GSSA
Geological Society of South Africa

geobulletin

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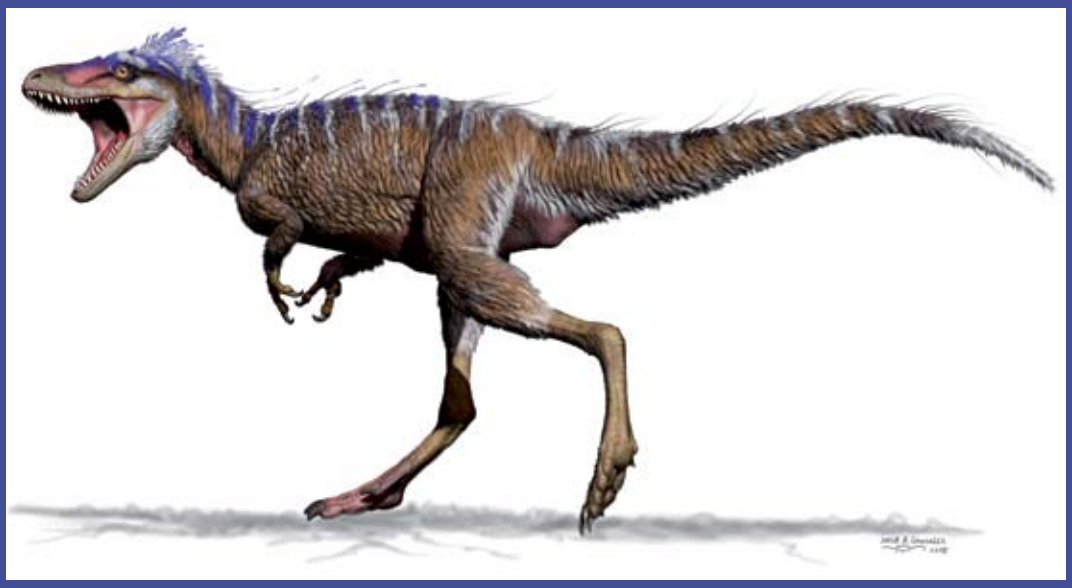
The Harbinger of Doom
Machine Learning in Geology
Geoheritage – Elandsputte

news

MSA
THE MSA GROUP



CENTREFOLD:

The Harbinger of Doom (see Article on pp. 19-21).

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Front Cover:

Two faceted tanzanite gemstones (left) 7.87 ct and (right) 4.89 ct. Merelani Hills, Lelatema Mountains, Simanjiro District, Manyara Region, Tanzania. Massimo Leone faceted gems, Bruce Cairncross crystal and photo.

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Geological Society of South Africa

GSSA
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from the editor's desk

Chris Hatton

These are trying and troubling times. The world is changing fast. In the three months since the last issue of Geobulletin we now have a government which has openly declared that is part of that community which considers climate change to be one of the major threats to the well-being of society, but breaking free from the patterns of the past is not easy. Eskom has saddled us with debts and promises to pay for power stations that are supposed to burn coal to supply us with electricity, but they aren't doing that particularly well. When Medupi and Kusile were conceived, they made good economic sense – coal provided a continuous, reliable source of energy and was much cheaper than alternative renewable energy alternatives. Although large dams can provide a continuous supply of renewable energy, and for years the South African government has been involved as a potential customer for electricity from the very large Inga Dams project in the Democratic Republic of the Congo, dams are not without their drawbacks, among them the environmental impact which muddies the green credentials of renewable energy. Another option for a continuous supply of energy from renewables has gathered momentum over the last decade. This is the use of batteries to store the intermittent energy from wind and solar panels. With Elon Musk championing their virtues, lithium batteries have emerged as a cost effective means of storing renewable energy, so much so that the British government has discontinued the favourable 5% VAT rate on home energy storage systems, now subjecting them to their standard VAT rate of 20%. Lithium batteries displaced lead acid batteries because their longer lifetime relative to lead acid batteries compensates for their higher initial cost. Vanadium redox flow batteries are poised to challenge lithium batteries for much the same reason. These batteries are bulky, requiring large plastic tanks but the bigger they are, the lower their overall cost becomes. Not currently suitable for the average household, vanadium redox flow batteries could find their place in solving the energy problems of rural communities. As a major source of vanadium, this bodes well for a resurgence of exploration and mining in the Bushveld Complex.

Renewable energy is a young industry and in the longer term hybrid systems which combine lithium and vanadium batteries to harness solar and wind power may emerge, but already it has become clear that renewable energy will be both cheaper and cleaner than coal. Why then should we continue with Medupi and Kusile? History has already passed judgement on power stations that burn fossil fuels – the best you can do with them is turn them into art galleries like the Tate Modern in London. The turbines on the south bank of the Thames roared for nearly a century before they were judged to have played their part in keeping London bright and warm. How long will it be before Medupi and Kusile will be put to rest, having damaged a debatable number of South African lungs and done their bit in pumping up the carbon dioxide content of the atmosphere?. Like Macbeth, Eskom argues that there is no turning back now - "I am in blood stepped in so far, that should I wade no more, returning were as tedious as go o'er." Economists counter that Eskom cannot afford to borrow more money and that the sensible option is

to discontinue operations, especially at Kusile, which is not as far down the road as Medupi. The decision to abort a power station even before it is finished cannot be decided behind closed doors. Medupi and Kusile were conceived in a corrupt atmosphere where the solution to fixing bad welds was simply to bribe the inspectors. This greatly benefitted those few who were in on the deals, but the enormous costs to the rest of us are only now becoming apparent. In the Professional Affairs Corner on pages 6 to 11 of this issue Tania Marshall highlights the prime importance of Geo ethics in professional affairs. Geologists are aware that we are the products of billions of years of evolution which is not driven by selfish individuals but by cooperative populations. This sentiment is embodied in the recent book by Bjornerud is entitled "Timefulness – how thinking like a geologist can help save the world"; thinking geologist can certainly help to save South Africa.

Chris Hatton

executive managers corner

Craig Smith

GSSA Geological Society of South Africa

Of particular interest to geochemists, 2019 is the International Year of the Periodic Table of the Chemical Elements (see https://www.iypt2019.org/), as proclaimed by UNESCO. The father of the Periodic Table is generally considered to be Dmitri Mendeleev, who published his table in 1869, 150 years ago. Discovering and organizing the elements was a hot research topic in the 1800's, however, and there are others who should be remembered, including Julius Meyer who shared the Davy Medal with Mendeleev in 1882. It is a great story, and I highly recommend the book "The Disappearing Spoon" by Sam Kean.

The first two weeks of May were significant as regards news and events related to earth science. The UN report on the state of earth's natural environment was released, and the executive summary alone is 39 pages. See:

https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/

https://www.ipbes.net/news/ipbes-global-assessment-summary-policymakers-pdf

The conclusions are disturbing, climate change being only one component of man's deleterious effect on the world around us.

Coincidentally, on May 6th the Department of Environmental Affairs of South Africa gazetted the Draft National Climate Change Adaptation Strategy, with an invitation to comment within 30 days. Note the term "Adaptation"; the debate has moved on as to whether climate change is happening or whether human activity is in large part responsible for it. The discusion about solutions has moved from mitigation, to mitigation and adaptation. Even if you do not intend to comment, the draft is a well-constructed document that is arguably important.

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We are regularly seeing climate related news, activities and actions around the globe, ranging from the record breaking Initial Public Offering in New York of Beyond Meat, to the UK attaining a milestone of a week's electricity production without the use of coal, and to stories about the difficulties of raising finance for new fossil fuel projects (particularly coal). More extreme yet, those of you who might enjoy a taste of 'climate change porn' should read "The Uninhabitable Earth" by David Wallace-Wells.

Environmental degradation and climate change is not disproportionally caused by geologists – or can be resolved by geologists – but every member of our community is an earth scientist. The UN report and the South African legislation in particular should be required reading for us because over the long term, the policies put into place will impact. Everyone. Whether you agree with policy or not. Who knows, members of our community may have the chance to set policy. If a geologist can run for President of the United States, it could happen here as well. Earth science has a role in the debate going forward and we need to be informed.

Please check the new-look website at www.gssa.org.za. We have deliberately cut back on content in order to better manage the site as well as to ensure that the important parts function property. Any feedback will be welcome.

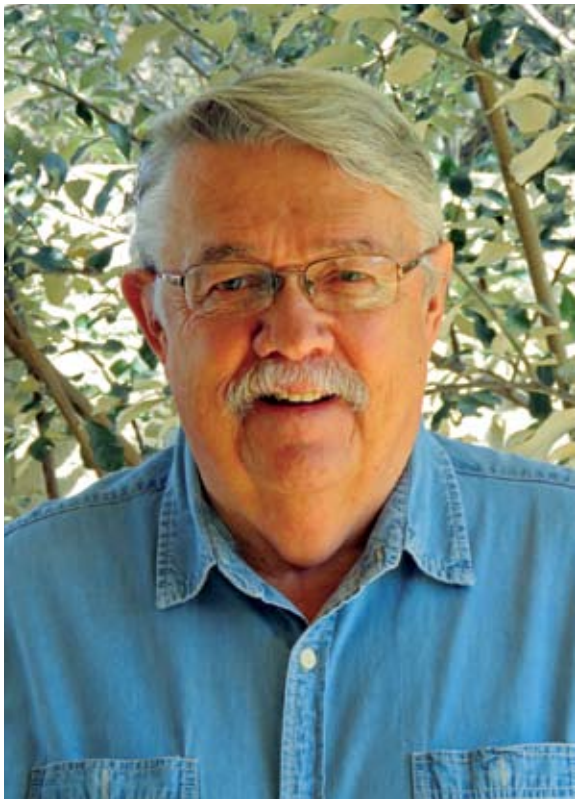
The 36th International Geological Congress in India is less than a year away (see http://www.36igc.org/index.php), and the 35th IGC Legacy Fund has invited applications for student support to attend the event. Because the dates for abstract acceptance by 36th IGC are still uncertain, the last date for application for support has been moved out from end May to end June, and proof of acceptance by 36th IGC will not be required by the Legacy Fund. Funding requests should be sent to 35IGCLegacy@geoscience.org.za. Any changes will be circulated.

Craig Smith

Geological Society of South Africa

president's column

Ed Swindell



In my last column I mentioned that we are delving into matters such as Open Access and I am pleased to tell you that we have made some progress. Certainly in respect of understanding what our position is. Questions such as access to the SAJG in this world of online access and the near terminal decline of postal service deliveries, had to be dealt with. A team consisting of the technical editors and some members of Manco have analysed our situation. In order to assist the process of accessing the SAJG online our editorial team and specifically Mike Knoper have come up with a solution that will facilitate ongoing access as well as access to past issues. Mike states the following by way of explanation;

The GSSA has recently established two digital online archives. The Geobulletin archive (https://gssa.pub/gb/content) is an open access repository containing current and past issues of the Geobulletin. Each individual issue is available for download in PDF

format. At present, the GB archive contains issues back to 2016; more issues back to 2010 will be added to the archive over the next few months. The other digital archive is of the South African Journal of Geology (https://gssa.pub/sajg/content/). By way of this closed archive, GSSA now offers a digital subscription to the SAJG. This means that non-members of the GSSA, including institutions and businesses, may subscribe digitally to the SAJG. Institutional members of the GSSA will be granted digital access to the SAJG as a membership benefit. The SAJG archive is a work-in-progress; papers published in the SAJG back to 2000 will be available in PDF format via a digital subscription.

Mike has put a lot of work into developing this solution and we are very grateful to him for all of his effort. The work of the task team will continue over the next few months. The next big issue we are grappling with is the tricky question of copyright and how best to manage that and the possible changes arising from OA that may be needed.

Our refreshed website is now up and running. We have instituted a fresh management system and hopefully it will prove satisfactory. It is now of growing importance that members familiarise themselves with the CPD point capture system. If and when you uncover glitches please let us know so that it can be dealt with. The basis of our CPD system is that the basic unit of development is the Professional Development Hour or PDH. This is one hour of formal learning in a formal structured environment. One PDH translates into one Continuing Professional Development Point or CPD. Our system is practical and simple and allows for a full range of types of personal development activities under a wide range of situations. We have also deliberately avoided following the route of accrediting individual courses, which we consider absurdly impractical and which favours only one category of learning activity, namely that of formal learning. We have preferred to rely on an audit system whereby members CPDs will on occasion be audited and have their activities validated. Our MOU with SACNASP ensures that your professional status is fully recognised. We believe that this system allows even people who cannot afford to attend expensive formal courses the opportunity to continue with their development and maintain their registration through bad times by for example getting involved in the Society, writing and publishing papers, and giving lectures or developing courses etc.

Attendance at Branch, Division and Council meetings is to be greatly encouraged. Your Society is built around you and your needs and the best way for you to get that match, with what the Society offers, and what it is you wish of the Society is for you to get involved. I call upon all of you to get involved and in the next year to support your next incoming President and Council whom I wish the very best of good fortune and strength through the coming years. I would like to thank everyone who has supported me so ably through the 2 years of my tenure and I am sure that you will all give my successor the same degree of support through his time.

Ed Swindell

codes of practice

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

THE PROFESSIONAL (AFFAIRS) CORNER

GEOETHICS, CODES OF ETHICS, CODES OF CONDUCT AND CODES OF PRACTICE

Competence, integrity, accountability and high ethical standards, judged peer-to-peer are the hallmarks of what it means to be part of a professional community (Allington R. A., 2016). This month's article focusses on the Geoethics Statements, Codes of Ethics, Codes of Conduct, Codes of Practice that are central to the concept of Professionalism in the Geosciences.

The field of **Geoethics** consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system (http://www.geoethics.org). Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities. Geoethics has its roots in the global academic community, with key concepts as freedom of choice, fairness and responsibility, obligation and consciousness, contribution, integrity and humanity as the basis for addressing geological situations, problems and dilemmas (Bobrowsky, Cronin, Di Capua, Kieffer, & Peppoloni, 2017) (Nikitina, 2016).

