GSSA
Geological Society of South Africa

geobulletin

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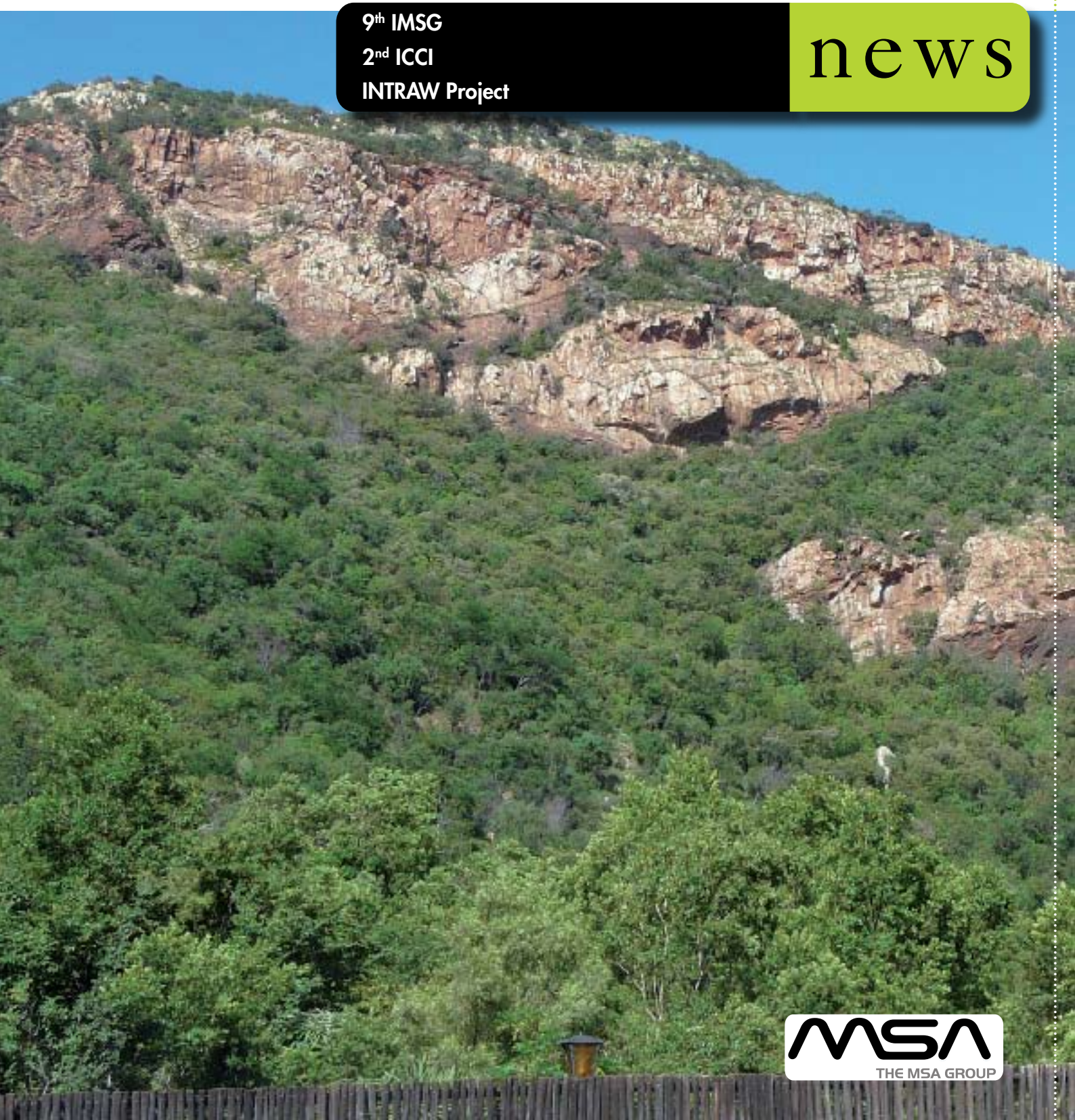
news

9th IMSG
2nd ICCI
INTRAW Project

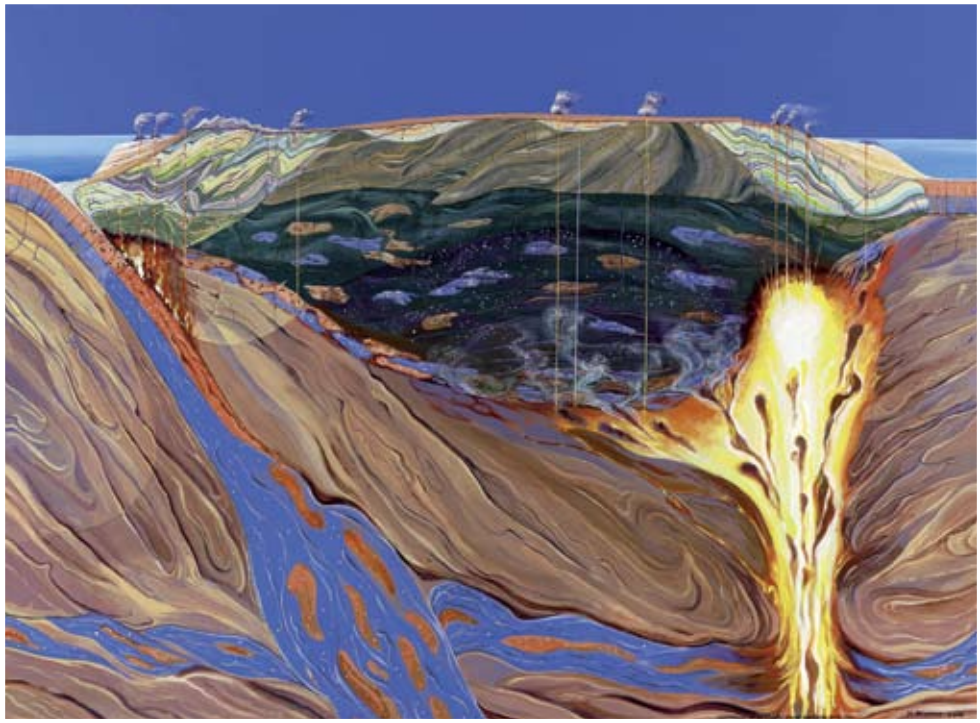


COVER PHOTO:

A view of the southern portion of the Zwartkops Hills, located along the north-west margin of the Johannesburg Dome, showing rocks of the Mesoarchean Witwatersrand Supergroup (lower West Rand Group). Four tectonic quartzite lenses surrounded by schist form the imbricate stack seen on the photograph.

Robyn Ormond

Photo: Chris Hatton



CENTRE FOLD

Diamond and Kimberlite Volcano Sources

Diamonds are much older than their host volcanoes (kimberlites) and are carried to surface as accidental fragments, called xenocrysts and xenoliths, from depth. Diamond is the high pressure mineral form of the element carbon and generally forms in nature at depths greater than 150 kilometres and temperatures greater than 1000°C within the upper mantle of the earth. Diamonds are old with ages ranging from 1000 to 3300 million years. Most carbon for diamond formation was derived from very deep earth fluids rich in CO_2 (carbon dioxide) and CH_4 (methane) and other carbon-bearing species. This carbon may be directly derived from the deep earth or be recycled from shallower depths in subduction zones. Kimberlite is the rock formed by a kimberlite volcanic eruption or intrusion and is the result of processes that caused the mantle to melt at great depth and this melt to be intruded to the earth's surface. Kimberlites are younger than the diamonds they contain. The pipes of Kimberley are only 90 million years old and contain diamonds ~3000 million years old. Diamonds occur in patches at depth in mantle rocks called peridotites (blue and green) and eclogites (orange) and therefore not all kimberlites contain diamonds. Kimberlites found within very old (>2500my) cold continental crust that is underlain by relatively cold mantle, have the highest chance of containing diamonds. These areas on earth are prime targets for diamond exploration programs.

Artist, Maggie Lambert-Newman.

contents

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from the editor's desk

Chris Hatton

Donald Trump lets you know where he stands. He unashamedly supports short term gains for the few at the expense of long term damage to the many. This is the man to look to for a fattened pay-cheque, regardless. Don't expect idealistic rhetoric from here – no more "ask not what your country can do for you, but what you can do for your country". Your country has plenty of coal and coal means jobs today, so burn it. Alarmed by Trump's cavalier attitude to the concerns of the climate change community in particular and to the science community in general, the American Association for the Advancement of Science has appealed to its members to make every effort to bring scientific findings to the attention of the public in as simple and as accessible a form as is reasonable. As discussed in previous issues the simple message on climate change is that there is close relation between the amount of carbon dioxide in the atmosphere and its temperature. For the last four hundred thousand years there has been a regular cycle of increases in carbon dioxide from two hundred to three hundred parts per million over a period of about ten thousand years. This is accompanied by an increase in temperature of about eight degrees. The carbon dioxide and temperature then decline for about ninety thousand years, until the next cycle begins. During the 'natural', that is to say 'uninfluenced by human activity', cycles of the last four hundred thousand years the carbon dioxide content never rose much above three hundred parts per million. Since the Industrial Revolution level of 280 ppm the levels have risen well above this 'natural' limit - as of September 2016 the southern hemisphere joined the northern hemisphere in breaching the 400 ppm marker. When 400 ppm was last reached, humans did not exist; will humans exist long after 400 ppm, asks the climate change community? Carbon dioxide is not the only thing you can choose to lose sleep about, but the message from the AAAS is that the duty of scientists is to bring the evidence to the attention of the general public so that each citizen can independently decide whether the benefits of burning coal exceed the costs.

In geology the most fundamental means of displaying evidence is the geological map. The 1984 1 : 1 million map of South Africa sketched the outlines of really catastrophic climate change event – the Permian-Triassic extinction in the middle of the Beaufort Series. In the 1925 1 : 1 million map of the geology of the then Union of South Africa the Beaufort Series appeared as an undivided green covering about a third of the country. So it remained through the 1958 and 1970 versions, until in 1984 the Beaufort Series became the Beaufort Group which was then separated into the Permian Adelaide Subgroup and the Triassic Tarkastad Subgroup. The Permian-Triassic boundary marks the wholesale transformation from Paleozoic life forms to Mesozoic life forms over a time scale on the order of a million years. A million years is the sort of time scale that can be shown on a 1 : 1 million map, but as the study of the Permian-Triassic extinction event has intensified, ever finer features have come into view. It now appears that there are in fact several events which contributed to a pulsed extinction of life forms. The particular event which is closest to the Permian-Triassic probably occurred on a ten thousand year scale. Depicting the units which could be deposited on this time scale is of course impossible on a 1 : 1 million map and even a 1 : 250 000 map is of little use for this kind of detail. A 1 : 50 000 map is the necessary starting point for this kind of investigation. Unfortunately maps at this scale are only available for 5% of the country.

Mercifully the recently appointed Acting CEO of the CGS has recognised that this situation is untenable. As Craig has alluded to in his Executive Managers Corner the CGS will be embarking on a ten-year program to map a quarter of the country at 1: 50 000 scale. This is a challenging program but the actions of the acting CEO give no reason to doubt that this will be accomplished.

The most direct way of looking at catastrophic climate change events is to examine the remains of the organisms that lived and died during those events. The bones left behind over the course of the transition from the Permian to the Triassic are of particular interest because by the end of the Triassic distinct mammalian characteristics had evolved from their reptilian Permian ancestors. However the remains of the plants that were catastrophically eliminated during the Permian-Triassic extinction events are far more abundant and their study may have been comparatively neglected. Geochemical studies, such as the determination of carbon and sulphur isotopic variations also provide quantitative evidence of dramatic changes which were associated with the extinctions. Some may feel that geochemical evidence is over-emphasised in comparison to the palaeontological data, but geochemistry is part of the ever expanding arsenal that is brought to bear on major events such as the Permian-Triassic extinction.

On p. 12-14 of this issue the opening of WIGL is reported on. This laboratory is part of CIMERA (the Centre for Integrated Mineral and Energy Resource Analysis), which is co-hosted by UJ and Wits but also co-operates and co-ordinates activities with several other geological institutions. Non-traditional stable isotopes will become available for study as part of the integrated studies carried out at CIMERA. These integrated studies are founded on the fundamental evidence of the rock formations which will again receive the close scrutiny they deserve when the 1 : 50 000 mapping program is implemented. This programme will have wide and far-reaching outcomes, some of them perhaps not yet predicted, but one outcome will be an evidence-based perspective on how the natural rhythms of the earth lead to climate change. ***Giya ngomhlaba – dance with earth.***

Chris Hatton

executive managers corner

Craig Smith

I attended Mining Indaba in early February on behalf of the GSSA, and there was definitely a bit more buzz about the resource industries for this year than was the case last year. Delegate numbers were probably about the same as last year, but there was more optimism in the air, and a number of service providers I spoke to indicated that business was picking up. Whether this will be the case in South Africa remains to be seen, and is very dependent on the final form of the Mining Charter and MPRDA amendments, the release of which is anticipated in the next month or so. The GSSA has provided comment to the DMR on both of these documents, but public statements at Indaba do not indicate investor friendly sentiment for

South Africa – and therefore South Africa is unlikely to see a wave of jobs created in the resource sector in the short term. There was little mention made of the current difficulty and lack of transparency in obtaining exploration licences. In short, Government would like us to believe they are on the same page as industry and is making progress, but there is still some way to go it seems. For its part the resource industry notes that it pays all the normal taxes, plus royalties, plus enormous CSI investments (effectively triple taxation) and feels progress is not being recognized. Mark Cutifani of Anglo American noted that the next three to four months will be the most critical in 150 years of South African mining history. All stakeholders need to be engaged.

A dominant theme for me was the generally upbeat mood for the resource industries in Africa in particular. There are signs that exploration across the continent is picking up a bit, reflected in more projects on display looking for finance. However, there are more unknowns compared to last year, not the least of which will be what the USA tax and trade policies will be under President Trump. A keynote by Ms Dambisa Moyo, a prominent economist and author (check out her website), was somewhat pessimistic about the medium term economic health of the planet, and ended her presentation with "*Buy Gold*". The general consensus as far as investors are concerned is that gold, zinc and copper may be the star commodities in the coming year. Battery metals (Li and others) got some airtime, but markets are small despite their importance. Every investor is going to have to make a prediction as to whether the dollar will strengthen (gold price will weaken) due to internal US tax reform, or whether the gold price might rather strengthen in response to geopolitical crises and unpayable national debt. Place your bets, please!

A theme that arose in several panels and talks was community involvement in resource projects. It is recognized and agreed by all stakeholders that not enough benefit is derived from mining and exploration by local communities, for a variety of reasons. More needs to be done than simply throwing CSI money at problems. This is going to be an issue of increasing importance in coming years, wherever in the world you may be operating.

For those of you involved in African exploration and mining, check the World Bank sponsored African Mining Legislation Atlas (AMLA) at www.a-mla.org. This project was launched at Indaba, and is a freely accessible database of all mining related legislation for all African countries (except Sao Tome). Further, comparisons can be made between countries at various levels of detail. I'm not normally too impressed with this sort of stuff – but I was impressed with this. This project can save you weeks of research and attendant costs at the touch of a button. And it's free!

Some good news for South African geology as announced by Minster Zwane of the DMR and confirmed in the corridor talk is that the Council for Geoscience will be embarking on geological mapping of South Africa at 1:50,000 scale. I suspect the CGS will be hiring and partnering (!), so watch this space. The GSSA will relay information as it becomes available.

A morning session was held on African Mining Vision (AMV), an effort being championed by the African Minerals Development Centre (AMDC) of the African Union. This is an Africa wide initiative endorsed by all 54 states of the AU that aims to bring industry and governments together on a range of issues in the extractive sector, comprising twelve core principles that should be adhered to. Transparency, governance, training, beneficiation and regulatory stability are some key concepts. There has not been a great deal of discussion about the AMV within South Africa as yet, but the concept deserves a higher place on the agenda. See www.africaminingvision.org.za for more information.

Two additional themes that caught my attention are beneficiation and technology. Governments are in general promoting beneficiation of minerals to create

more value that stays within borders, and secondly to create jobs. The policies that will be put in place to achieve this will need careful thought. In one forum, a representative of the Mining Association of Canada noted that in the Canadian experience, beneficiation was not as effective in creating value as the development of local services and goods suppliers.

Everyone is talking technology in the exploration and mining sectors! This is great news for those people who have the capacity and skills to benefit. It is bad news for unskilled labour, but this is where the world is headed. Increasing use of technology is the only way to increase safe access to deeper and deeper resources, while reducing costs.

Craig Smith

Women in Mining South Africa

It was satisfying to see the emphasis on women in mining at the Mining Indaba 2017. Several panel discussions and functions in, and around, the Indaba concentrated on diversity in the workplace and the inclusion of women in the sector.

At a luncheon arranged by South32 and Austrade, Minister of Women in the Presidency, Susan Shabangu, pledged her, and the government's, support for women in mining and said that representation of women was central to transformation in the sector.

Women in Mining South Africa's (WiMSA) annual panel discussion focused on our annual industry research, particularly on the perception that women ask for permission to succeed. We were thrilled by the number of men that attended. Maybe it was just for the free breakfast?

During the 2nd Annual Young Leaders Career Development Programme, a big part of the programme was on attracting women to the mining industry.

The general message coming from conversations and media articles at the Indaba is that, although we have come a long way in South Africa, more should be done to address the issue of empowering women in the mining industry.

Noleen Pauls,
past WiMSA Chairperson

From left to right;
Lindiwe Nakedi, Director of Gubhani Exploration and WiMSA chairperson; Dr Jeannette McGill, Head of Telstra Mining Services; Claire McMaster, Group HR Manager at The MSA Group; Safiyya Patel, Partner at Webber Wentzel; Noleen Pauls, Independent Consultant.

