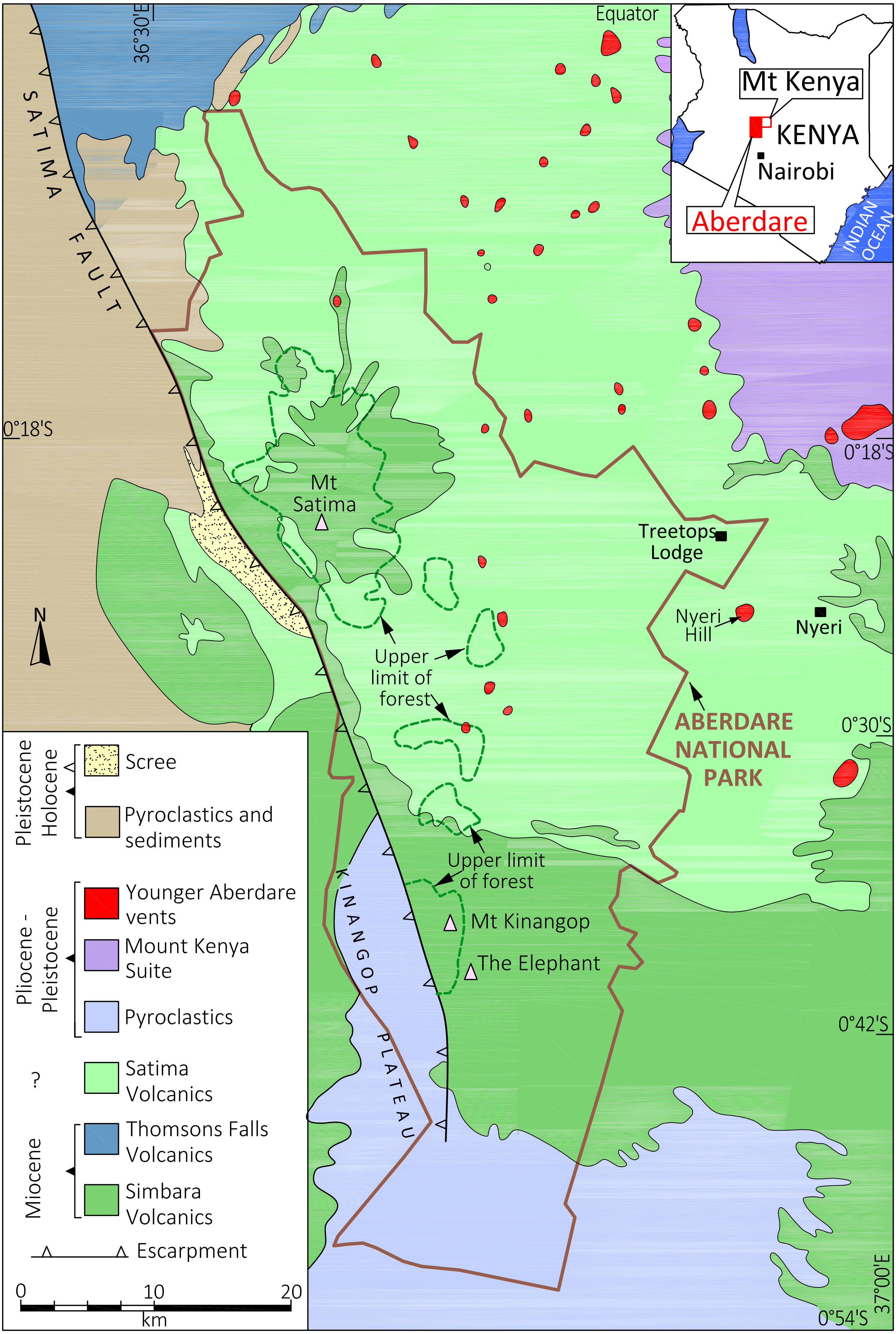
Nelion (5,188) are part of a group of jagged peaks that can only be ascended with a degree of technical difficulty. They are separated by a 250 m-wide gap known as the Gate of the Mists.

