GSSA
Geological Society of South Africa

geobulletin

QUARTERLY NEWS BULLETIN ~ MARCH 2024

VOLUME 67 NO.1

news

12TH INTERNATIONAL KIMBERLITE CONFERENCE

12 IKC

30 YEARS OF DIAMONDS IN CANADA

8–12 July 2024 • Yellowknife

Ekati, Canada's first diamond mine, Northwest Territories. Copyright © Arctic Canadian Diamond Company

SCIENTIFIC THEMES

1. Diamonds
2. Emplacement and Economic Geology of Kimberlites and Related Magmas
3. The Origin and Evolution of Kimberlites and Related Magmas
4. Diamond Deposits – Exploration and Mining
5. Cratonic Mantle – Petrology, Geochemistry and Geophysics

FIELD TRIPS

1. Northwest Territories Diamond Mines
2. Kimberlites from Across Canada
3. Slave Craton Geology
4. Northwest Territories Kimberlite Drill Core Collection
5. Advances in Drift Prospecting for Kimberlite in Canada

SEMINARS

Invited speakers present a state-of-science summary covering emergent topics followed by moderated questions and extended discussion.

1. Kimberlitic Olivine: Tracking Mantle Cargo and Kimberlite Melt Evolution
Dr. Geoffrey Howarth, University of Cape Town, South Africa

2. Large Type-II Diamonds: Genesis and Transport to Surface
Dr. Evan Smith, Gemological Institute of America

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Front cover photo:

View of Mawenzi peak (5,149 m), Kilimanjaro, from Barafu Camp. For a hiker's guide to the geology of Mt Kilimanjaro, see pg. 26. (Photo: Matt Mullins)

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guest editorial

ESG: Still Generating Buzz or Is the Hype Tapering Off?

Lynne Soulsby

When I was asked to write this editorial, I hesitated at first, concerned that exploring ESG from this angle might be unpopular or that expressing the 'wrong' opinion when it comes to matters of ESG could lead to a backlash. However, I reminded myself that opinions are subjective, shaped by personal experiences and interactions with a given topic. They do not necessarily represent facts but rather individual perspectives, which is what is presented in this editorial.

ESG (namely Environmental, Social and Governance for those who have been living under a rock—pun intended) has undoubtedly become a popular buzzword, tossed around by both those in the know and equally those less so. ESG, however, is not a novel concept or framework; rather one that has evolved over time and undergone various iterations within the industries, particularly the mining industry.

When I first entered the mining industry two decades ago, fresh out of my tertiary studies, I was immediately immersed in the realm of what we now call ESG. However, back then, the social component went by a different name—corporate social responsibility (CSR)—while environmental was largely focused on legal compliance. Governance was misunderstood and often confused with Governmental factors! At that time, CSR had just begun to gain traction in the South African mining industry with the introduction of Social and Labour Plans (SLPs) under the Mineral and Petroleum Resources Development Act (MPRDA). Community protests and pressure from non-governmental organisations led to a heightened emphasis on CSR among companies.

A few years later, the conversation shifted towards sustainability in mining and revolved around conducting mining operations in a manner that carefully balanced economic, social, and environmental considerations to secure the industry's long-term viability, while minimising negative impacts. Even then, sustainability was mainly linked to environmental management and less so towards economic and social considerations.

A couple of years later, a new term emerged: ESG. While the environmental and social aspects were familiar and mostly well understood, the inclusion of governance was novel and often not thoroughly grasped, having been misconstrued to be a "governmental factor". However, governance simply refers to the systems and processes through which companies are directed, controlled, and managed to ensure accountability, transparency, and ethical behaviour in conducting their operations. This sounds straightforward, but the "G" represents a severely misunderstood concept in the ESG framework.

Suddenly, mining companies, legal firms, consultants, and small businesses everywhere began substituting mentions of CSR, sustainability, and climate change with ESG whenever the opportunity arose. Websites featured new dropdown menus, inboxes were inundated with discussions, while conferences and webinars centred on ESG proliferated. These covered topics ranging from 'What is ESG?' to 'How to successfully manage ESG' and 'Why is ESG so important to both operators and investors?'.

Articles, podcasts, and webinars consistently included segments on the significance of ESG and its increasing importance to mining and

other industries in the future. Personally, I transitioned from a Social Scientist to an ESG Technical Advisor, specialising in matters related to the "S" in ESG.

Around the world, there was a rush to establish ESG committees and taskforces to ensure that frameworks, guidelines, and reporting standards for assessing, managing, and reporting on environmental, social, and governance performance were integrated into all aspects of businesses.

Nevertheless, amidst all this discussion, the question still lingers: What has truly changed, aside from the terminology?

As an ESG practitioner, should I consider playing devil's advocate and propose that beyond mere noise and propaganda, the actual change has been minimal? Would taking this stance diminish my effectiveness as an advocate for ESG awareness? Or alternatively, should I argue that ESG has completely transformed the mining industry, becoming a top priority in assessing new projects or investing in established ones? The answer to these questions is perplexing and, frankly, a bit contradictory. So instead, I offer you some observations based on my nearly 20 years of experience working in the mining industry across different commodities and jurisdictions.

ESG is not a novel concept; rather one that has undergone a process of rebranding and evolution

Industries, particularly mining, have been addressing aspects of ESG since its inception. What has changed is the improvement and efficiencies in handling these aspects and the integration of environmental, social and governance factors when developing business strategies and plans. There's now improved understanding of the environmental and social impacts of mining, while the necessity to mitigate these impacts for both the mine and the surrounding communities has become an integral part of everyday business operations and projects.

Engaging in social projects and uplifting communities around operations is also not a recent practice; the emphasis has simply shifted to ensuring that these contributions are sustainable and truly beneficial to the community and workforce. Lessons have been learned, mistakes have been made, and giving back has become an integral part of daily operations. Legal compliance is no longer sufficient for ensuring uninterrupted operations, which brings another connecting dimension to the ESG equation—social licence to operate.

Mining companies' increasing emphasis on ESG is accompanied by commitments, yet it somehow still feels obligatory rather than genuine

This point might stir up some tension and initial resistance, but please hear me out. When it comes to ESG, many senior mining executives, despite paying lip service to the matter, are still not participating in the genuine discourse of ESG matters. Talks and webinars regarding ESG remain largely unattended by senior executives in the mining industry but are predominantly attended by consultants preaching to other consultants about how to help clients take accountability for ESG matters. With that said, I also haven't seen these senior executives attending courses on mineral resources and reserve estimation, or enhancing mine design and modeling. Could this be because aspects of ESG have gradually integrated into everyday industry practices and operations? Similar to ore grade, mining techniques, resource prices, and processing, they might only address these issues outside of their departments when faced with a serious problem. Has it become so routine that it's simply treated as another Capex or Opex line item in the business plan, with an attitude of merely associating a cost to fix any issues that may arise? I've often heard remarks that essentially suggest, "Yes, ESG matters might pose a problem, but with the right amount of money, the issue can

☞

be resolved". One is left to wonder whether ESG considerations are genuinely regarded as critical by both investors and operations, despite the numerous claims that it is their top priority. Senior executives often become intimately involved in ESG when developing projects or operating in environmentally or socially complex areas or when there is bank financing required to develop a project. In such cases, ESG is embedded in a company's strategy and business plan.

ESG matters are increasingly becoming a Red Flag for industries and operations

Despite the often nonchalant attitude encountered regarding matters of ESG, corporate reputation, bottom line, and share price are all jeopardised when things don't go according to plan or when the money simply isn't enough.

Communities are growing more mobilised and empowered. Transparency in reporting grants, and stakeholder's access to previously inaccessible information on environmental and social risk management and commitments, has enabled these same stakeholders to hold companies or operations accountable. The realm of social media and modern communications, coupled with a "woke culture", facilitate swift action by local community members. If grievances remain unaddressed, they can be shared with the world, including investors, shareholders, and lawyers/activists/NGOs ready to advocate for those affected by non-compliance with ESG issues.

Hype surrounding the popularity of all things ESG can lead to the ignorant misapplication of its principles

Being an advocate for ESG doesn't entail being against anything that may cause significant environmental and social impacts. It simply means understanding and scrutinising both the positive and negative effects, along with the mitigation measures and action plans in place, to determine whether the benefits outweigh the drawbacks.

An example of this can be observed in Panama recently, where pressure from locals not only led to the closure of the world's largest copper mine but also to a ban on any future mining activities. Protestors have hailed this as a significant

victory for the country and its protection of the environment and indigenous people. However, in a world consistently advocating for ESG principles and a transition away from fossil fuels, copper remains a fundamental requirement, including the copper that would have been extracted at Cobre Panama. Furthermore, the mine accounted for 3–5% of Panama's GDP and was expected to pay $375 million annually to Panama as compensation for its negative impacts. Additionally, Cobre Panama employed about 7,000 people, with another 33,000 individuals indirectly dependent on the mine. This raises questions about whether ESG matters were applied logically and carefully, and whether the broader ESG implications were fully appreciated.

So, is the hype around ESG fading? From my perspective, maybe or maybe not. ESG as a framework has stood the test of time and progressed beyond the "fad" tag. Companies and projects will increasingly prioritise compliance with the highest environmental and social standards, as not doing so becomes less of an option. Constant ESG reporting and greenwashing will become less necessary as good ESG practices will become standard and ordinary.