Codes of ethics, typically, govern decision-making, and codes of conduct, govern actions, represent two common ways that companies and other organisations self-regulate (https://www.whistleblowersecuritycom/code-of-ethics-and-code-of-conduct-whats-thedifference/). Typically, good Codes of Ethics include several common clauses that will be found in many other codes of ethics regardless of country or culture of origin. For example, they will all include a clause referring to the fundamental need to protect the public from harm by the practitioner, or a clause requiring that the professional may only practice in the field for which he / she is qualified and experienced in. There is always a clause requiring the practitioner to adhere to the law, both international and local.

Codes of Conduct may be employed to expand on the actual behaviours that the code of ethics may define. The details of a code of conduct are generally more specific to standards of norms and behaviours in respect of activities peculiar to the organisation. Both types of Codes are used to encourage (or discourage) specific forms of behaviour; the Code of Ethics are typically more generalised and non-specific, whereas the Code of Conduct characteristically provide a clear set of expectations regarding required, acceptable or prohibited actions or behavioural norms. However, there is no international standardization of definition of codes of ethics or conduct and many organizations use the terms interchangeably.

A Code of Practice, by contrast, is a set of written rules which explains how people working in a particular profession should behave https://www.collinsdictionary.com /dictionary/english/code-of-practice). The purpose of codes of practice is, generally, to ensure compliance with an agreed upon set of objectives that a specific set of interested and affected parties (https://lawpath.com.au /blog/what-is-an-industry-code-of-practice). These objectives usually concern the promotion of best industry practice, improving safety standards and enhancing consumer confidence. The Code of Practice most applicable to GSSA members is the SAMCODES, which set out the minimum standards, recommendations and guidelines for the Public Reporting of mineral related issues in South Africa.

International organisations that promote geoethics as well as professional ethics abound. Probably the most well-known are:

International Union of Geological Services (IUGS) Task Group on Global Geoscience Professionalism (TG-GGP)
(https://tg-ggp.org/).
See last quarter's article for a more detailed discussion on the TG-GGP.

International Association for Promoting Geoethics
(http://www.geoethics.org/)
The International Association for Promoting Geoethics (IAPG) is a multidisciplinary, scientific platform for widening the discussion and creating awareness about problems of Ethics applied to the Geosciences. IAPG promotes geoethics through the international collaboration with Associations and Institutions. During the 2016 35th IGC, the concepts, values and views on individual responsibilities of geoscientists, were reflected in the creation of the *"Cape Town Statement on Geoethics"*. The statement aims to capture the attention of geoscientists and organisations, and to stimulate them to improve their shared policies, guidelines, strategies and tools to ensure they consciously embrace (geo)ethical professional conduct in their work.

The IAPG Executive Council also approved a *White Paper on Responsible* Mining on 1 December 2017. This document intends to provide essential reference elements for framing this important topic (responsible mining) from an ethical perspective and to draw geoscientists', companies', policy makers' and society's attention to the ideas and approaches that the actors involved in mining have developed and use.

International Association for Geoethics (IAGETH) (http://www.icog.es/iageth/)
IAGETH has as its stated objectives:

- To improve both the quality of professional work and the credibility of geoscientists,
- To foster excellence in geosciences,
- To assure sustainable benefits for communities, as well as to protect local and global environments;
- All with the aim of creating and maintaining the conditions for the healthy and prosperous development of future generations.

IAGETH has 49 National Chapters globally (including South Africa) that make it possible to emphasize in each country the more appropriate and needed fields of activities.

The GSSA Code of Ethics
Adherence to a Code of Ethics/Conduct or Practice is typically associated with those members who are operating in the applied or "industry" sector of the geosciences. However, it is reasonable to expect that such codes should also be applicable for all geoscientists, irrespective of their field of expertise (Allington & Fernandez, 2015). So, if we accept the premise that all who work in the geosciences are professionals, then the GSSA Code of Ethics applies equally to all of its members in industry, academia, research and even regulatory administration.

The GSSA Code of Ethics (Annexure 2 of the GSSA Constitution) comprises of a Preamble and NINE clauses, each of which is followed by a set of principles that define acceptable or non-acceptable behaviour. *The GSSA Code of Ethics is binding upon all members of the GSSA and that membership with the GSSA implies that the member agrees to abide by them and be subject to them and the associated Complaints and Disciplinary processes described (Annexure 3 to the GSSA Constitution*).

PREAMBLE
The purpose of the code of ethics is to commit members to uphold and enhance the honesty, honour, integrity and dignity of their professions, such that the members and their professions merit the highest esteem by the community. Alleged behaviours, which could be deemed a breach of the code of ethics, include:

a. Any breach of the specific clauses of the code of ethics. Breaches without dishonesty, intent, repetition or reckless incompetence should be deemed as "non-compliance" which could result in personal

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counselling and/or admonition, but not suspension. More serious breaches (with the aforementioned characteristics) should be deemed as 'unethical behaviour" and could give rise to suspension, expulsion, and/or publication

b. Any breach of any rule or code of the Society, or relevant to the profession that is characterised by dishonesty, intent, or reckless incompetence (further, any repeated code violations would be taken as a *prima facia* case of "unethical behaviour").
c. Gross professional incompetence, misconduct or unethical behaviour
d. Professional defamation.
e. Criminal conduct.

Provisions contained within the code of ethics are not designed to restrict competitive behaviour in any way. The Society is committed to promoting vigorous competition within the industry.

For an "unethical behaviour" to occur, the alleged behaviour must be sufficient in nature to "bring the members and their profession' into disrepute with the community. Behaviours that could potentially merit such an outcome include:

- Any breach of the specific clauses of the code of ethics;
- Dishonesty and misrepresentation;
- Professional incompetence;
- Defamation; and
- Criminal conduct.

CLAUSE 1:

In conducting their professional activities, the responsibility of members for the welfare, health and safety of the community shall at all times come before their responsibility to the profession, to sectional or private interests, their clients or employers, or to other members.

The principle here is that the interests of the community have priority over the interests of others. It follows that members:

a. Shall avoid assignments that may create a conflict between the interests of their client or employer and the public interest.
b. Shall work in conformity with acceptable technological standards and not in such a manner as to jeopardise the public welfare, health or safety.
c. Shall endeavour at all times to maintain technological services essential to public welfare.
d. Shall in the course of their professional life endeavour to promote the well-being of the community. If their judgement is over-ruled in this matter, they should inform their client or employer of the possible consequences (and, if appropriate, notify the proper authority of the situation)
e. Shall, if they consider that by so doing, they can constructively advance the well-being of the community, contribute to public discussion on scientific and technological matters in their area of competence.

CLAUSE 2:

Members shall at all times act so as to uphold and enhance the honesty, honour, integrity and dignity of the profession.

The principle here is that the profession should endeavour by its actions to merit the highest esteem of the community. It follows that a member:

a. Shall not be involved with any business or professional practice that is known to be of a fraudulent or dishonest nature.
b. Shall not use association with other persons, corporations or partnerships to conceal unethical acts and relationships.
c. Shall not knowingly continue in partnership with, nor act in professional matters with any person who has been removed from membership of The Society because of unprofessional conduct.
d. Shall, whenever called upon to give professional advice, provide an opinion that is objective and reliable, to the best of his/her knowledge and ability. If, having given professional advice a member becomes aware that it will not be followed, he/she shall take all reasonable steps to ensure that the person(s) neglecting his/her advise is (are) aware of any danger or other serious consequence which may result.

CLAUSE 3:

Members shall not take on the functions of an expert in fields other than their own or accept professional obligations that they are not competent to discharge.

To this end the society has determined that members:

a. Shall inform their employer or client and make appropriate recommendations on obtaining further advice, if an assignment requires qualifications and experience outside of their field of competence.
b. In the provision of professional services members shall not describe themselves, nor permit themselves to be described, nor act as a consultant or contractor unless they are a member or fellow of the Society, registered with SACNASP, occupy a position of professional independence, are prepared to design and supervise works or act as an unbiased and independent adviser, and conduct their practice in strict compliance with the conditions approved by the Council of The Society
c. Shall not give a professional opinion, make a report, or give legal testimony, without being as thoroughly informed as might be reasonably expected, considering the purpose for which the opinion, report or testimony is required; and the degree of completeness of information upon which it is based should be made clear.

CLAUSE 4:

Members shall build their professional reputation on merit and shall not compete unfairly.

The principle here is that members shall not act improperly in a professional sense to gain a benefit. It follows that a member:

a. Shall only approach prospective clients or employers with due regard to their professional integrity and to this Code of Ethics.
b. Shall promote the principle of engagement upon the basis of merit. They shall uphold the principle of adequate and appropriate remuneration for professional staff and shall give due consideration to terms of employment which have the approval of the profession's appropriate association.
c. Shall not attempt to supplant another, employed or consulting, who has been appointed.
d. In the practice of consulting, shall not undertake professional work on a basis that involves an undisclosed speculative fee or remuneration that is conditional on implementation of the work unless fully disclosed.
e. Shall neither falsify nor misrepresent their own or their associate's qualifications, experience and prior responsibility.
f. Shall neither maliciously nor carelessly do anything to injure, directly or indirectly, the reputation, prospects or business of others.
g. Shall not use the advantages of a privileged position to compete unfairly with others.
h. Shall exercise due restraint in explaining their own work and shall refrain from unfair unjustified criticism of the work of another.
i. Shall give proper credit for professional work to those to whom credit is due and acknowledge the contribution of subordinates and others.
j. Shall refrain from plagiarism in both oral and written communications and not knowingly accept credit rightfully due to another and will not submit the same professional paper for publication in more than one peer review journal.
k. May properly use circumspect advertising (which includes direct approaches to prospective clients by any means) to announce their practice and availability. The medium or other form of communication used, and the content of the announcement shall be dignified, becoming to a professional person and free from any matter that could bring disrepute on the profession. Information given must be truthful, factual and free from ostentatious or laudatory expressions or implications.

CLAUSE 5:

Members shall apply their skill and knowledge in the interests of their employer or client for whom they shall act, in professional matters, as faithful agents or trustees.

It follows that a member:

a. Shall at all times avoid all known or potential conflicts of interest. He should keep his employer or client fully informed on all matters, including financial

interests, which could lead to such a conflict. In no circumstances should he participate in any decision that could involve him in conflict of interest.

b. Shall, when acting as administrator of a contract, be impartial as between the parties in the interpretation of the contract. This requirement of impartiality shall not diminish his duty to apply his skill and knowledge in the interests of the employer or client.
c. Shall not accept compensation, financial or otherwise, from more than one party for services on the same project, unless the circumstances are fully disclosed to, and agreed to by all interested parties.
d. Shall neither solicit nor accept financial or other valuable considerations, from material or equipment suppliers for specifying their products unless fully disclosed.
e. Shall neither solicit nor accept gratuities, directly or indirectly, from contractors, their agents, or other parties dealing with their client or employer in connection with work for which they are responsible;
f. Shall advise their client or employer when as a result of their studies they believe that a project will not be viable;
g. Shall neither disclose nor use confidential information gained in the course of their employment without express permission.
h. Shall not, without a satisfactory reason, destroy calculations or documentary or other evidence required for verification of his/her work.

CLAUSE 6:

Members shall give evidence, express opinions or make statements in an objective and truthful manner and on the basis of adequate knowledge.

It follows that:

a. Member's professional reports, statements or testimony before any tribunal shall be objective and accurate. They shall express an opinion only on the basis of adequate knowledge and technical competence in the area, but this shall not preclude a considered speculation based intuitively on experience and wide relevant knowledge.
b. Members shall reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect their judgement in a technical matter about which they are making a statement or giving evidence.

CLAUSE 7:

Members shall continue their professional development throughout their careers and shall actively assist and encourage those under their direction to advance their knowledge and experience.

The principle here is that members shall strive to widen their knowledge and improve their skill in order to achieve a continuing improvement of the profession. It follows therefore that members:

a. Shall maintain personal competence by keeping abreast with developments in his/her field or speciality, by doing all or some of the following: - research, further studies, reading, attending conferences, courses and lectures etc.
b. Shall encourage their professional employees and subordinates to further their education.
c. Shall take a positive interest in, and encourage their fellows to actively support, the Society and other professional organisations that further the general interests of the profession.

CLAUSE 8:

Where members are involved in preparing public reports, or portions thereof, for mining and exploration companies the member shall comply with all laws and government regulations relating to the mineral industries, and with the rules, regulations and practices as established and promulgated by the stock exchanges with respect to the official listing requirements for mining and/or other companies, within the country in which one is working.

It follows that members:

a. Shall inform themselves of the laws and regulations relating to the mineral industries in South Africa and in other countries where they may be engaged as an employee or consultant.
b. Shall observe the requirements of stock exchanges in respect to reports on mineral exploration and

assessment issued by listed companies. In the particular case of the Johannesburg Stock Exchange they shall meet the requirement of a "Competent Person".

CLAUSE 9:

Members shall comply with all relevant laws and regulations of any country in that they work, including laws, regulations, policies and practices regarding intellectual property.

It follows that members:

a. Shall inform themselves of the relevant laws, conventions and regulations in South Africa and in other countries where they may be engaged as an employee or consultant.
b. Shall observe the relevant laws, conventions and regulations relating to Intellectual Property with respect to commercial, consulting and academic intellectual property. For example, ownership of a report prepared for a company normally would remain with the company and not the author.

Enforcement of the Code of Ethics

Without a robust and enforceable Complaints and Disciplinary process, any Code of Ethics or Conduct or Geoethics Statement remains purely aspirational.

"It is a well-established feature of the human condition that too many of our species will act corruptly if they think they can get away with it"

(Paul Hoffman, Sunday Times, 14 Jan 2018).

The next article in this series will examine the Complaints and Disciplinary process that is binding upon the GSSA membership in the application of the Code of Ethics.