Contact up date

The GSSA has lost contact with the following members, and we would like to obtain up-to-date contact email and postal addresses as well as phone numbers.

Please let us have any information at: **info@gssa.org.za**.

(note that the surnames are first).

968499 - MODISANE Gaopalelwe
968046 - MUTOBVU Tyson
968637 - KUNENE Sadamu Mr
966215 - TSHABALALA Sipho Johannes
969515 - LIGEGE Rudzani
969516 - SANDANE Godfrey
969253 - NDLOVU Senzo
965034 - APOLLUS Mr L
57300 - WAKERMAN Dr BW
964929 - KHOROMMBI Mr. Hulisani
969337 - MSOMI Andisa
967851 - MATHEBULA Victoria Ms
966406 - PHAKOE Mr. Thabang
965433 - MOTLOUNG Ms Mpai
966197 - NONDWANGU Mrs D
966226 - BUSAKWE Malwande
966349 - GUMEDE Mr. Mlungisi
966423 - DUBE Mr Mukudzei M
966509 - NKOSI Mr. Sibusiso Clement
966527 - MATLALA Mr AS
966569 - MAKWINJA Mr Mk
966576 - PUSOE Mr Bashimane J
966608 - TSHIVHASE Mr. Thakhani
966793 - KUNENE Ms Thandolwakhe M
966973 - MONEI Mr Lehlohonolo V
967038 - EVANS Mr Richard Robert
967185 - NKUNA Bontle Precious
967192 - SEOKAME Mr. Phillip Seokame
967199 - MAHLANGU Mr. Mapoti Daniel
967268 - RAMADI Ms. Tshilidzi Grace
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969034 - MUSENGI Shandirai
969180 - MUNYAI Ntambudzeni Caroline
969193 - MUKHITHI Sedzani Jubilliah
969267 - HlOPHE Nkosenhle

GSSA
Geological Society of South Africa

president's column

Jeannette McGill

Some call it the curse of the GSSA President, while others ascribe it to the global interconnectedness of the sector that allows broader networks to form... but whatever the reason I find myself in the same position as fellow Past- Presidents: Matt Mullins and Pamela Naidoo-Ameglio - that of a GSSA President being located in Australia.

The opportunity to manage and lead Telstra's global mining business coupled with my mother's mild heart attack and the chance to once again be close to immediate family meant that the opportunity to relocate to Melbourne was personally important.

Council was asked if they supported my continued remote presidency and this was largely endorsed. This has meant that I now support the GSSA, the Executive Manager, MANCO and Council largely from offshore, with intermittent visits back to South Africa (more about my most recent trip later). In an increasingly connected world and through the adoption of remote work practices I have been able to maintain my attendance at management meetings and regular updates and mailings with Craig. My email is available to the membership for any correspondence.

The reality is one can never foresee these changes at the beginning of a term, especially if the extended Presidential term is accepted. However, the President doesn't make the society alone and through careful task selection by the Manco and Council members the core duty remains of guiding and leading the society, maintaining the strategic direction and drive. I wish to thank the entire team of office bearers for continually striving to keep the GSSA focus and for their valued individual contributions.

The Society is seeing an expanding use of remote operating practices – already evident in the use of the now well established Hout Bay office of the GSSA. Interestingly the work culture from my Australian employer encourages a 2 or 3 day a week work from home policy to support improved lifestyles. The use of online meeting tools and webinars is ever increasing. I do maintain that visual meetings take precedence over voice calls as meetings where reactions and body language can be gauged do seem to yield better results. Manco members are currently researching video conferencing opportunities for our committee meetings. The opportunity to have a broader geography of office bearers in the society now becomes possible with the adoption of these technologies. I think the upside could be regular input from branches a well as members that live away from the current Gauteng-centric main office. The need to improve geographic participation in the Society remains a key focus for the membership and transformation teams.

Jeannette learning how to live in Melbourne by attending the Australian Open Tennis tournament.

But! – I will add that the need to balance these remote engagements with good old fashioned networking cannot be ignored. Which is why the meetings and conference program remains critical.

My most recent trip was to attend the Mining Indaba in person as the opportunity to take the industries' temperature remains key. The Society supported Craig's attendance and we were able to consolidate on a number of items while I was in South Africa. I know Craig will provide additional commentary on this important

☞

event in the African mining and geosciences calendar, but from my perspective (and my personal thoughts only, not those of my employer) I was encouraged by the upbeat nature of the sentiment. There seemed renewed transactionary discussions, also leading indicators of increased exploration activities seemed to underpin some sector upside. Macro-economic turbulence will remain, slowing down global growth projections. Overall the African continent is clearly a good place to pursue geological endeavours; unfortunately the South African context remains uncertain and challenging and we all look forward to the impending resolution and clarity of important legislation in this area.

Since 2012, I have been able to view the government and regulatory side of the South African mining sector through the lens as the GSSA representative on the CGS Board. Following various term extensions the current Board term is ending at end February 2017 and at the time of writing the new Board and representative for the geosciences community has not yet been announced. I do wish my successor well in providing an important and objective view of the juncture. The CGS remains an important and prestigious organization in the geological landscape. It has weathered various headwinds over the past few years and I look forward to following future growth and successes. It was an honour to serve on the CGS Board, and ensure the voice of the geological community was heard. So while my Board term is ending, I remain committed to the GSSA Presidency until the AGM in July 2017 – be it in person or via global connectivity. Then we can assess who on Manco might be in need of an Australian relocation!

Dr. Jeannette E. McGill

all the news fit to print

UNIVERSITY OF PRETORIA

Diamond Short Course at the University of Pretoria, 18- 21 October 2016

For the fifth year running the Diamond Short Course was held at the University of Pretoria from the 18th to 21st October 2016. Although the structure of this short course has remained much the same over the years, the content, which provides a specialist and unique insight into primary and secondary diamond deposits from exploration, evaluation, mining, and marketing, is continuously upgraded to cover all new developments of the diamond pipeline.

It was attended by the 17 honours students from the Department of Geology at the University and 17 outside delegates from South Africa (10x), Botswana (6x) and USA (1x). These represented De Beers, Debswana, Council of Geoscience, Botswana Geoscience Centre, Department of Minerals and Energy (DMR), Alexkor, University of Johannesburg and University of Florida (USA). The objective of the course is to provide the participants an opportunity to get exposure to all aspects in diamond geology, mining and evaluation of diamond deposits and the valuation of diamonds, presented by a number of world experts in these fields.

From the history of diamonds, world diamond markets, origin of diamonds, kimberlites and lamproites, cratons, geophysics and exploration (*John Bristow, Fanus Viljoen, Johan Stiefenhofer, Hielke Jelsma, Gavin Selfe* and *Mike de Wit*) on the first day, to mantle mineralogy, indicator minerals, alluvial diamond deposits in Africa, and the offshore marine deposits (*Katie Smart, Hilde Cronwright, John Ward, Lyndon DeMeillon* and *Mike de Wit*) on the second day, the third day was dedicated to mining methods and diamond recovery, rough diamond valuation and pricing, the evaluation and valuation of alluvial deposits and the introduction and importance of the Samrec code (*Alex Holder, Derek Lahee, Grant Ziegler, John Bristow* and *Tania Marshall*).

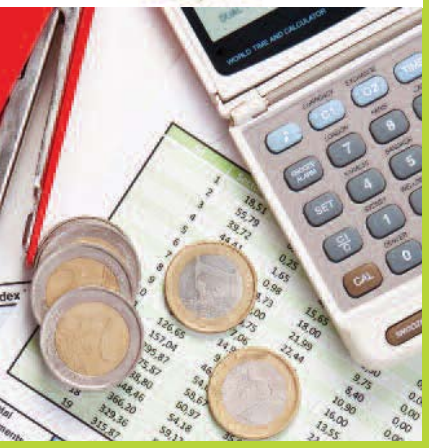
As in all previous years the practical on the fourth and final day of the Short Course followed the the theory; all 34 particpants were treated to an underground visit

Back by popular demand!! Previous three schools were fully subscribed
Book your seats early!

4th Mineral Project Valuation Colloquium

27–29 June 2017

The University of the Witwatersrand



BACKGROUND

The SAIMM announces the 4th Mineral Project Valuation School following three previous successful schools in 2011, 2012, and 2014 that were fully subscribed. The audience included international delegates from the United Kingdom, Australia, Namibia, Zambia and Zimbabwe. This School will provide you with insights into these and other developments that will affect the way you conduct mineral project valuations and equip you with relevant techniques for undertaking MAV. Seats are limited so book your seats early as the next SAIMM Mineral Asset Valuation School will only be run in 2019.

OBJECTIVES

- To cover basic theory and principles of valuation techniques and focus on the commonly used valuation approaches (cost, market, income) and methods
- To evaluate risk in mineral project evaluation
- To critically assess the pros and cons of the valuation approaches and methods
- To cover the integration of inputs and assumptions from resource to market and their impact on mineral asset valuation
- The impact of sustainability (social, government, environment) on mineral asset valuation and decisions
- Beyond DCF - future applications, scenario planning, opportunity identification and options selection and alternative valuation techniques as it applies to the mining industry
- To cover aspects that mining companies and banks (commercial and development) consider in evalution and valuation of mineral assets
- Industry leader perspective through a panel discussion.

WHO SHOULD ATTEND

- Exploration geologists
- Mining engineers involved in feasibility studies
- Project managers
- MRM managers
- Mineral industry advisory consultants and academics
- Accountants involved in mining project feasibility studies
- Professionals involved with mining project reviews
- Financial managers
- Chief financial officers
- HSE managers.

SPONSORSHIP

Sponsorship opportunities are available. Companies wishing to sponsor or exhibit should contact the Conference Co-ordinator.

SAIMM
THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY

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Event Announcement

Participants of the 2016 Diamond short course underground at Cullinan Mine near Pretoria

to Cullinan Mine which was generously made possible by **Petra Diamonds Ltd**. This makes the course unique as it provides the students and delegates a first-hand opportunity to see a world-class diamond mine in operation.

There is also strong emphasis on ensuring that the material presented at this Short Course is current with industry developments impacting the diamond business. For instance, to recover large diamonds before these may be broken in the metallurgical process using new X-ray technology, separating waste from kimberlite before treatment in a processing plant, and new ideas in geophysics and mantle minerals, were introduced. Feedback from both students and delegates was again extremely positive in all respects.

Since the start of this program in 2012 the revenue generated from this Diamond Short Course hasbeen used to cover the registration expenses for the Geology honours students of the University of Pretoria and to fund post-graduate students for some of their field and laboratory expenses in the Geology Department at the University. The presenters of this Short Course all provide their services on a voluntary basis and their efforts are gratefully acknowledged by the Course organizers.

Consulmet, De Beers, the Geological Society of South Africa and the **MSA Group** are thanked for their generous sponsorships and **Petra Diamonds** for hosting the group once again at Cullinan which makes this course so special.

The success of this course clearly highlights the need for such opportunities to combine specialist knowledge with an opportunity to visit a Tier 1 diamond mine. The dates for next year's course are being planned and will be incorporated in the 2017 Geological Events and Short Courses calendar.

Mike de Wit

STELLENBOSCH

Ph.D. position: low temperature cycling of gold.

Funding is available for a Ph.D. candidacy in the low-temperature biogeochemical cycle of gold at Stellenbosch University. The position is supported by funding from the National Research Foundation (NRF) and includes bursary (R60 000.00 per annum plus top-up) and research funding for a three year duration (2017–2019). The research will focus on the low temperature geochemical cycle of gold (i.e., gold solubility and secondary gold precipitation), with particular emphasis on the inorganic, organic and biological controls on this cycle. For more information or to apply, please email Bjorn von der Heyden: (bvon@sun.ac.za).

Preparations of the low-flying P-3 before take-off (a) outside the aircraft (b) main cabin of the P-3 aircraft, literally a laboratory space.

Stellenbosch student participates in NASA Shadow Programme

Ismael Kangueehi, one of our current MSc students, cherishes the memories of his internship with the NASA ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) programme in September 2016. ORACLES is NASA-funded and aims at understanding the roles of biomass burning emissions and low-level clouds in changing the regional climate around Southern Africa, as well as global climate. The team consists of scientists from Namibia, South Africa and the US, and brought two research aircraft to Walvis Bay, Namibia, for a month of observations.

Southern and central Africa produce almost a third of the Earth's aerosol particles from biomass burning, but the influence of these on regional and global climate is poorly understood. One of the primary aims of the mission is to determine the impact of African biomass burning aerosol on cloud properties and the radiation balance over the ocean. Ismael's own focus is aerosol geochemistry and he was interested to see how the NASA conducts field analysis. What stood out is the great variety of experts and the fact that engineers, meteorologists, modellers, chemists and pilots can work together to make a success of a scientific mission. There are two aircraft for this mission – the P-3, which flies at altitudes from as low as 60 m to about 7 km, and the ER-2, which flies up to an impressive 20 km. All the ORACLES Shadowing students got a rare opportunity to join the P-3 flights, or the "flying laboratory", packed with scientific instruments and sensors. The data are captured daily during this month-long field campaign; all eventually freely available on the NASA websites.

Layering in the You Yangs batholith

Research visit to Southeastern Australia

During late November to late December 2016, Prof. John Clemens had a very successful research visit to Southeastern Australia. One purpose of the trip was to liaise with the other organisers of the Granites 2017 (Granites: Crustal Evolution and Mineralisation) meeting that will be held in Benalla, Victoria, from 15 to 28 September 2017. A link to download the flyer for the meeting can be found at https://sjsresource.worldsecuresystems.com/BookingRetrieve.aspx?ID=26095. A variety of very interesting field trips were crafted (for inclusion in later flyers), and the meeting itself will hold interest for geologists from both industry and academia, as well as for the lay community.

The second purpose of Prof. Clemens's visit was to progress fruitful research collaborations with several colleagues based in Victoria. Their focus is on the structure and petrogenesis of granitic batholiths in the region, and what these tell us about the depth, thickness and composition of the hidden crustal block from which these post-orogenic granitic magmas were formed by partial melting in the Devonian. Among many discoveries that are being made, two of the most startling are the near-ubiquitous presence of large-scale shallow-dipping layering in these granites, and the relatively thin, sheet-like character of many apparently huge batholiths. The Benalla meeting will reveal a good deal more about these aspects, but the photograph below provides a taste.

Somewhat incredibly, the layered structure evident in this photograph of Flinders Peak (at a dizzy elevation of 319 m ASL, in the You Yangs batholith) has never been recorded in the literature. One objective of Prof. Clemens's trip was to sample these rocks (last studied in 1935!) to try to determine whether this particular layering is compositional as well as structural.

John Clemens

WITS

The Ultra-Clean Wits Isotope Geoscience Laboratory Opens Its Doors

The School of Geosciences at Wits University recently launched the Wits Isotope Geoscience Laboratory (WIGL), a state-of-the-art, ultra-clean, metal-free laboratory designed to perform chemical separation and isotope dilution on samples destined for isotope mass spectrometry. Besides traditional chemical isotopic techniques (Sr, Nd, Hf, Pb, U-Th), non-traditional stable isotope techniques (e.g. Fe, Mg, Cu, Zn, Be) will also be developed in an environment designed to reduce background or blank concentrations to the lowest level possible. As an illustration of the cleanliness, the air

A view of one of the 5 ultra-clean, metal-free rooms that make up the Wits Isotope Geoscience Laboratory.

supplied to the metal-free laboratory space is filtered multiple times, reducing the contaminating particle count from well-over 1 million particles per cubic foot to between 1-10 particles in the cleanest work areas. The WIGL was designed as a multi-user facility (up to five users simultaneously) for interdisciplinary research and will be able to process a range of sample materials including rocks, fossils, archaeological artefacts, water samples and biological material. The chemically processed samples can be analyzed using a mass spectrometer at the newly installed LA-MC-ICPMS laboratory at the University of Johannesburg (UJ), through a strong collaboration with the Wits Isotope Geoscience Laboratory.

Dr Grant Bybee, Lecturer in the School of Geosciences at Wits, was the main driving force behind the construction of the laboratory. His coconspirator in this endeavor, Prof Robert Bolhar, is currently spearheading the acquisition of a new suite of mass spectrometers for the School's Earth Lab. Profs Roger Gibson (Head of School) and Helder Marques (Science Faculty Dean) officially opened the laboratory that was funded through contributions from the Faculty of Science, the School of Geosciences at Wits, Prof. Grant Cawthorn and the DST-NRF Centre of Excellence for Integrated Mineral and Energy Resource Analysis (CIMERA). Dr Linda Iaccheri, who recently completed her PhD research at the University of Western Australia, will join the WIGL team as laboratory scientist and manager later this year. Dr Ed Kable and Profs Jan Kramers and Marlina Elburg provided valuable advice and collaboration throughout the project. Prof Elburg was "instrumental" in championing the LA-MC-ICPMS at UJ and together the two institutions have formed a strong isotopic collaboration.

The WIGL is an important facility for the scientific research community in Africa as a whole, and in South Africa in particular. It follows on a history of pioneering

M.Sc. students, Arantxa Naidoo and Kimberly Beaton demonstrate the new column chemistry in the WIGL.

Grant Bybee working in the column chemistry room in the WIGL where particulate counts in the hoods are between 1-10 particles per cubic foot - a significant reduction from regular air with 1 million particles per cubic foot.

isotopic work at Wits University through a generation of researchers at the Hugh Allsopp Laboratory in the Bernard Price Institute for Geophysics and Department of Geology (now the School of Geosciences). The WIGL teams looks forward to continuing this tradition, in addition to facilitating and inspiring the next generation of researchers in the production of exciting science. Further details on the laboratory capabilities can be obtained from Dr Bybee at: Grant.Bybee@wits.ac.za.

George Henry & Grant Bybee

Isotope geochemists (and one structural geologist) at the official opening of the WIGL.