Does this suggest that ESG is no longer generating buzz? The answer to this is perhaps not as much buzz, but a considerable level of interest will always remain, particularly when things go wrong. Responsible management of ESG matters is crucial for the mining industry. Integrating ESG factors into daily decision-making and identifying and managing risks associated with environmental regulations, social conflicts, community opposition, and reputational damage, are vital to ensuring long-term value creation and avoid ESG failures. The G in ESG places certain responsibilities across the various actors from a company's board to the shop floor level and all the stakeholders.

In my younger, more naive days in the industry, someone once told me, "If it's not grown, it's mined." So, if you want to continue to switch on your light, wear your diamond engagement ring or drive around in electric cars, mining and ESG (or whatever it may be called next) are here to stay.

Lynne Soulsby
Senior Technical Advisor at The Mineral Corporation and Chairperson of the GSSA ESG Division

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executive manager's corner

Craig Smith

The GSSA has both formal and informal relationships with other professional societies locally and internationally. The key objectives of the various organisations vary, depending on membership profile and focus. The GSSA differs from most other organisations in having the majority of its members employed in industry and not academia, and in having fewer members than many other organisations such as the Geological Society of America or the American Geophysical Union, both with tens of thousands of members. It is also true that the objectives of professional and scientific societies can differ markedly between developed and developing economies.

With these distinctions in mind, it is interesting to benchmark against the policies and objectives of other international societies. The GSSA receives regular updates on strategy and policy from the European Federation of Geologists (EFG), which represents 28 organisations with a collective membership of about 45,000 geoscientists. In the latest policy statement draft being prepared for the European Parliamentary elections later this year, nine policy recommendations are proposed to (political!) decision-makers (not necessarily in order of priority):

1) Make geology a core subject in school syllabuses to address the shortage of youngsters entering the profession.
2) Train geologists to manage the huge trove of data available to geoscientists (i.e. Data Science; AI applications).
3) Assist in Carbon Capture and storage projects with finance, public engagement and competency certification.
4) Support the development of policy regarding geothermal energy and natural hydrogen.
5) Support geotourism in order to promote greater awareness of geology and geological processes.

6) Better monitoring of soil and water health, and integrating geology with biodiversity.
7) Require geological risk assessment for all major buildings.
8) Make provision of geohazard information available to vulnerable communities.
9) Make use of the large number of expert groups and extensive data sets available.

It is emphasised that these policy recommendations are in draft format only, and the final version may look considerably different. But it is illustrative of the differences in Earth science priorities between the developed and developing worlds. There is no mention of sourcing strategic minerals, for example (though that is likely covered under a different set of policy recommendations). In South Africa, many of these recommendations would be 'nice-to-haves' rather than the top priorities, because of the lack of manpower, finance and expertise, as well as the economic importance of the resource sector. There is no mention of the need for basic mapping, and most countries have a functional cadastre system in place. Point 9, a plea to the politicians to make use of science-based evidence, is applicable around the world.

There is a distinctly first-world emphasis on these policy recommendations; in contrast to mining and exploration probably topping a policy list closer

to home. Stopping illegal mining and cutting back bureaucracy would also be high on a South African list.

In a March 2 Bloomberg Green newsfeed, it was noted—to a global audience—that the Vaal Triangle with a population of 1.7 million people is the most polluted area of comparable size anywhere on Earth. Maybe South Africa could use a little more 'green' in its policy choices, without losing sight of the resource perspective.

While I'm on my soapbox, there is an interesting article in the February 10 issue of The Economist (p. 62) on how universities contribute to slow economic growth. In 1980, there were 4 million academic researchers world-wide. Currently there are 15 million, and this is correlated with a productivity slowdown over the same period and a 1.5% per annum decrease in corporate patenting. The argument is that in the post-war years, industry laboratories produced more innovation and scientific breakthroughs than universities. In the years since, more and more industry giants are closing laboratories and farming out R&D to the university sector, which is less efficient in turning research into economic growth. There are twists and turns in the story—but are the world's university-based researchers a substitute for industry-based expertise? Are these generalisations applicable to exploration and mining?

Craig Smith

president's column

Steve McCourt

Let me start this column with the hope that 2024 will be a peaceful and prosperous year for all GSSA Members, Fellows, and their families.

For the Society, 2024 will be a year to remember. By the time Geobulletin 67-1 is posted online, we will have relocated the GSSA office from the Mandela Mining Precinct and hosted the 36th Alex du Toit Memorial Lecture Series.

The GSSA has enjoyed prime office space in the CSIR Mandela Mining Precinct in Melville, Johannesburg since 2017. The MMP site boasted a small conference facility, which served us very well on many occasions, access was easy, there was ample storage space and security was good. However, in keeping with global trends, during the pandemic most of the organisations resident in the MMP, including the GSSA, adopted remote working practices, including conferencing, and none have reverted to pre-pandemic office usage. As a result, CSIR has decided to sell the site and the tenants must exit at the end of the current lease period. Following discussions in Manco and Council, it has been decided that, rather than pay for expensive office premises, the GSSA will operate from a virtual office in Thornhill Office Park, Midrand. As part of this move the rock collection will be relocated to Wits Geosciences and the generic library will be moved to CIMERA at UJ. The map collection, as well as the over 150 theses currently housed at MMP, will be retained, and eventually made available as reference material. The collection of Africana books will be professionally archived and placed in a secure facility. The exit from MMP was managed by the office staff and I take this opportunity to recognise Lully and her team and to thank them for their hard work.

After an absence of 5 years, the A L du Toit Memorial Lecture was presented by Christoph Heubeck from the Friedrich-Schiller University, Jena, Germany

at 5 venues across the country during February. Lectures were held at Stellenbosch University (WC Branch), University of the Free State, Wits University, UKZN in Durban (KZN Branch) and in Barberton. In addition, to accommodate those members unable to reach any of the venues, the lecture at Wits on February 22nd was recorded and has been uploaded to the GSSA YouTube Channel. Our thanks to Grant Bybee and Robyn Symons from Wits School of Geosciences for organising this recording. The biennial Alex du Toit Memorial Lecture is organized by the Fellows Committee, but the hard work is done by the regional representatives, and for this series of lectures I recognise and thank Tahnee Otto (SU), Matome Moitsi (UFS), Grant Bybee and Robyn Symons (Wits) and Tanja Reinhardt (UKZN).

As a learned society, the GSSA is underpinned by a formal Constitution and a set of By-Laws (see website under Members tab), which require that the various committees that assist Manco and Council are reconstituted every 2–3 years. In keeping with this process, a new Fellows Committee has been selected for the period January 2024 to December 2025. Paul Nex has stepped down from the committee and the Executive thanks Paul for his contributions over the last few years. Judith Kinnaird has resigned as Chair but will remain on the committee at least for 2024. Andrew MacDonald and Bertus Smith are welcomed as new members of the committee and Louise Coney, who has served on the Fellows Committee for the last 3 years, has been elected as the new Chair. Louise will represent the Fellows on both Council and Manco. The role of the Fellows Committee is to oversee the evaluation of nominations received for the various awards and memorials of the GSSA and to make recommendations to Council on the recipients for these awards. During the next few months both the Ethics and Disciplinary committees will be re-constituted, and members are requested to respond positively to the call for nominations that will be sent out from Craig's desk.

The GSSA Meetings Committee has put together a series of continuing education options for 2024 that include online, hybrid and face-to-face meetings (e.g., the African Exploration Showcase in November). In addition, to celebrate the discovery of the first economic platinum deposit in South Africa in 1924, the Society is organising the Merensky Reef Centenary Meeting, combining a two-day scientific conference with pre- and post-conference field trips to the Eastern, Western and Northern limbs of the Complex and a pre-conference workshop. Selected papers presented at the scientific meeting will be published in a special issue of the SAJG dealing with the Origin of the Merensky Reef of the Bushveld Complex at the end of 2024 or early in 2025. The committee tasked with organising the meeting and the post-conference fieldtrips is chaired by Chane de Jager, assisted by Loni Gallant (Sponsorship) and Rais Latypov (Technical Sessions). Roger Scoon is organising the pre-conference field trip (15th to 18th August) to the Eastern Limb, including the Mooihoek discovery site. The dates for this Merensky 100 Anniversary meeting are 15th to 23rd August 2024 and registration is now open (see the Events tab at www.gssa.org.za).

Looking ahead to events in 2025, plans are in hand for the Namaqualand Diamond Centenary conference and associated fieldtrips in March organised by Tania Marshall, and Geocongress at UFS in July with Martin Clarke taking the reins as Chair of the Local Organising Committee.

Steve McCourt

professional affairs

THE PROFESSIONAL (AFFAIRS) CORNER

The SACNASP/GSSA Mentorship Programme is well underway for this year and we'd like to give thanks to all the mentors and mentees throughout the years. We can't manage these programmes without you. And we can't manage them without our partners in the industry. These include people giving talks and courses, advising us, and those attending our events to build the mentees' networks.

We'd like to shine a spotlight on our online mentoring session partners, Briony Liber and Mark Turpin. In their personal capacities, Briony and Mark are corporate coaches, and are always happy to share their expertise with us.

Briony Liber does one-on-one coaching as well as online courses, including Position your expertise on LinkedIn, Manage your Career like a Business, and Connect with your Business. Briony's Optimise Your Career Mentoring Programme kicks off in mid-March and details are available on her website.

Mark Turpin is an Executive Coach, Mediator, Organisational Development Consultant and Lecturer. Mark facilitates the GSSA group mentoring sessions.