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Tania R Marshall (VP Professional Affairs)

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- *strives for improved SET education in South Africa*
- *inspires participation by the youth, and*
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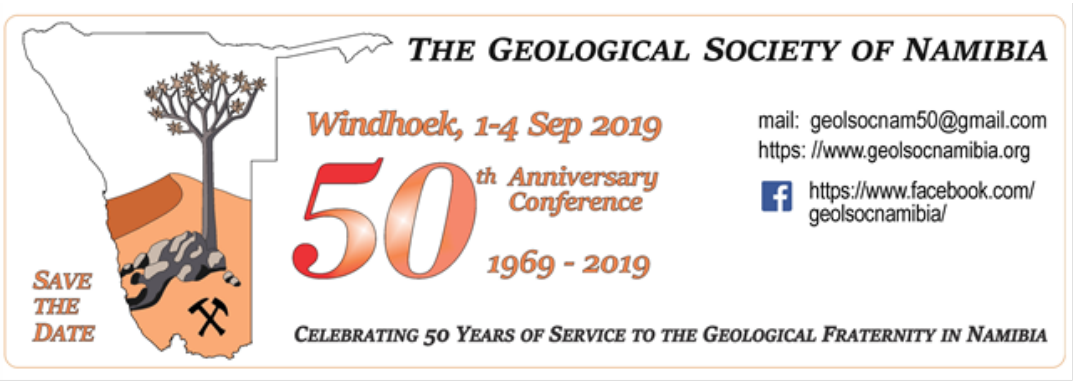

Circular #03 : Excursion Update

As an update to the excursion list from Circular #2 please find below brief descriptions and pricing of the available excursion options. This will be followed up shortly with a link to the full itineraries for each excursion.

Excursions #1, #2 and #3 are pre-conference trips.
Excursions #4, #5, #6 and #7 are post-conference trips.

RE EXCURSION Payments:
Prices are given in Namibian dollars (N$ or NAD).
All banking and transaction fees to be covered by participant.

PLEASE NOTE that all EXCURSION payments are due to AfricaMosaicSafaris (contact Ms Almut Talmage at almut@africamosaicsafaris.com).

Bank:	First National Bank of Namibia	**Swift Code:**	FIRNNANX
Branch code:	289 375	**Branch name:**	Grove Mall Windhoek
Account number:	6226 7392 612	**Acc. Type:**	Cheque/current
Account name/ Beneficiary:	Africa Mosaic Safaris		
Payment reference:	SURNAME and INITIALS, followed by ''Geol50'' and Excursion ''#''		

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1. Mines and Exploration Tour Western Namibia

29th August to 1st September - 4 days- Lodging

N$ 9,450

Leader – Berti Roesener

This excursion will visit mining and exploration projects within the central and western portions of the Damara Orogenic Belt. Visits are planned to Navachab gold mine, the Calcrete hosted, Trekkopje Uranium mine (on care and maintenance) and the Alaskite hosted Uranium mines at Rossing Uranium and Husab Mine. There will also be a surface visit to the Namib Lead and Zinc Mine 25 km east of Swakopmund and Osina Resources have offered a field visit and core viewing from some of their gold prospects in the Wilhelmstal and Omaruru area of central Namibia.

Pit visits will be arranged where possible.

2. Geology and Stratigraphy of Southern Namibia

28th August to 1st September - 5 days – Lodging

N$ 10,600

Leaders – Dr. Ingrid Stengel, Helke Mocke

This excursion will visit the Karoo and Nama stratigraphy and fossils as well as geomorphology of southern Namibia. The first day is dedicated to details of the Dwyka tillites, glacial striations, Karoo stratigraphy and volcanics, fish and *Mesosaurus* fossils. The following days will focus on the Nama Group stratigraphy. Highlights will be the Ediacaran fossil record at farms Aar and Swartpunt, Black Limestone stromatolites and karst, the nature of the Nama base unconformity, and the overall extensional tectonics, as well as prehistoric sites on the Black Limestone (rock engravings and paintings).

The first overnight stop will be in Karoo country (Keetmanshoop), the following three nights will be in Aus. The return route will take us along the Rooirand/ Namib margin and Schwarzrand escparment, back to Windhoek.

3. Diamond Excursion (fluvial and marine diamonds, Sperrgebiet/ Namdeb Mines)

25th August to 1st September - 8 days – Lodging and Camping (bring own sleeping bag) –
Limited to 12 Participants

N$ 20,425

Leaders – Gottfried Grobbelaar, Dr. John Ward, Dr. Roger Swart

Since the initial discovery of diamonds in 1908 near Lüderitz, this regional composite placer deposit has yielded over 100 million carats of +95% gem quality stones. Most of this diamond production has been recovered from a variety of placer types that range in age from contemporary deposits to those that are some 42 million years old. Diamond Area No.1 hosts four major placer types, fluvial placers (Orange River licence), marine placers (Mining Area No.1/SCM, Bogenfels and Douglas Bay licences) deflation and aeolian placers (Bogenfels, Elizabeth Bay and Douglas Bay licences).

This excursion, which offers a very rare opportunity to travel through the relatively pristine coastal desert environment of the Sperrgebiet, will cover all four of the major placer types starting on the Orange River and the marine operations around Oranjemund, then working north through the Sperrgebiet, stopping at Bogenfels (own sleeping bag required) en-route to Lüderitz. The excursion ends with a visit to either E-Bay or the Douglas Bay deflation deposits.

4. Damara Orogen Special Excursion

5th September to 11th September - 7 days - Camping

N$ 18,500

Leader – Dr. Roy Miller

This excursion led by Dr. Roy Miller has been the signature field trip of the Namibian Geological Society for the past 3 decades. It will probably be the last such excursion led by Roy.

The excursion examines all aspects of the development of the NE trending arm of the Damara Orogenic Belt. As intracontinental rifting of Rodinia (± 880 Ma) evolved through spreading (± 760-635 Ma) and continental separation (635 – 600 Ma), we will see rift-phase playa-lake evaporites, rift-shoulder submergence, passive margin turbidites, the whole of the Damara stratigraphic succession, the marker horizons of the Sturtian (Chuos Fm) and Marinoan (Ghaub Fm) Snowball-Earth glacial deposits and their associated cap carbonates, and pre-tectonic metagreywackes with the MORB of the 350-km long Matchless Amphibolite (635 – 600 Ma). Syn-tectonic features (595 – 542 Ma) will include the Southern Margin nappes, thrusts and accretionary prism, 4-stage evolution of F1 folds in marble domes, D1 to D3 structures, diapiric D3 marble domes with marble mylonites, arc-trench metagreywackes, progressive shortening and sheath-fold development during collision in the Southern Zone, and contamination of Damaran granites. Late- to post-tectonic features include M2 LTHP and HTLP metamorphic assemblages (± 535 Ma), partial melting of granitic basement, Damaran metagreywackes, and of various syn-tectonic, 654 – 542 Ma Damaran granites, Nama Group shelly fossils (± 555 – 542 Ma), Nama deformation (542 Ma), the fore-arc Donkerhoek Granite (534-505 Ma), a tin pegmatite, and the gravity-induced emplacement

of the Naukluft Nappe Complex at 495Ma. Younger features of the Namibian geology will be pointed out during the excursion.

5. **North West Namibia ("Gondwana to post-Gondwana evolution of NW Namibia during the Palaeozoic and Mesozoic")**

5th September to 11th September - 7 days - Camping

N$ 16,200

Leader – Dr. Roger Swart

This excursion, in one of the most scenic parts of the country, will look at the geology, geomorphology and geological evolution of the continental margin. The stratigraphic range that will be covered will be from the Dwyka glaciation event through to the breakup of Africa and South America, an event heralded by the Cretaceous Etendeka Volcanics. In addition, what we know of the climate and subsequent erosion history will also be examined in light of the offshore geological record as well as observations from onshore.

6. **Alkali Intrusive Excursion ("Carbonatite and alkaline volcanic complexes in north-central Namibia")**

5th September to 10th September - 6 days - Lodging

N$ 15,350

Leader – Peter Siegfried

This excursion follows much of the route undertaken during the very successful HiTech AlkCarb field trip held in April of last year which was also led by Peter Siegfried. The excursion focuses on the alkali complexes of Central Namibia and Damaraland with stops planned at the **Otjizazu** Carbonatite, North of Windhoek; **Eisenberg**, part of the Kalkfeld cluster, which has been dated at 240Ma and not the Aptian age of the Damaraland Alkaline Province, suggesting that many of these spatially congregated complexes can in fact be active over many millions if not tens of millions of years; the apatite rich **Ondurokorume** Carbonatite; **Lofdal** which has undergone significant exploration in recent years for its high HREE content; the HFSE enriched **Amis Gorge**, part of the Brandberg intrusion, with the final stop being the Damara aged (521Ma) **Eureka Carbonatite**.

7. **Central and Northern Namibia Mines Tour ("Economic geology of north-central Namibia")**

5th September to 9th September - 5 days - Lodging

N$ 12,500

Leader – Eckhard Freyer, Oliver Krappmann

This five-day excursion will visit six mines in central and northern Namibia, including one day in the Etosha National Park. The 30-year old **Navachab** Gold Mine near Karibib and the five-year old **Otjikoto gold mine** halfway between Otjiwarongo and Otavi are both orogenic gold deposits, which will be interesting to see and compare. At Tsumeb we will see the **Tschudi copper mine,** well-known for its SX-EW copper cathode plant, and the open-cast of the world-famous, now closed **Tsumeb polymetallic mine**. Although the **Okanjande graphite** and **Okorusu fluorspar mines** are both under care and maintenance, it will be possible to see them.

En route we will cross the Southern, Central and Northern Zones as well as the Northern Platform of the Damara Orogen.

* * *

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all the news fit to print

STELLENBOSCH UNIVERSITY

The second quarter at Stellenbosch University has largely been business as usual, albeit with the conspicuous absences of Prof's Buick and Clemens whose respective expertise and characters have left a notable void within the department. To fill this void, a series of interviews were conducted to fill academic positions for a Metamorphic Petrology post and a Geohydrology post. Both posts have attracted incredibly high calibre applicants and we look forward to hopefully reporting the outcomes in the next issue of the Geobulletin. Aside from staffing matters, the second quarter at SU has seen some notable research successes (including the discovery of a new species from the T. Rex family) as well as another exceptional mine tour undertaken by the highly enthusiastic Hons. class of 2019. Finally, it may be pertinent to mention in brief that Stellenbosch University has agreed to host the 2020 edition of the Geocongress conference. The event will mark important anniversaries for both the GSSA and SU Department is Earth Sciences, so promises to be an event that not be missed. Initial planning is underway and all are encouraged to keep an eye open for forth-coming and important announcements.

Andile Mkandla (SU Honours) and Ismael Kangueehi (SU PhD) preparing to take the team's first soil samples in the Saldanha Bay area.

Inter-university geochemistry research partnerships

Stellenbosch University Honours students together with an M.Sc. student from University of Pretoria have initiated a joint research project investigating pollution pathways from soil to dust to water to marine sediment. This multi-facetted research project is being conducted in the ecologically-sensitive Saldanha Bay area and will also study the impact of the pollutants on the microorganisms living in the broader ecosystem. The ultimate goal of this research is to better understand the biogeochemical cycling of pollutants such that effective remediation strategies can be developed or prescribed.

A new species from the T. Rex family

Dr Ryan Tucker was intimately involved in a research project that recently published in the internationally-

Dr Ryan T Tucker exposing new fossil material in the uppermost Cedar Mountain Formation, of Central Utah

Intense discussion on methodologies for our ancillary data (SU Honours Sage Govender and Warrick Daws)

acclaimed journal Nature. His work reports the finding and identification of a new species named *Moros intredipus* which is 90 times lighter and at least 15 million years older than its more (in)famous cousin *Tyrannosaurus rex*. Dr Tucker contributed the zircon geochronology and sedimentary facies identification and reconstruction to this important study, which meaningfully adds to paleontology's understanding of North America's geological history and its apex predator's evolutionary pathways (See article on pp. 19-21).

2019 SU Honours Tour to the Northern Cape and southern Namibia

Between 12 and 24 May, twenty-two SU Honours students and their lecturer (read: part-time cat-herder) Dr Bjorn von der Heyden undertook the annual Honours mine tour to various southern African mining and geological exploration operations. This tour is a critical component of the students' Honours curriculum as it offers them important learning opportunities related to the practical aspects of the minerals industry. Much of this learning is derived from the once-in-a-lifetime experiences that were offered to our students (e.g., underground mine visits). However a perhaps more important component of the learning is derived from the direct interactions between the students and the industry-based geologists. For this, the students and SU are eternally grateful to our industry hosts for the enthusiasm and passion with which they shared their knowledge, and for the efforts and planning that our hosts undertook in order to make our tour a success.

The tour started with a big drive between Stellenbosch (in isiXhosa: idolophu lewayini (direct translation: town of wine)) and Kimberly (I guess in isiXhosa: idolophu umngxuma (town of hole)). Our first visit was to the Finsch diamond mine (Petra Diamonds), which boasts a world-class operation employing sub-level stoping mining methodologies. For many of our students, this was the first time underground and the experience provided great opportunities to observe various kimberlite facies in situ. Our second and third stops provided the student cohort with an opportunity to observe bulk open-cast mining methods, particularly employed in some of South Africa's extraordinary chemical sediment endowments e.g., Banded Iron Formations (Kolomela mine (Anglo American)) and the Kalahari Manganese Field (Mamatwan mine (South32)). A journey westwards took us into the Aggenys-Gamsberg ore district brought us to our fourth mine visit hosted by Vedanta Resources. Here the large student group split into three groups which were respectively afforded experiences of Gamsberg open-cast mining, base-metals exploration activities, and an underground visit to the Broken Hill-Deeps ore body. The final visit of the first week incorporated an

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Bogenfels Arch

educational field mapping exercise of several Sillimanite deposits near to Aggenys where we were hosted by a past class-mate now representing Van Zyl Mining.