From left to right: Phil Janney, Grant Bybee, Roger Gibson, Marlina Elburg, Helder Marques, Dirk Frei, Tom Andersen and Chris Harris.

IMSG meeting 2017

Report on the 9th Annual Igneous and Metamorphic Studies Group (IMSG) Meeting 2017

The Department of Geology at the University of Johannesburg had the honour of hosting the 9th Annual Meeting of the IMSG from the 15th to the 18th January 2017. The IMSG started in Pretoria in 2008 as a forum for geologists with an interest in igneous and metamorphic geology to present and share their latest research findings. It grew in size with time, with the venue rotated around South Africa's universities, the 2016 host being the University of Cape Town.

Instead of the confines of a lecture hall, the event this year was held in the Glenwillow Meeting Room at Glenburn Lodge, in the Muldersdrift area about 33 km northwest of Johannesburg city centre. The popularity of the meeting is indicated by the 106 registered delegates, the highest number ever. The venue is in an idyllic setting and the nearby Bush Willow Tented Camp provided affordable housing for both out-of-town attendees and locals who did not wish to commute daily.

The program began with an ice-breaker function on Sunday 15th when the delegates began registering, and got to know one another over a drink or two. Having not attended an IMSG meeting before (much to my regret!) I started networking with people that I knew by name only from their publications, and also got to meet students who are funded by the DST-NRF Centre of Excellence for Integrated Mineral and Energy Resources Analysis (CIMERA), with whom I am affiliated. It was a pleasure to see Goonie Marsh of Rhodes University again after almost 25 years or so! We first met back in 1981 when I undertook an M.Sc. in Exploration Geology at Rhodes. *Tempus fugit!*

The formal proceedings started on the Monday morning, with the chairperson of the IMSG, John Clemens of Stellenbosch University, welcoming all to the conference. The first session on matters metamorphic was chaired by Johann Diener of UCT,

Delegates at 9th Annual IMSG meeting in front of the Glenwillow Meeting Room at the Bush Willow Tented Camp, Glenburn Lodge

followed by sessions on impact-related topics, the Bushveld Complex, and mineralization. The second day was devoted to felsic, alkaline and mafic rocks, with the final session on kimberlites and their kin. The 28 posters, displayed on the walls of the meeting room, complemented the oral presentations, and were very good indeed, eliciting much discussion. For those who wish to peruse the abstracts of the meeting, they are available at: https://www.uj.ac.za/faculties/science/geology/Documents/Abstract%20Volume%20IMSG2017.pdf.

Having sat through two days of mostly excellent talks on highly technical aspects of igneous and metamorphic petrology and petrogenesis, with their phase diagrams, pseudo-sections, etc., etc., I have been put in a quandary as to what type of geologist I am. I started my work career looking for calcrete- and sandstone-hosted uranium deposits, then switched to studying the tectonostratigraphic evolution of the metamorphosed Damara Sequence in central Namibia, after which I explored for (meta-) sediment-hosted lead-zinc deposits and orogenic gold. Can I patent the term "meta-sedimentologist" or even "pseudo-metamorphic petrologist"? Perhaps I should just stick to plain old "geologist"!

The IMSG awards student prizes for excellent presentations and posters at the meeting, which are customarily presented at the end-conference dinner. This took place on the Tuesday evening in the Glenburn Lodge Glenkyle dining room that has a picturesque view down to the Blaauwbank River.

Robyn Ormond from UJ won the IMSG prize for the best MSc student presentation. She studied the enigmatic Zwartkops rocks in the Muldersdrift area for her Honours project, and has enrolled this year for a masters' degree at UJ on a related topic.

Katie Hill, who has submitted her masters' dissertation on her study on rocks of the Kunene Anorthosite

Robyn Ormond receiving the best MSc student presentation prize from John Clemens of Stellenbosch University.

Best PhD talk prize to Quinten van der Meer

Katie Hill (Wits) receiving best student poster prize from John Clemens

Tebogo Makhubela (UJ), Jarlen Beukes (UFS) and Kobi Sito (UJ) at Jarlen's poster

Jeremie Lehmann (UJ Geology) explaining the rock outcrop along the Blaauwbank River at Glenburn Lodge. Note babe-in-arms Magdalena Huber!

Complex in southern Angola, won the best student poster award. She studied at Wits.

Quinten van der Meer of UCT gave the best presentation on a doctoral research topic; I confess that I wouldn't recognize a HIMU source even if it hit me in the face! Well done to the three prize winners!

A Wednesday morning field trip took in two traverses across the 3 200 or so million year old granitic rocks of the Johannesburg Dome that comprise part of South Africa's geological foundation.

The first traverse was along the Blaauwbank River a short walk down from Bush Willow Camp, led by Jeremie Lehmann, Marlina Elburg and Trish Owen-Smith of UJ. Good exposures of meta-diorites that have undergone amphibolite facies metamorphism are found along the hiking trail. What sticks in my mind is little Magdalena Huber, a true babe-in-arms, who was carried by her father Matthew for the walk! I think she slept through most of the geological discussions at the outcrop.....

The complex rock outcrop on the farm Nooitgedacht, about 4 km south of Lanseria Airport, was well explained by Prof Emeritus Carl Anhaeusser of Wits, who mapped and studied it in detail in the late 1990s. The oldest rocks, a suite of mafic to ultramafic volcanic/intrusive rocks, are intruded by 3 340 million year old tonalite-trondhjemite gneisses that are in turn cut by two mafic dykes. This geological mess was then intruded by 3 121 Ma granitoids and 3 000 Ma pegmatites! Phew! Now you know why it is safer to stick to being a meta-sedimentologist! Thanks to Carl for a fascinating few hours.

The meeting and field trip were an unqualified success, due mostly to the efforts of Marlina, Trish and Jeremie who bore the bulk of the organization, and the several student volunteers who assisted with the logistics. They are to be heartily thanked for their hard work. Finally the low cost of the meeting (basically free!) was made possible by generous sponsorship from the Department of Geology at UJ, the Palaeoproterozoic Mineralization Study Group (PPM) at UJ, DST-NRF CIMERA, the Geological Society of South Africa, Wirsam Scientific, SMM Instruments, Geo-Explore Store and Struik Nature. We are looking forward to the next meeting to be held at the University of the Western Cape.

George Henry

2nd ICCI 2017

All interested geoscientists are invited to attend the 2nd International Conference of Continental Ichnology, which will be held near Langebaan and followed by a field trip from 1st to 8th of October 2017. This international conference is dedicated to the study of continental trace fossils. We expect that this event will bring together international geoscientists whose research focuses on investigating various ichnofossils (burrows, nests, tracks, trails), which are important not only for detailed characterization of past depositional environments, recognition of unconformities, prospecting for hydrocarbon resources, and biostratigraphic subdivisions, but also for the direct link they provide to ancient animal behaviour, all geared towards a better interpretation of the geological record.

In the recent decades, this field-based geoscience research theme, which bridges palaeontology and sedimentology, has been neglected in South Africa, in spite the rich trace fossils heritage of our country. This conference therefore will be a great opportunity to promote and further develop ichnological research in South Africa, most of all for the benefit of our postgraduate students and early (and not so early) career geoscientists.

Please check out our website for more information: https://sites.google.com/site/icci2017conference/home

Dr EM Bordy
ICCI2017 Chairperson
UCT,
Cape Town

the eminent eight

International Kimberlite Conferences (IKC's) are, without a doubt, the premier venue for advancement of our understanding of kimberlites, the upper mantle and diamond genesis. The first IKC was held in Cape Town in 1973 and was heralded as a major breakthrough in symbiotic cooperation between the diamond industry and academia. The 11th International Kimberlite Conference (11 IKC) will be held in Gaborone from 18th to 22nd September 2017 to mark the 50 year anniversary of the 1967 discovery of economic diamond deposits in Botswana. Delegates from over 20 countries had registered for 11 IKC by early February this year, and there will be 230 oral and poster presentations and eight keynote lectures on offer at the 11 IKC in September.

International Kimberlite Conferences (IKCs) take place every 4-5 years and previous conferences have been held all over the world:

1st • Cape Town, South Africa (1973)
2nd • Santa Fe, New Mexico, USA (1977)
3rd • Clermont-Ferrand, France, (1982)
4th • Perth, Western Australia (1986)
5th • Araxa, Brazil (1991)
6th • Novosibirsk, Russia (1995)
7th • Cape Town, South Africa (1998)
8th • Victoria, Canada (2003)
9th • Frankfurt, Germany (2008)
10th • Bangalore, India (2012).

At 11 IKC in Gaborone there will be eight delegates – The Eminent Eight - who have attended every one of the previous ten IKCs, but there is a back-story: in 2003 at the 8th IKC in Victoria, there were twelve delegates - The Dirty Dozen - who had attended all the preceding IKC's They were Mike Skinner, Bram Janse, Bill Griffin, Barry Dawson, John Gurney, Mal McCullum, Herb Helmstaedt, Steve Haggerty, Jeff Harris, Volker Lorenz, Roger Mitchell and Barbara Scott Smith. Mike, Bram, and Bill did not make it to the 10th IKC, reducing the Dirty Dozen to nine "Old Farts" (quoting Barry Dawson). Sadly Barry died suddenly in January 2013, leaving only the "Eminent Eight".

The idea of an International Kimberlite Conference began in late 1970 with the suggestion from Joe Boyd, Henry Meyer, Ian Mac Gregor and Tony Erlank that a conference be held in southern Africa to bring together scientists interested in kimberlites, diamonds and the upper mantle. They met coincidentally at a Lunar Science Meeting in Houston. All four of them were already engaged in upper mantle research and it was bugging Joe in particular that he had never yet made it to southern Africa to see kimberlites from the classical localities, his supply of rocks having been provided by Peter Nixon. Nixon had a U.N. position in Lesotho,

10th International Kimberlite Conference: Eight of the nine "Old Farts". From left to right; Mal McCallum, Roger Mitchell, Barry Dawson, Barbara Scott Smith, Volker Lorenz, Jeff Harris, Herb Helmstaedt & John Gurney. Steve Haggerty is missing.

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

which was a follow up on his PhD studies at Leeds University. Also attending the Houston Conference was John Gurney, who was in the U.S.A. on a post-doctoral fellowship at the Smithsonian, with a PhD under his belt on trace element distribution in mantle rock types. The group of 5 discussed the merits of the idea and Gurney was instructed to find out if De Beers in South Africa and the UN mission in Lesotho were amenable to participation in the proposed Conference and associated field trips. Having obtained an enthusiastic "yes" from De Beers' Chief Geologist Barry Hawthorne as well as Peter Nixon in Lesotho, the Conference became a reality and was convened by Prof Louis Ahrens, Joe Boyd and Prof Barry Dawson and managed through sub-committees headed by Hawthorne (Field trips around Kimberley), Nixon (Field trips in Lesotho) and Gurney (the Conference itself). The endlessly energetic John Gurney also organised the 7th IKC held in Cape twenty-five years later, in partnership with his son James.

John Gurney studied chemistry at the University of Cape Town (UCT) and was enticed into the field of geochemistry by the late Professor Louis Ahrens. Here he completed his PhD on mantle peridotites and eclogites from Matsoku, Lesotho and then set about teaching mantle studies at UCT. John is rather unique – a world renowned academic, businessman, consultant (Mineral Services), sportsman and mentor to many of us who made a career in the diamond industry. From a consultancy point of view, he is perhaps most widely known for his confident interpretation of the kimberlite indicator mineral chemistry data in the early days of kimberlite exploration in Canada. This confidence played an important role in the subsequent development of the first Canadian diamond mine in 1998. Most recently John Gurney and colleagues created the Messengers from the Mantle Exhibit which had its premiere at the 35th International Geological Congress in Cape Town and will be also at the 11 IKC.

John speaking at 10 IKC

South of the Canadian border in the USA open pit diamond mining had begun in late 1996 on the two largest pipes in the Kelsey Lake kimberlites. This followed on from the discovery of diamonds in the kimberlites of the State Line District by Mal McCallum in 1975. Mal was professor of geology, mineralogy and mineral exploration at Colorado State University, Fort Collins, Colorado from 1962 to 1995, and worked on mapping programmes with the U.S. Geological Survey throughout the Rocky Mountain region from 1956 to 1985. He is co-founder of HDM Laboratories Inc. that specializes in diamond and gold exploration sample processing and evaluation. He has been a consulting geologist for mineral exploration companies since 1985, specializing primarily in diamonds and has been involved in kimberlite and diamond related research and exploration since 1964, and was a major participant in the discovery of a number of diamondiferous kimberlite occurrences in Colorado, Wyoming, Venezuela, as well as the NWT and BC in Canada. He has served as a Technical Advisor to a number of diamond and gold exploration companies.

Mal McCallum at 8IKC

Kimberlite exploration in West Africa has long been of interest to Steve Haggerty. In 2015 Steve announced the discovery that the plant, Pandanus candelabrum, grows only on kimberlites pipes in Liberia. Steve is a world authority on the opaque minerals found in kimberlites. Steve's happy mantle hunting ground for years has been the Jagersfontein kimberlite dumps and numerous remarkable specimens have been collected and described by him from this locality. The mineral Haggertyite honours his contributions to mantle mineralogy. Steve was born in South Africa but immigrated to Canada and from there to the UK where he graduated from the Royal School of Mines and the University of London (PhD). After a post doc at the Carnegie Institute he taught at the University of Massachusetts. He is now retired and is a distinguished research professor at Florida International University.

Steve was a principal investigator in all of the Apollo and USSR Luna missions and served on NASA's Lunar Sample Analysis Planning Team. He has published on meteorites and has had a longstanding interest in the controversial carbonado-diamond. But who as a young post-graduate can ever forget this sun-burnt mad prof charging over the mine dumps dressed just in shorts and boots; and best to forget the evening parties!

Another member of the Eminent Eight who also has a mineral named after him, is Jeff Harris. Jeff, a graduate of the University of Liverpool and the University of London (PhD), was for many years a Senior Research Fellow at the University of Glasgow, Scotland. His named mineral Jeffbenite is only found as an inclusion in superdeep diamonds, and the name also refers to Ben Harte, another pioneer in the investigation of these intriguing samples. Jeff was De Beers' external diamond consultant and headed a team at HOH in Kimberley that studied the characteristics of diamonds and their inclusions from De Beers' mines. He was also responsible for the distribution of these diamonds to the global scientific community. This work resulted in the first dating of garnet inclusions in diamonds by Steve Richardson of UCT in 1984. Jeff's home away from home was the Kimberley Club in Kimberley and he delighted in timing his consulting visits to South Africa to coincide with the famous cherry festival in Ficksburg where he has many friends.

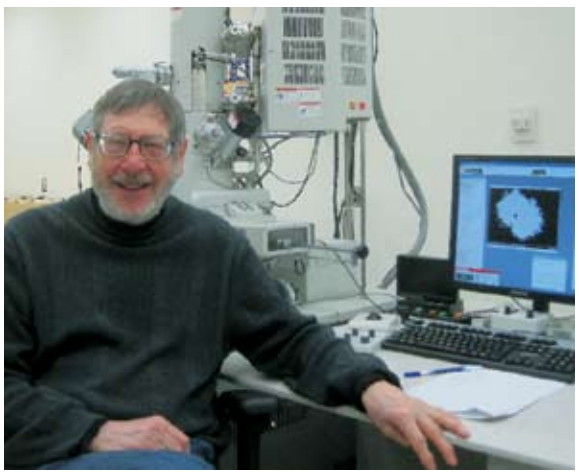
Steve and Pandanus candelabrum

Jeff

Fittingly, the first paper in the proceedings volume of the 1st IKC is the 'Model of a Kimberlite Pipe', based on Barry Hawthorne's observation in the De Beers mines around Kimberley. The second paper in this volume is Volker Lorenz's application of his studies of the phreatomagmatic maars and diatremes of Western Europe to kimberlite diatremes. The 'Lorenz model' has become the standard reference for phreatomagmatic activity and the role of meteoric water in driving explosive magmatism. Application of this model to kimberlite magmatism remains however a hotly debated topic. Volker for years was Professor of Volcanology at the University of Wuerzburg in Germany.

Volker

Leading the argument that kimberlite magmatism is little influenced by meteoric water are Roger Mitchell and Barbara Scott Smith. Roger's keen interest in kimberlite volcanism is perhaps best summarised in the description of his 1986 book: "This is a book about the petrology of kimberlites. It is not about upper mantle xenoliths, diamonds, or prospecting for kimberlites." Roger "retired" from Lakehead University in 2006, but like so many in the kimberlite community continues to be as active as ever. Roger is also a world expert on the mineralogy of lamproites and with Bergman has published a book on this topic. Lamproites found in Australia are a second volcanic rock type that can contain diamonds. Roger also has a mineral named after him – *Rogermitchellite!!* Roger is chairman of



Roger the mineralogist at work

IKCAC – the International Kimberlite Conference Advisory Committee. He was intimately involved in the organization of the 10th IKC held in Bangalore, India.

Barbara Scott Smith is the principal organiser of the upcoming 11 IKC in Gaborone. After obtaining a PhD from Edinburgh University, Barbara began her career as a research mineralogist on diamond-related ventures for Anglo American Research Laboratories and the De Beers Kimberlite Petrology Unit in South Africa. Since 1982, she has been based in Vancouver, Canada as an independent consultant offering specialist services in applied kimberlite geology relating to world-wide diamond exploration and mining projects for a variety of major to junior companies. In particular she investigated many of the kimberlites discovered over more than the last 25 years during the Canadian Diamond Rush. Barbara is passionate about the application of kimberlite volcanology and petrology to resource modelling. Barbara also organized the largest and probably best IKC – the 8th IKC held in Victoria, British Columbia, Canada. Barbara like John Gurney will with the completion of the 11IKC, have organized two IKC's each.

Barbara, Barry Dawson and Roger with Maasai guides at Ol Doinyo Lengai, Tanzania in 2007.