Noleen Pauls

REGISTRATION WITH

SACNASP
South African Council for Natural Scientific Professions

01 LEGAL COMPLIANCE NSP ACT (27 of 2003)

02 RECOGNITION AS A PROFESSIONAL

03 PUBLIC CONFIDENCE IN YOU AS A SCIENTIST

04 MARKETABILITY (EMPLOYERS REQUIRE REGISTRATION)

05 CODE OF CONDUCT – TRUST FOR ETHICAL VALUES

06 INPUT TO GOVERNMENT – SACNASP VOICING SCIENTISTS' INPUT AT MINISTERIAL LEVEL

07 NETWORKING – WEBINARS, WEBSITE NETWORKING PORTAL

08 POTENTIAL FAVOURABLE RATES FOR PROFESSIONAL INDEMNITY INSURANCE

09 CAREER ADVERTISEMENTS – EMPLOYERS ADVERTISE VACANCIES ON SACNASP WEBSITE AND SOCIAL MEDIA

10 VOLUNTARY ASSOCIATION EVENTS – NETWORK WITH FIELD OF PRACTICE PEERS AND GAIN VOCATIONAL CAREER ADVICE

11 FACILITATES LIFELONG LEARNING THAT IS CRUCIAL TO A PROFESSIONAL'S CAREER PATH – CANDIDATE MENTOR PROGRAMME

12 CONTINUING PROFESSIONAL DEVELOPMENT – ONLINE LEARNING

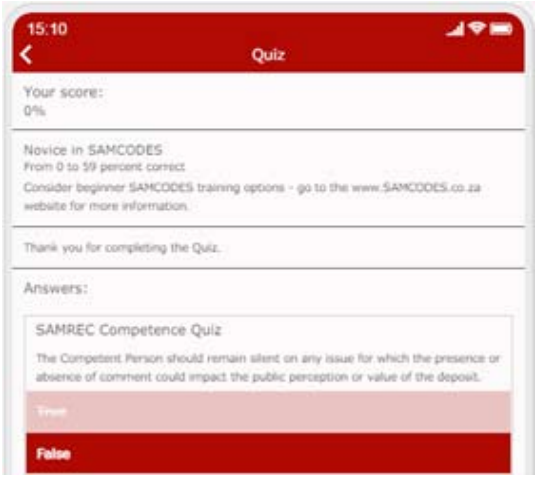
SAMCODES

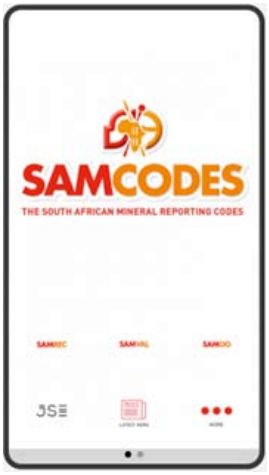
SAMCODES Quarterly Snaps

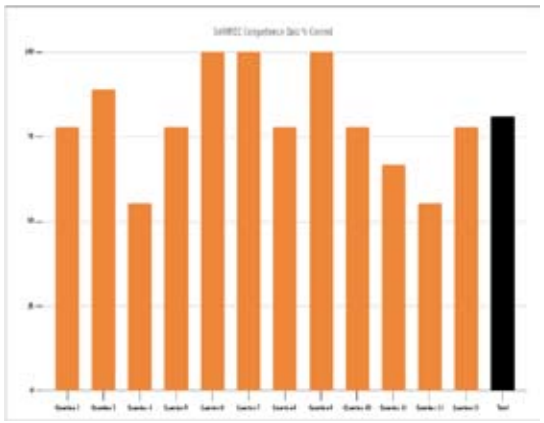
What's hAPPening with the monthly Quiz?

- One SAMREC and one SAMVAL quiz was sent out on the SAMCODES App.
- Users got immediate feedback (scores) on how they did on the ±10 questions.
- Apple app development is still ongoing and CPD points are being investigated.

The SAMCODES App is available for download on the Play Store and instructions for downloading the iOS version are available here.

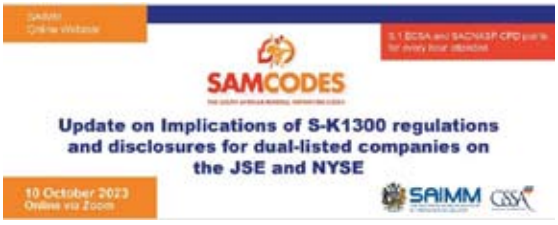






Training programmes

1. The S-K 1300 follow-up workshop in October 2023 was a knowledge update based on feedback from listed entities and consultants concerning the SEC's views and recommendations ensuing from round 1 of S-K1300 reporting. This provided feedback for further lobbying with the SEC to streamline reporting for QPs/CPs. Feedback is also available on the SSC S-K 1300 forum site, which you can register for here.
2. An introduction to the SAMCODES course was also held successfully in October 2023 for students.
3. The UNFC Workshop of 20 February 2024, hosted by the GSSA, is focused on what the UNFC is, including case studies of how it is applied, the Critical Raw Minerals Act, AMREC, and a brief introduction to PARC, and then what the situation is in South Africa, as well as an update on the UNFC and CRISCO bridging document.



Committee updates

SAMREC	The committee has been driving the use of the SAMCODES App and running quizzes
SAMVAL	Reporting of brines and non-solid minerals, S-K 1300 disclosure requirements and discount rates were discussed
SAMOG	SAMOG updates to commence in the new year

SAMCODES ESG Working Group Activities

The ESG Working Group continued with work for incorporating ESG recommendations into the SAMCODES through the following activities, since the follow-up ESG workshop held in July 2023:

- The front end of SAMREC Code is essentially complete.
- SAMREC Table 1 completed, with ESG Section (5.5) in progress.
- ESG summary section for addition in SAMREC is in progress.
- SAMVAL Code and SAMVAL Table 1 is complete.
- SAMESG Guideline update is in progress.

International Liaison

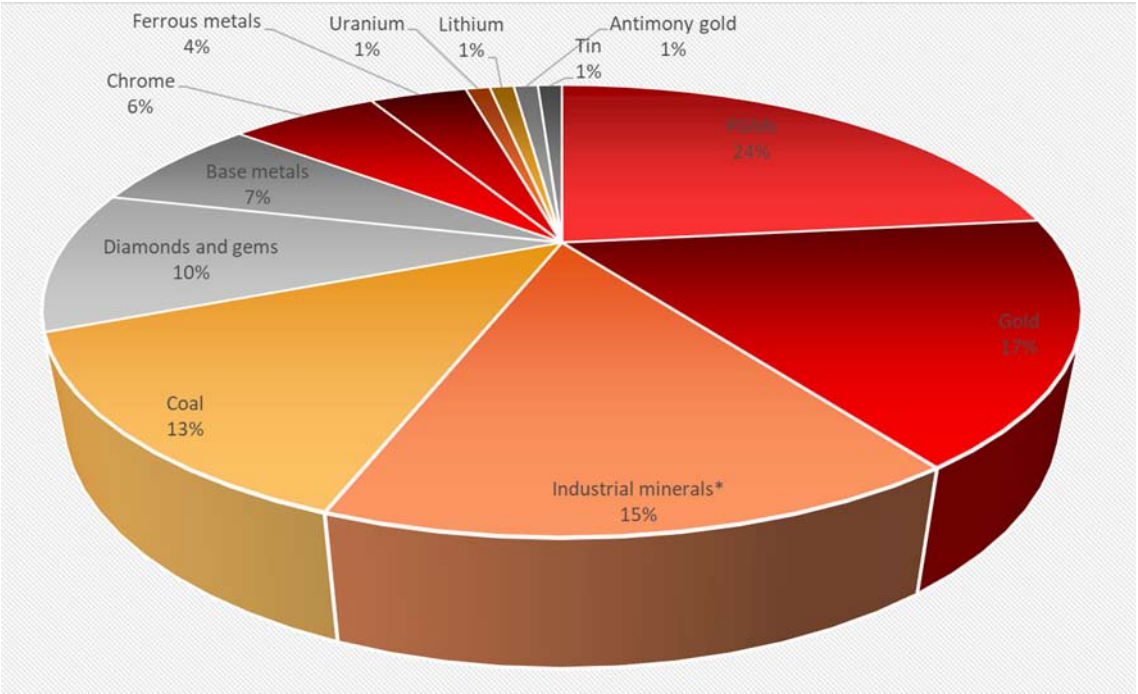
CRIRSCO–ESG definitions have been issued during the recent CRIRSCO AGM in Brazil, including reference to ESG factors that will be used as guidance for SAMCODES. Philippines became a member of CRIRSCO, so now up to 15 members.

Guideline for Reporting of Industrial Minerals

The need to compile a guideline for the estimation and reporting of mineral resources and mineral reserves for industrial minerals is being considered by the SSC and SAMREC.

JSE Reader's Panel

Since inception of the JSE Reader's Panel, a total of 282 reports have been reviewed by the Reader's Panel. During the past five years, 25% of CPRs were accepted on first submission, 58% on second submission and the remainder on third submission—a considerable improvement in quality of CPRs since 2016. The split of minerals covered by the CPRs is shown in the pie chart below.