Three magma groups are recognized in the volcanism associated with development of the Gregory Rift (Baker, 1987). Each group reveals a discrete fractionation trend over time. First, magmas with a nephelinite to phonolite trend (including carbonatite) were erupted during the early Miocene pre-rifting stage (22-12 Ma). Second, magmas that evolved from alkali basalt to phonolite were erupted during the late Miocene and very early Pliocene half-graben stage of rifting (12-4 Ma). (iii) Third, the Pliocene and Pleistocene (4 Ma-10,000 BP) saw a full graben stage with outpourings of transitional basalt, trachyte, and rhyolite. The Miocene-age volcanism of the Aberdare is typical of the second group found on platforms that parallel the Gregory Rift. Many of the central volcanoes – they occur up to several hundreds of km from the Rift Valley - and include the Pliocene-age Mount Kenya, however, reveal individual trends. Examples of the first and third stages of activity are Mount Elgon (at 22 Ma the oldest of the rift-related volcanism in central Kenya) and Mount Longonot (Pleistocene-), respectively.

The 160 km-long Aberdare Range is aligned almost parallel to the north-south aligned Gregory Rift. The western side is demarcated by a prominent escarpment that has developed on the Satima Fault. The downthrown block located between here and the valley is known as the Kinangop Plateau. The eastern side of the Aberdare reveals a broad valley bordered by Mount Kenya. Large parts of the 766 km^2 Aberdare National Park are covered by dense montane forests. Deep, thickly forested ravines and the myriad of watercourses is a notable feature. The high plateaus extend through the forest into a zone of heathlands and moorland. They include Kinangop (3,906 m) and the Elephant (3,600 m). Several large waterfalls, including the Gura Falls (302 m) and Karura Falls (272 m) occur on the rims of plateaus. Located to the north of the Aberdare Range is Thomson's Falls, a popular tourist destination where the Ewaso Naruk River plunges 72 m over a resistant flow in the Miocene-age Laikipia Volcanics.

Two groups of volcanic rocks are identified in the Aberdare Range. Basalt and agglomerate of the Simbara Volcanics dominate the southern part. These rocks are unconformably overlain in the central and northern parts by thick sequences of phonolite and trachyte known as the Satima Volcanics. The age of the latter is poorly

Forested hills of the Aberdare Range give way to heathlands on the high plateaus.