The weekend was marked by journey across the border into southern Namibia. Along the way we stopped by the Blesberg pegmatite where Peter Hibberd gave us an excellent overview of zoned pegmatites. During our journey, we were also able to appreciate the beauty and geology of the Richtersveld and the Fish River canyon. Week 2 began with a visit to the exploration project and historical adits of the Aukam graphite deposit (Gratomic Inc.) where a visit to the test-plant further allowed students to appreciate the interplay between the disciplines of geology and minerals beneficiation. Our seventh operation visit was conducted at Rosh Pinah (Trevali Mining) where an exciting full-day program comprised an underground visit, an overview of the core-yard, and a site visit to a gossanous exploration target. Finally, we ended our tour with a fantastic two day tour of the Orange River diamond placer deposits during which time we were thoroughly spoilt by Namdeb Diamond Corporation. Day one revealed the different fluvial placer settings (pot-holes, gravel bars, etc.) and on Day 2 we were afforded the unique experience of visiting the restricted areas north of Oranjemund to understand the effects of sea-level fluctuations and wind action (deflation terraces) on diamond distribution in this important mineral field. The tour was capped by the unbelievable experience of staying over at the ghost town of Bogenfels, where the prominent Bogenfels Arch is a memorable site to behold.

Bjorn Von der Heyden

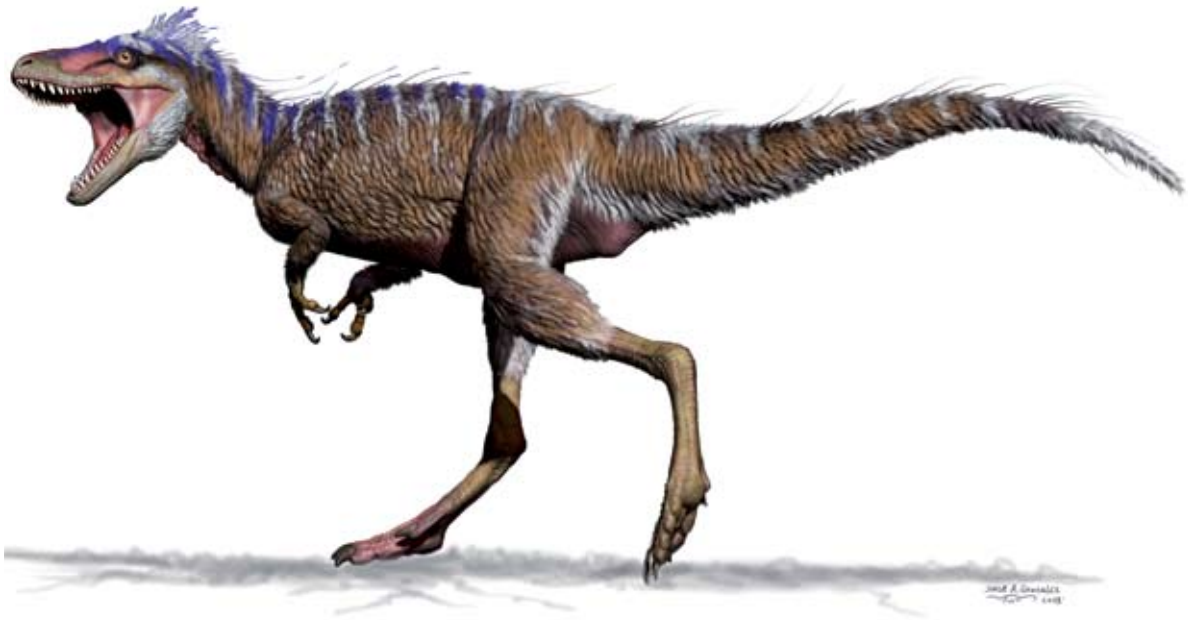
the harbinger of doom

Tyrannosaurus rex ("Tyrant Lizard King") is a well-known Tyrannosaurid, first discovered in the Late Cretaceous Lance Formation of North Eastern Wyoming by famed paleontologist Barnum Brown in 1905. Since then, Tyrannosaurus rex has become infamous, as one of Earth's most ferocious predator, with an average body-length of 12 meters long, approximately 6 m tall at the hip, with massive jaws that could produce up to 5.8 tons of bite-force (modern saltwater crocodile is around 3,700). However, this world-famous predator reigned for only a short period, spanning roughly three (3) million years, during the end of the cretaceous period (68.0 – 66.5 Ma). Early on in their evolutionary history, tyrannosaurs hunted in the shadows of archaic lineages, such as allosaurs that were already established at the top of the food chain, yet this period of evolution in North American biomes remains enigmatic. During the mid-Cretaceous, the continent of America was split into three large islands to the north, the east and the west. The western island, known as Laramida, teamed with a diverse range of dinosaurs, that had begun a separate evolutionary journey due to geological and geographic barriers. Their extinction came about during the Cretaceous-Tertiary mass extinction 65 million years ago. While the first evidence of the North American tyrannosaurs lies within the Jurassic, roughly 150 million years ago, little is known until the occurrence of large-bodied Tyrannosaurids no older then 80 million years ago.

Researchers struck gold in 2013, when Lindsay E. Zanno stumbled across fossilized remains of a partial leg jutting out of Utah's mid-Cretaceous Cedar Mountain formation. This partial right hind leg belonged to a subadult individual, which included portions of the femur, tibia, fourth and second metatarsals and phalanges of the fourth digits. These skeletal remains were complemented with tyrannosaurid premaxillary teeth. Zanno then led a team of researchers and scientists, including Dr. Ryan Tucker from Stellenbosch University, to unravel the mystery of the origin of the *T.Rex* lineage.

Dr. Lindsay Zanno, Dr Ryan T Tucker, Haviv M. Avrahami and Aaron Giterman

Moros
Credit Jorge Gonzalez



Cue *Moros intredipus*, an approximately 78-kilogram new taxon member of the Tyrannosauroidea, ninety times lighter than the famous *T.rex*, dated to around 96 million years ago. Moros, (Greek) the embodiment of impending doom, and *Intrepidus*, (Latin) for intrepid, (in reference to the hypothesized intracontinental dispersal of tyrannosaurs during this interval.) *M. Intrepidus* represents the oldest Cretaceous tyrannosauroid skeleton found in the region, pushing the date record back by 15 million years, and is believed to be closely related to the tyrannosaurid taxa living in Asia during the mid-Cretaceous. The size of the dinosaur meant that it was light weight, exceptionally fast, and reached skeletal maturity at 6 – 7 years. This meant they could take advantage of new opportunities when warming temperatures, raising sea levels, and shrinking ranges restructured the ecosystems at the beginning of the Late Cretaceous.

M. Intrepidus was found within the lower portion of the Mussentuchit member of the Upper Cedar Mountain Formation, Emery County, Utah, USA. The Cedar Mountain formation was deposited within a distal backbulge to eventual forebulge of the Sevier fold-thrust

Sunrise along the J (Morrison Fm.)-K (Cedar Mountain Formation) unconformity exposed in the Last Chance Desert, Central Utah, USA

belt, belonging to a portion of the Western Interior Basin (a long-lived retroarc foreland basin). The skeletal remains, along with co-occurring detrital zircons (120 in total), were recovered from volcanilithic-rich, intercalated silty mudstones to muddy siltstones. Site-specific facies analysis and reconstruction indicates that sediments and fossil materials were emplaced along a coastal mudflat, with the average youngest maximum depositional age at 96.4 Ma.

This exciting find is helping paleontologists better understand the evolution of North America's Tyrannosaurs in the context of changing environmental conditions. It constrains the timescale of development and provides crucial insights into the evolutionary drivers responsible for transforming *M. Intrepidus* into the towering, apex predator *T-Rex*.

The scientific paper: *"Diminutive fleet-footed tyrannosauroid narrows the 70-million-year gap in the North American fossil record"* by Lindsay E. Zanno, Ryan T. Tucker, Aurore Canoville, Haviv M. Avrahami, Terry A. Gates and Peter J. Makovicky published in Nature Communications, Biology.

Schultz, T.G., and **Tucker, R.T.,**

machine learning

Machine Learning in Geology

In recent years there has been increasing interest in machine learning, or deep learning as it is also known, in particularly the exploration geology community. Due to the large volume of complex information, it has becoming increasingly challenging to understand if and where this tool fits into consultation businesses or mining operations. Machine Learning (ML) has been around since the 1980's, but the commercial use has only gained traction in the last four years due to affordable, high performing Graphical Processing Units (GPUs), and easy access to cloud compute allows for the capability of complex computations that are fast and cheap enough for anyone outside of a research organisation to utilise. ML has also become one of the main topics when discussing the fourth industrial revolution. Concerns have however also been expressed that this will contribute to even further job losses in the mining sector due to the shift towards automation and mechanisation.

The question remains, is there substance to the hype? According to the Gartner Hype Cycle, Machine Learning is still in the 'Peak of Inflated Expectations'. It's currently on the downward trend heading towards to the 'Trough of Disillusionment' and is not expected to reach the 'Plateau of Productivity' for another two to five years. It should also be noted that ML is not the same as Artificial Intelligence (AI), as ML is only focussed on data processing technique that solves a specific problem for an AI or human. AI is a combination of different techniques, including ML, to solve complex/multifaceted problems that only humans can do today. The main considerations when undertaking an ML-based geological project is: consider the data you have available and if it is the right type, representativeness or quality to be able to solve the problem. For example, poor quality and blurry core tray photos will be useless for any image classification and consequently it would be a waste of time. The old saying, garbage in, garbage out holds true for ML. Cognisance should also be taken to select the correct method, as some techniques are only suitable for particular types of data.

Tabled data is referred to as 'structured data' in this type of application. The most common geoscience examples would be core logs, multi element assays and other geochemistry results from assays, grab samples and stockpile samples captured in the form of excel spreadsheets or in SQL database platforms. Other types of applicable geological data include

LIDAR point clouds, hyperspectral images and seismic sections to name a few. Challenges that commonly face ML database development are mainly related to source and format. Data used tend to be at multiple resolutions of space and time, with varying degrees of noise, incompleteness, and uncertainties. The process is also based on a number of assumptions, such as variables are independent and identically distributed. A prime example is in the field of structural geophysics, where variables are structurally related to each other in the context of space and time, unless there is a discontinuity, such as a fault, across which autocorrelation ceases to persist. Cognizance of the spatio-temporal autocorrelation in geoscience data collected in continuous media is crucial for the effective modelling of geophysical phenomena.

Machine learning also has the ability to link, combine and process different types of data together making it easier to synthesise a holistic interpretation. A simple application of ML can be done by importing photos of a core tray or a face in mining. The ML will then attempt to crop out core from a tray, or reading core blocks. In the case of the face phote, ML will attempt domaining ore versus waste zones. In a supervised learning approach the operator will instruct the ML model what the most likely solution is using training and validation datasets. The operator can assess the accuracy of the solution to improve the model in a variety of ways to increase the prediction accuracy. A simple improvement may involve examining the labelled data for any mistakes and changing the label. The main challenge with supervised learning is small sample size initially and a lack of established standards being applied.

There are two main approaches, the first is Simple Neural Networks and the second is Deep Learning Networks. A simple way to explain the difference is that the Simple Neural Network approach will entail trying to do many different computations simultaneously. The Deep Learning Network on the other hand break up the computations into separate steps with each layer learning something different based on the output of the previous layer. This hierarchy of representations seems to enable Deep Learning to predict better on new data than the Simple Neural Network.

Another approach is utilising 'Deep Fakes' utilising a two network system. The Generator tries to fool another network, the Discriminator. The Discriminator penalises the Generator for obviously fake information and so the Generator "learns" to produce better and better fake information in each cycle. This application is currently being developed extensively by the oil and gas industry to evaluate seismic sections and velocity models.

Other industry applications currently in development deal with:

- Classify various characteristics using spatial data obtained via GIS systems.
- The use of Neural Networks/SVM in analyzing temporal signals like those of seismometers to predict phenomenon such as earthquakes and Tsunamis.
- Applications for landslide prediction using seismic data.
- Several Machine Learning algorithms such as decision trees and Neural Networks have worked well in Mineral Exploration using remote sensing data.
- Subsurface characterization using various acoustic signals also use some forms of Machine Learning for specific problems which involve detecting types of minerals, various types of folds and fracturing.

Case Study

Unlike highly visible mineralisation, such as massive, semi-massive and disseminated mineralisation (e.g. base metal mineralisation), trace mineralisation is harder to develop a ML process. A project was undertaken by Cate et al., (2017) to identify gold mineralisation in core utilising geophysical results. Gold distribution is not homogeneous in drill core, and it is subject to a high local variability (nugget effect), which makes ore bodies modelling difficult. The presence of gold in rocks is usually associated with specific rock formations (e.g., banded iron formation or intrusive rocks), alteration, and the presence of veins, information on rock composition is critical to the prediction of gold mineralization.

The input data was derived from neutron activation and natural gamma measurements. The team used a

hand-held XRF to measure the variability of the major elements. Six machine learning algorithms were used to predict the presence of mineralization. Results indicated that the integration of a set of rock physical properties measured at closely spaced intervals along the drill core with ensemble machine learning algorithms allows the detection of gold-bearing intervals with an adequate rate of success. The use of this type of tool in the future will help geologists in selecting sound intervals for assay sampling, which in turn could potentially increase the reserve and in modelling more continuous ore bodies during the entire life of a mine. Along with predicting the presence of metals in rocks, physical properties combined with machine learning have the potential to classify lithologies, characterize hydrothermal alteration, and estimate exploration vectors and geotechnical information in the drill core. The success rate of predictions will increase as increasing amounts of data are collected. This method should be applied from the very beginning of the exploration stage (i.e., starting from the discovery hole) so that the initial model can be trained and continuously updated with new drill holes.

Reference

Caté, A., Perozzi, L., Gloaguen, E., and Blouin M. (2017). Machine learning as a tool for geologists. The Leading Edge, Special Section: Data analytics and machine learning p. 64 – 68.

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geoheritage

Geoheritage – Elandsputte

First Diamond Discovery of the Lichtenburg (Transvaal) Diamond Fields

In December 1924 the postmaster of Lichtenberg, John Voorendyk, discovered a 3 carat diamond on his farm, Elandsputte, while digging a hole for a cattle dip. He contacted Dr Harger the state geologist and prospector, but Harger was not impressed and while visiting the farm in 1925 concluded that the land was not diamond bearing and that Voorendyk's find "must have been carried and dropped there by a bird".