*Industrial minerals include all non-metallic minerals

SSC Changes for 2024

SSC Chair:	Sifiso Siwela (GSSA)
SSC Vice-Chair:	Joseph Mainama (SAIMM)
SSC Immediate Past Chair:	Andy McDonald (SAIMM)
SAMREC Committee Chair/CRIRSCO representative:	Nicole Wansbury
GSSA representative on SSC:	Jacques Nel

Sifiso Siwela

Joseph Mainama

Nicole Wansbury

Jacques Nel

branch & division news

The Northern Cape Branch of the Geological Society of South Africa 2024 UPDATE

The Northern Cape Branch of the Geological Society of South Africa continues to strive in creating awareness and opportunity in the province, promoting development and combining all stakeholders and interested parties together in participation of the growth and understanding of geological deposits through networking and skills development.

This year started off with the new committee members' strategy meeting for the year 2024, with other upcoming events listed below. We would like to thank all our members, sponsors and interested parties for their continued support in making this happen. We look forward to a great year ahead.

Loni Gallant
NC Branch Chairperson

Northern Cape Branch 2024 Events:

West Coast Diamonds Event, Port Nolloth, Kleinsee, NC – 17 & 18 May 2024
Event registration link:
https://www.cognitoforms.com/GeologicalSocietyOfSouthAfricaWestCoastDiamondsEventAndExcursion1718May2024

Online Talk:
Topic: "Manganese and South Africa - A match made in History, a relationship for the future"
Speaker: Prof. Bertus Smith, University of Johannesburg
Recording available on the GSSA website/YouTube channel

Other planned events:
Future "Cluster Events", e.g. Iron Ore Event & Geoheritage
Future "Career Day and Awareness" events

Important links:
Free NC Branch membership registration link: https://docs.google.com/forms/d/e/1FAIpQLSeQAxcK4_0CQtqzGgtOGBTtn2SqCjBpms5fP_ej3ZdOUMOmvQ/viewform
NC Branch page on the GGSA website: https://www.gssa.org.za/?page_id=7101
NC Branch LinkedIn page: https://www.linkedin.com/company/the-northern-cape-branch-gssa/?viewAsMember=true

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REI report

REI Report: A study of secondary copper minerals forming on sulphide slag in the Okiep area, Northern Cape

This article outlines the results of the study of historical slag sampled near Concordia and at Nababeep in the Northern Cape during 2020 and 2022. REI funding was obtained in 2021 and 2022 to assist with slag sample collection and analysis. Full results and references are contained in the report submitted to the REI and GSSA in June 2023,[1] as well as in the abstract submitted to Geocongress 2023 earlier in the year.

Copper mining and processing has been practised in the Northern Cape for many years but fell upon lean times towards the end of the last century, leading to abandoned mines and plants being scattered around the district. Many of these are now being reworked, as there is a revival of interest in copper recovery.

The furnace slag at Jubilee, close to Concordia, was the main focus of this study. Characteristic large black blocks of this slag were produced and deposited in an area next to the old Jubilee copper mine. The smelter was constructed by the Namaqua Copper Company in 1905 and featured a blast furnace to process local ores, as well as ore from further afield. Smelting operations came to an end in 1930.

Part of the slag dump at Jubilee (October 2020).

Slag samples were collected from the central and southern side of the Jubilee slag dump in October 2020. These consist mainly of black glassy material, with minor interspersed coarse "frothy" bands. Secondary samples were collected from more oxidised areas on the surface of the dump.

More extensive sampling, in August 2022, covered additional areas of Jubilee dump material: the eastern, western and northern parts of the slag dump, as well as the dry riverbed where green secondary minerals are common, but not always sourced from slag.

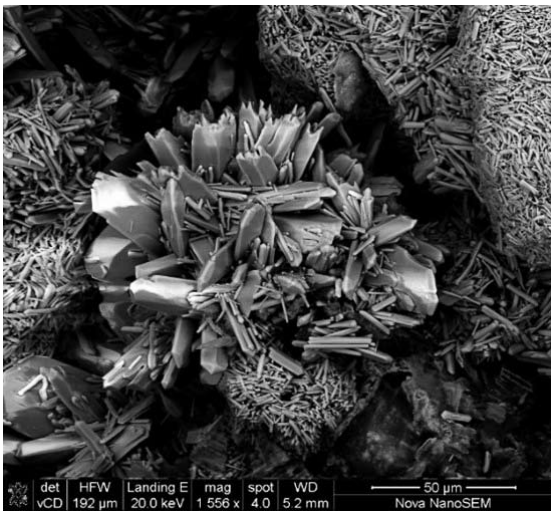
By 2022, the Nababeep furnace was reduced to the stack and a large slag heap.

Younger slag samples were collected from the furnace slag heap and apron at Nababeep Smelter and used for a comparison with the Jubilee material. This operation was run on a larger scale- copper concentrate was fed into a reverberatory furnace (built in 1939), the resultant matte was then converted and cast, the final product being

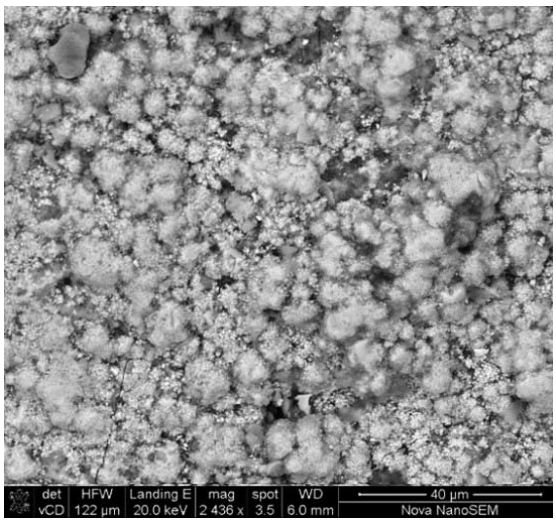
Rocks coated in green secondary copper minerals in the dry Jubilee riverbed (August 2022).

blister copper. This smelter stopped operating in 2007, and the site is now the property of Copper 360. The slag sampled from Nababeep in 2020 was granulated, and both crushed material and pit lumps were contributed by Copper 360 staff in 2022.

The slag samples were examined and analysed using light microscopy and scanning electron microscopy (SEM) at the Universities of Cape Town and Stellenbosch. Selected samples were also analysed using X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF) and trace element techniques. The use of low-vacuum SEM on secondary phases proved especially helpful, as traditional sample preparation can result in material being lost, damaged and/or misidentified. Drawbacks include skewing of EDS results due to topography; this can be compensated for by using multiple analyses, and electron imaging to provide crystallographic information. Details of the mineralogical techniques used to identify the secondary minerals and the pathway of copper removal from the slag into the environment were published in the *Minsa Newsletter* in September 2023.[2]



Brochantite surrounded by antlerite on Jubilee slag. Both are green copper sulphates. BSE image.



Amorphous copper chloride, probably atacamite, or a partially hydrated form. This forms as green crusts on Jubilee slag where there is groundwater contact. BSE image.

Although the Jubilee and Nababeep primary slags have comparable composition and produce similar secondary minerals, textural differences were noted both on a large and a microscopic scale. Analytical and SEM-EDS results showed all to be silicate slags containing iron, aluminium and calcium, and smaller amounts of magnesium, titanium, sodium, potassium and phosphorous. The mineral content as determined by XRD and SEM-EDS is primarily amorphous iron-silica glass, olivine ($(Fe,Mg)_2SiO_4$), magnetite/spinel group (M_3O_4) and anorthite ($CaAl_2Si_2O_8$). Minor to trace copper-iron-sulphide matte has been entrained within the silicates and oxides—this is the main source of copper removal from the slag through secondary mineral formation.

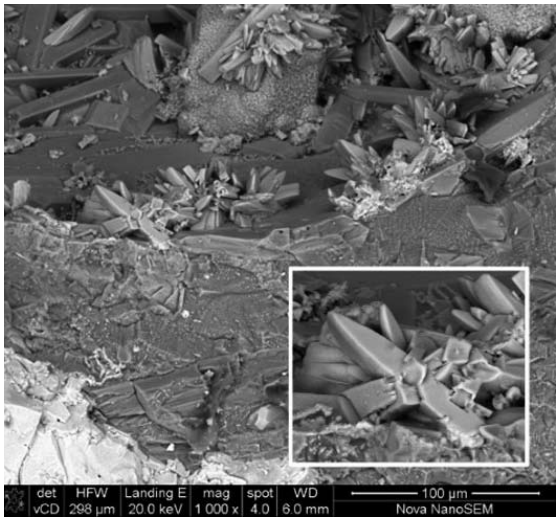
Secondary phases identified on the slag surfaces included antlerite ($Cu_3SO_4(OH)_4$) and brochantite ($Cu_4SO_4(OH)_6$), as well as other, possibly hydrated, copper sulphates, atacamite ($Cu_2Cl(OH)_3$), hydrated iron oxides and jarosite ($KFe_3(SO_4)_2(OH)_6$). Atacamite was only observed on Jubilee slag—no chlorides were recorded from Nababeep.

The copper sulphates originate from copper and copper-iron sulphide matte inclusions or veinlets entrained in the slag. SEM-EDS analysis of exposed matte inclusions provided insights as to the alteration history. A compositional comparison of the alteration shell with the original matte suggests that copper has leached out leaving an iron-enriched residue.

Transport of copper into the environment appears to be as dissolved sulphate. Brochantite forms on slag in small cracks and cavities close to entrained matte and is redissolved during higher rainfall episodes. The masses of doubly terminated antlerite crystals form in larger cavities from saturated copper

☞

This partially eroded matte inclusion on the Nababeep slag surface shows that copper is being removed as sulphate, leaving an iron oxide/hydroxide shell. BSE image.