Processes below the cratons have long been the interest of Herb Helmstaedt, former head of the Geology Department of Queen's University, Kingston, Canada.

Barbara

At the 1st IKC Herb pointed to similarities between lawsonite-bearing eclogite xenoliths in diatremes on the Colorado Plateau, then thought to be kimberlites, and Franciscan eclogite rocks as evidence for eastern-directed subduction of oceanic lithosphere beneath the North American continent. He then suggested that certain eclogite xenoliths in diamondiferous kimberlites may also represent samples of subducted oceanic crust. As a long term collaborator with John Gurney, Herb presented the lecture honouring John's extensive contributions to kimberlite and mantle petrology at the opening of the Messengers from the Mantle exhibition at the IGC in Cape Town 2015. This exhibition will also be on display at Gaborone and provides yet another compelling reason to attend this conference.

Herb (right) preparing the view for a graffiti exhibition in Kingston.

Chris Hatton, Jock Robey

INTRAW project

Fostering International Cooperation on Raw Materials

Fostering International Cooperation on Raw Materials - the INTRAW Project and the European International Observatory for Raw Materials.

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[5] *LaPalma Research Centre for Future Studies Calle La Paz 6 E- 38789 Puntagorda, La Palma, Islas Canarias, Spain.*

In the last decade, there has been a structural change in the world's mineral markets and an increase in the global demand for raw materials. Securing the domestic minerals supply in a sustainable way will be challenging to most countries. The International Cooperation on Raw Materials (INTRAW) project was launched in 2015, with the focus of mapping amongst other factors the national best practices and policies of five technologically advanced partner countries: Australia, Canada, Japan, South Africa, and the United States of America.

The outcome of the ongoing mapping and knowledge transfer activities will be used as a baseline to set up and launch the European Union's International Observatory for Raw Materials as a definitive raw materials knowledge management infrastructure.

INTRODUCTION

In the last decade a structural change has taken place in global mineral markets. The old rule of thumb – 20 percent of the world population in Europe, United States of America (USA) and Japan consuming more than 80 percent of the total minerals production – is not valid any more. With the integration of India, the People's Republic of China and other populous emerging countries like Brazil and Russia into the world economy, today more than half of the world's population claims an increasing share in raw materials. Thus the global demand for raw materials stands at the bottom of a new growth curve. It is assumed that by 2030 the worldwide need for raw materials will have doubled.

Access to raw materials on global markets is one of the European Commission's priorities. Over the last decade the European Union (EU) has become increasingly aware that securing a reliable, fair and sustainable supply of raw materials is important for sustaining its industrial base, an essential building block of the EU's growth and competitiveness. This was triggered by the increasing demand for unprocessed minerals and metals

The Horizon 2020 funded project "The International Cooperation on Raw Materials" (INTRAW, www.intraw.eu), runs during the period 2015-2018, with the objective of mapping best practices (Aims of INTRAW) and boosting cooperation opportunities on raw materials with technologically advanced non-EU reference countries (Australia, Canada, Japan, South Africa, and the United States) in response to similar global challenges. The ultimate goal of the project to set up and launch the European Union's International Observatory for Raw Materials as a definitive raw materials knowledge management infrastructure.

Aims of INTRAW.

The creation and maintenance of the EU's International Observatory for Raw Materials will narrow the existing gap in aspects of the raw materials knowledge infrastructure in the EU by providing a link to the knowledge infrastructure in technologically advanced countries. It will enable better alignment of the Research and Innovation (R&I) activities among the individual EU members, and will leverage cooperation with third countries by boosting synergies with international research and innovation programmes.

The INTRAW project started with an integrated and holistic bottom-up approach to benchmark the contextual environment of the reference countries with regards to the evolution of their raw materials industry and raw materials supply policies. This article presents findings from the benchmarking made, crossing historical, cultural, social, legal and economical factors from the XIX century onward, and highlights factors that explain how Australia, Canada, Japan, South Africa and the USA built a competitive superior position on raw materials supply.

KEY ENABLERS OF A SUCESSFUL MINING INDUSTRY: LESSONS FROM FIVE COUNTRIES

Research and Innovation

Since the steel-based industrial revolution of the late 1890s, the USA has joined the ranks of world leaders in innovation. Government and industry-funded institutions in the USA developed throughout the 20th century which resulted in solid Research and Development (R&D) infrastructure, including government-funded labs, high-tech profile innovation clusters like Silicon Valley, and many others. Econometric studies strongly suggest that R&D spending has a positive influence on productivity, with a rate of return that is likely to exceed that on conventional investments. After the USA, Japan ranks 2nd in the world in terms of total expenditure on R&D with 3.3% of GDP. The knowledge and resource base (infrastructure) in the USA and Japan has been of high importance in their transition towards a knowledge-based economy. Canada and Australia have a well-established science, technology and industry systems. South Africa also has a well-developed science system, which has been developed in relative isolation due to sanctions and since the end of apartheid has been reconnected to the world's developments.

The USA, Japan and South Africa have strong R&D cultures. USA companies are highly sophisticated and innovative, supported by an excellent university system that collaborates admirably with the business sector in R&D. Japan´s R&D culture developed during the 20th century and was led by technology transfer process from the West to Japan during the catch-up period and afterwards when Japan took the lead in innovation. R&D in Japan is mostly (70%) financed by the private sector. Despite South Africa's strong R&D tradition, it's Gross Expenditure on Research and Development (GERD) of 0.8% is below that of other emerging economies with

much of the research being business-driven. Australia and Canada rank poorly internationally in innovation and do not have strong R&D cultures.

The USA has an excellent track record at continuously investing in geoscientific data and related research as they are considered critical factors enabling the development and growth of the mining industry. The information acquired and published by the US Geological Survey (USGS) is internationally considered reliable and their data and publications are amongst the most widely used around the world for mineral statistics.

Raw materials-related R&D is conducted in South Africa by public and private partners. Mintek is one of the world's leading technology organisations specialised in mineral processing, extractive metallurgy and related areas. One of the mandates of the Council for Geoscience is to develop and publish world-class geoscience knowledge products and to render geoscience-related services to the South African public and industry.

Canada is also heavily invested in geoscientific data but unlike the USGS, the data acquisition and related research is done by provincial geological surveys, with the data made publicly available. The mining industry has continuously invested in R&I and it has become a driving force in Canada's new knowledge-based economy. New technologies in mining have created a circle of growth and innovation that circulates through two-way linkages between mining and the rest of the economy. A large part of innovations in the mining industry takes place in the exploration sector, with some 1,200 exploration companies located in the British Columbia (the greater Vancouver area).

Australia has traditionally maintained a high level of investment in R&I in the mining sector. One of the most significant Australian innovations was the development of flotation, widely used in the international metal mining industry. Australia keeps pioneering R&I to increase productivity and cost control and the Pilbara region acts as the main focus for innovation activity in mining. Testing and running automation technologies such as driverless haul trucks, automated wheel changers for haul trucks, remote train and ship loading, remotely operated drill and smart blast activities, as well as the development of a new class of tunnelling machines for underground mines.

Education and Outreach

During the last decade, skills shortages have been arguably the mining industry's most significant problem. Mining is undertaken in over 100 countries and it is estimated that on a global basis the formal mining sector employs more than 3.7 million workers. The organisational structure of a mining company generally includes senior corporate staff, managers, university-educated specialists, supervisors, and operational staff and skilled and semi-skilled staff and associated contractors.

Today's mining industry relies on highly skilled workers with a diverse skill set, the ability to use sophisticated technology and operate in challenging environments. It typically seeks skilled operators, graduates and technical specialists with not just mining knowledge but also digital literacy, problem solving ability and good interpersonal skills, who can work safely in both a team and individual capacity.

Mining education encompasses a wide range of education and training options that can be accessed by students seeking to enter the industry, mature entrants reskilling, in-work employees' upskilling and even those taking courses purely for interest. Universities offer a range of mining focused undergraduate degree options around applied geology, mining engineering, mineral processing and metallurgy, as well as a raft of generic but relevant subjects in engineering, business, environment, etc.

Training for technician and administrator levels in mining related areas are usually delivered by technical colleges and training centres. These usually involve a combination of conventional teaching with placements and work-based learning, and include technical, commercial and clerical provision. Mining investment in efficiency, mechanisation and automation will push up

the required skills levels and reduce the opportunities for low skill jobs.

Volatility in the industry and increased resource nationalism, as well as demand of producer countries for local staff to take over the more senior roles, is leading to a need for rapid upskilling and loss of experienced international staff. The cyclical nature of the industry has caused endemic skills shortages followed by oversupply, which lags the industry cycles and results in elevated costs and loss of experience from the industry. Employers need to consider funding, retaining and upskilling staff through the downturns and this may require new models of employment.

Real-time skills and employment data are not easily accessible and new methods are needed if prediction through the cycle is to be realistic. Training needs to be more aligned with industry cycles –good practice evidence is available but there is a need for more creative solutions to in-work education and industry-education partnership arrangements.

In aiming to address educational issues in the mining industry, in addition to the key findings outlined above, the analysis has produced a list of possible metrics to benchmark and compare EU countries against and form the basis for action plans:

- Number of universities teaching mining/minerals geoscience
- Length of programs and quality of curriculum (including staff: student ratio)
- Number of students and demographics
- Amount of mining/minerals geoscience in secondary school curriculum
- Number of mining education organizations and membership
- Training data and workforce shortages
- Qualification requirements
- Others metrics identified in reports by the Mining Industry Human Resources Council - Canada (MiHR), Society of Mining Professors (SOMP) and national workforce planning exercises

Industry and Trade

During the second half of the 20th century the international trade of raw materials, importantly of metals and minerals, expanded remarkably and it consolidated as a principal driver behind the economic growth of industrial economies such as the USA and Japan. Dramatic decreases in transport and communication costs coupled with reductions in trade barriers have been the driving forces behind today's global trading system. Special mineral trade bilateral partnerships during the 20th century and which still today remain very important were those of USA-Canada and Japan-Australia

The USA-Canada partnership was due to geographic proximity and similar historical cultural characteristics, the USA and Canada share a history of economic development based on the domestic use and bilateral trade of mineral resources. In 2013 U.S. exports to Canada accounted for 19% of overall U.S. exports, in turn, Canada's exports to the U.S. accounted for a 75% of all exports (2014).

The Japan-Australia partnership main enablers were the creation of bulk transport vessels (lowering transportation costs), the adaptation of port facilities, and the bilateral agreements on commerce and business, with the Commerce Agreement signed between both countries in 1957 (the first trade agreement of Japan after WWII). Notably since the 1960s (Siddique, 2011), Japan has traditionally imported strategic resources (iron ore, coal, manganese) and exported vehicles and machinery to Australia.

In a globalized market economy, countries tend to base their minerals supply and demand on multiple partners with smaller but significant shares. The USA is a good example of changing and multiple sources for supply combining domestic extraction and imports. The domestic endowment of natural and mineral resources was highly important in the early phases of the industrialization, but then the economy began a transformation process towards a knowledge and services-based economy in which the availability of

domestic resources became less important. Currently the USA is the world´s largest economy and consumer of natural resources using roughly 20% of the global primary energy supply and 15% of all extracted materials (Gierlinger & Krausmann, 2012).

In Japan, the government and the mining industry have been historically closely interrelated. Japan's post-WWII high growth era and its sustained economic and industrial development was enabled by a dynamic mineral resources policy which ensured that the Japanese industry secured a stable supply of raw materials to overcome its extreme import dependency of minerals. The latter encompassed not only securing the supply of primary raw materials via agreements with countries and direct investments by private capitals in overseas mines and in exploration in Japanese offshore resources.

Nowadays the government administrative agency Japanese Oil, Gas and Metals National Cooperation (JOGMEC) is a key actor in the Japanese resources policy. With a worldwide network of 13 offices, JOGMEC leads a multi-faceted strategy and permanently supports the domestic and overseas development of the minerals industry, both primary and secondary, fostering innovation and cooperation. Such a strategy encompasses joint operations, training for experts, providing equity capital and loans and liability guarantees for metal exploration and development by Japanese companies, conducts overseas geological surveys to help Japanese companies secure mineral interests and to support their exploration projects, among others.

South Africa has also been closely related in minerals trade with Japan as supplier of essential minerals such as chromium, manganese, cobalt, vanadium, and PGMs of which South Africa hosts 95% of world reserves (USGS, 2016). Japan is, in fact, South Africa's third largest trading partner and over 100 Japanese companies have a presence there.

The key drivers behind the success of the domestic non-energy extractive industry in all mineral resource-rich countries were analysed. The historical circumstances of each country differ and the mining industry evolved adapting to internal and external situations, the INTRAW project identified a series of common drivers. The most important are listed below:

Exploration phase:

- Availability of public and reliable geoscience data
- Well-developed and dynamic exploration cluster

Exploitation phase:

- Politically and institutionally stable framework
- Access to land, energy and water
- Efficient permitting procedures
- Granting of the social licence
- Skilled workforce

THE ROLE OF THE EU INTERNATIONAL OBSERVATORY FOR RAW MATERIALS

The Observatory will be launched before 2018 aiming at the establishment and maintenance of strong long-term relationships with world key players in raw materials technology and scientific developments. It will be part of the EC raw materials infrastructure that will remain operational after the project completion. In terms of functions the Observatory is relatively broadly defined in the INTRAW Grant Agreement as "a permanent body that will ensure improved co-ordination of an effective research and innovation programmes, funded research activities, and synergies with international research and innovation programmes for the EU raw materials sector."

This relatively broad definition provides sufficient room to fine-tune the Observatory concept to match present and expected future requirements. The immediate support to "small-scale" cooperation, exchanges, networking and scholarships would likely generate substantial interest, whilst it would not result in resistance from any of the global key players. There is danger of adding to bureaucracy instead of making things easier and the possible birth of a new type of resource colonialism, with the EU taking the lead, should be avoided as it can result in resistance from other global players.

In the longer timeframe the Observatory is seen as an important catalyst in aggregating international

research, resulting in a better availability of data, including data for basic/academic research. Industry participation in the work of the Observatory was seen beneficial as it could lead to investment in applied research and raw materials exploration, exploitation and recycling.

In terms of project vision it has been agreed that the Observatory will not only continuously monitor cooperation possibilities but will also actively promote these via facilitating the establishment of dedicated bilateral and multilateral incentives for raw materials cooperation between EU and technologically advanced countries outside the EU.

CONCLUSIONS

The global challenges being faced by the non-energy minerals industry such as skill shortages, price volatility, market distortions and supply risks, lack of social licence to operate, and others, need to be approached by means of international cooperation, and not only via competition mechanisms. The historical analysis of the five reference countries has shown that bilateral trade partnerships can be a long-term source of mutual benefits for countries or regions, allowing stable economic growth and a politically and institutional stable environment attractive for investments. The key drivers of mining success have shown that countries face similar challenges but are resolved in different ways and can learn from each other. Results have shown that cooperation should not only be among governments, but also between governments and the industry. The close relationship of the government, its agencies and the industry in Japan is a good example. Another example is given by the constant support of the Canadian and Australian governments to the exploration sector by financing the public availability of digital data on exploration or by assigning case managers to projects in order to ensure the smooth approval of necessary permits. Further results and conclusions are available in the Country Reports of the five reference countries.
see http://intraw.eu/publications/

ACKNOWLEDGEMENTS

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field trip highlights

Some Highlights of the Eastern Bushveld, Eastern Escarpment and Kruger National Park Field Trip

This was a three in-one, post congress field trip. The **first leg** covered some highlights of the layered igneous rocks, including chromium, platinum and vanadium-rich layers of the Eastern Limb of the Bushveld Complex. The layered rocks have been beautifully exposed by erosion caused by the Olifants River and its tributaries in the north east segment of the Complex.