Shortly after this Harger however learnt of another diamond find at a farm next to Lichtenburg and went prospecting there. He concluded these were diamond-bearing gravels and the first official proclamation of a digging in the Lichtenburg area was issued. Honingklip, a farm north of Elandsputte, was Harger's next prospecting target, however, he got lost and unknowingly prospected on Elandsputte. He found a 6 carat diamond and set up camp. He started prospecting at the "donkiegat", the site where a donkey had been

Elandsputte cattledip postcard

buried and which later became a famous landmark on the diggings. Harger's first wash delivered 21 diamonds, the next 36. The farm was proclaimed in February 1926 and triggered Lichtenburg's first big diamond rush with thousands of diggers taking part.

Further prospecting in the region proved successful and by the end of 1927 there had been 45 more proclamations on 8 farms. The diggings had become vast, covering an area 36 km long and 1.6 km wide. After the proclamation of Elandsputte, followed Treasure Trove, Ruigtelaagte, Witklip and Klipkuil by the end of 1927. Diggers came from all over South Africa and from as far afield as Australia and Europe, some were

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experienced diggers but most were adventurers hoping to strike it lucky.

Between 1926 and 1929 Lichtenburg was the richest public diggings in the world, boasting the biggest gathering of diamond diggers in history. Within a year or two of the first proclamations a city of tin shacks had sprung up around Lichtenburg housing approximately 150,000 people. It was a "temporary city", the only one of its kind in the world even having its own street names such as Eloff, President and Prichardt all of which had been taken from Johannesburg in remembrance of the early days of the Rand gold rush. The main part of this resultant shanty town was known as "Bakers" or later "Bakerville" after the land owner Albert Baker. In the business centre was upwards of 250 diamond buyers' offices, each with their own flag and basic restaurants and as many as 60 cafes, shops, barbers, butcheries and other businesses plus bioscopes and even a merry-go-round.

It was the unbelievably vast amounts of diamonds found just beneath the top soil in the gravel runs that made the Lichtenburg diggings so extraordinary. In one specific week £75,000 worth of diamonds were found on the Treasure Trove proclamation alone. On the 4th of March 1927 the Grasfontein diggings were proclaimed. Here the biggest diamond rush in world history took place with 25,000 runners partaking in the staking out of the claims. Grasfontein yielded more than 2 million carats of diamonds. Between1926 and 1945 the combined Lichtenburg diggings produced over 7 million carats of alluvial diamonds. At the height of the area's productivity in 1927 the diggings delivered 79% of Transvaal's alluvial diamond production, which in turn accounted for nearly 95% of the country's entire production for that year.

However, from 1928 onwards the prosperity of the Lichtenburg diamond grounds reduced significantly. The surface gravel runs started to become worked out, the price of diamonds fell with the onset of the Great Depression, credit sources dried up and labour became prohibitively expensive.

National Heritage Site

Today the areas has but remnants of its once cosmopolitan "diamond city" and only a handful of die-hards are still digging and reprocessing the gravel heaps for small diamonds. In 1980, John Voorendy's original cattle dip on Elandsputte was declared a National Monument. The site can be reached by traveling 25 km north on the Zeerust road outside of Lichtenburg. For the more adventures geo-traveller, turning into the Bakerville village and asking for directions from the locals will lead to sites such as the famous Malan's pothole that is accessible. Other famous potholes can be visited by requesting

Grasfontein diamond diggins 1927 postcard.

Malans Pothole today.

permission from the current landowners or mine operators. The Digging Museum in Lichtenburg is worth a visit.

Lichtenburg is in the centre of the maize triangle and host a small agricultural museum as you enter the town with a large tractor collection. Next to the municipal offices there is a number of monuments, the most impressive being a twice life-size statue of General Koos de la Rey, (also known as "die Leeu van die Wes-Transvaal" during the Tweede Vryheids Oorlog). The town is also home to the Willem Allendale art museum, with works from various famous South African artists. Other geological sites worth a visit is the Burning Vlei, a peat deposit that smouldered for decades, but has stopped since the establishment of the dams, but flares up in dry years. The Wondergat sinkhole is located 40 km north of Lichtenburg.

Geological Setting

In the Lichtenburg alluvial diamond fields the gravels overlie dolomites of the Transvaal Supergroup. The gravels occurrence runs, representing anancient braided drainage system running east to west and covering an extensive floodplain. The runs now form a positive topographic expression. This is due to the hard gravels protecting the underlying strata from being eroded whilst the rest of the floodplain is denuded.

Large dolomitic palaeo-karst sinkholes or potholes are often present either within or outside of the runs. These potholes are formed by dissolution in areas of increased groundwater flow, usually in areas of structural weaknesses or faulting. The potholes were either formed during or post the run deposition and contain gravels. The gravel within the potholes exhibits steep dips, and even overturning in places, indicating that solution subsidence was active both during and after deposition of the gravel. The pothole fill is normally a complex mixture of its own alluvial fill, together with collapsed material from the adjacent deposits. The diamond grades recorded in the potholes are therefore dependent not only on the morphology of the pothole, but also to a great extent on where it is situated relative to the run.

There are three distinct gravel types:

a. "Rooikoppie" gravel: chemically mature one to two metre thick, unsorted lateritized colluvial gravel unit, situated on hillcrests and the upper sections of hill slopes;
b. "Terrace-type" gravels: one to four metres thick occurring on the lower slopes of the present drainage valleys; and
c. "Spruit type" gravels: texturally and compositionally similar to the terrace-type gravels and occur in the current river valley floors.

/Continued on pp 28


JORGE A. GONZALEZ
2018

No primary sources for the diamonds in any of these alluvial fields have been identified. The prevailing hypothesis of the deposition of the alluvial diamonds in the Lichtenburg–Delareyville–Bloemhof–Klerksdorp–Lichtenburg (LDBKL) field is related to post-glacial deposition. Diamond-bearing material was transported by ice sheets and glaciers during Dwyka Group deposition event and may have concentrated along eskers and/or drumlins and/or as a thin sheet of moraine on the Chuniespoort Group dolomite.

The directions of movement of the glaciers and preferred orientations of the eskers and possibly drumlins suggest that the 1 180 Ma, 32 hectare Cullinan kimberlite pipe may have been a major source of alluvial diamonds in the North West Province. Relatively thicker deposits of moraine and end-moraine were deposited by fluvio-glacial streams and during the melting of ice sheets in the areas predominantly underlain by the Ventersdorp Supergroup lava

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obituary

Marian Tredoux †

Marian Tredoux (1952-2019)

Marian was born on September 20th 1952 and was brought up on the slopes of the Tygerberg Hills in the northern suburbs of Cape Town. She attended D.F. Malan High School in Bellville and then studied at the University of Stellenbosch, where she graduated with a B.Sc. degree Geology, Geochemistry and Chemistry in 1974. Following her studies, she was employed as an analyst at the JCI Minerals Processing Laboratory in Germiston. She decided to further her studies two years later, completing an Honours degree in Geochemistry at the University of Cape Town in 1977.

Marian spent the next 12 years as a research officer at the Schonland Research Centre at the University of the Witwatersrand, where she established herself as an expert in Platinum Group Elements and their analytical determination. This period produced papers on analytical chemistry, PGE abundances in the Bushveld, PGE 'clusters', meteorites, Barberton, Vredefort, and the Bon Accord Ni-rich 'body'. The last named was a lifelong interest of Marian, and this culminated in a new mineral ($NiSb_2O_6$) belonging to the Byströmite Group being named tredouxite in her honour in 2017. Her years of research at the Schonland Research Centre culminated in the award of a PhD by the University of the Witwatersrand in 1990, with a thesis entitled "The platinum-group elements: Nuclear methods for their analyses and their behaviour in terrestrial rocks and meteorites".

Marian moved from Wits to UCT and joined the then Department of Mineralogy and Geology in 1989. Her teaching responsibilities mainly involved trying to improve the success rate of an increasingly large cohort of underprepared students, which she looked after with great dedication. She was responsible for a programme called 'Geoteach', which involved getting school children and teachers interested in geology. She also took a full part in mainstream teaching and research, including the honours supervision of current UCT academic staff member, Petrus le Roux. Marian viewed mentorship of students and younger staff as

being extremely important. For all her 15 years at UCT, she was the only female academic staff member. Improving the gender balance was close to her heart but her strong views were always put across without malice, and she was a well-loved colleague. She had a long list of collaborators and took special pleasure in her 6 months sabbatical spent at Caltech. She was promoted to Senior Lecturer in 1993. One of the last items in her staff file at UCT is her letter of resignation written in 2005, before her move to the Department of Geology at UFS. It was clearly a difficult decision, but it seems to have worked out very well. Marian never lost contact with former colleagues at UCT, and she always told them how much she enjoyed being at UFS.

Marian was appointed Associate Professor in Geochemistry at UFS in 2006. There she continued her outreach activities aimed at school children and teachers under the EarthWISE initiative. She was an avid believer in making science accessible to the general public, and became a well-known voice to many Afrikaans-speaking people through her regular appearances on the radio program "Hoe verklaar jy dit?", that was broadcast on Radio Sonder Grense (RSG). She also contributed to a monthly column in the Afrikaans newspaper, Die Burger, entitled "Die wetenskap vandag".

Marian was instrumental in establishing a chapter of the Inkaba ye Africa (followed by Iphakade) research program at the UFS. Through this program, approximately 150 postgraduate students at the UFS received bursaries to complete their studies successfully. This program, which has been continuously running since 2009, will serve as a constant reminder and legacy of Marian's unselfish dedication to students and their scientific endeavours.

Over the course of her career, Marian supervised the research of numerous postgraduate students, including three doctoral graduates, one graduating from UCT and two from UFS. She successfully led nine MSc students (and many more honours students) to graduation over the course of her association with the UFS.

Marian was a member of numerous learned societies including the Geochemical Society, the Geological Society of Africa, the Geological Society of South Africa (where she was elected a fellow in 2008), the Royal Society of South Africa, the Association of Geologists for International Development and the Mineralogical Society of South Africa. She was also a member of the "Friends of the Boyden Astronomical Observatory", where she served on the executive committee for several years.

Marian relished the opportunity to expand her horizons through the attendance of conferences, workshops and research visits. Her last trip overseas (in May-June 2018) saw her presenting a workshop on the Economic Mineral Deposits of South Africa at Sapienza University in Rome, and attending a workshop in celebration of the naming of 3 new minerals at the Eugen F. Stumpfl Electron Microprobe Laboratory at the University of Leoben, Austria. The last local conference that she attended was the 13th International Platinum Symposium in Polokwane (in June-July 2018).

Marian was a very popular and visible member of the South African Geological community, and both UCT and UFS are proud to claim her as 'one of ours'. She was interested in ballet and was an avid attendant of classical music concerts. She also loved watching cricket. She was a polyglot, being fluent in English and Afrikaans and having a working knowledge of German, Dutch, Flemish and French.

Her later years involved a number of health problems relating to a weakened heart. This she managed in her typical no-nonsense style and once when asked how she was doing, responded that she needed a heart transplant but was certainly not going to have one. The writing was, therefore, on the wall, and at the January IMSG meeting where Marian was due to speak, the meeting was informed that she was in ICU and unable to attend. In a message she apologized for her absence and sent everybody her love. She died a week later, on 19 January 2019.

At the time of her death, she was still actively supervising postgraduate students and mentoring younger staff at UFS, she still wanted to visit her beloved Bon Accord body in the Barberton Mountainland to pass on her knowledge on this enigmatic body to younger colleagues, she was leading the establishment of a Re-Os isotopic sample preparation facility at UFS and

☞

Grant Cawthorn, Marian, Giorgio Garuti and Federica Zaccarini at the last conference attended by Marian, the 13th International Platinum Symposium in Polokwane (June-July 2018). (Photo supplied by Grant Cawthorn)

she was involved in the establishment of a national repository for the housing and curation of South African meteorites.

Our deepest sympathy goes to her family. The South African geological community and many outside of South Africa will also miss her greatly. We are consoled by the fact that as the final curtain was drawn on her exceptional life, she could say, without hesitation "I did it my way".

Chris Harris
Department of Geological Sciences
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obituary

Jackson (Jay) M. Barton Jr, 1945-2019

Jackson (Jay) M. Barton Jr, 1945-2019 †

Jackson M. Barton Jr, born in Midland, Texas, grew up in Omaha, Nebraska where his father was a highly successful petroleum geologist. He studied geology at Yale University and completed a PhD at McGill University in Montreal, Canada, where he met his wife Erika, who is also a geologist. We first met during his Postdoc years at the University of Massachusetts in 1975, in their flat decorated with geological maps of the Grenville Front and similar geologically exciting areas. It was not long after this that Jay and Erika moved to Johannesburg to join the group of researchers working with Hugh Allsopp at the Bernard Price Institute of Geophysical Research. In those days of leaded petrol and before the advent of SHRIMP, the methodology still widely used for old rock units was the rubidium-strontium whole-rock isochron analysis which had been pioneered by Hugh Allsopp in 1961 and was accessible to labs that did not have the ultraclean facilities required for zircon dating. Jay put that method to good use and combined it with whole-rock lead isotope isochron dating. In this, he was in good company, as Steve Moorbath and his group in Oxford, also using that approach, found the oldest (then) rocks in the world in Isua, West Greenland. Jay's main brief was to work on the Precambrian Geochronology of South Africa, with particular emphasis on the enigmatic high grade province known as the Limpopo Mobile Belt. He also became involved in Antarctic research, taking part in two field seasons from 1979 to 1981.

In the late 1970's and through the 1980's the papers flowed, establishing a framework for the chronology of the granitoid-greenstone basement of the northern Kaapvaal Craton and the southern Limpopo Belt in particular. Landmark publications were the Geological Society of South Africa Special Publication 8 (1983), "The Limpopo Belt" and Special Volume 55 (1992) of Precambrian Research ("The Archaean Limpopo Granulite Belt: Tectonics and Deep Crustal Processes"), in which Jay contributed ten chapters and six papers,

respectively. Not all of this may now, 30 years later, reflect the state of the art, but it stands as a body of work that was tremendously important in guiding later research. After having closely cooperated, from the BPI and subsequently (very briefly) at the Chamber of Mines, with the group of Chris Roering, Dirk van Reenen and Andre Smit working on the Limpopo Belt at the then Rand Afrikaans University, Jay joined the teaching Staff of that University as a Professor in March 1986. In 2004 he was part of its transformation to the University of Johannesburg, from which he retired in March 2006. He then taught at the University of Fort Hare for a further three years as adjunct Professor, before bidding Academia goodbye.