Curved-faced brochantite crystals may be a sign of cyclical erosion and deposition. A thin layer of copper sulphate connects the cavity to the matte source and the slag surface. BSE image.

sulphate solutions, and eventually the copper will be leached into the surrounding soils. The presence of a perennial river running through the area is unfortunate, although it was probably useful for processing!

The average copper grade of the Jubilee slag is low at 0.6 %, so it seems that a great deal of the copper transported into the soils or water systems came from other sources such as rock piles, slimes dumps and material associated with the mine itself that have been used on roads and for infill. The green copper chlorides coating rocks and even slag where it is in contact with the perennial river water flow are unlikely to have originated from the slag itself.
Copper recovery by flotation from the slag heaps around Nababeep has been attempted during recent years, and it is possible that copper will be extracted in future using an oxide-based copper recovery process. Recovery of copper from Jubilee slag, however, would require breaking up the large (remarkably unweathered) slag blocks after removing the various foreign materials from the dump.

This interesting project has shown that new techniques can improve our understanding of slag stability during weathering, as well as the behaviour of entrained copper matte, such as erosion and transport into the environment. A great deal of data has been collected as part of the project and it is hoped that this can be used to inform an environmental assessment of mine waste in the Northern Cape.

I would like to acknowledge the grant received from the Andrew Geddes Bain Fund of the GSSA, which has made this study possible.

All photographs and backscattered electron images taken by the author.

Lesley Andrews

References

1. Andrews, L. A study of secondary copper minerals forming on sulphide slag from the Okiep area. Northern Cape, *REI Report*, June 2023, 36 pp.
2. Andrews, L. Use of low vacuum SEM to study slag weathering and secondary phase formation. *The Geode*, vol. 10 no. 3, September 2023, 10–12.

The slag dump at Jubilee also contains buried rock discards and iron-oxide tinted river sand.

COP28

A Geo's Reflections on COP28

Participating in COP28 was a privilege and an exceptional chance to interact with international policymakers, specialists, and visionaries dedicated to confronting the multiple challenges of climate change.

COP28 took place between the 30th of November and the 13th of December 2023 and was hosted by the United Arab Emirates (UAE). The Conference of the Parties (COPs) refers to the annual gatherings organised by the United Nations Framework Convention on Climate Change (UNFCCC). During these events, countries that are party to the convention convene to discuss and negotiate actions aimed at combating climate change. The primary aim of these COPs is to generate policy recommendations to facilitate sustainable development. It is intended to drive momentum that governments around the world can leverage to take the urgent steps needed to secure a greener future and mitigate climate change. However, the extent to which COP28 delivered on its objectives is debatable, as many participants left the talks frustrated by the lack of clear global consensus.

From our perspective, the outcomes and key take-homes in relation to mining revolved primarily around implications for commodity-rich developing countries, the definition and parameters of a just energy transition, the implementation of robust environmental and social standards, and climate finance, including the reform of conventional mining finance.

The current investments in extraction and processing are vastly insufficient to meet the expected demand of a sustainable future focused on green technologies. These technologies rely on critical materials, which encompass approximately 50 minerals, with lithium, cobalt, nickel and copper the most prominent. The need for nations to secure access to critical minerals either through mining investments or international trade is compounded by the imperative to decarbonise.

An additional layer of complexity emerges from conflicting legislative frameworks like the EU's Critical Raw Materials Regulation and the Carbon Border Adjustment Mechanism (CBAM). Without effective global governance, these discrepancies could heighten geopolitical risks and hinder international collaboration on critical environmental and economic matters.

In our opinion, in order to truly transition from fossil fuels, equitable access needs to be secured

Joshua Kilani at COP28 in Dubai.

to critical energy transition minerals. South Africa is a perfect case study of the need for a just transition not just locally but in light of international geopolitics. The highly publicised announcement in the previous year at COP27 in Sharm el-Sheikh regarding the decommissioning of the Komati coal-fired power plant serves as a poignant illustration of the potential adverse local socioeconomic effects stemming from well-intended efforts to decarbonise. Moreover, on a national level, South Africa may face challenges in transitioning rapidly enough to remain competitive in a decarbonised international market, while unable to compete with global powers to secure critical minerals.

This dilemma underscores the urgent necessity for international collaboration, bespoke policies, and supportive mechanisms to aid developing countries in transitioning toward sustainable, low-carbon economies. While COP28 was anticipated to address these challenges, its effectiveness remains to be seen.

Joshua Kilani
Managing Director of XMS

12th IMSG

12th Annual IMSG at Oribi Gorge, KZN

In late January (22–24), the 12th annual meeting of the Igneous and Metamorphic Studies Group (IMSG) took place. This was the first meeting of the society since 2019, thanks to COVID and to conflation with the Geocongress in 2023, and the first meeting in the "post-Clemens" (P.C.) era of the gathering, meeting cofounder John Clemens (Stellenbosch) having retired in 2019. It was also the first time that we as a society had agreed to brave KwaZulu-Natal in January (insert amusing Rorke's Drift reference here), but having previously experienced plastic chairs collapsing under us on the Highveld, and stifling heat under canvas on the west coast, we reckoned we had nothing to lose by trying. And as it worked out, the conference went extremely smoothly, ably organised by the host committee of Tanja Reinhardt (UKZN), Jürgen Reinhardt (UWC), Lauren Hoyer and Saumitra Misra (both of UKZN), with some societal facilitation from our President, Steffen Büttner (Rhodes U.), and facilitated by beautiful mild weather with no heavy rains nor extreme temperatures. Some organisational alacrity was required to shift the half-day field excursion to a time less threatened by inclement weather, but this was conducted seamlessly. The meeting was financially sponsored by generous donations (listed

in order of generosity) by the Geological Society of South Africa, CIMERA, Rhodes University Faculty of Science, UKZN, the GeoExplore Store, and Luhlaze Consulting.

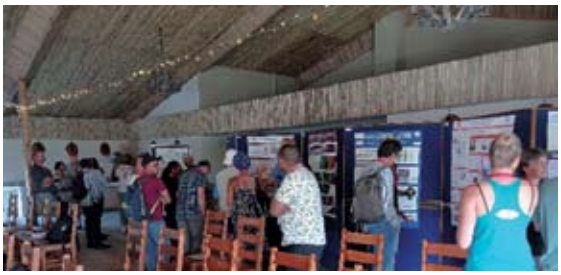
The meeting was hosted at the Lake Eland Game Reserve, on Oribi Flats, north of Port Shepstone, in southern KZN. The Lake Eland staff are to be commended for their hospitality and accommodating service. Participants were housed on site in a range of accommodations, from single units, huts for two, larger chalets, and for the adventurous (Martin Klausen and friends), tents.

The meeting was attended by in excess of 60 participants, broadly consistent with past meeting attendance, and consisted of around 50 oral presentations (plus over a dozen posters) over two and a half days, with a half-day excursion to the granulites and migmatites near Port Edward, on the KZN coast, an hour and a half away. A large number of the participants arrived by vehicle, including most of those travelling from Johannesburg and Cape Town, where they have real airports at hand. Incidentally, the online consensus is that for vehicles containing three or more people, driving produces fewer greenhouse gases or a smaller carbon footprint, if you prefer, than flying the equivalent distance. And it's cheaper. Two people per car works out about the same as flying, maybe slightly worse. So my sense is that the IMSG is probably more C-sensitive than many such meetings historically.

The meeting commenced on Sunday afternoon with registration and ice-breaker, in this case also featuring actual ice (not just broken but crushed) in the form of marguerita daiquiri slushies, a bargain at R35, and an instant hit. On Monday morning (but not too early) the actual technical programme kicked off with a welcome address from Prof. Büttner, in his first formal public appearance as IMSG President, to which he was nominated (and which he accepted; he was the obvious choice, as he already had opinions and a goatee, same as his predecessor) at the 2023 Geocongress.

It's lonely at the top. IMSG President Steffen Büttner prepares his "recognitions and thank yous" meeting-closing speech.

The Monday session contained 17 talks divided into three topical subsessions: Granitoids (including igneous petrology, geochronology, scandium chemistry, and metasomatic phenocryst modification); Metamorphism and Granites (megacryst origins, crustal tectonics, and Namibian deformation), and finally, the Bushveld Igneous Complex (mostly magmatic processes in the mafic rocks, but also some granitoid chemistry, and some thoughts on (PGE) plots). The day ended with an hour and a half devoted to the poster presentations, of which there were 16 of typically high quality, and a vigorous discussion session ensued.



Vigorous discussion ensuing.

The second day was to have commenced with a half-day field excursion to the coast, but predictions of bad weather led the organisers to prudently exercise some sleight of hand to move the excursion to Wednesday afternoon. Tuesday thus commenced with 21 scheduled talks, with topical sessions on Volcanics & Analytical Techniques

(including palaeomag, thin section image analysis, integrating aeromag with ground data, and Andean oxygen isotopes); Structure & Metamorphism (folding, shearing, ductile deformation, and shock metamorphism, plus mechanical limitations on impact melt injection modelling); Granitoids (II) (featuring mostly Kaapvaal Craton granitoid work, including studies integrating drone and remote sensing with ground data), and lastly Alkaline Rocks (examples in the Arctic and Antarctic, plus carbonatites, and even anorthosites, technically full of Na-Ca plagioclase, even if not normally typically alkaline in terms of petrogenesis). And it did actually rain in the morning, justifying the precautions.