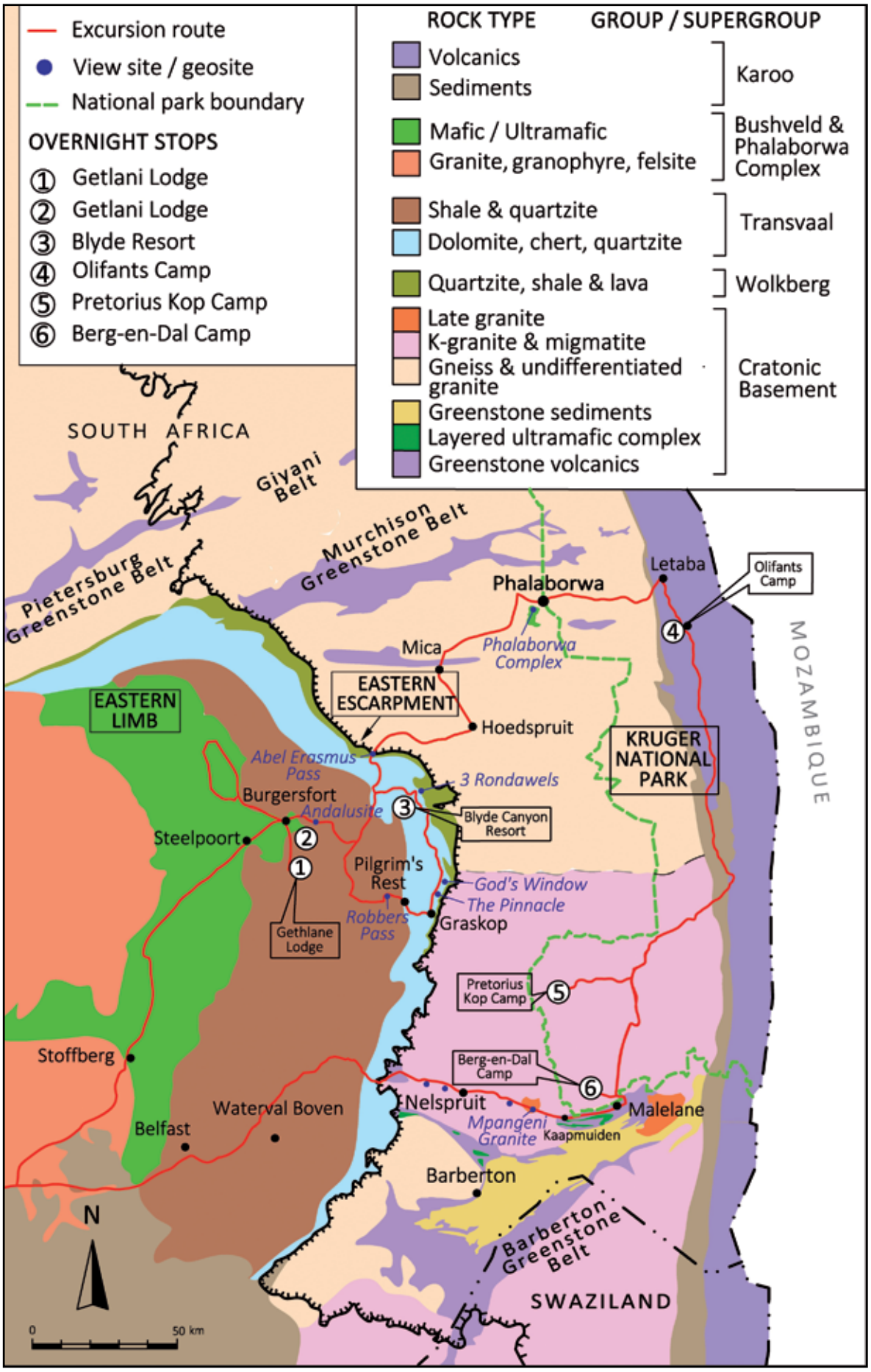
The **second leg** of the field trip covered the Eastern Escarpment of north eastern South Africa. Points of interest included the historic gold mining town of Pilgrims Rest as well as scenic sites along the escarpment edge. Visits to Bourkes Luck Potholes, calcareous tuffa waterfalls, as well as the spectacular Blyde River Canyon were of particular interest on this scenic leg of the excursion.

The **third leg** of the trip covered the central and southern portions of the world famous Kruger National Park, focusing on geology, landscapes and soil development and their relationship to ecozones. Excellent sitings of the Big Five as well as many other animals and birds were seen on numerous occasions and added to the excitement of the trip.

The distinguished group consisted of 40 participants from 15 different countries and included 15 PhD's and 5 professors. There was one participant from South Africa in addition to tour assistant Alison Blackhurst and myself. I would like to thank Alison for her tremendous assistance on the trip, very competent handling of various logistical issues that arose and for interacting so effectively with all of the participants. Alison and I would like to thank the group for their patience and understanding of the problems that arose and Sam Monageng for his cautious and safe driving. Thanks also to participants and for their emails and favourable comments on the trip.

The group interacted extremely well and appreciated the classical geological features and scenery. In the Eastern Bushveld visits to the Modikwa and Marula Platinum Mine properties were undoubtedly highlights with the remarkable continuity of the chromitite stringer at the top of the Merensky Reef being a feature that

Partly coalescing potholes at the mouth of the Treur River where it joins the Blyde River at Bourke's Luck, Eastern Escarpment area.



Excursion route in relation to the Regional Geological Setting of the Eastern Bushveld, Eastern Escarpment, Lowveld and Kruger Park.

Dolerite dyke swarm (including one felsic dyke) dipping steeply westward and intrusive into the sequence of lava flows. These dykes which represent feeders to overlying flows, are the first manifestation of the split of the Gondwana continent and formation of the proto-Indian Ocean

impressed everyone. Thanks are due to the mines and in particular, Wimpie Britz and colleagues of Modikwa platinum mine and Bennie Cilliers and colleagues of Marula platinum mine for arranging and conducting outstanding visits. Other localities visited in the Eastern Bushveld included the Main Magnetite layer at Magnet Heights, the UGI and UG3 chromitite layers, and Marginal Zone melamorite associated with spectacular examples of contact breccias or agmatites. The Onverwacht platiniferous dunite pipe and sites with magnesite veining in altered dunite of the Lower Zone were also visited.

Localities visited in the escarpment region included Robbers Pass, Pilgrims Rest the Pinnacle, God's Window, Blyde Canyon, calcareous tuffa waterfalls and various sites on Abel Erasmus pass on the Escarpment edge.

On the lighter side I had cautioned the group that at Magnet Heights we were likely to encounter locals doing their washing in a small stream at the site and laying it out to dry on the top dip surface of the Main Magnetite Layer. We were also likely to see cars being washed. What we encountered at the site was well described by Ronald Smith in an email circulated recently as follows: *"In the event there was a man washing not only his car but himself. While being observed by much of the group he received a cell phone call whilst in his entire nakedness. With his free hand he waved cheeringly and unconcernedly to his audience and proceeded with his ablutions".*

We were entertained by a local singing and dancing group in very colourful attire performing in the parking lot at God's Window viewpoint on the Escarpment edge. African curios were a hit at the Stydom Tunnel and photos of some of the group with a local touring party were taken.

In the Lowveld we visited Phalaborwa Copper Mine where specimens of the different rock types were made available and were avidly collected by participants. In the Kruger National Park we visited a number of sites in the granitic basement terrain although a highlight was undoubtedly a traverse along the mini-gorge immediately east of Olifants camp. We did this in 2 groups of 20 accompanied by 3 rangers. In the gorge a sequence of gently, east -dipping basaltic lava flows of the Karoo have been superbly exposed. Features include massive, resistant basal parts of flows and resistant upper amygdaloidal components, often topped by breccia's sometimes containing lava bombs. Large potholes in massive lava and smaller potholes in amygdaloidal lava are a feature. The mini gorge has been formed largely by

the process of potholing. A dolerite dyke swarm dipping steeply to the west is part of an extensive north-south trending dyke province intruding the earliest horizontal lava flows. They represent the earliest manifestation of the splitting of the Gondwana continent and formation of the Indian Ocean.

Although confined to tarred roads in the Kruger National Park in our large luxury bus, we had numerous outstanding game sightings including superb repeated sightings of the Big Five.The excitement from the group of overseas geologists, particularly the Chinese participants, was immense. Finally a group photograph which included all but three of the group was taken on the last day of what was considered by many as a successful, enjoyable and informative trip.

I attach two quotes from emails sent to Alison by excursion participants which she asked me to include:- *Thank you Morris for sharing with us your exceptional knowledge, not only in the geological field, but also on the history, the industry, the people, the fauna and the animal life during our field trip. We appreciated your endless energy in enlightening us and answering our continuous questions for the good part of a 14 hour day. Prof, you gave us a field trip of a life time!*

Members of the group having photos taken with a local touring group at the Strydom Tunne

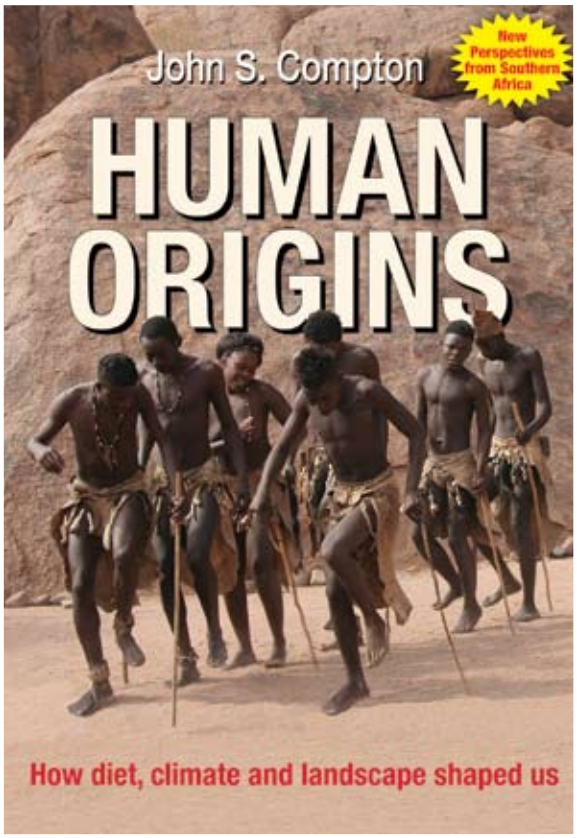
A second quote:-
'I am still marvelling on how wonderful this fieldtrip was and so beyond my expectations. I want to go back to your amazing country!'

Morris Viljoen

Some of the many outstanding game sightings encountered during the tour of the Kruger Park.

book review:

HUMAN ORIGINS:
How diet, climate and landscape shaped us
by
John S. Compton
Department of Geological Sciences
University of Cape Town
Published by Earthspun Books in 2016.



In 2004, Juta published Californian John Compton's small (A5, 3 chapters, 112 pages) book entitled The Rocks and Mountains of Cape Town. It was launched via a 5-lecture course at UCT's annual Summer School and has proved to be very popular. It has recently been reprinted in a Second Edition.

John's new book, published by Earthspun Books, is, literally, a weightier book, of 384 pages and 10 chapters and was launched at UCT Summer School in January, 2017. Instead of a parochial scope, the world is its oyster. We geologists are well aware of our wide range of time-scales and of dimensions and this book deals with the Birth of Planet Earth, billions of years ago through to the Population Explosion of the last few decades. In dimensions he ranges from light-years in the Universe to the details of individual cells.

The chapter titles are quite original and sometimes enigmatic. They are well explained on pages 8 and 9, in the Preface, along with the time-scale for each chapter, starting with the Big Bang in Chapter 1 and ending with a prediction for the future of humankind in Chapter 10:

1. Abiotic to animal.
   Big Bang (13.8 Ma) to earliest animals (600 Ma).
2. Endless forms most beautiful.
   Cambrian Explosion to apes.
3. Breaking human.
   Late Cenozoic hominin evolution, mostly in Africa.
4. Out of an unsettled world.
   Late Quaternary evolution of hominins.
5. African cradle.
   Expansion of Homo sapiens beyond Africa.
6. Seafood and our speciation.
   Fluctuations of Quaternary sea-level vs food.
7. Our long, slow cultural evolution.
   Late Quaternary cultural evolution.
8. Conquering the world.
   Late Quaternary expansion across Planet Earth.
9. Our dominion.
   Hunting, domestication, farming, civilization and industrialization in the Holocene.
10. A species with a future and a past.
    The modern interconnected world and a future world.

Geological time from the Big Bang through the Hadean, Archaean, Proterozoic and Phanerozoic eons is covered in the first two chapters, whereas the focus for the other eight chapters is on the Latest Cenozoic (Pliocene, Pleistocene and Holocene).

The book is aimed at the intelligent lay-reader. One of

its many achievements is to communicate how hominins evolved during a time of global cooling, accompanied by accelerating and more frequent climate change. However, this book succeeds in communicating the relevance of such fluctuations to the lay-reader and marrying them to human and cultural evolution, which is generally more familiar to the general public. He includes a trio of photographs illustrating the technological revolution from computers the size of a room, to an IBM 360 desktop computer, like the one John used to type his PhD at Harvard, to the suddenly ubiquitous SmartPhone.

The graphic designer, James Berrange, who worked closely with John, has produced a wonderful array of exquisite colour illustrations. The captions are often at the bottom of the page and not under the illustration.

The back-up references are all at the back of the book, chapter by chapter and page by page. The illustration credits are similarly listed.

Finally, John draws on his experience of supervising the PhD of Dr Hayley Cawthra on the marine geology of the seafloor off the world-renowned archaeological excavation in a coastal cave at Pinnacle Point (Mossel Bay). He elaborates on the expanse of new coastal plain that emerged each time there was a Pleistocene hypothermal regression, when sea-level dropped by 130 m, to create living-space on the emergent Agulhas Bank. As it happens, with the recent recipient of the Draper Memorial Medal, Richard Dingle, I wrote a short paper in the Transactions of the Royal Society of South Africa in 1972, using our newly acquired bathymetric data to show where the coastline and the rivers would have been on an emergent Agulhas Bank. John's Afrocentric book now brings that thinking to a world audience and links it to The Great Expansion of Homo sapiens out of Africa to the rest of the world.

This ambitious and beautiful book is available in e-book format, as well as in print via: www.johnscompton.com.

John Rogers

obituary

Linley Alice Lister †

LINLEY ALICE LISTER MSc, DPhil, PGSSA.
5th August 1936-15th December 2016.

Many may not have really known the Person who was amongst us, whether she may have been met at Pleasant Ways, within the realms of music, as a fellow teacher, a student in the lecture theatre or in the field, or even as a member in an audience at one of her talks on the subject of Final Exit. For we all have a story, and I hope that I can impart to you just a little on the Life of Linley Alice LISTER, who was born KING in Pietermaritzburg on 5th August 1936.

Linley was born to her Mother, Molly – a New Zealander, and Father – Lester Charles King. Lester had emigrated to New Zealand from London in 1925 to be a teacher in a subject in which he was to become

World renowned – that of the shape and evolution of our own Earth. With degrees behind him and an interest in playing the cello, he and Molly then moved to their new home in South Africa in 1934 where Lester took up a post as Lecturer at the University College of Natal in Pietermaritzburg. Here Lester earned his further degrees in the subject of the Earth he loved from UNISA and the University of New Zealand, he wrote his famous textbook South African Scenery, became Professor in 1946, was president of the South African Geographical Society and of the Geological Society, and a Fellow of the Royal Society of South Africa. In 1948 Lester was asked to found the Geology Department at the University of Natal in Durban, and the family moved to their new home at 314 South Ridge Road in Glenwood, where more books and papers on geomorphology, seafloor spreading and an expanding Earth were born.

The influence on Linley was overwhelming. She had already become proficient at playing the piano and the vibrant atmosphere of ideas on how the surface of the landscape around her had evolved was electric. Perhaps there is little wonder in the fact that she followed in her Father's footsteps and achieved in her own right. Linley gained her BSc (Honours) degree in Geology in 1958 and, whilst teaching in her subject back in Pietermaritzburg, achieved her Masters Degree with distinction on her study of the Post Karroo Stratigraphy across Durban. She presented this research at the First Annual Congress of the Geological Society of South Africa held in Johannesburg in 1958, a meeting also attended by her father and by a person who would have a further great influence in her life, one Geoffrey Bond. In 1959 Linley was to write a joint paper with Lester on their ideas on a structure known as the Natal Monocline, which dominates the scenery of South Africa northwards from Hluhluwe through Swaziland to the Lebombo Range marking the eastern border of South Africa with Mozambique.

There was a need for Linley to spread her wings and in 1961 we find her teaching in the Department of Geography at the University of Queensland in Brisbane, Australia. During 1962 and 1963, with the help of a small inheritance, we find Linley describing an amazing flight that had her hanging out of the aircraft window absorbing the morphological wonders that passed beneath her up the length of Africa to Israel and Iran, over Pakistan and India to Thailand, Hong Kong, Japan, the Philippines and Singapore, and then across the Indonesian archipelago to her roots in New Zealand and back across the expanse of Australia via the Cocos Islands and Mauritius to her home in Durban. Then, gathering her belongings, Linley flew to Salisbury in April 1963 to join Professor Geoffrey Bond as junior lecturer in geomorphology in his fledgling Geology Department at the University College of Rhodesia and Nyasaland. It was not long before they, with colleagues Clive Stowe and John Morgan moved from their temporary hut to the new aluminium-clad Geology Building, which became known as 'Bond's Biscuit Box'. The six inaugural students of 1960 gained their degrees, four of whom continued to Special Honours in Geology. It is true to say that Linley had an influence on the lives of every student, some 850 individuals, who passed through the Geology Department up until the time of her joint retirement with Professor James Wilson on 31st December 1996.

Linley was given the intricacies of crystallography to teach and, apart from geomorphology, her lecturing load included imparting the detail of South African stratigraphy. She became Senior Lecturer in 1975 and when Geoff Bond was appointed Deputy Vice Chancellor and Vice Principal to the University in 1978, Linley took on the teaching of palaeontology to the students. As number two in the Department, she would take on the administration should it be either Bond or Wilson who was away, and time-tabling became her forte. Not only did Linley lecture to the Geology students but she also gave talks at schools and was author to a book, African Landscape Studies, based on a TV lecture series. She earned Honorary Membership to the student's Mennell Society and was elected a Professional Member of the Geological Society of South Africa.

Her interest in the game of badminton led her to meet her husband, Jim Lister, another ardent player. They were married on 31st August 1965. Linley took periods of sabbatical leave in the late sixties and it

was Jim who accompanied her all over Zimbabwe and Malawi driving a Landrover in her quest to define and describe succeeding land surfaces and landforms as a basis for her DPhil thesis. Fellow lecturer, Dave Bowen, supplemented her analysis by flying her to observe much of the country from on high. Her 1967 publication on the Erosion Surfaces of Malawi remains current in that country and her doctorate on the Erosion Surfaces of Rhodesia was granted by the University of Rhodesia in 1976. During the intervening period, however, Linley applied herself to what might be considered her magnum opus in the formidable task of editing the 55 papers that comprise the proceedings of Granite '71, a Symposium on Granites, Gneisses and Related Rocks staged by the Rhodesian Branch of the Geological Society of South Africa and produced locally in 1973. Within the 509 pages of this tome rests Linley's own contribution describing the microgeomorphology of granite hills in northeastern Rhodesia. Linley was invited by the Director of the Geological Survey to abridge her thesis with the view to reproducing this as a Bulletin. This was eventually achieved in 1987 following editorial work by Euen Morrison and assisted by Tim Broderick. The consequence of the publication of Bulletin 90 was that Linley was awarded the 1989 A.E. Phaup Award for the most important contribution to the furtherance of Zimbabwe geology in the period under review. She also became an Honorary Member of the Geological Society of Zimbabwe.