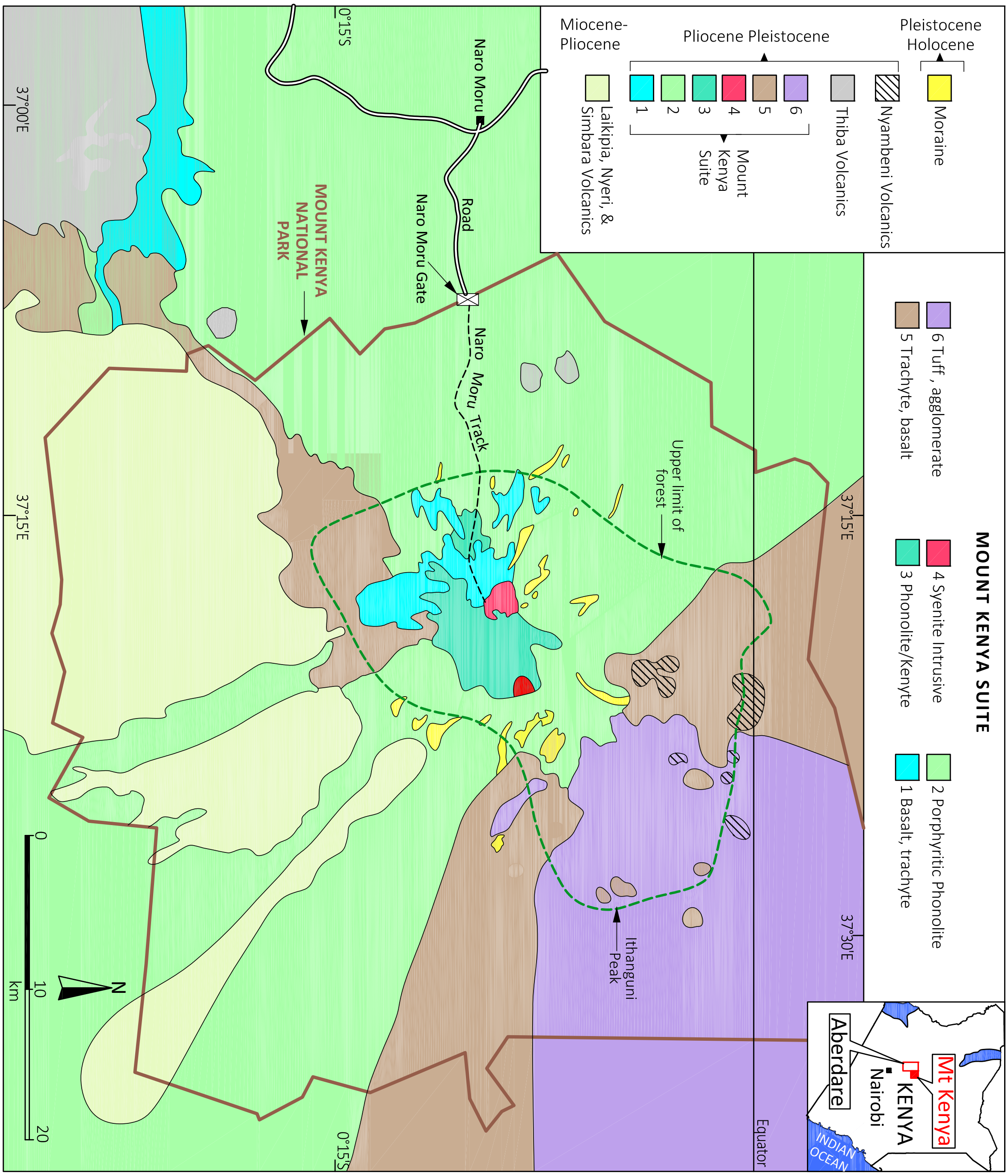


Geological map of the Aberdare National Park simplified from Quarter Degree Sheets 43NW and 43SE *constrained. They were originally mapped as Pliocene (they are demonstrably younger than the Simbara) but were reported as contiguous in the northern section with the Laikipia Volcanics. The Simbara and Satima Volcanics were erupted from fissures and small cones with lavas flooding an ancient landscape to form a stepped topography. Plateaus, including Mount Satima consist of uplifted blocks of Simbara Volcanics. The area to the northeast of the park comprises lavas of the Mount Kenya Suite. Small cones in the northern and central parts of the park that penetrate both the Satima Volcanics and the Mount Kenya Suite are ascribed to a younger phase of volcanism with an estimated Late Pleistocene age. The Aberdare Vents as they are known include several prominent koppies, e.g. Nyeri Hill. Pyroclastic rocks to the west and south-west of the park are associated with eruptions either on the Kinangop Plateau or in the Gregory Rift. The latter includes tephra from Mount Longonot. The absence from the Aberdare of volcanism coeval with Mount Kenya suggests some reciprocity between the two fields.*

The Mount Kenya National Park covers an area of 715 km^2, most of which occurs above 3,000 m. The cluster of peaks over 4,700 m that dominate most photographs make up only a fraction of the mountain. Batian, Nelion, Midget (4,770 m), and Point John (4,883 m), for example, are distinctive, triangular-shaped peaks, whilst others are part of a group of summit ridges. The Petit Gendarme and Great Gendarme are obstacles on the west ridge of Batian, fist climbed by E G Shipton and H W Tilman in 1930. Mackinder's pioneering route used the south ridge to reach Batian by the 140 m-deep Gates of the Mist. Prior to extensive erosion during the Pleistocene, the mountain is estimated to have contained a summit crater at almost 7,000 m.

The age of the Mount Kenya Suite is poorly defined. Some of the volcanic products have a maximum age of 4.5 Ma but the intrusive plugs (3.1-2.64 Ma) and parasitic events are considerably younger. Large sections of the volcano - which covers an area of some 7,000 km^2 - are thought to have been built directly upon the Basement. Gneiss and schist of the Neoproterozoic Mozambique Belt crop out on the lowermost south-western flanks (outside the area of the map). The north-western slopes merge onto the older terranes of the Aberdare Range but the northeast and south-western flanks, respectively, are covered by the younger Nyambeni Hills and Thiba Volcanics.