The final day consisted of a morning session with 9 talks, on topics consisting of Kimberlites and Mantle Chemistry (emphasis on megacryst chemical and isotopic compositions, and on Cr in garnets), and Pegmatites (Kenya, Malawi, and RSA) and Meteorites (the South African meteorite record of falls and finds).

After the talks, we headed off in a small convoy of vehicles for the hour and a half drive to the Port Edward area, where a few hundred metres of granulites *sensu lato*, charnockites and/or enderbites, and migmatitic pegmatitic granites awaited us. They had been waiting for about a billion years. A lot of the foundational research on these rocks had been conducted (and published) by Geoff Grantham and colleagues in the 1980s, and we were fortunate to have Geoff as the trip leader to share his thoughts.

Geoff shares his thoughts on (literally and conceptually) the granulites.

Charnockite or enderbite; the excursion hits the beach.

Taking the opportunity to feel the sand and surf between your toes, the geological way (steel toes).

The conference final evening commenced with the speeches of thanks; they commenced with an impromptu thanks by two of our student presenters, Dr Robyn MacRoberts (nee Ormond) and Ms Sinelethu Hashibi offered thanks to the conference organisers and participants for providing a student-friendly, supportive and constructive platform for their emerging research. Steffen Büttner thanked the IMSG community, the conference organising committee, the venue hosts, and then it was time for the student awards (featuring actual monetary prizes of R2000 each). The award for Best Presentation of PhD Research went to Dr Robyn MacRoberts, for her excellent presentation on "Prolonged HTLP metamorphism during polyphase deformation, Central Zone of the Damara Belt, Namibia", conducted at the University of Johannesburg.

Robyn MacRoberts accepts her award for best PhD presentation from Steffen Büttner, on behalf of IMSG. (Saumitra Misra looks on.)

TOP:
Lizzie Tau (UJ and CIMERA) accepts her award for best MSc/Hons presentation.

BOTTOM:
Llelani Coetzer (Stellenbosch) received an honourable mention for her Honours Presentation.

The award for Best Presentation of MSc or Honours research went to Gobona Lizzie Tau (also of the University of Johannesburg) for her talk, "localised ductile shearing along the northern margin of the Johannesburg Dome – a record of contractional tectonics at ca. 2.1 Ga on the Kaapvaal Craton".

A further award of honourable mention was given to Ms Llelani Coetzer (Stellenbosch University) for her excellent presentation on her Honours work, "Conditions in the crust overlying the source of the Darling Batholith within the southernmost pan-African Saldania Belt". She got a T-shirt. Don't spend it all in one place.

A big component of the appeal of IMSG over the 16 years since it began has been its friendly, accessible, supportive environment. After two years or more of pandemic-related lockdown and related restrictions, the value of a cozy in-person meeting was very apparent. The conference featured at least ten institutions and/or organisations (from west to east, UCT, Stellenbosch, Rhodes, NWU, UJ, Wits, UFS, UKZN, Aubière (France), and the CGS). Of the 50 or so talks, 15 of them (thats 30%) were by postgrad students, all at a competitive standard. The unscheduled student thanks noted above highlighted that this philosophy is evidently "working", which is very good to hear for those of us whose student days are distant memories. It has been very gratifying over the years to watch postgrad students attend, some winning student awards, and then moving on to their next degrees, and eventually rejoining as faculty members with their own students. Some regulars were absent this year and were missed, but for good reasons, including the recent delivery of a baby, and the recent delivery of a microprobe. Both are expected to bring joy to their respective communities. Some social highlights are depicted in the following photos.

An impromptu braai on Monday night promoted inter-varsity interactions. The usual social protocols applied: "No politics, no religion, and nobody cares if the Bushveld was emplaced as a non-consecutive stack of small pulses or as massive magma blobs", and everyone went home happy at the end.

Jean-François ("Jeff") Moyen (Magmas and Volcanoes Laboratory, Aubière—Puy-de Dôme, France) had the privilege of celebrating his birthday during the meeting; it did not go unmarked.

Immediately following the speeches, it was conference dinner time.

There was also a game park, recreational activities, and Oribi Gorge to serve as additional attractions. There wasn't a lot of time to indulge in these for the conference participants, but a lonely zebra

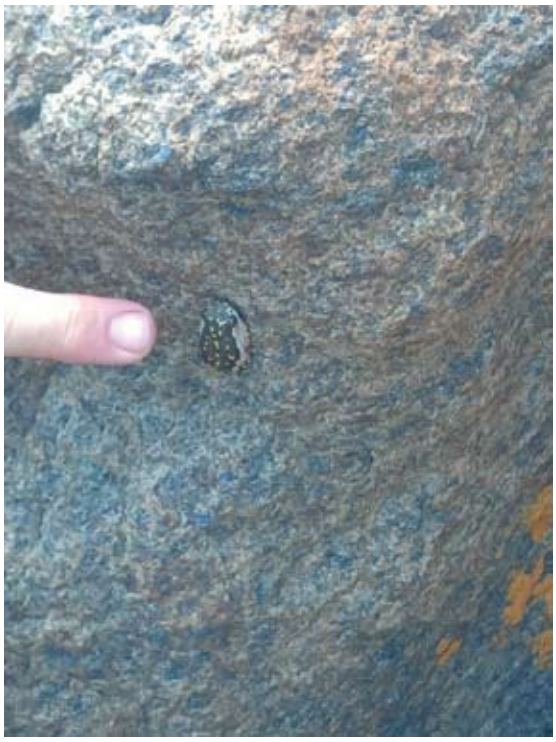
Special guest for the conference dinner, a rhebok (or a rooibok; there was some dispute; usually I'd go by the horns, but there's not a lot to work with from that angle.) In foreground, John Clemens makes sure it's none the wors for wear.

Oribi Gorge: how did such a tiny creek create such a big gorge? If only we'd let sedimentologists or geomorphologists attend our meeting, we'd know. Oh well, something to do with glaciers, maybe dykes, or aliens. Probably not important.

Steffen Büttner and Roger Gibson defy vertigo on Thursday morning.

Ernesto the lonely zebra gets his graze on, as the only ungulate in the camp area. (Not his real name; I have used this nom-de-plume to protect his privacy.)

Ungulates without a care or conception of the angst of uncertainty as to whether the 2.0 Ga metamorphism of the Limpopo Belt was just post-orogenic shearing or an actual collisional, if not orogenic, episode.



A very small frog on the enderbite, disguised from predators by camouflaging as an orthopyroxene crystal, including the exsolution lamellae showing crystallographic control. Definitely a specialised evolutionary niche. Darwin would be proud. Or concerned. I'm pretty sure there's a paper in this.

did actually come in to visit the conference dinner area one evening, and there were zebra, giraffe, and various bok visible on the hillside opposite our camp over the duration of the conference. Many conference participants took the opportunity of visiting Oribi Gorge on the morning after the conference, accessible from Lake Eland resort (about 7 km to the south of it).

The final order of business was to determine the site and frequency of the next IMSG meeting. Having established that we will recommence with annual January meetings, come hell, high-water, or Geocongress, Gary Stevens very kindly offered Stellenbosch as the hosts of the 2025 IMSG event. We look forward to it.

Steve Prevec

kilimanjaro

A Hiker's Guide to the Geology of Kilimanjaro

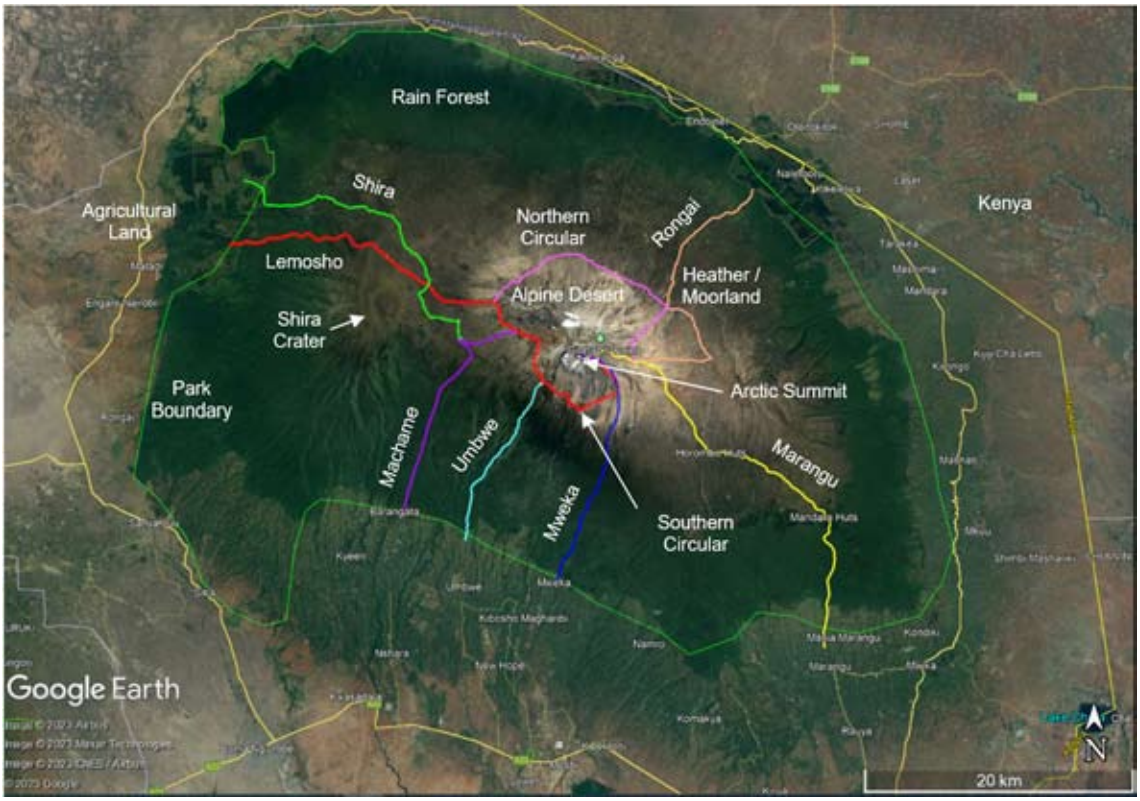
Background

Have you ever thought of climbing Mount Kilimanjaro? The hike is not only challenging, especially the summit day, but also provides a fascinating trek through a number of climatic zones on your way to the top of Africa's highest point—Uhuru Peak at 5,895 m. The geology of the trek is also fascinating and the pole-pole (slowly-slowly) hiking pace gives you plenty of time to acclimatise and to admire the surrounding scenery and the magnificent volcanic rocks. Be warned, preparation is essential as summit success rates are reported to be as low as 65%, depending on the route you take and over how many days.