Linley Lister did not remain static in her passion to see the World for she spent two sabbatical leaves studying Alpine Landscape in Switzerland; she visited the Gregory Rift and Olduvai Gorge in East Africa; she taught as a guest at the University of Adelaide, South Australia and attended a palaeontology conference in Sydney; and then she visited some of the scenic wonders that grace the United States. She then took on various consultancies such as the study of soil erosion in the Sinamatella region of Hwange National Park, and took up an interest in the subject of 'medical geology'. Sadly, however, this momentum was checked with the unexpected death of her husband Jim on 26th February 1989 followed closely by the demise of her father, Lester, in Durban on 1st April of the same year. She remained in the family home at No. 7 Waller Avenue in Mount Pleasant, Harare and continued to sustain her lecture programme at the Geology Department until the time of her joint retirement with her great friend and colleague Professor Jim Wilson at the close of 1996. Whilst maintaining her domestics of long service and her beloved dogs at Waller Avenue, Linley now turned her focus to rekindling her first love, that of music. She practiced daily on the piano, took lessons with Neil Chapman of the College of Music, held musical recitals with a group that involved Dawn Siemers and others, and she attended concerts and shows with her friends who included Dawn and Marina Bond.

It was only in 2008 that the decision was made to sell the house at Waller Avenue and to buy into Pleasant Ways where she acquired a cottage. Linley effected the move on her own, a monumental task of down sizing but also involving the difficult decision to put down her dogs. However, her music went with her and she continued to be part of a musical group led by Dawn Siemers and to impart joy in her new community. Her love for opera and the classics was satisfied through her formidable collection of some 312 compact discs.

Linley had always held an interest in the Living Will and she involved herself with the local chapter of the international organization Final Exit, later to become its Chairperson. Together with colleague Keith Martin, Linley would regularly give talks to groups on various relevant subjects including the right to die with dignity. She authored the local Newsletter for Final Exit until 2010 before passing on the baton. She downsized again to a single room at Pleasant Ways and later, with her descent into Alzheimers, she was moved into a care facility. The love and support from her colleagues at Pleasant Ways and from her close friends continued until her peaceful passing on 15th December. We all lived with and were enriched in some way by the life of this many-facetted, unassuming, meticulous and intelligent person whose life we celebrate.

Tim Broderick

With the help of so many

Tony Bloomer †

Tony Bloomer passed away on 13th November 2016 unexpectedly after going into hospital for a routine but supposedly minor operation. He was 75 years of age.

Tony was born in Scarborough on 23rd August 1941 and grew up in and around Scarborough and Whitby as a true Yorkshire man and graduated from Leeds University in geology and then left his native land with his wife Anne to begin his career in geology in South Africa at the tender age of 23. As such, Tony was one of an unusual generation of earth scientists who typified the post Vine and Matthews unshackling of geological thinking and a period of earth science that was a true age of research and discovery. The link between scientific work, commercial exploration and government geological surveys was a unified force for the globe and men like Tony were at the forefront of this time in industry. For most of his life he lived in Roodepoort so being close to the universities including Wits and EGRU kept him patched in to the science world.

Tony worked for Rio Tinto Exploration for almost 25 years and was a dedicated field geologist quite happy to rough it. Most of our era went through the field mill and how adept we became at positioning a camp and setting it up just like home. The core sheds and sampling office and stores were comparable to the living quarters and showers and mess with "fridge" to keep beers cold! How many of us remember camp life with affection?

But the breed of geologist at the time made new conceptual ideas come to life supported by field observation and careful field mapping transgressing the era from the Brunton compass to the GPS and computer modelling. Boy did times change and Tony always kept abreast of it.

His contemporary Jos Hauman remembers him as contributing extensively to the Rio Tinto efforts and being highly productive. He recounts "as part of a 3-geologist team mapping a large farm in the Aggeneys/Gamsberg area, his two colleagues were delayed by 2-weeks due to other commitments and when they eventually arrived only 4-days mapping was left to be completed!"

I first met Tony in 1979 on a Geocongress trip and I joined Rio Tinto Exploration for just 6 months in 1981 under Tony's guidance. We always enjoyed each other's company and when Venmyn needed wise counsel it was Tony that I called upon to help after he retired from Rio Tinto. I know he loved working with the Venmyn "girls" who he treated like his daughters! A more caring mentor they could not have wished for.

When I think of Tony I think of a hands on "grey beard" and a man passionate about our minerals industry and with a special love for diamonds. He was one of a breed of geologists who were dedicated to field work and "observation" but at the same time he was very computer literate and embraced modern techniques with a naturally enquiring mind.

Tony became part of the Venmyn family and he and Anne were often part of our Christmas and party functions happily being with children, contemporaries and the "younger" team. He loved children and they loved him. He would always have a story to tell and I think when he was initially at a loss he could merrily make up the rest! Competent and confident he was the hallmark of an expert.

As Heidi Sternberg reflects, "One of my fondest memories of Tony and Anne will always be of us lunching in the botanical gardens, enjoying a bottle of wine (and smoking up a storm as we all did in those days) and discussing whatever new project Tony was tacking before getting stuck in the indigenous nursery on the way out, Anne forever moaning that he couldn't possibly have any more aloes in his garden. I miss those days in the sun under the waterfall. One was never too old or too young for Tony to take an interest."

His interest in nature was well known from birds to plants and especially the geology.

His loving wife Anne passed away in 2012 and to

see her pass on was very difficult but he found a new partner Annetjie and remarried on 6th September 2015. I think he hated to be on his own!

Of course it is always nice to reflect on a person's quirks and Jos remembers that he thought he was the best driver in the world and on long trips wanted to do all the driving all day long, getting more aggressive as he was getting tired and pushing the car(s) in front of him off the road to get past. Eventually the company made a rule that drivers should be changed every 2 to 3 hours more for the sanity of the passengers than other drivers!

He enjoyed gardening and his place was always neat well-kept with many innovative ideas.

At one stage he had 21 snakes in cages at his house and Anne had to look after them when he was away, which she did not always appreciate.

I haven't had much contact since Anne passed but I always had a soft spot for Tony as did many of the Venmyn team.

People often talk to me about legacy but in my view the mutual love and respect of family and friends is the only important legacy.

To fellow geoscientists I think we are becoming used to seeing the passing of men like Tony as a special brand of "Baby Boomer" or should I say Bloomer.

Tony you will be fondly remembered for just being you, a true Yorkshire man, father to Simon and Jonathan and his grandchildren Caitlin and Keagan and loving husband to Annetjie. Farewell my friend but never forgotten.

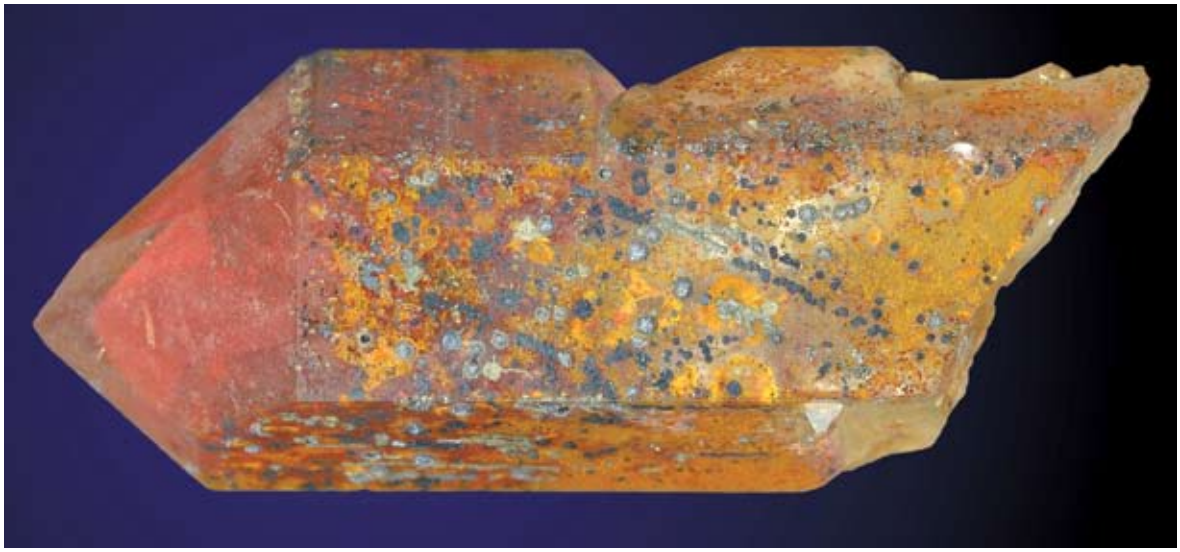
Andy Clay

Goethite from the Devil's Reef gold mine, Swaziland

Bruce Cairncross
Department of Geology, University of Johannesburg

Mention goethite to most geologists, mineral collectors and museum curators and the reaction one gets is that it is a rather ho-hum boring mineral. It usually occurs as earthy masses on rocks and other minerals and more often than not degrades the quality of a mineral specimen and usually gets removed by cleaning or dissolving away with acid. However, if one looks closer at goethite (commonly and erroneously referred to as limonite, a non-approved IMA mineral name) and in fact goethite can exist in a great variety of different habits and colours and in an extremely diverse array of geological settings. Just click on goethite on the Mindat.org website (http://www.mindat.org/min-1719.html) and it kicks out 2,768 photographs of goethite from many worldwide localities. Some of these show goethite as large museum-sized specimens, others are hand-sized specimens but the occurrence featured here in this Mineral Scene requires a closer look, literally, and the goethite from Devil's Reef in Swaziland is best viewed with a hand lens or a binocular microscope.

The Barberton greenstone belt is well known for its gold deposits in South Africa. Across the border in Swaziland, one such hydrothermal gold deposit is found in the Hhohho District, Pigg's Peak area, called Devil's Reef (Jones, 1962). As with many of the greenstone belt occurrences, the gold occurred in masses and produced spectacular gold grades, albeit erratic at times. The defunct Devil's Reef "mine" is interesting for two reasons, one economic, the other mineralogical. The ore body when mined was extremely rich. From 1890 to 1891, 87.63 kg gold was produced from just 69 tons of ore with an average grade of 1.27 kg/ton (Jones, 1962). Wilson-Moore and Carrington Wilmer (1893, page 44) reported that "… from 30 up to 50 ounces per ton have been obtained, the ore closely resembling that of many of the Barberton gash veins …".



A 4.5 cm quartz crystal with inclusions of red hematite, silver hematite and yellow-orange goethite. Bruce Cairncross collection and photograph.

The other aspect of the deposit that was somewhat unusual is that the gold occurred in vugs enriched in manganese oxides, hydroxides and wad, together with large, up to 15 cm, euhedral quartz crystals. These quartz crystals are both coated or partially coated by goethite and have inclusions of goethite and hematite, the latter producing a red colouration to some crystals.

On a macro scale, the goethite imparts a somewhat fuzzy yellow-golden hue to the quartz crystals and combined with the red hematite, creates attractive specimens (see the macro image of the quartz specimen). But it is under enlargement that the goethite comes to the fore (see close-up photograph of the featured specimen). The fine detail of the goethite shows tiny acicular to fibrous crystals most commonly bundled together and radiating outwards from a central point. Some of these clusters are bowtie in shape, some completely spherical and others fan-shaped or multiple fan-shaped. The silver clusters of crystals in the close-up image are hematite, composed of aggregates of microcrystals. The goethite also nucleates around some of these, either completely encircling the hematite 360° but in other instances, radiating out from one or several sides of the hematite spheres. The distribution of the goethite within the quartz is most commonly parallel to the same crystallographic plane, suggesting that as the quartz was crystallizing, conditions in the fluid were met only once when the iron oxides and iron hydroxides crystallized from the solution. The same applies to the red hematite – this forms as "phantoms" in the termination and sometimes down the prism faces, and only coats one surface before being covered by further growth of the quartz.

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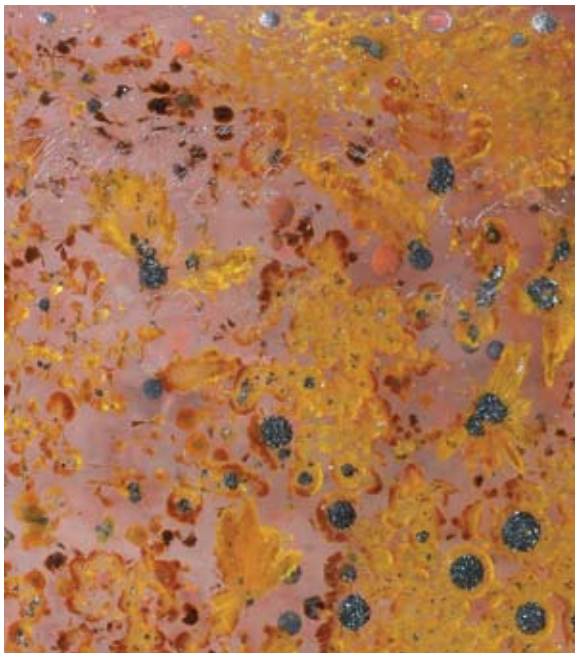


A close-up showing the delicate nature of the included goethite. See text for details. Field of view is 1.3 cm. Bruce Cairncross collection and photograph.

conference

7th UNESCO Global Geoparks International Conference, September 2016.

Some of the stands at the conference

7th UNESCO Global Geoparks International Conference, September 2016.

The 7th International UNESCO Global Geoparks conference was held over five days in Torquay, UK, at the end of September 2016. The venue is within the English Riviera UNESCO Global Geopark, and attracted some 800 delegates, mostly from Europe, the Far East, and with a large contingent from China. The conference had eight themes, with emphasis on engaging communities, education and interpretation, health and wellbeing, conservation, science and research, and the success and challenges of existing and aspiring Geoparks. The programme comprised some 300 oral, poster, and plenary presentations embracing these themes.

The label UNESCO Global Geopark was ratified in November 2015 by the 195 UNESCO member states. A Geopark is a single, unified geographical area with sites and landscape of international geological significance, managed according to the themes in the conference. There are 120 Geoparks in 33 countries. Many of these had exhibition stands adjoining the conference hall sessions. There was one presentation from Africa, about the Baringo aspiring Geopark in Kenya; this area was described in a recent Geobulletin by Geotraveller Roger Scoon.

The English Riviera UNESCO Geopark is Europe's only urban Geopark, it is within the Torbay area of Devon, the main town being Torquay, and is one of the 37 European Geoparks network. There 32 important geological sites in the Riviera Geopark, and the area is an important one for geological and geomorphological research. All these sites are readily accessible along a network of well documented pathways and trails. The park is described at www.englishrivierageopark.org.uk, along with expositions about Geoparks in general, and a link summarising the 7th Geopark conference (GGN2016 archive).

A good example of engaging the community is a local Geoplay park near Torquay. Here, a brochure and information boards descibe a geological trail chidren can follow, swinging across the Devonan sea, climbing ancient mountains, trekking through sandy deserts, and riding on a sabre toothed tiger.

There were three field trips to take in the local sedimentary geology that evolved over 400My, comprising collision zone structures, raised beaches, and recent coastal erosion and landslips, the latter taking dwellings onto the beach below. Also visited were carbonate caves containing evidence of hominin occupation tentatively dated at 44200 years BP. For more geology, a detailed and well-illustrated field guide by Ian West of Southampton University, The Coast around Torquay, is at www.southampton.ac.uk/~imw/Torquay.htm

The conference presentations continually emphasised that a Geopark is an area that uses the geological heritage as the primary promotional tool but, importantly, promotes other aspects of the natural and cultural heritage such as archaeology, history, biodiversity, gastronomy, crafts and cultural traditions, attempts to re-establish the link between humanity and the planet. It is an area that respects human rights. There must be community involvement, a strong management plan, and secure financial status. *"Once established, a Global Geopark is subject to re-evaluation after four years, and assessing the progress in these spheres. If problems remain after the review and remedial recommendations, membership of the network is ended."* (Murray Gray (2013), Geodiversty, Wiley Blackwell, 495pp.). Such was the fate of the only Geopark in Australia, Kanawinka. From this it is evident that *"a Geopark is not just an area of strong geological heritage, not a small site of geological interest, or a geological theme park, it cannot be an area with no community involvement, or an area with*

no sustainable development strategy" (Gray, 2013). The European Geoparks Network has excellent pages about tourism and education in Geoparks under the activities tag: www.europeangeoparks.org. These pages give in detail the how Geoparks operate and the commitments required for the success of a Geopark.

The journal Geoheritage (published by Springer,

four issues a year) was introduced at the 35IGC and also at the Geoparks conference. The journal relates to all aspects of Geoheritage and is a reference for assessment, management, and educational use of geosites and documentation of geodiversity.

The establishment of a UNESCO Global Geopark is a substantial and costly undertaking (the application process is detailed at: www.unesco.org/new/en/natural-sciences/environment/earth-sciences/). More information is at www.globalgeopark.org. However, this not to say that a Geopark has to be a member of the international network; national or regional Geoparks can be defined. In a way, the designation "Geopark" is a brand, and even if it is not part of the international network, the criteria applying to a Geopark should be followed. A regional or national Geopark can later become an "aspiring Global Geopark", leading to Global Geopark status, should the management plan allow.

Given the development priorities in South Africa, the Geotrail methodology using the Barberton Makhonjwa Geotrail model may be the most effective way of opening geodiversity and geoheritage to the lay public. This Geotrail approach has been developed in Australia, in the absence of enthusiasm for Geoparks (for example www.leisuresolutions.com.au. and links therein). In South Africa, along with the National Parks and provincial nature reserves, there are several UNESCO Biosphere Reserves and World Heritage Sites, where the geodiversity can be incorporated into the management plans. However, where a Geopark includes a Reserve or Heritage site, clear evidence has to be provided on how Geopark status will add value by being independently branded and in synergy with the other designations. Except perhaps for the Vredefort Dome , the Biosphere Reserves and World Heritage Sites emphasise the biotic diversity, and the abiotic diversity is relegated to a back seat. However there is the work of the Council for Geoscience and the many ongoing Geoheritage endeavours of local GSSA branches keeping the public informed by means of brochures and information boards. With this view perhaps there is no local requirement for Geoparks.