Based to a large extent on Jay's work, the Limpopo Belt became in the early 1990's internationally accepted as the oldest (late Archean) example of a Himalayan-style collisional mountain belt. At the same time, however, Jay was among the first geologists in South Africa to take seriously the growing evidence that a major orogeny occurred there much later (at ca 2000 Ma). It took some courage to participate in the deconstruction of an edifice that he had helped to build. As Rb-Sr dating lost its shine, various cooperations using other techniques were intensified and new ones started: with Rainer Klemd and Armin Zeh in Germany, and with our group in Switzerland. The 1990's were interesting times, during which Jay also took part in field work in the Aldan Shield as part of a scientific cooperation with Russia. Erika, as Principle Specialist at the dating laboratory at DeBeers Group Services, made available various dating methods which were put to good use in Jay's projects.

The Transactions of the Geological Society of South Africa became the South African Journal of Geology in 1987, and Jay and Lew Ashwal became its editors in 1999 with Jay being also the executive production editor. A voracious and fast reader with a photographic memory, he continued to provide this invaluable service to the Society until 2015, long after his retirement. A Fellow, and active member of Council of the Geological Society since 1997, he was the Society's president in the year 2004-2005. He served as its representative on the SAIMM Council from 2004 to 2007, and on the Board of the Council of Geoscience and chairman of its technical committee from 2004 to 2012. He was a

Fellow of the Geological Society of America and of the Society of Economic Geologists.

It is not possible to think of, or relate Jay's scientific life separate from the personal angle, and the Bartons' hospitality, which was legendary. During our projects from Bern in the Limpopo Belt in the 1990's, their house in Westcliff was our base (and that of our jalopy Peugeot 504 station wagon field vehicle). Groups of Russian and German visitors and co-workers were also frequently hosted by them, and I recall many evenings filled with lively conversation and discussions which usually became robust because aside from the occasional scientific issue, our political disagreement was as good as complete. But it shows that you can remain friends in spite of differences of opinion, and Jay remained a comrade in arms when it came to rocking the boat in South African geology.

Jay passed away unexpectedly on Sunday 20th January 2019 at their retirement home in northern Johannesburg. He leaves behind his wife Erika, a son Jack and 2 daughters Jesse and Samantha and a grandson François Daniel Theron Jr whom he never met but knew was on the way! Condolences go with this, also on behalf of the Geological Society. Go well, Comrade in arms.

Jan Kramers

mineral scene

Tanzanite, Merelani Hills, Arusha, Tanzania

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A gemstone has been selected for this "Mineral Scene" but not merely any old gemstone, one of Africa's premier gems and one that still remains unique to Africa, tanzanite. Tanzanite is a variety of zoisite and as such, is not officially recognized as a valid mineral species by the International Mineralogical Association, but that has not deterred the buying public, or the gemstone marketing sector from glamourizing tanzanite as one of the most desirable fancy gemstones on the market. Zoisite as a species forms prismatic crystals that display striations parallel to the length of the crystal with perfect cleavage parallel to a prism face. It is found in a variety of colours including green, violet, brown, pink, yellow, grey or colourless, but it is the blue variety, tanzanite, that is most famous, although most tanzanite gemstones seen in jewelry has been heat-treated between 400-650°C to achieve the intense blue colour the stones exhibit (Vitali-Herbert, 1994).

The original discovery of tanzanite in Tanzania has seen a litany of claims and counter-claims and arguably the most comprehensive and accurately historical referenced work of this is given by Wilson *et al.*, (2009). Suffice to say that the original discovery dates back to the late 1950s and once the name 'tanzanite' was given to the species by Tiffany's in New York in 1968, the new tanzanite gem created a sensation in the jewelry and gem trade.

Tanzanite crystal morphology is highly varied with more than 40 different crystal forms having been identified by Hurlbut (1969). Some crystals have single terminations while others display multiple terminations. Sizes of crystals are variable with many in the 1-cm range or smaller, but larger crystals are relatively common. The biggest know specimen (to-date) albeit not gem quality, is pale blue and heavily included and weighs 6.5 kg. One of the largest crystals yielding gem quality material, was mined in 2005, is 22 cm long and weighs approximately 3 kg. Other large gem-quality crystals are known to have been found since then. For example, Wilson *et al.* (2009) describe a faceted cushion-cut eye-clean 525.55 carat (5.1 X 4.5 X 2.8 cm) tanzanite that was on display in Tucson in 2009. In addition, a 754.12 carat faceted tanzanite was on display at the Munich mineral show in 2012. Tanzanite is associated with graphite, diopside, pyrite, quartz, grossular (tsavorite), dolomite and calcite, all minerals found at Merelani.

A natural (unheated) tanzanite crystal with a yellow base and blue apex, 2.5 cm. In contrast to the crystal in figure 219, this crystal has a yellow base and blue upper section.

Two faceted tanzanite gemstones (left) 7.87 ct and (right) 4.89 ct. Merelani Hills, Lelatema Mountains, Simanjiro District, Manyara Region, Tanzania. Massimo Leone faceted gems, Bruce Cairncross crystal and photo.

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Tanzanian tanzanite crystals on public display at the 2012 München Mineralientage in Germany. The crystal on the right, aptly name "Kilimanjaro" is 22 cm and weighs 11,000 ct. Marcus Budil collection, Bruce Cairncross photo.

Canadian Rocky Mountains

THE GEOTRAVELLER

By Roger N Scoon

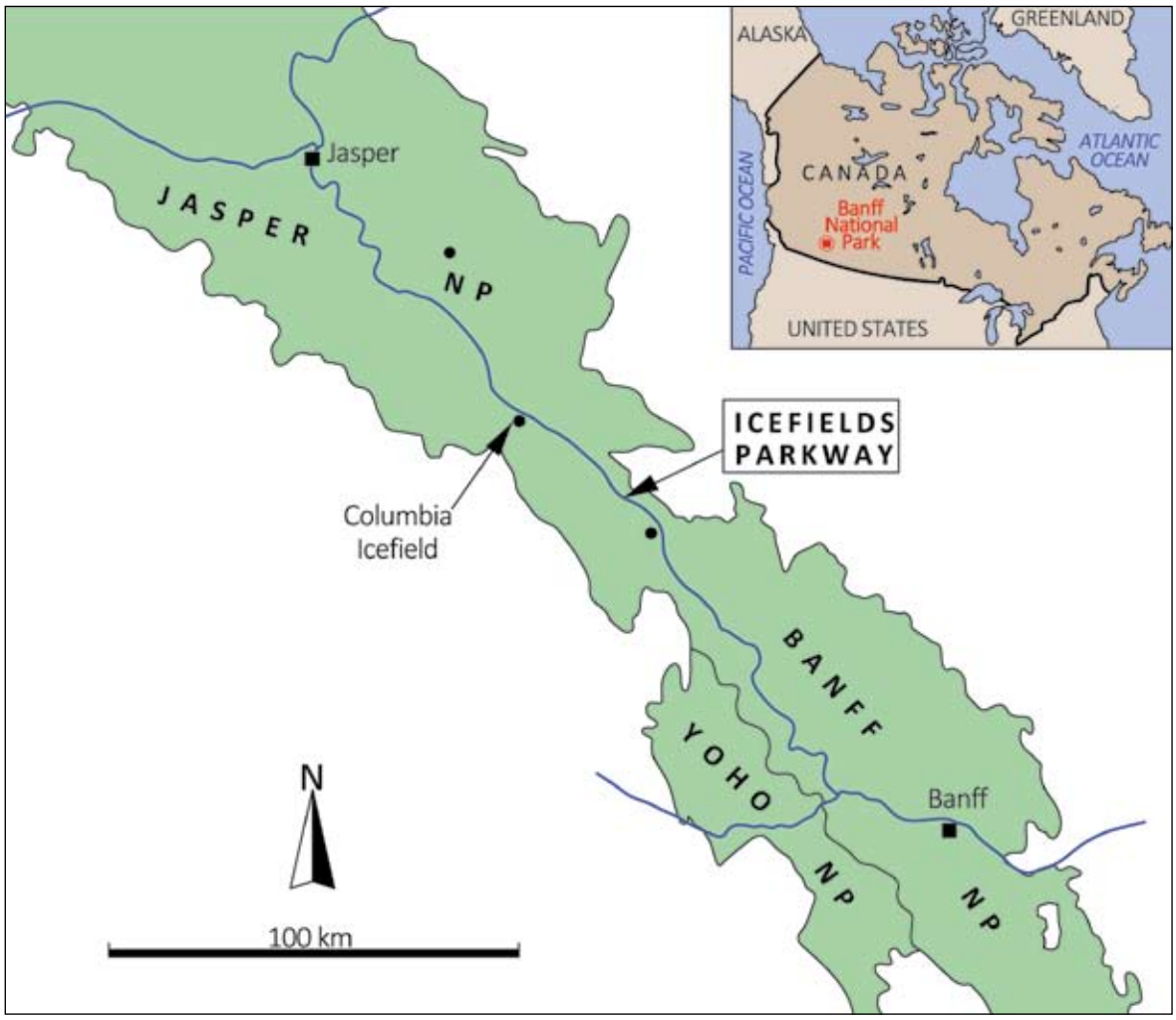
Geology of the Canadian Rocky Mountain National Parks:
Fold Mountains and Glacial Landforms

The landforms and spectacular scenery of the Canadian Rocky Mountains have been internationally known since building of the railways that crossed the continental divide. In 1886, the general manager of Canadian Pacific Rail was quoted as saying "if we can't export the scenery, we'll import the tourists". The Banff, Jasper and Yoho National Parks now attract millions of tourists annually. Banff and Jasper are located east of the divide in the province of Alberta and Yoho is situated on the western slopes of the Rockies in British Columbia. The parks include snow-capped peaks, summit icefields, slope glaciers, fast-flowing rivers, waterfalls, and mountain lakes. The two highest peaks are Mount Robson (3,954 m) and Mount Columbia (3,747 m).

The contorted strata and thrust belts for which the Canadian Rockies are well known attest to the tectonic activity associated with Fold Mountains. A highlight is the opportunity to examine the marine fossils of the Burgess Shales (discovered by surveyors during building of the railways), a national heritage site associated with the Cambrian explosion of life. Other sites of interest include the Columbia Icefield, waterfalls of the Athabasca River, and the picture book scenery of high altitude lakes such as Maligne Lake and Lake Louise.

The completion of the Canadian Pacific Rail linking eastern and western Canada was a remarkable feat of engineering. The distance of 4,655 km from Montreal to the west coast of British Columbia (the first journey took 139 hours) involved long tunnels and use of switchbacks in the Rocky Mountains. Large areas of wilderness had to be surveyed and the role of Major Albert Bowman Rogers in discovering a 1,300 m-high pass through the Selkirk

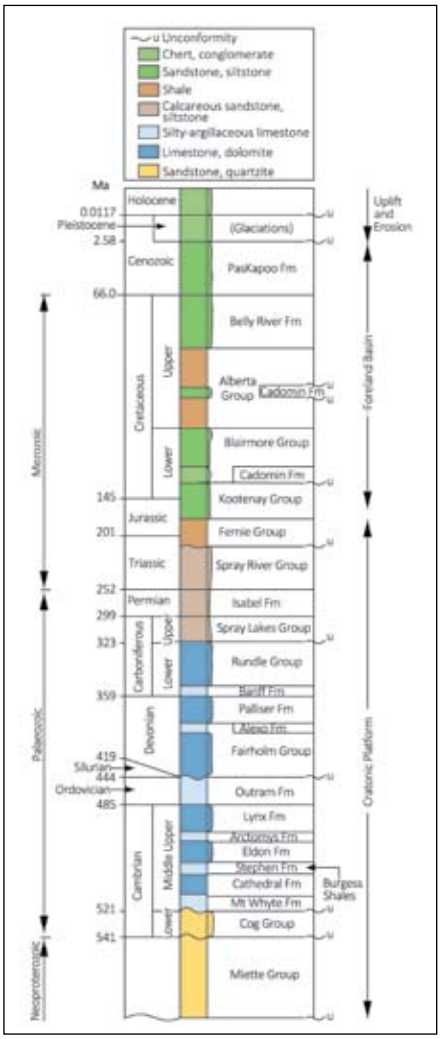
The Icefields Parkway looking south from the "Skywalk", Jasper National Park. The U-shaped valley of the North Saskatchewan River reveals ice-scoured cliffs with stratified Palaeozoic strata.



The Banff, Jasper and Yoho National Parks are accessed by either the Trans Canada Highway (Banff-Yoho) or the Icefields Parkway (Banff-Jasper).

Mountains was crucial. This southeast trending arc of peaks extends for 320 km in the western Rockies. The area is now accessed by major highways which make use of routes pioneered by the railways. The Banff and Yoho parks are situated on the Trans Canada Highway. Banff and Jasper are linked by the Icefields Parkway, a scenic route which passes close to the foot of glaciers fed by the Columbia Icefield.