Thompson's Falls plunges some 72 m over a lava flow in the Laikipia Volcanics.



Geological map of the Mount Kenya National Park simplified from Baker (1967).

Baker (1967) recognized three principal events within the Mount Kenya Suite: an early group of parasitic events, a main volcanic component erupted from the central conduit, and later parasitic activity. The latter occurred after emplacement of intrusive plugs (these can be considered as a fourth component of the suite) that blocked the central conduit. The older parasitic activity includes flows of basalt on the lower south-western slopes, as well as of trachyte on the higher southern slopes. The younger parasitic activity is more extensive and for sake of clarity only two of a number of events are shown on the simplified map. The oldest of these are flows of olivine basalt and trachyte, which have a combined thickness of 470 m and were erupted from small fissures on the upper, northern and eastern flanks. The final phase of activity produced cones of lava, agglomerate, and pumice together with widely distributed tuffs. They include Ithanguni Peak, a prominent parasitic vent. The parasitic cones show some affinity with the Nyambeni Hills Volcanism with which they may be coeval.

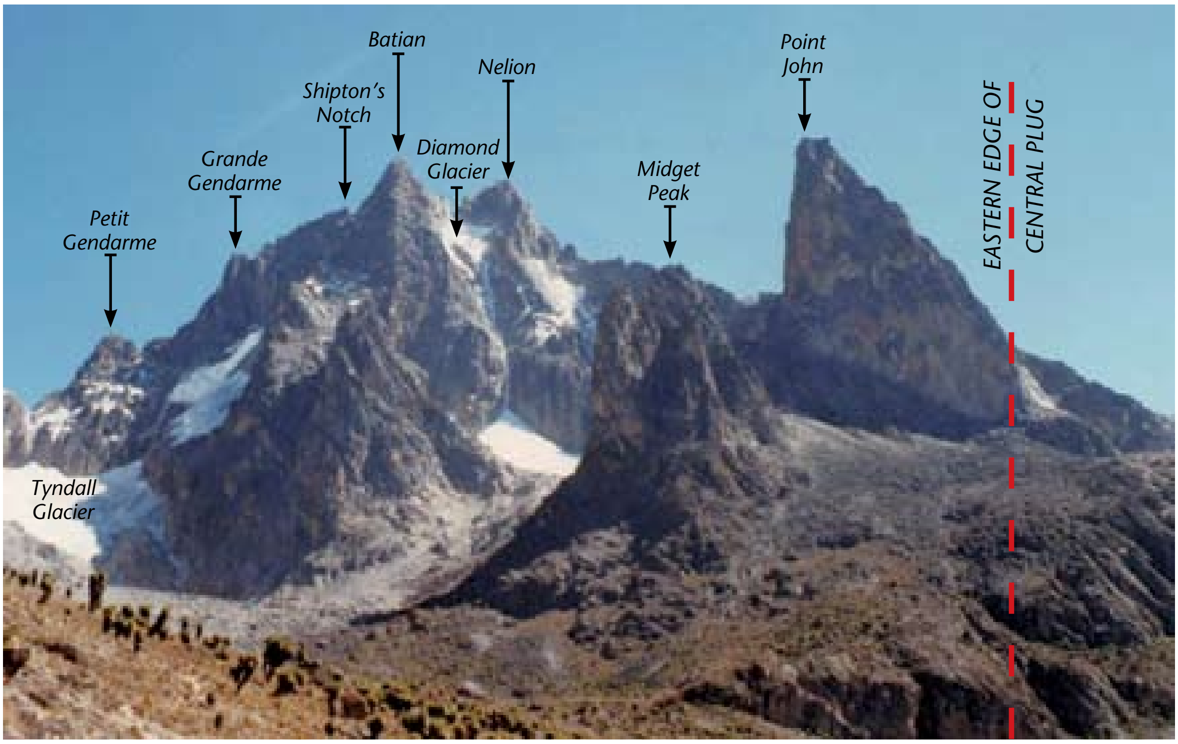
The bulk of Mount Kenya is, however, built up of flows *with radial, outward dips indicative of eruption from a central conduit. The exposed flows (excluding parasitic activity) have a combined thickness of over 600 m with some 2,850 m of lavas estimated to not be exposed. Proximal to the central conduit, flows are relatively thin, whereas those on lower slopes are much thicker. The dominant products are porphyritic phonolite and agglomerate. Large, partially resorbed phenocrysts of plagioclase up to 4 cm in length are a notable feature of the phonolite. Some feldspar occurs as thin laths with a prominent alignment. The phonolite weathers into rounded blocks and boulders and also crops out in low cliffs with columnar jointing. Agglomerates are most common on the upper slopes and can be seen from the Naro Moru track in low cliffs that include several caves. The porphyritic phonolite grades upward into a distinctive glassy phonolite for which Gregory proposed the name "kenyte" (this name is no longer in common usage). Kenyte is most prominent on the upper slopes and is distinguished by phenocrysts of nepheline; vesicles filled by small, pale coloured crystals of zeolite; and weathered faces with orange or purple colours. This phase of volcanism oscillated between quiescent lava eruptions and explosive tephra events: pyroclastics intercalated with the kenyte were derived from intrusive plugs that temporarily blocked the central conduit prior to be ejected as volcanic bombs.*