GSSA is thanked for underwriting the registration fee; conference documentation is lodged with the GSSA.

Chris Lee

media monitor

MINING AND EXPLORATION NEWS

Copper

Ivanhoe mines released the results of an independent preliminary economic assessment (PEA) for the development of the high-grade Kakula and Kamoa deposits in the DRC. The initial option considers a 4 Mt/a underground mine at Kakula producing an average of 216 000 t/a copper in concentrate for the first 10 years of operation, for a pre-production capital cost of US$1.0 billion. The production scenario schedules 82.6 Mt to be mined over 23 years at an average grade of 5.76% Cu, producing 7.5 Mt of high-grade copper (>50% Cu) concentrate containing approximately 9.1 billion pounds of copper. A possible alternative could involve a two-phase expansion to 8 Mt/a (292 000 t/a copper) from Kakula and the adjacent Kansoko mine at Kamoa. A follow-up PEA, expected in the first quarter of 2017, will assess the potential for an 8 Mt/a standalone mine at Kakula, as well as combined mining of 12 and 16 Mt/a from both Kakula and Kansoko. The Kamoa-Kakula Project – a joint venture between Ivanhoe, Zijin Mining Group, and the DRC government – has been independently ranked as the world's largest high-grade copper discovery, with current Indicated Resources of 944 Mt at 2.83% Cu.

Glencore has purchased the Fleurette group's remaining 31% stake in Mutanda Mining for US$922 million, and

a 10.25% stake in Katanga Mining Limited for US$38 million. Glencore now owns 100% of Mutanda and 86.33% of the shares in Katanga. Mutanda operates three adjacent open pit mines in the DRC's Katanga Province, with a production capacity of about 200 kt/a of copper cathode 23 kt/a of cobalt in cobalt hydroxide. Katanga Mining owns the Kamoto underground mine and concentrator and the Luilu metallurgical plant in the Kolwezi region.

Australian company MOD Resources completed a scoping study for its 70%-owned T3 copper-silver deposit in the Kalahari Copper Belt, Botswana. The study includes an open pit operation and 2 Mt /a processing plant producing approximately 21.8 kt copper and 665 000 ounces of silver per annum, with first production in 2019. The life-of-mine is approximately 10 years. MOD and joint venture partner Metal Tiger plc (30%) will proceed with a prefeasibility study in early 2017.

Gold

Gold Fields announced the results of the rebase plan for its South Deep mine on the West Rand. The goal to get the mine to cash breakeven by the end of 2016 has been achieved, and production is expected to ramp up to steady state at about 500 000 ounces per annum in 2021/22, at all-in costs below US$900 per ounce (2017 terms). As an ultra-deep bulk mine, geotechnical considerations and mine design are critical at South Deep. The regional support design has been improved by reducing the corridor span between regional pillars and increasing the dimensions of crush pillars, resulting in lower excavation convergence rates and an increase in overall rock mass stability. Gold Fields expects to spend a total growth capital of R2.280 million at South Deep over the next six years, peaking at R582 million in 2019.

Industrial Minerals

Birimian Resources has begun a prefeasibility study at its Goulamina (Bougouni) lithium project in Mali, following a successful scoping study that outlined the potential to produce up to 190 kt of 6% LiO2 concentrate per annum over a life of 13 years. The capital cost is estimated at US$83.4 million for a two-stage development. The mineral resource at the Goulamina is 15.5 Mt at 1.48% Li2O for 229 kt contained Li2O, positioning the deposit as among the highest grade hard-rock lithium deposits in the world. Earlier, the company terminated the proposed sale of the project to Shandong Mingrui Group for A$107.5 million. In the same area Koudal Minerals plc completed a first round of RC drilling on its lithium pegmatite project (also called Bougouni), and raised £1 million through a share placement to accelerate exploration activities.

Platinum Group Elements

Anglo American agreed to sell its 42.5% interest in the Pandora Joint Venture with Eastern Platinum, a wholly owned subsidiary of Lonmin, for a deferred cash payment of between R400 million and of R1.0 billion, plus a rental agreement for the use of and full operational control of Lonmin's Baobab concentrator for three years. The transaction will increase the Lonmn's interest in the Pandora JV to 92.5%, with the remaining 7.5% owned by Northam Limited through Mvelaphanda Resources. The Pandora area, which is contiguous with existing with Eastern Platinum operations, contributed 37 553 platinum ounces (74 019 PGM) ounces) to Lonmin in financial 2015.

Sibanye Gold reached a definitive agreement to acquire US palladium and platinum producer Stillwater Mining Company for US$2.2 billion (approximately R30 billion) in cash. The transaction, which is expected to close in the second quarter of 2017, will be funded through a US$2.7 billion bridge loan commitment. Stillwater, which is the largest primary producer of PGMs outside of South Africa and the Russian Federation, comprises two underground mines, Stillwater and East Boulder, located in Montana, and the Columbus metallurgical complex, which produces base metals and a PGM-rich filter cake for further refining. The company also owns the Marathon PGM-copper deposit in Ontario,

Canada and the Altar porphyry copper-gold deposit in the San Juan province of Argentina. Sibanye bought Anglo Platinum's Rustenburg mining and concentrating operations in 2015 and the company acquired Aquarius Platinum in 2016.

Rare Earth Elements

London-listed Rainbow Rare Earths raised US$8 million to fast-track its Gakara project in western Burundi through trial mining and into production in 2017. Gakara is described as one of the world's highest-grade rare earths projects, with an exploration target (as per the JORC Code) of between 20 kt and 80 kt grading 47–-67% total rare earth oxides (TREO) and weighted heavily towards the magnet rare earths, including neodymium and praseodymium, which account for 70% of annual global REE sales. The mineralisation, comprising coarse-grained bastnaesite and monazite, occurs in veins or stringers forming stockworks and is thought to be related to late-stage hydrothermal events associated with a carbonate source. Test work indicates that a combination of crushing, jigs, and shaking tables can upgrade the Gakara ore to a concentrate grade of at least 55% total REO, at recoveries of 82–93%. The company has a 10-year distribution and offtake agreement with multinational Thyssenkrupp Raw Materials for the sale of 5000 t of concentrate per annum.

Tin

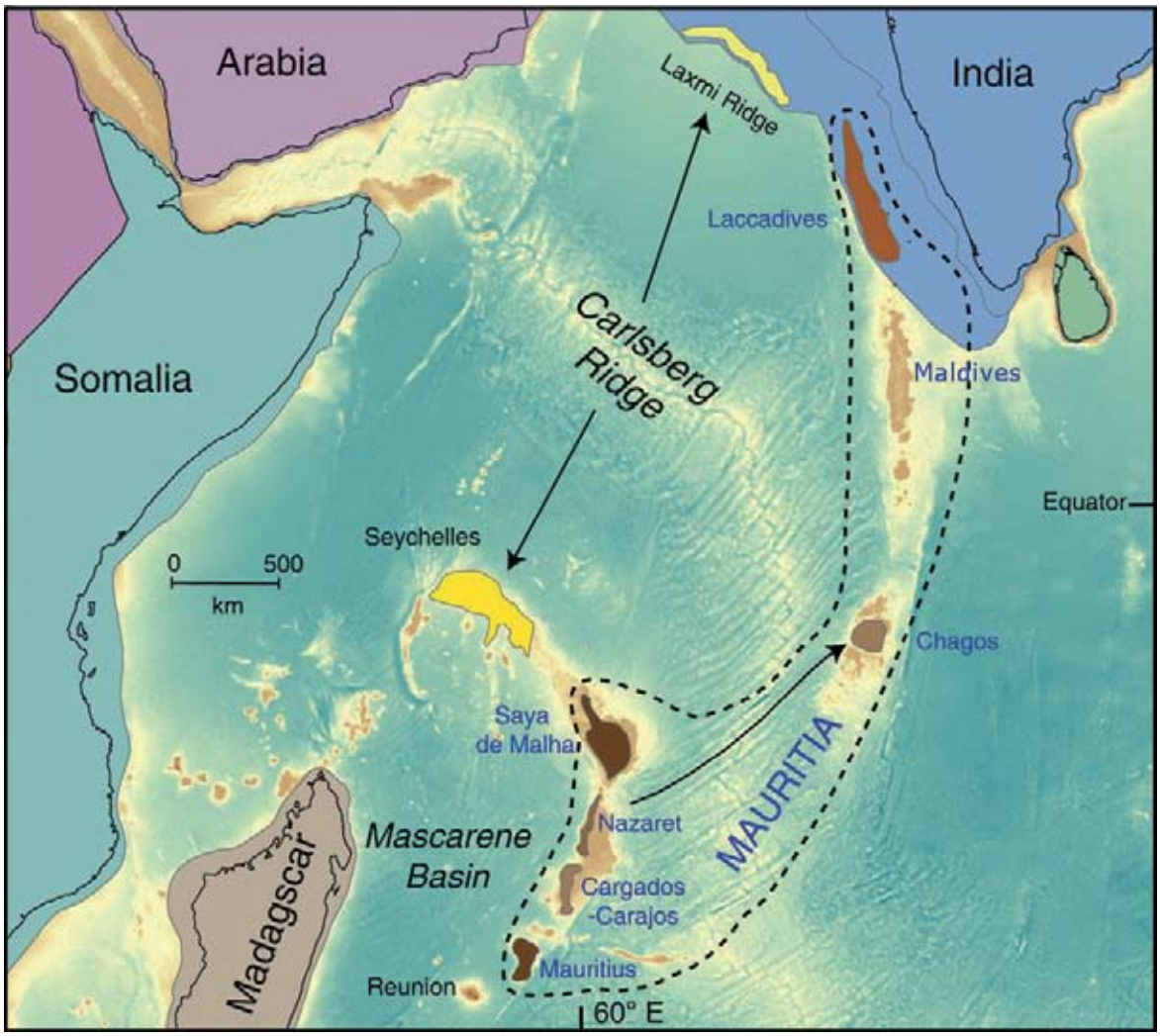
Bushveld Minerals has agreed to purchase a 49% interest in the Uis tin project in Namibia for approximately £0.65 million. Uis is one of the world's largest undeveloped opencast hard-rock tin deposits, with tin resource on three licenses, the most significant of which is the ML 134 resource estimated at 70.3 Mt at 0.14% Sn for a total potential resource of over 90 kt of contained tin. The mining rights to the 20 Mt of tailings at Uis, which contain lithium grades of up to 0.95% LiO2, were purchased in 2016 by Tawana Resources. The company has completed initial resource drilling of the tailings and expects to begin metallurgical testwork and complete a resource estimate in the March quarter

Other Geoscience News

A fragment of continental crust has been previously suggested to underlie the young plume-related lavas of the Indian Ocean island of Mauritius, on the basis of gravity inversion modelling (crustal thickness) and the occurrence of Proterozoic (660–1.971 Ma) zircons in basaltic beach sands. In a paper published 31 January in Nature Communications (doi: 10.1038/ncomms14086), Professor Lewis Ashwal (University of the Witwatersrand) and colleagues Michael Wiedenbeck (German Research Centre for Geosciences) and Trond Torsvik (University of Oslo) document U–Pb ages ranging between 2.5 and 3.0 Ga for xenocrystic zircons recovered directly from 5.7 Ma Mauritian trachytic rocks, thus confirming the existence of ancient continental crust beneath Mauritius. The U–Pb ages indicate that this crust has an affinity with central-east Madagascar, which is currently located about 700 km west of Mauritius. The authors propose that several crustal fragments, collectively termed 'Mauritia' and dominantly underlain by Archaean continental crust, originally formed part of the ancient nucleus of Madagascar and southern India. Mauritia became separated from Madagascar and was fragmented into a ribbon-like configuration by a series of mid-ocean ridge jumps during the opening of the Mascarene ocean basin between about 83.5 and 61 million years ago.

Location of possible continental fragments in the Indian Ocean (Ashwal, L.D., Wiedenbeck, M., and Torsvik, T.H. 2017. Archaean zircons in Miocene oceanic hotspot rocks establish ancient continental crust beneath Mauritius. Nature Communiations, vol. 8. doi: 10.1038/ncomms14086)

Meanwhile, in the southwestern Pacific Ocean, a new continent is a step closer to being recognised. In a paper published in GSA Today, the journal of the Geological Society of America, Nick Mortimer of GNS Science and co-authors contend that an area of continental crust centred on New Zealand and spanning 4.9 million km2, nearly two-thirds the size of Australia, is large and distinct enough to constitute a separate continent rather than a microcontinent or collection of continental



fragments. About 94% of the land mass, termed Zealandia, is submerged at an average depth of 1100 m below sea level, mainly as a result of widespread Late Cretaceous crustal thinning preceding the breakup of Gondwana. However, various lines of geological and geophysical evidence, including its elevated bathymetry relative to the surrounding oceanic crust, diverse and silica-rich rocks, and apparent structural intactness, support its definition as a coherent, albeit thinned and stretched, continent with interconnected and throughgoing geological provinces. The American geophysicist Bruce Luyendyk was the first to apply the name Zealandia to a southwestern Pacific continent in 1995, but the concept is still not well known in the international scientific community. Its significance lies in the fact that Zealandia, which once made up about 5% of the area of Gondwana, exemplifies the different styles of continental rifting and breakup that occurred in the core and along the margins of the supercontinent.

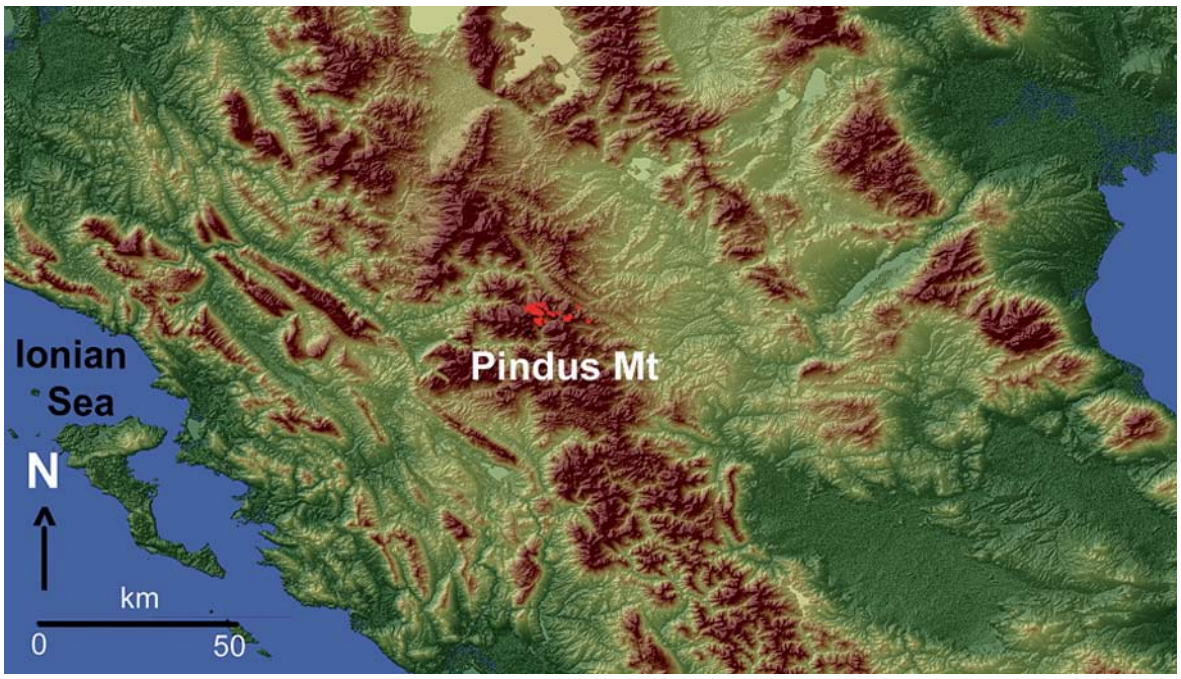
Spatial limits of Zealandia (Mortimer, N. et al. 2017. Zealandia: Earth's Hidden Continent. GSA Today, vol. 27. doi: 10.1130/GSATG321A.1)