The Rockies are a discontinuous series of fold-and-thrust belts, or cordilleras, that stretch from British Columbia (Canada) southward into the USA. The Canadian Rockies extend northward to 60°N latitude. Each area and each range has distinctive geological features and the Canadian Rockies differ from ranges farther south as they are dominated by metasedimentary rocks, rather than gneiss and granite. The Canadian cordillera comprises a north-south aligned tectonic zone, in part arcuate, and with a width of less than 100 km. The cordillera is flanked to the west by the Omineca tectonic belt, an uplifted and eroded volcanic terrain with granitic plutons and high-grade metamorphics. The eastern side is comprised of the Foothills terrane, the western extent of the interior plains. In the Early Cretaceous, the Canadian cordillera constituted a microcontinent known as "Cordilleria", located 1,500 km south of its present position (Chamberlain and Lambert, 1985). In the Middle Jurassic, Cordillera collided with the craton to form the earliest component of the fold-and-thrust belt, the western part of the Rockies (Engebretson and Gordon, 1985). The eastern portion of the Cordillera is comprised of overlapping thrust sheets and detached folds that formed between the Middle Jurassic-Early Eocene (Evenchick et al., 2007). Radiometric ages based on major thrusts reveal the eastward propagation of the Rockies (Pana and Van der Pluijm, 2015). In the Main Ranges, the Pyramid Thrust (163.0 Ma), and Simpson Pass Trust (161.7 Ma) – both of which are exposed close to the Icefields Parkway – are related to an early stage of deformation during the Middle Jurassic. Thrusts in the Front Ranges on the eastern side of the cordillera are younger. The latter encompass a range of ages, between approximately 75 Ma (e.g., the Sulfur Mountain Thrust) and 52 Ma. This later period of

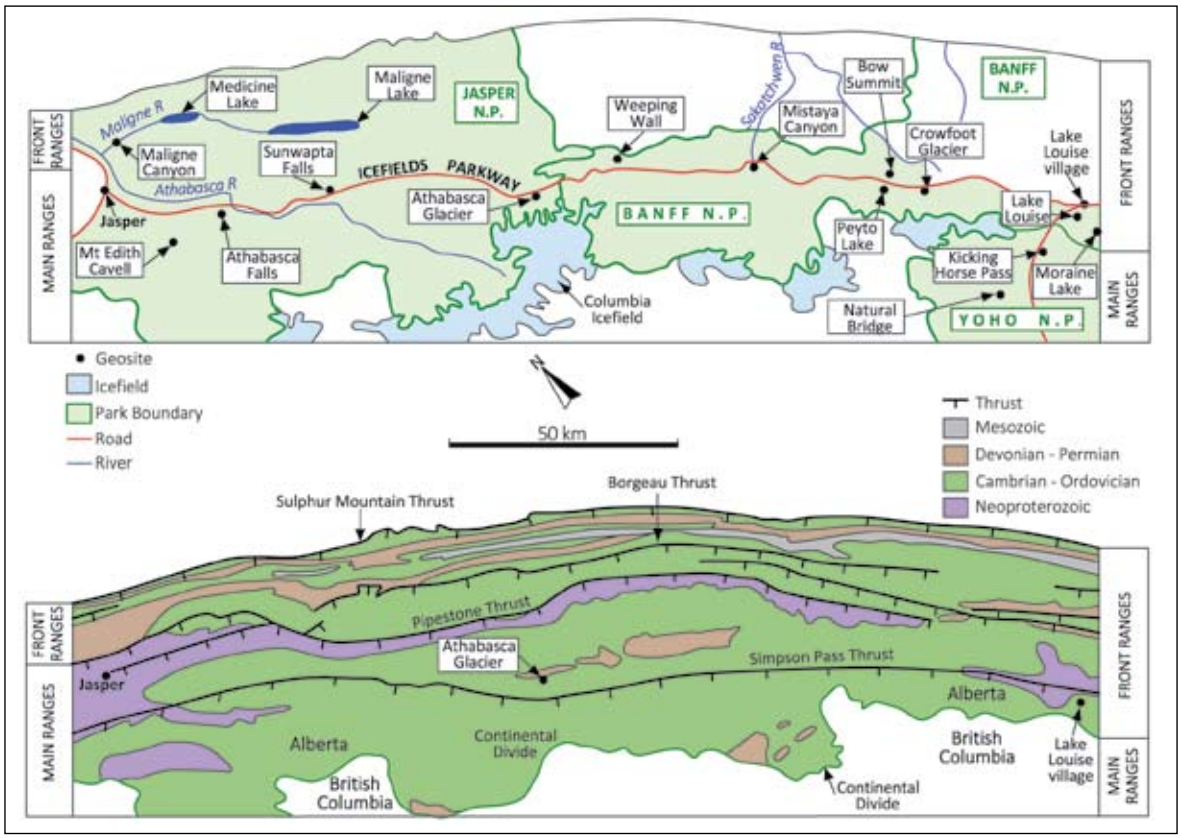


A simplified stratigraphic column for the Canadian Rocky Mountains (after Leckie, 2017).

thrusting and tectonism correlates with the Laramide orogeny (80–50 Ma). Subduction of the palaeo-Kula Plate caused terranes in the west of Canada to collide with the Canadian Shield.

The strata exposed in the Banff, Jasper and Yoho National Parks are part of the cratonic platform, thick sequences of sedimentary rocks of the Western Canada basin (Evenchick et al., 2007). The oldest is the Neoproterozoic Miette and Windermere Groups. They are dominated by sandstones, grits, and shales and are overlain by quartzites of the Lower Cambrian Cog Group. In a generalized way, the strata become younger towards the east as the older rocks were thrust over the younger sequences. The central and western parts of Banff and Jasper are dominated by Middle Cambrian through Middle Jurassic rocks. These successions include thick sequences of shales and limestones. Cretaceous strata occur in the eastern part of Banff.

Most fold mountains associated with collision zones form 300-600 km inland from subduction zones and the interior position of the Rockies is problematic. At the termination of the Laramide orogeny, the Rockies constituted a high altitude plateau (the elevation may have been as high as 6,000 m). During the last 50 Ma huge thicknesses of strata were eroded to expose the cores of the older generation of mountains (Leckie, 2017). Large palaeo-glaciers developed during the Pleistocene Ice Ages. The relics of some of these icefields are located on, or close to the continental divide. Glacial landforms include deep U-shaped valleys, cirques, triangular peaks, and hanging valleys with small lakes.



Maps showing geosites (upper) and geology (lower) of the central parts of the Banff, Jasper and Yoho National Parks (simplified from various sources including Leckie, 2017).

The northern part of the Icefields Parkway follows the course of the Athabasca River. The Main Ranges in this section of the Jasper National Park consist of resistant NeoProterozoic and Lower Palaeozoic strata.

The bedrock and glacial moraines are continuously being eroded and rivers include sections of rapids with waterfalls. Major rivers including the Athabasca, which flows northward, and the North Saskatchewan and Bow Rivers (the principal headwater of the South Saskatchewan River) which flow eastward and southward, respectively, are sourced at Banff and Jasper. These fast-flowing rivers are primarily fed by meltwater from ice sheets and glaciers. The rivers occupy steep-sided, U-shaped valleys carved during the Pleistocene Ice ages.

The Jasper National Park covers an area of 11,000 km^2 and includes numerous snow-capped ranges. The 232 km-long Icefields Parkway reveals views of over a hundred small glaciers. The parkway parallels the peaks of the Main Ranges east of the Continental Divide, exploiting a sequence of valleys associated with the Simpson Thrust. Multiple thrusts occur east of the parkway, including the Pipeline Thrust and the Sulphur Mountain Thrust. Cambrian and Ordovician strata are exposed on either sides of the parkway, together with remnants of the Devonian-Permian. The broad, flat-floored valley of the Athabasca River is a feature in the southern part of the park. A viewpoint overlooking the township of Jasper is located close to the confluence of this river and a significant tributary, the northward-flowing Maligne River. Both valleys were carved during the Pleistocene Ice Ages, but the latter is a hanging valley (associated with a subordinate glacier) perched 90 m above the main valley. Interesting geosites can be observed in the Maligne Valley. The valley parallels the Pyramid Thrust, a major NW-SE trending structure in the Front Ranges (Roed, 1964). Glacial features such as moraines associated with hummocky ground, depressions with small lakes, and deposits of sand and gravel can be examined. A large moraine, associated with the most recent of the ice advances dams the northern end of Maligne Lake. This is one of the largest (22 km long) and deepest (98 m) lakes in the region and is rimmed on the eastern side by high peaks of the Colin Range, part of the Queen Elizabeth Mountains. The Colin Range is comprised of steeply-dipping limestones (Devonian-Carboniferous) which impart a classic saw-tooth pattern, e.g. Mount Brazeau (3,470 m). West of the lake, the relatively subdued Maligne Range consists of quartzite and shales (Neoproterozoic-Cambrian) which were severely eroded and rounded during the Ice Ages.

Located downstream from Maligne Lake is the appropriately named Medicine Lake: the levels show considerable variability). The outflow from the lake is influenced by rockslide deposits which include large blocks and boulders of the Palliser Formation limestone (Devonian) and Banff Formation mudstone (Carboniferous). Rock slides are due to glacial undercutting of dip slopes near the base of the Colin Range. Medicine Lake flows into the Maligne cave system. A 16 km-section is located entirely underground prior to the river emerging northward in the Maligne Canyon. In summer the volume of meltwater causes Medicine Lake to rise as much as 18 m (cave system cannot cope with the flow), but in winter the reduced ingress causes the level to drop substantially, revealing mudflats and isolated pools.

Maligne Canyon has cut through thick surface deposit of glacial debris and till (which block access to the caves) into limestone of the Palliser Formation (Leckie, 2017). The sinuous nature of the canyon, or gorge, is ascribed

The upper section of the Maligne Canyon reveals evidence of an extensive cave system in the walls.

The narrow gorge of the Maligne River is carved into flat-lying limestone of the Devonian Palliser Formation.

to jointing of the limestone during the Laramide orogeny. A hiking trail into the gorge includes six bridges. In the upper part, between First and Second Bridge the canyon is particularly narrow and the river drops 50 m over a succession of falls with well-developed potholes. Large blocks or chockstones are wedged between the gorge walls. Between Third and Fourth Bridge, several side streams enter a wider section where the gorge is fringed by terrace gravels. Springs with small falls occur on the canyon walls between Fourth and Fifth Bridge. The flow of the river varies both between bridges and seasonally, due to changes in springs and filling of subterranean channels. The gorge is thought to be part of a palaeo-system associated with dissolution of the limestone, i.e. an exhumed cave system, rather than entirely being a post-glacial feature.

The Athabasca Valley includes views to the west of Mount Edith Cavell (3,363 m) comprised almost entirely of quartzite of the Gog Group (which may be 1,400 m thick). The Glacial Trail at the foot of the mountain accesses the Cavell Glacier and includes views of the steep Angel Glacier, perched 300 m above the valley, and the Ghost Glacier (elevation of 2,800 m). In the 1700's, Cavell Glacier extended to the trail head and until the mid-1940's Angel Glacier merged with the latter. During the summer months the Angel Glacier regularly sheds blocks of ice into Cavell Lake. Part of the trail is no

Part of the Maligne River is fed by springs from the cave system.

longer accessible as in August 2012 an unusually large section of the Angel Glacier collapsed; large blocks of ice falling into Cavell Lake triggered shock waves causing a debris avalanche, including metre-sized quartzite blocks, to flow down the lower part of the valley, cutting a new channel through the moraines. The moraines contain large boulders partially covered by lichen; the size of the Rhizocarpon geograpicum patches has been used to date the age of some moraines.

Located 32 km south of Jasper, the Athabasca Falls creates an impressive roar as a large volume of water is squeezed through an 18 m-wide gorge. The gorge is cut into large blocks of Cog Formation quartzite,

Mount Edith Cavell (3,363 m) is comprised almost entirely of resistant quartzite of the Lower Cambrian Gog Group.

The Angel Glacier, Mount Edith Cavell (Photograph: Daniel Doolan).

deposited by a palaeo-glacier. An abandoned channel, part of the walkway below the falls, includes prominent cross-bedding in the quartzite, indicative of the marine origin of the primary sandstone. Situated a further 23 km south, the Sunwapta Falls occurs in a hanging valley eroded by tributary glaciers perched above the primary Athabasca Glacier during the Ice Age. The Sunwapta River has eroded a deep gorge into limestone of the Cathedral Formation (Middle Cambrian). The gorge exhibits a zigzag pattern between the upper and lower falls due to well-developed orthogonal jointing. Large potholes located on the walls of gorges ere relicts of

The gorge below the Athabasca Falls occurs in finely-bedded quartzite of the Lower Cambrian Gog Group.

Large potholes on the walls of the Sunwapta Gorge are relicts of higher water stands. The gorge is cut into limestone of the Cathedral Formation (Middle Cambrian).

higher water stands. This is characteristic of hanging valleys that are being rapidly eroded. The crenulated face of Mount Geraldine (2,930 m) on the western side of the Athabasca Valley can be observed near the Sunwapta Falls.

The highlight of the Icefields Parkway is the "Glacier Skywalk" and Icefield visitors centre. The glass floor of the 1 km-long skywalk projects outward at a height of 280 m over the Athabasca Valley with views of the Columbia Icefield. This is the largest of the ice fields in the Canadian Rockies, with an area of 325 km^2, and transects the boundaries of the Jasper and Banff National Parks. The depth of the ice varies between 365-100 m (Leckie, 2017). Annual snowfall can be as much as 7 m. The icefield formed during the Illinois Glaciation (238,000-126,000 BP) with additional advances occurring during the Main Ice Age (110,000-11,500 BP).

The crenulated face of Mount Geraldine (2,930 m), located on the western side of the Athabasca Valley, includes large cirques associated with small glaciers (foreground left and centre). The mountain is comprised of Cambrian-Ordovician strata adjacent to the Simpson Pass Thrust.

Sentinel-2 image of the Columbia Icefield (8th August 2018) modified by Copernicus Sentinel data and processed by Phillip Eales. Terminal moraines exposed by the receding Athabasca and Saskatchewan Glaciers clearly visible. The Icefields Parkway is located near the Icefield Centre.

The ice also advanced during the Little Ice Age (1200-1900 AD). The ice field is associated with eleven peaks of over 3,000 m; Mount Columbia with an elevation of 3,747 m is the highest mountain in Alberta. The icefield has spread down the eastern slopes of the main ranges, preferentially flowing down valleys carved by much larger palaeo-glaciers. Ice sheets typically become unstable when the thickness exceeds 30 m. The slope glaciers are moving at approximately 15-125 m a year. The Athabasca Glacier is one of a number of slope glaciers that is currently receding, despite some of the annual snowfall not melting (Gadd, 2011). Since the last glacial maximum, the extent of the 6-km long Athabasca Glacier peaked around 1844 with a length of 8 km. The glacier is also thinner with an estimated thickness of 320 m compared with 2 km in 1844. The toe of the Athabasca Glacier is currently retreating faster than the ice is moving forward (10-25 m/annually).