Agglomerates with clasts several tens of cm in size are a common feature of the Mount Kenya Volcanic Suite.

Porphyritic basalts of the Mount Kenya Suite contain abundant phenocrysts of plagioclase.

The central plug within the Mount Kenya Suite was interpreted by Baker as having blocked further activity from the central conduit: it was the last of a sequence of similar plugs. The plug constitutes a cylindrical body with a diameter of approximately 2.4 km and is at least 900 m in depth as it is exposed on the precipitous cliffs of Bastian and Nelion. The central plug is concentrically zoned. A core of nepheline syenite is enclosed by a rim of phonolite; the composition of the latter closely resembles the kenyte lavas. The phonolite divides into two wedge-shaped bodies in one part of the plug. The syenite reveals tabular crystals of feldspar up to 1.5 cm in length in the centre, but is notably finer-grained proximal to the chilled rim. The large tabular crystals are emplaced in a matrix of finer-grained mosaics of feldspar and reddish nepheline. The reddish colouration is pronounced in the Amphitheatre, a sheer face on the northern side of Batian. The shape of many of the peaks is defined by prominent jointing within the nepheline syenite and columnar jointing is preserved on Batian and Nelion. A 450 m-wide plug of nepheline syenite located near Polish Man's Tarn is a secondary vent from which some of the porphyritic phonolites described above were erupted.

Mount Kenya is the catchment for two of Kenya's largest rivers, the Tana (southern and eastern parts of the massif) and Eyaso Ng'iro (north-western). Large numbers of people in the fertile valleys surrounding the mountain rely on the myriad of streams in addition to the larger rivers. The mountain has created an area of increased rainfall in comparison to the drier plateaus due to the orographic effect during the southeast monsoon. A typical, daily weather pattern is the build up of clouds on the lower western slopes in the late morning that generally cover the central peaks by early afternoon as they are swept eastward prior to dissipating over the drier plains.



The rocky summit of Mount Kenya includes the two highest peaks of Batian and Nelion comprised of an intrusive plug of nepheline syenite. (Internet)

The lower slopes of Mount Kenya show no evidence of glacial activity, but the upper slopes and high peaks were severely glaciated. The Pleistocene-age ice cap originally covered some 400 km², an observation of Gregory that was treated with considerable importance in Europe as it signified the Ice Ages were probably a worldwide, rather than localized phenomenon. Glacial retreat was ascertained by Baker (1971) from detailed mapping of moraines, most of which are linear features located in valleys that define a radial pattern at heights of 3,000-4,500 m. A cluster of moraines can be viewed from the Naro Mori track near Teleki Tarn and Shipton Peak. A number of moraines mantle the subsidiary Ithanguni Peak (3,887 m) located to the east of the mountain near Alice Lake. Twelve individual glaciers were identified by early explorers, of which the Lewis Glacier, on the eastern slopes, is the largest. This glacier has been retreating at approximately 7.4 m/annum since 1900. The remnants

The montane and bamboo forests of Mount Kenya are replaced by heathlands and moorlands at a height of approximately 3,000 m.

of the Tyndall, Darwin, and Diamond Glaciers can be observed from the southwest. In the late 1890's the entire summit was ice-capped, but by the 1980's an area of only 0.7 km2 was covered. Formation and recession of ice sheets on Mount Kenya has probably followed a similar pattern to other East African Mountains such as Elgon, Ruwenzori, and Kilimanjaro.