Pindos Mountains, Ioannina & Meteora

THE GEOTRAVELLER

By Roger Scoon

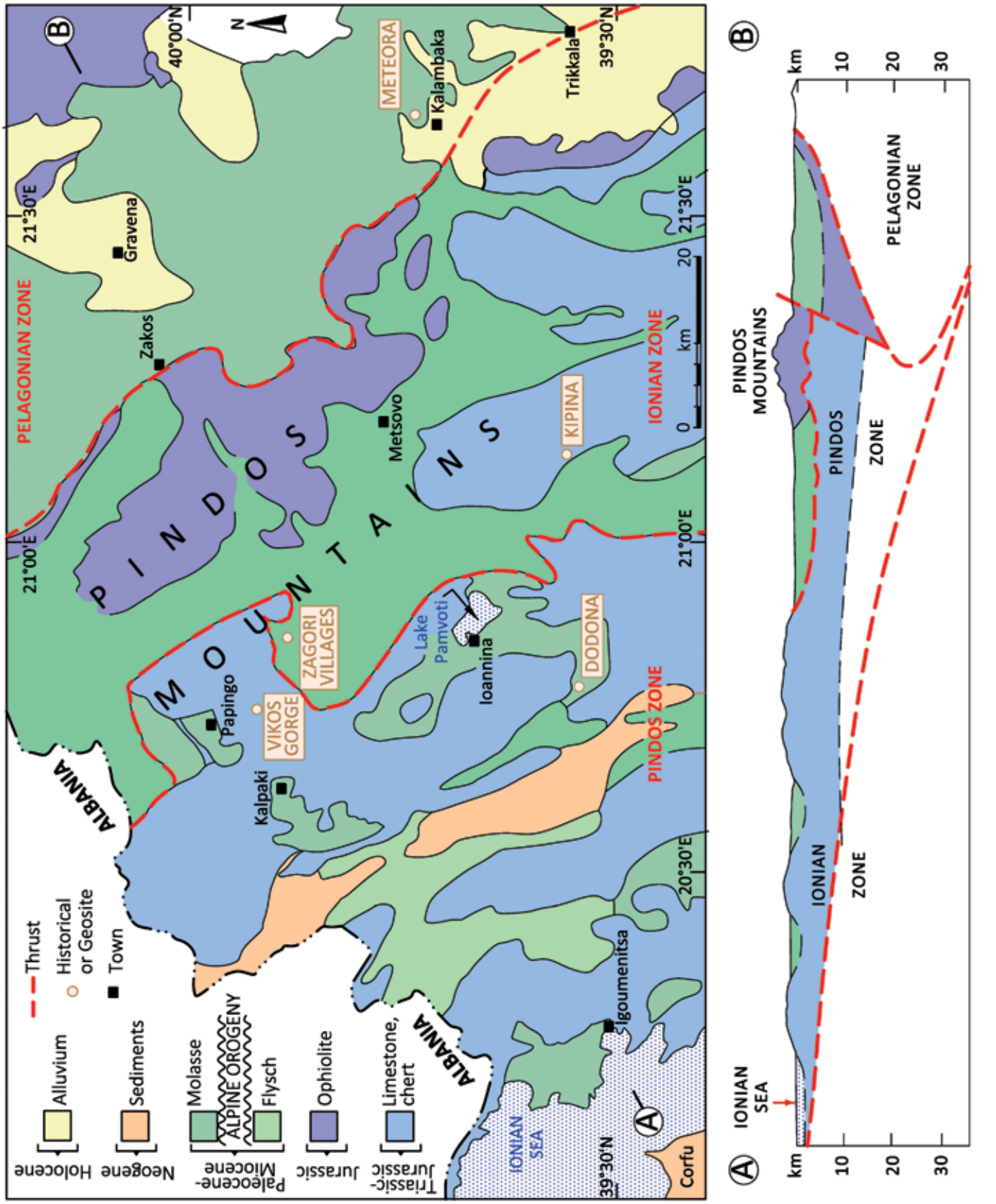
GEOLOGY OF MOUNTAIN PARKS AND HISTORICAL SITES OF NORTH-WESTERN GREECE:
Pindos Mountains, Ioannina and Meteora



The Pindos (or Pindus) Mountains in north-western Greece constitute several ranges aligned approximately parallel to the Ionian Sea coast and the island of Corfu (Kerkira).

The Pindos Mountains in north-western Greece constitute one of the most remote parts of Europe. The area is generally approached from the west by the regional city of the Epirus region, Ioannina, or from the south by Trikkala in the region of Thessaly. Several national parks as well as the Vikos-Aoös Geopark have recently been proclaimed. The area is also well known for monasteries, some of which are located on near-vertical cliff faces. The most famous site is the Meteora (meaning "suspended in air"), near Kalambaka, where monasteries are perched on the crests of steep hills and pinnacles. The remoteness of north-western Greece has resulted in an unusual history with some unique architectural styles.

The mountain landscapes have in part been shaped by tectonism driven by the Alpine orogeny, which commenced at the end of the Cretaceous and persisted episodically through the Palaeogene. The active plate movements that characterize the Eastern Mediterranean are also significant. Collision of the Eurasian and African plates has been widely described (e.g., King et al., 1993). Three main structural zones are identified in north-western Greece, from west to east these are Ionian, Pindos, and Pelagonian. They are dominated by Mesozoic and younger formations although the Pelagonian Zone is in part underlain by Palaeozoic basement. The Ionian and Pindos zones are dominated by limestones and chert that formed during the Mesozoic in a basin associated with the Palaeotethys Sea. The Pindos Zone also includes a near-linear array of ophiolite complexes, obducted slabs of the Tethys Ocean floor. The Ionian and Pindos zones contain, in addition to the Mesozoic limestones and ophiolites, substantial terranes of Late Palaeocene-Oligocene age flysch. These relatively soft marine sediments of marls, sandstones, and gravel were deposited in a foreland basin at the base of the rising Pelagonian nappes to the east. The Mesozoic and Palaeogene rocks were subjected to a series of thrusts during the Hellenic collision. This



Geological sketch map and section of north-western Greece compiled from various sources including regional maps and Higgins and Higgins (1996).

The tourist village of Metsovo is dwarfed by the high peaks (mostly ophiolite complexes) of the North Pindos Mountains. Construction of a bridge and tunnel, part of the Via Egnatia highway is visible in the valley.

produced distinct structural zones stacked one upon the other. The older, Mesozoic formations were particularly severely deformed.

The Ionian and Pelagonian zones reveal thick Molasse deposits located on the flanks of mountain ranges. The molasse, which is dominated by cross-bedded conglomerate and sandstone, is mostly of Oligocene and Miocene age. Sediment was derived from erosion of mountains and Neogene-age horsts. The latter are linked to regional sutures linking Greece and western Turkey that reactivated some of the older Cretaceous and Palaeogene structures. Neogene basins contain substantial deposits of sand and gravel. Active grabens are infilled by Holocene-age alluvium.

The mountainous area between Ioannina (west) and Gravena (north-east) includes a number of ranges collectively known as the Pindos Mountains. The highest peak of Mount Smolikas (2,637 m) is part of these 160-km long ranges that strike approximately NW-SE. Most of the ranges higher than 2,000 m are comprised of either limestone or ophiolite complexes. The limestone is of Triassic-Jurassic age; ophiolite complexes are dated at approximately 170 Ma (Rassios and Smith, 2000). Broad valleys between ranges are mostly underlain by either flysch or molasse deposits. Piper (2006) has noted that the flysch of this area differs from deposits father south in the Peloponnese.

The Pindos Mountains include numerous national parks and protected areas that attract summer and winter (ski resorts) visitors. The mountain village of Metsovo, located at an altitude of 1,160 m some 64 km east of Ioannina is particularly scenic. Metsovo is situated on the new Via Egnatia highway which links north-western Greece with Turkey. This road cuts through the Pindos Mountains via a series of spectacular bridges and tunnels. The remoteness of Metsovo resulted in an unusual history during the Ottoman Empire: residents were granted self-autonomy and excused from taxes (in part as they provided a service by guarding the mountain passes). This resulted in a special socio-economic situation that led to the phenomenon of Beneficence, a cultural principle in which the richest residents supported the entire economy of the area.

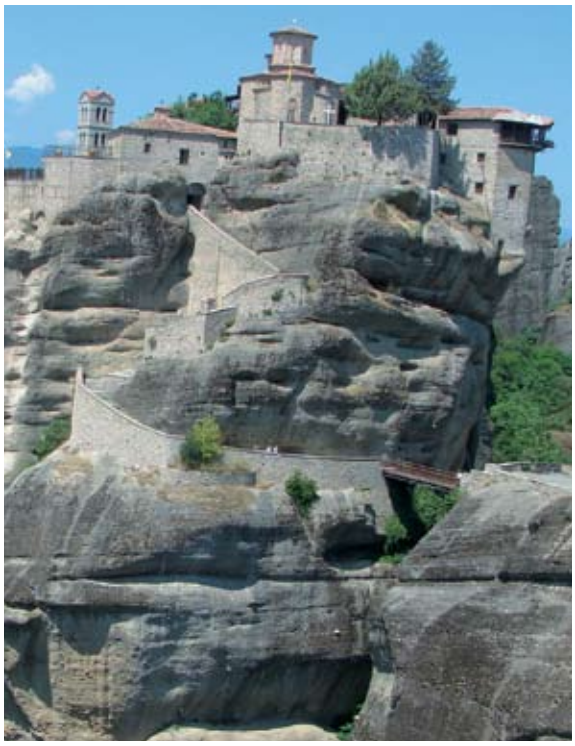
Located to the north-west of Metsovo in an even more remote sector of the Pindos Mountains is Zagoria. A group of 46 mountain villages, known as the Zagoria villages were self-governing prior to establishment of the modern state of Greece. This resulted in considerable prosperity in comparison to surrounding areas. The villages have a unique architectural style with large houses that include

fortified courtyards and slate roofs. The Zagoria also includes four historic arched bridges built of the local limestone.

The North Pindos National Park - located between Metsovo and Gravena - includes a group of a dozen or more substantial peaks dominated by ophiolite complexes. The principle rock-type is grey- and green-coloured peridotite (with accessory Cr-spinel). Small, podiform deposits of chromite have also been identified. Many of the peridotite layers have been altered to black or dark green serpentine. The South Pindos National Park – located to the south of the village of Papingo - is characterized by rugged limestone peaks and deep gorges. The Vikos Gorge is the principle feature of the Vikos-Aoös Geopark. The trail through the gorge reveals karst landforms such as near-vertical pinnacles and caves. Extensive limestone pavements – barren wastelands – are an additional feature. Archaeologists have uncovered evidence of human settlement in the gorge dating from 4,000 BC, mostly from evidence in limestone caves. The Provatina Cave has a depth of 407 m, possibly the second deepest in the world.

The Pindos Mountains are sufficiently high as to have been severely glaciated during the Pleistocene Ice Ages. Features such as serrated ridges, corries, moraines, and hanging valleys with high-level lakes, e.g., Dragon Lakes can be observed. Hughes et al. (2006a) recognized three glacial stages of which the oldest (350,000 BP) and most prominent produced extensive ice fields. According to Hughes et al. (2006b), glacial erosion was more effective on limestone where pronounced glacial incision and sub-glacial and glacio-karst processes produced some complex topography. Pleistocene glaciers formed on a range of slope orientations. Intriguingly the largest

The Vikos Gorge is the principle feature of the Vikos-Aoös Geopark (internet).



Many monasteries of the Meteora were formerly only accessible by ropeways.

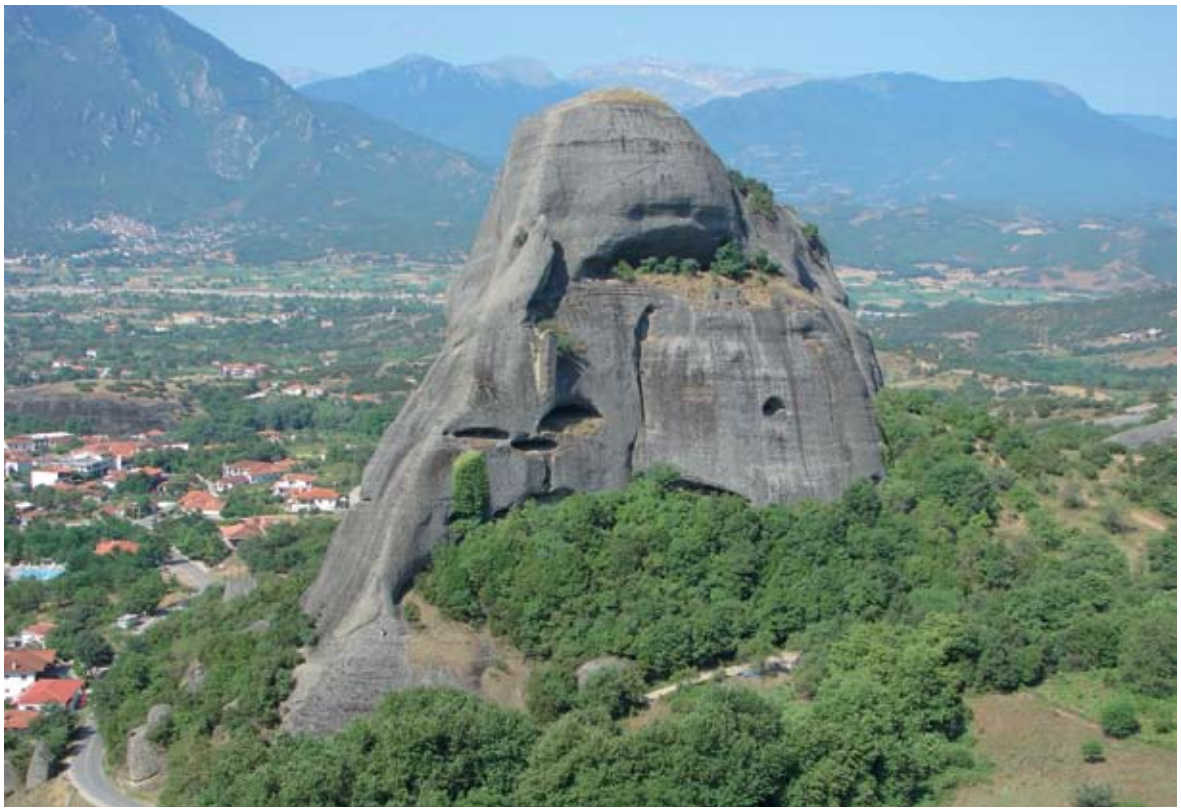
icefields developed on southward-facing limestone slopes, in contrast to ophiolite complexes where glaciers were mostly controlled by a more typical northward aspect.

The monasteries of the Meteora sit atop hills and pinnacles that rise to heights of 450 m above the Thesalian Plain. Most monasteries date from the 14thC AD when it was essential to build in locations that could be easily defended. Access was traditionally made from baskets slung on rope windlasses, sights made famous as they have featured in several action films. Tourists now use pathways with staircases cut in the rock face, although some precarious looking ropeways and skips are still used by the local inhabitants.

Meteora occurs within the Pelagonian Zone which extends from north-western Greece to the Aegean Sea.

Limestone pavement, Vikos-Aoös Geopark (internet).

View looking south-west from a molasse pinnacle, Meteora (Pelagonian Zone) over the Peneois Valley towards limestone and ophiolite peaks of the Pindos Mountains (Pindos Zone).



The nearest town of Kalambaka is situated in a wide valley associated with the meandering Peneois River. This river has exploited a Neogene-age graben, bordered to the south by Mesozoic-age limestones and ophiolites of the Pindos Zone. The monasteries are restricted to a group of hills on the northern flanks; they are comprised of Oligocene to Miocene-age molasse (Higgins and Higgins, 1996). The dominant lithology is an unusually resistant conglomerate, with subordinate (and softer) sandstone and shale. Sediments were derived from the Mesozoic-age ranges to the north-east. They were deposited in deltas that were reworked; pebbles were sourced from older limestone, marble, and serpentine.

Conglomerate of the Lower Meteora Formation is typically very poorly sorted and includes both rounded and angular pebbles.

The steepest cliff sections of the Meteora consist of conglomerate of the Lower Meteora Formation (Miocene). This rock exhibits spectacular cross-bedding aligned at 15-20^0 southwest. The overlying Upper Meteora Formation consists of somewhat less-resistant conglomerate, sandstone and marl, with near-horizontal bedding. Erosion of the molasse commenced in the Neogene due to reactivation of the Peneois graben. Removal of the softer layers of sandstone and marl has created block-like cliffs. A distinctive feature is the presence of rounded boulders of conglomerate perched precariously on summits. The physical appearance is also enhanced by widely-spaced vertical joints that weather to create steep columns and evenly-spaced blocks. Some sections also reveal hollows that may define softer layers.

Ioannina sits on the western shores of the relatively large Lake Pamvotis. The city, which is surrounded by mountain vistas in a particularly scenic location, is known for production of silver jewellery, the metal originally being locally derived as a by-product of lead mining. Historically, north-western Greece was the centre of a large mining industry that sustained many ancient cultures. The archaeological site of Dodona, situated in a narrow gorge 22 km from the city is one of the oldest

The pinnacles and narrow columns of the Meteora are associated with closely-spaced vertical joints in the molasse.

Bronze Age cultures in Greece (originally settled around 2,500 BC). The gorge is enclosed by high ramparts and scree-covered slopes of Jurassic-age limestone. The valley is dry as the mountains streams are trapped by sinkholes at the base of the slopes (Higgins and Higgins, 1996). The site includes a theatre and acropolis; the latter is constructed on a platform of Palaeocene-Eocene limestone with distinctive veins of chert.

Ioannina is inextricably linked with Ali Pasha (1788-1822), a famous tyrant (in part known for his attempts to create an autonomous colony in East Africa), who used the wealth of the city as a base for a fiefdom that stretched across much of northern Greece during the Ottoman Empire. He was murdered in the Agios Pandeleimon monastery on an island in Lake Pamvotis. The Perama Cave, located 4 km from Ioannina is one of the largest in Greece with three levels and 1,100 m of pathways. The dazzling white stalagmites and stalactites alone are worth a visit. Surprisingly for such a large system it was only discovered during WWII.

The village of Kalarrytes, situated in a remote area to the south-east of Ioannina is approached via a narrow road that winds up the southern Pindos Mountains. The main attraction here is the location of several 13-14th century monasteries cut into the Triassic-age limestone rock faces. The Kipina Monastery which is built across the entrance to a limestone cave appears to hang on a vertical cliff face. The entrance to the monastery is via a narrow, rather exposed pathway and drawbridge.

The molasse of the Lower Meteora Formation reveals small hollows associated with softer layers.

The Kipina Monastery is approached from Kalarrytes via a road that snakes up the flanks of the South Pindos Mountains.

The Kipina Monastery, Kalarrytes, is perched on a seemingly inaccessible face of Triassic-age limestone.

View from the Kipina Monastery looking towards the South Pindos Mountains.

Photographs by the author except where referenced

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The monastery of St. Nicholas Anapausas in the Meteora, near Kalambaka, is perched precariously on the crest of a near-vertical pinnacle of Oligocene-Miocene molasse sediments.

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

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