Kilimanjaro comprises three discrete volcanic centres covering an area of 80 km x 48 km and towering more than 5,000 m above the regional plateau. It is situated on the border of Tanzania and Kenya, about 480 km northwest of the capital, Dar es Salaam, in an area characterised by giant free-standing volcanoes, like Mount Meru and Mount Kenya.[1] The national park is wholly within the borders of Tanzania, and is accessed by road, or by air through the international airport at the nearby town of Arusha.

This hiker's guide to some geological features of Kilimanjaro is designed to assist hikers in understanding some of the volcanic and sedimentary rocks traversed, and although it focuses on the Lemosho route, it also includes some broader descriptions of the rocks on the mountain.

Throughout this note, the author has drawn liberally from the observations made in the book: "The Geology of Kilimanjaro" describing the first geological expeditions, in 1953 and 1957, authored by C. Downie and P. Wilkinson of the University of Sheffield, and published in 1972.[2] The photographs and observations were made by the author on an ascent at the end of September 2023.



Main Kilimanjaro features and hiking routes.

History of discovery and exploration

Kilimanjaro has always captured our imagination, ever since Ptolemy of Alexandria wrote in about AD150 of "a great snow mountain". Early records spoke of a "silver-covered mountain protected by djinns" (evil spirits) and later it was speculated that this mountain was the source of the Nile.[3]

The mountain was positively identified by European explorers for the first time by Johann Rebman, a Swiss missionary, who on 11 May 1848 wrote on seeing the mountain for the first time: "At about 10 o'clock I observed something remarkably white on the top of a high mountain and first supposed it was a very white cloud … the most delightful recognition took place in my mind of an old well-known European guest called Snow."

During the mid to late 19th Century, European missionaries and explorers made several attempts to climb the mountain. A young Methodist missionary, Charles New, managed to ascend the mountain to about 4,000 m in August 1871, marking the first time that a European explorer had reached the snowline.

For 20 years thereafter Kilimanjaro attracted very little attention, no doubt associated with the decline in East African geographic interest once the riddles of the Nile source and of the great lakes were solved.

In 1887, the German geology professor Hans Meyer reached the lower edge of the ice cap on Kibo, where he was forced to turn back because he lacked the equipment needed to progress across the ice.

In 1889, Meyer was successful on his third attempt with the Austrian mountaineer Ludwig Purtscheller, summitting the highest point on 6 October 1889. On 18 October, they re-ascended Kibo to enter and study the crater, cresting the rim at Hans Meyer Notch.

In the 1940s, sightings of fumaroles and active sulphur emissions raised questions about whether the mountain was extinct. These questions were fuelled by the active melting of the glaciers, which was also of concern due to the perception that the snow melt was used for irrigation on the slopes below.

These disturbing questions led to the first geological expedition to the mountain, which took place in June 1953. At the invitation of the Tanganyika Geological Survey, the University of Sheffield assembled a party of seven geologists, who focused on mapping the mountain above 12,000 feet (about 4,700 m).

The second expedition in 1957 comprised six members from Sheffield University and formed part of the International Geophysical Year Programme. This program focussed on mapping the glaciers and the lower slopes of the mountain below 12,000 feet. This survey formed the basis for a special Kilimanjaro sheet of the Tanganyika Geological Survey, published in 1965, and the results were written up by Downie and Wilkinson in 1972.[2]

Physiography and climate

The Kilimanjaro massif is situated at 3°05' south 37°20 east, within the 1,700 km^2 Kilimanjaro National Park. The mountain rises from the surrounding plain at an elevation of about 1,600 m to the Uhuru peak at 5,895 m and is ringed by towns and agricultural activity on the warm tropical plains, which extend up to the borders of the park. Temperatures average about 30 °C on these plains and drop to below freezing on the upper reaches of the mountain. Rainwater runoff from the equatorial forest zone provides water for the numerous streams and rivers that sustain the agricultural activity on the outskirts of the park.

Kilimanjaro comprises three east–west-aligned main volcanic centres: Mawenzi (5,149 m) and Kibo (5,895 m) form prominent peaks, while Shira (4,006 m) forms a broad plateau to the west of Kibo. Shira (2.5–1.9 Ma) is part of the older (Pliocene–Upper Pleistocene) volcanism. Mawenzi (1.0–0.45 Ma) and Kibo (0.48–0.15 Ma) are part of the younger volcanism of this area. Uhuru Peak, at 5,895 m, is the highest point and it is situated on the crater's southern rim. Volcanic rocks erupted from these centres cover an area of about 6,000 km^2 and extend well beyond the borders of the National Park.

A total volume of 4,790 km^3 was erupted, including 500 km^3 from each of Shira and Mawenzi, and 3,790 km^3 from Kibo. The dominant flow directions for the three centres are southwest (Shira), east (Mawenzi) and north, south and west (Kibo).[2]

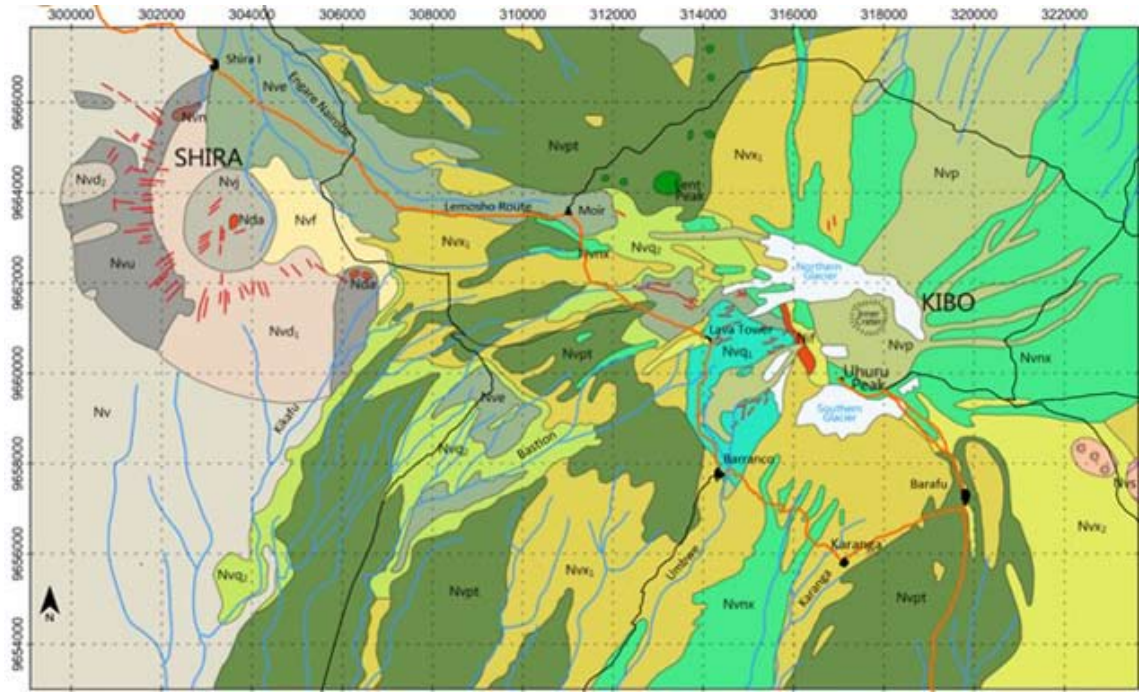
As Kibo was the latest volcanic vent, it only conforms to a typical shape above about 5,100 m. Below this elevation its lavas were dammed up and diverted by the pre-existing Shira and Mawenzi cones. Erosion of all three cones is greater on the southern side, attributed to greater rainfall and runoff. Above about 4,700 m the Kibo slopes and streams are dry, except for minor glacial runoff to the south and southwest.

Water drainage is radially away from these peaks. Erosion has given Kibo a concave shape, with the overall higher rainfall on the southern slopes of all three peaks resulting in a more dissected landscape than the northern slopes.

Shira forms an upland plateau at about 4,000 m and is bound to the west by a continuous wall known as the Shira Ridge, and to the south by a similar although more broken up ridge. The most prominent feature of the plateau is the Platzkegel, a horseshoe-shaped peak situated on the southern ridge.