Botanical zones on equatorial mountains adjacent to the Rift Valley (Aberdare, Mount Kenya, and Mount Elgon) are more varied than other areas. Unusually dense, montane forests have developed from enhanced rainfall and fertile, nutrient-rich soils. The montane forests on Mount Kenya occur up to a height of 2,500 m where they are succeeded by zones of bamboo forest (up to 3,000 m), heathlands (up to 3,500 m), and Afro-Alpine moorlands (up to 4,500 m). The heathlands and moorland, first described by Gregory and subsequently confirmed by botanists as having similarities with the Cape Floral Kingdom, include endemic species such as Senecio brassica and Senecio keniodendron (giant groundsels) and Lobelia keniensis and Lobelia telekii (tree lobelias). They occur up to heights of 3,800 m. Rare and endangered species of large animals occur in the montane and bamboo forests, including Bongo and Giant Forest Hog. Large cats such as Leopard, Serval, and Genet have evolved a melanistic camouflage. Moreover, males of larger species, such as Elephant, Buffalo, and Bushbuck are far darker than normal and may be entirely black. This is consistent with the rapid speciation which appears to have characterized East Africa. The camouflage can be explained by the luxuriant nature of the equatorial montane forests on the volcanic peaks.

All photographs by the author (2015) unless otherwise referenced.

The high moorlands of Mount Kenya include the endemic Lobelia keniensis.

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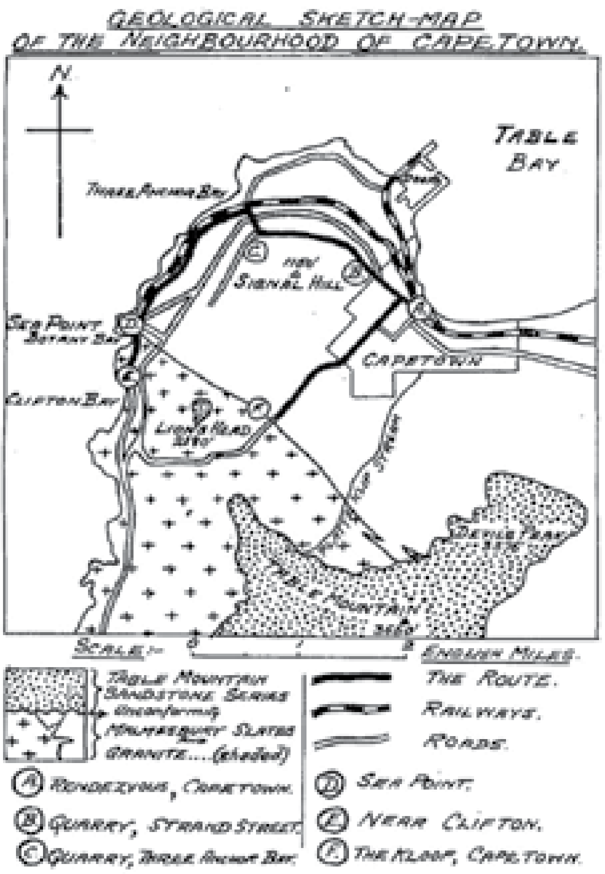
15th IGC, Pretoria 1929

Field trips then and now

Palache and Daly at the Sea Point contact. From left to right Prof Shand, Prof Young, Mr Bijl, Mrs Bijl, Mrs Molengraaff, Prof Palache , Mrs Shand, Prof Daly. These photographs of the Shaler Memorial Expedition are from a photograph album, "Zuid-Afrika 1922", probably compiled by Prof Molengraaff.