Recession of the ice-sheets and glaciers in the Canadian Rockies is not consistent as during the hotter and wetter periods of the Early-Middle Holocene (global event) large sections of the Pleistocene ice had melted, e.g. at 5,000 BP the Athabasca Glacier was part of a forested valley (Leckie, 2017).

View overlooking the moraine exposed by recession of the Athabasca Glacier. The vehicles visible on the glacier are specialized tour buses.

The Athabasca Glacier is fringed on the eastern side by a prominent lateral moraine.

Some geological highlights of the Banff and Yoho National Parks will be presented in a separate Geotraveller.

All photographs by the author

The foot of the Athabasca Glacier reveals an extensive terminal moraine exposed by the receding ice.

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16th GWD Groundwater Conference & Exhibition

Port Elizabeth, Eastern Cape, South Africa

Groundwater has proven to be a reliable **source** for decades, within the agricultural sector as well as the municipal sector, but the recent droughts in South Africa have prompted an explosion of private drilling in residential erven. Private groundwater usage has therefore increased beyond the point where it can be managed by the water authorities or even the private users themselves. Water quality, availability and sustainability are therefore key issues to consider when trying to protect this vulnerable and limited resource.

Conservation has become a key word where water scarcity is experienced. Cities/ towns throughout South Africa had to impose water restrictions, but also made progress in making people aware of the need to use less water. Educational programs have been put in place to educate the water user to adjust usage of water according to the availability thereof. Gone are the days where increasing water demands are being met with increased source development, as there are simply no more sources to develop. We simply need to use less water and use it more efficiently.

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The Ground Water Division of South Africa and its Eastern Cape Branch invite **businesses, universities, municipalities, water authorities and the private groundwater users** to join us in discussing and addressing these critical issues. Come and share your knowledge, your products, and your experience; or come and gain vital exposure and knowledge that you can take back to your clients or your business partners to be more water prepared!

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Date	Event	Venue
25 January	CPD Workshop	Mandela Mining Precinct, JHB
20 – 22 February	Drilling Methods in Johannesburg	Mandela Mining Precinct, JHB
28 March	SAMOG Compliance	NH The Lord Charles Hotel, Cape Town
12 April	Geophysics Workshop	Mandela Mining Precinct, JHB
25 – 26 April	Coal Day Evaluation of Coal Data	Glenhove Conference Centre
09 May	Core Logging	Mandela Mining Precinct, JHB
16 - 17 May	SAMREC Compliance and Reporting	Glenhove Conference Centre, JHB
27–29 May	Economic Evaluation of Mineral Deposits	Glenhove Conference Centre, JHB
13 June	Critical Metals	Glenhove Conference Centre, JHB
18 July	The Internet of Things and Data AGM	Glenhove Conference Centre, JHB
14 – 16 August	Geoskills	Glenhove Conference Centre, JHB
22 – 23 August	Structural Geology for the Mine Geologist and Structural Modeling	Glenhove Conference Centre, JHB
18 - 20 September	Drilling Methods	Avianto Muldersdrift / Rustenburg
10 – 11 October	Iron and Manganese Day	Northern Cape
20 – 23 October	16th Groundwater Division Conference and Exhibition	Port Elizabeth
31 October – 01 November	Geochemistry in Exploration	Glenhove Conference Centre, JHB
13 November	Fellows Dinner	Johannesburg Country Club, Woodmead
14 -15 November	Technology Day African Exploration Showcase	Glenhove Conference Centre, JHB

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Dates: 6 October 2019 (AYGE)
7 – 9 October 2019 (XVII ARC)

Venue: Century City Conference Centre and Hotel, Century City, Cape Town, South Africa

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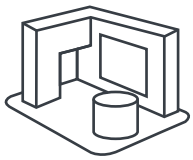

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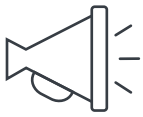

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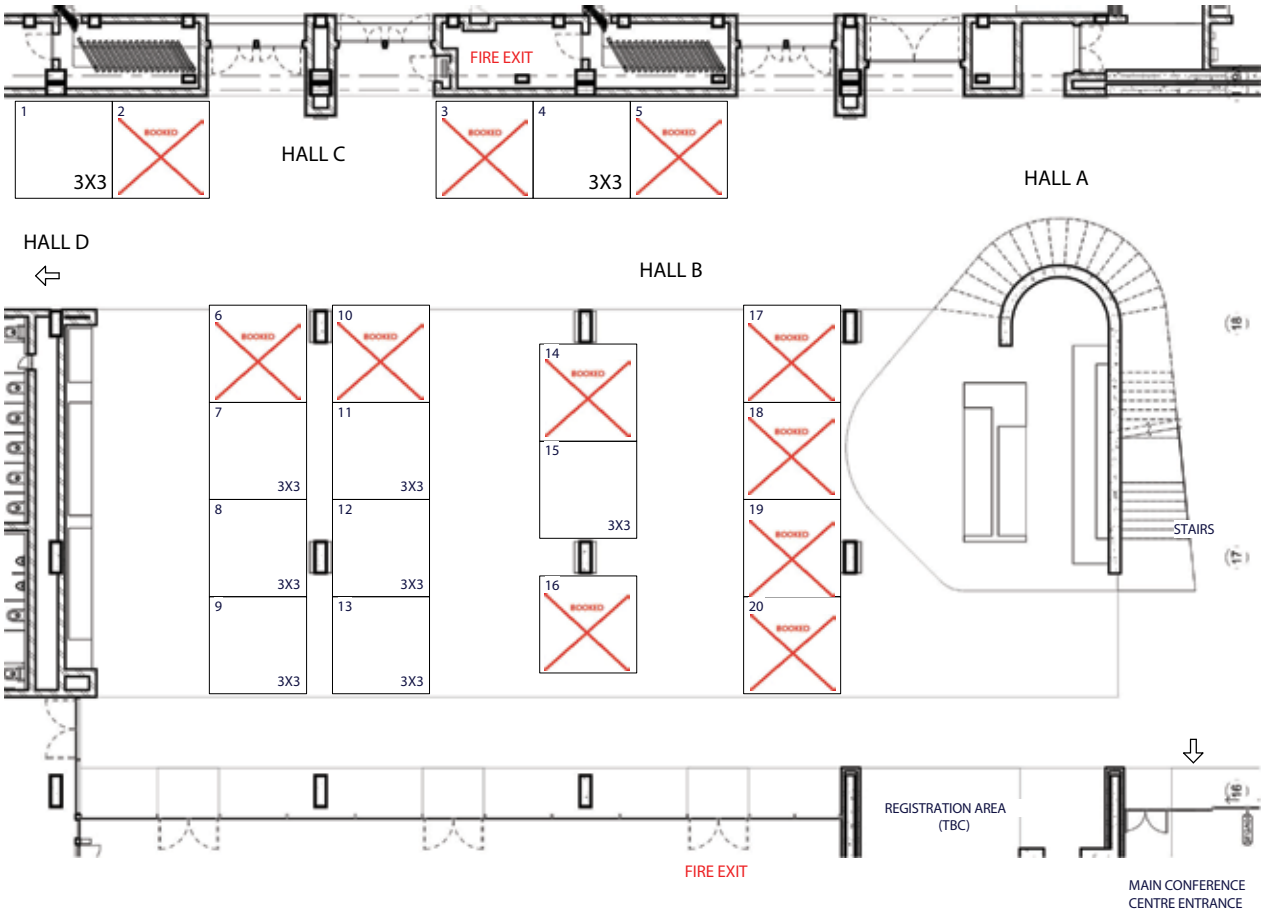

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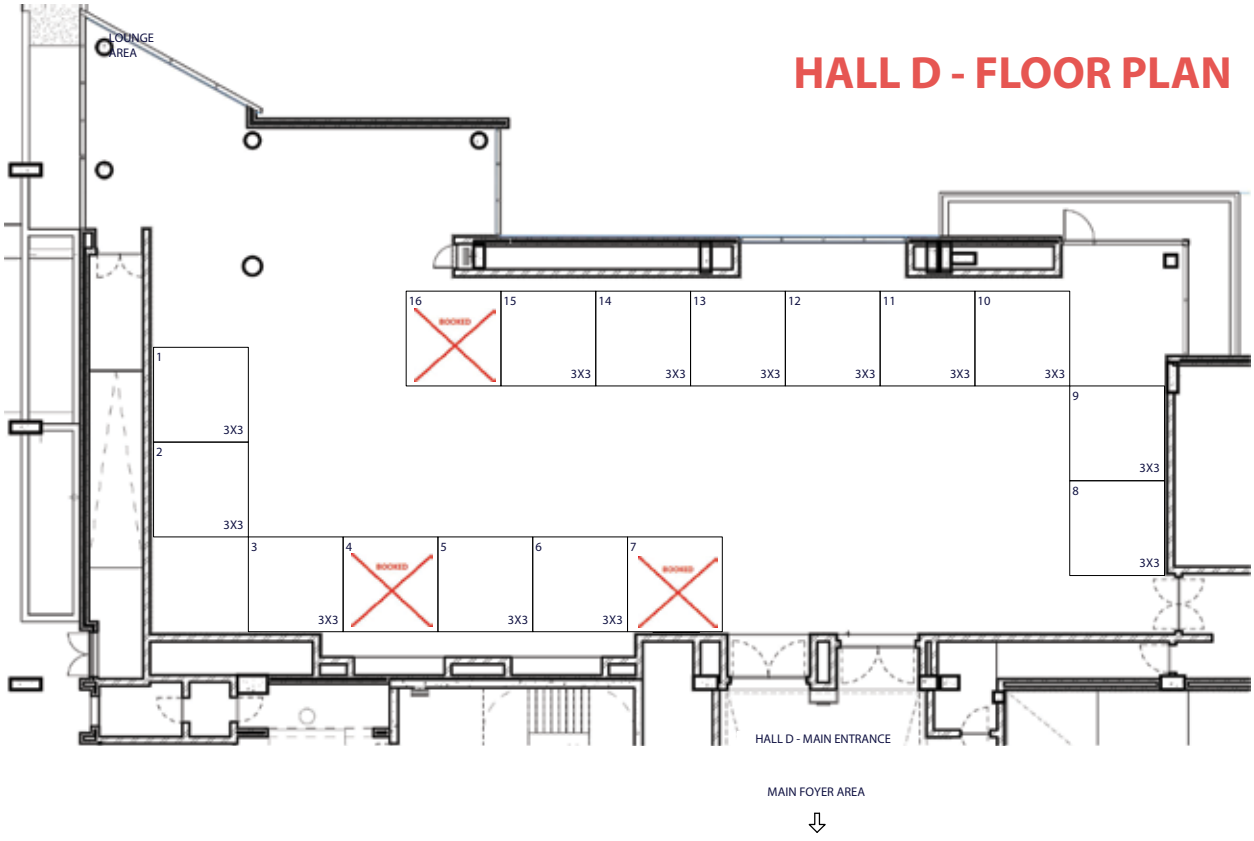

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FPF/C	R16 000.00	R15 285.00
Half Pg F/C	R12 480.00	R11 800.00
Quarter Pg F/C	R 9 860.00	R 9 440.00

Special Positions

Inside Front/Back	Outer Cover B/C only
R23 990.00	R23 035.00

Professional Directory: (Black & white only)

Company:	R965.00	R960.00
Individual:	R720.00	R710.00

Size: 45 x 90 mm wide

Advertorial rate per column per cm

Full column, ± 500 words:
R3 390.00 R3 390.00

2. MECHANICAL DETAILS

Trim Size:	297 mm x 210 mm
Full Bleed	297 mm x210 mm +5mm all round
Type Area:Full Page:	275 mm x 190 mm
Half Page:	275 mm x 95 mm (Vertical ad)
	135 mm x 190 mm wide (Horizontal ad)
Quarter Page:	135 mm x 95 mm (Vertical ad)
Screen:	300 dpi or more
Material:	CD or High resolution PDF in cmyk

3. PRINTING MATERIAL

Material to be supplied on CD as a FH MX/InDesign CS2 or PDF file. Accompanying images should be high resolution in CMYK format (NO RGB or Pantone colours). Any full page material to be trimmed to 297 x 210 mm must include a bleed of 5 mm all round. A COLOUR HARDCOPY MUST ACCOMPANY MATERIAL. Any modifications to incorrectly supplied material will be charged to the advertiser at R300.00 per hour.

4. LOOSE INSERTS

R7 315.00. Printed material to be supplied. Please ensure that the inserts do not exceed the trim size of 297 x 210 mm. All inserts must be delivered to the GB Editor (see Society Office).

5. DEADLINES FOR COPY AND ADVERTISING MATERIAL

March issue:	15 February 2019
June issue:	15 May 2019
September issue:	15 August 2019
December issue:	15 November 2019

6. CANCELLATIONS

Four weeks prior to deadline

7. ADVERTISING AGENCY COMMISSION

Excluded

8. CIRCULATION

Geobulletin is issued and dispatched at no additional charge to all of the various members of the Society and its local and overseas exchange partners. **The circulation list exceeds 2,800 (this is not a reflection of readership as it is read by a far wider audience - students in libraries, all geologists in a single company)** and reaches all of the decision-makers in the geoscience and mining community; the geological consultants and leaders in the Mining Groups, the Mining Industry and Government Institutions, universities, private, public and state libraries. Electronic versions of the GB are freely distributed through the society's web page.

9. ADVERTISING BOOKINGS AND SUBMISSION

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10. ADDITIONAL CONTACT INFORMATION

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The design and layout of the adverts is the responsibility of the advertiser. If you wish to utilise the services of the GB graphics and layout supplier, please contact Belinda directly, well in advance of the advert submission deadline to make arrangements.

2019

GSSA
Geological Society of South Africa