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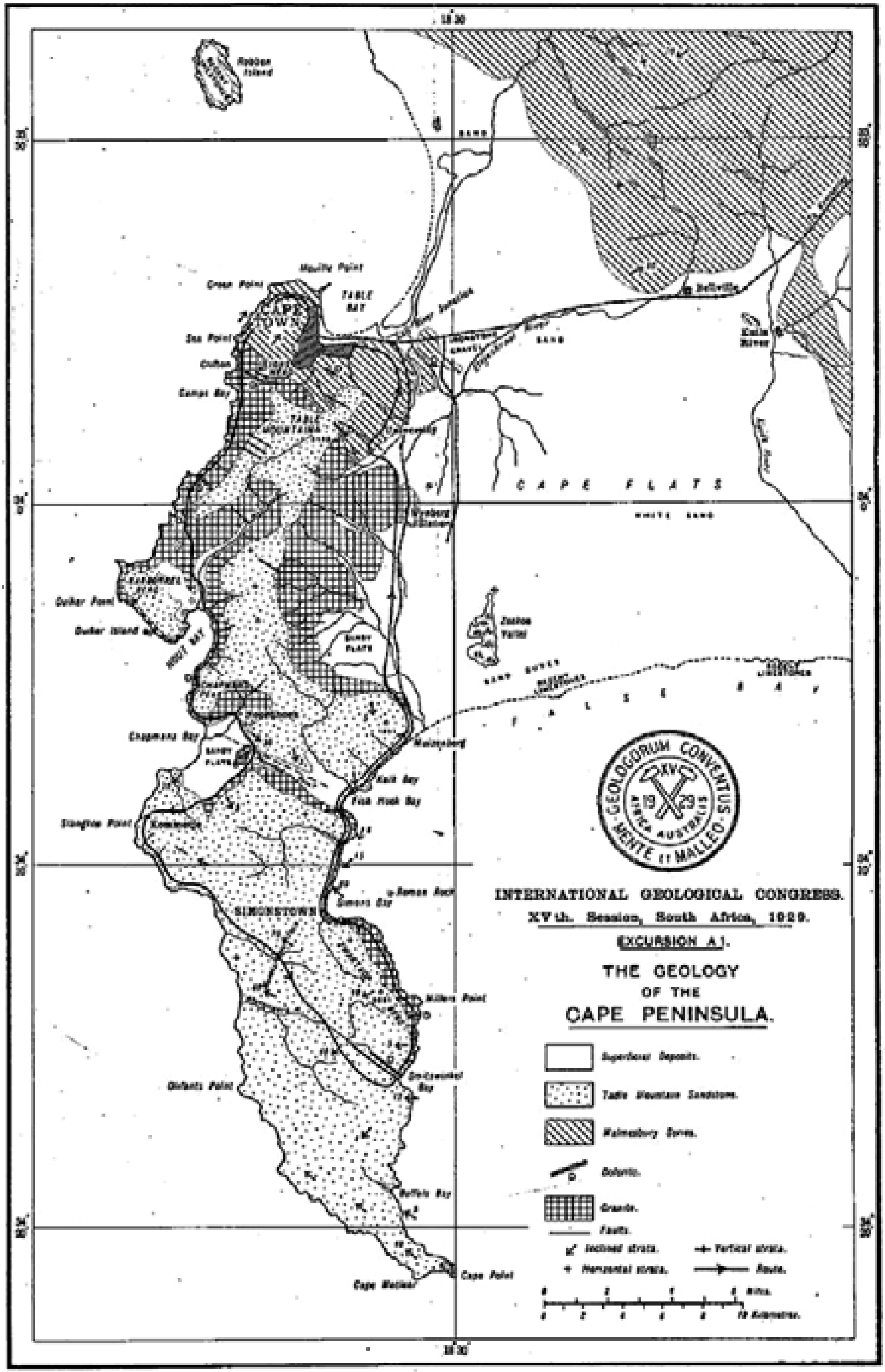
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    - Africa's Top Geological Sites
    - Mineral Fields of Africa (as a special issue of Episodes)

The Geological Society of South Africa is proud to be assisting the Council for Geoscience in staging this once-in-a-lifetime event.

See www.35igc.org for up to date details on the full program. Please visit the GSSA stand in the Exhibition Hall of the Cape Town International Convention Center.