A Kilimanjaro ascent will typically progress through five climatic zones, from agricultural land at less than 1,800 m (adjoining the park gates) through rain forest, at between 1,800 m and 2,700 m, a heather-moorland zone, at 2,700 m to 4,200 m, to an alpine desert zone at 4,200 m to 5,000 m, and finally an arctic summit zone. Kibo is permanently covered in glaciers, which have progressively melted over the past 200 years or more.

About 73% of the southern glacier has disappeared in the intervening 70 years between Downie's expedition and 2022. At this rate of melting the southern glacier could disappear in about 20 to 25 years' time, or before 2050.



Detailed geological map of the Lemosho Route (after Downie and Wilkinson[2]).

LEGEND

NEOGENE VOLCANICS

Related to Centres of Eruption

Shira

- Nvf — 'Amphitheatre' sediments; bedded fluvio-glacial deposits
- Nvn — Nephelinite
- Nvj — Platzkegel agglomerate lavas
- Nvd_2 — Upper trachybasaltic group
- Nvu — Ultramafite and melanephelinitegroup
- Nvd_1 — Lower trachybasaltic and basaltic group
- Nv — Undifferentiated
- Nda — Essexitic intrusive

Kibo

- Nvp — Inner Crater group; aegerine phonolite
- Nvnx — Caldera Rim group; nepheline rhomb porphyry
- Nvx_2 — Small-rhomb porphyry group
- Eruptive centres — Lent group
- Nvpt — Phonolites, trachytes, etc.
- Nvx_1 — Rhomb porphyry group including Penck rhomb porphyry and Weru Weru agglomerate
- Nvq_2 — Upper rectangle porphyry group
- Nve — Upper trachyandesite group
- Nvq_1 — Lower rectangle porphyry group. Lava Tower trachyte and lower trachyandesite groups
- Nif — Analcime syenite

Parasitic

- Eruptive centres
- Nvs — Basalt

Other

- Permanent ice
- Dyke
- Parasitic cone with crater
- Streams

Hiking routes

In a complete climb, a hiker will use an ascent route, a summit ascent route, and a descent route, which is determined by the latter.

There are six ascent paths, as follows:

Rongai Route: The Rongai Route is the only route emanating from within Kenya, and joins up with the Northern Circular path and the Marangu Route to summit.

Marangu Route (also known as the Coca-Cola Route or Tourist Route): This route gives good views of Mawenzi, and of the eastern volcanic succession.

Umbwe Route: The Umbwe route merges with the Lemosho Route at Barranco Camp. The Umbwe Route is also used as an emergency evacuation route from the western side of the mountain.

Machame Route: The Machame Route merges with the Lemosho Route at Shira II Camp.

Lemosho Route: The Lemosho Route can camp on day 3 at either Shira II Camp or at Moir Huts.

Shira Route (aka Shira Plateau Route): The route merges with the Lemosho Route at Simba Cave Camp, between Shira I and Shira II Camps.

At about 4,000 m elevation these routes all merge with a circular trail that runs around the Kibo cone called either the Southern or Northern Circular Route. From these circular paths there are three summit ascent routes: the Normal or

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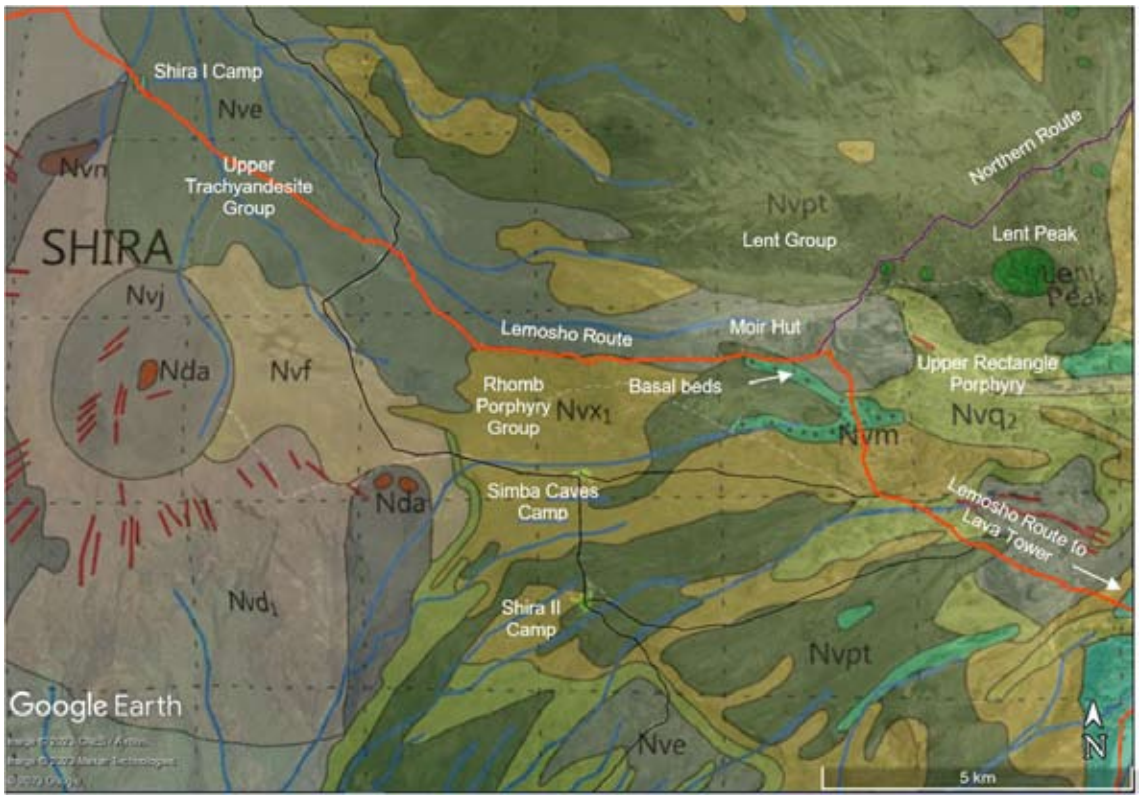

Geology of the Shira Plateau and Lent Peak area (after Downie and Wilkinson[2]).

Marangu Route, which reaches the crater rim at Gillman's Point (Rongai or Marangu Route); the Barafu Ascent Route, which reaches the crater rim at Stella Point; and the Western Breach Ascent Route (from any other route). The descent route is determined by the ascent path. If you ascended via the Rongai or Marangu Route, you will descend via the Marangu Route. From all other routes you will descend via the dedicated Mweka Descent Route.

The seven- or eight-day Lemosho Route, combined with the Southern Circular Route and an ascent via Gillman's Point, will provide the hiker with an almost complete succession through the Shira and Kibo volcanics, especially if the hike overnights at the Moir Huts.

Regional geological setting

Kilimanjaro is the largest of about 20 volcanoes located near the eastern flank of the southern end of the East African Rift Valley (EAR). The EAR is part of a 'Y'-shaped active continental rift system where the continental lithosphere is being stretched and thinned to form two new plates: the Nubian and the Somalian plate.[3]

The rifting in the EAR began in the Miocene around 22–25 million years ago and continues today. It is thought that as the Nubian and Somalian plates continue to drift further away from each other, the lithosphere between them will grow thinner and drop below sea level. New oceanic lithosphere may form along the centre of the rift, producing a narrow ocean basin with its own mid-ocean ridge. The EAR began to assume its present shape about 2 Ma ago.[1]

The park itself is dominated by volcanic rocks from the three main volcanic vents, Shira, Mawenzi and Kibo. The western part is underlain by Shira lavas, by parasitic lavas with volcanic cones, and in the northwest by Ol Molog lavas. The Shira plateau averages about 3,500 m and slopes gently to the west, terminating at the Shira Ridge. The central part of the park is underlain by Kibo volcanics, while the eastern part is underlain by Mawenzi undifferentiated lavas and agglomerates, and by parasitic lavas with volcanic cones. The southern boundary of the mountain is deeply incised, particularly at the Kibo Barranco.

Geoheritage

Lava Tower, looking towards the southwest.

The detailed map of the hiking route is shown in the figure below, and is based on the map produced by Downie and Wilkinson in their 1972 publication,[2] and uses the same terminology and map abbreviations. The Lemosho route is shown in orange, and the other routes in black. The dedicated Mweka Descent Route is also shown in orange.

The overnight camps used on this particular ascent are shown on the map. The Lava Tower is also shown, but not the Western Breach ascent, which extends upwards from the Lava Tower to the crater rim and onwards to Uhuru.

The Lemosho hiking route traverses undifferentiated Shira volcanics to just east of the Shira Ridge, and onto the Upper Trachyandesite Group (Nve) of the Kibo Volcanics in the vicinity of Shira I Camp. From there the route traverses across the slightly easterly dipping Shira plateau, until encountering phonolites of the Lent Group. Rocks and boulders of this group of lavas are scattered across the landscape. After crossing the rescue road, the path follows the Lent Valley along the contact between the basalts and phonolites of the Rhomb Porphyry Group (Nvx_1) and the Upper Trachyandesite Group (Nve). On the northern side of the valley, glacial moraines can be seen. Close to Moir Hut, the trail follows the contact between the Rhomb Porphyry Group and an outlier of the basal beds of the Caldera Rim Group.

A short hike to the north from Moir Hut along the Northern Circular Route takes the hiker to close to the Lent Peak and associated lava plugs, and across the contact between the Upper Trachyandesite Group (Nve) and the lavas of the Lent Group (Nvpt). From this trail there are magnificent views of thick individual lava flows of the Upper Trachyandesite Group (Nve) and of the Upper Rectangle Porphyry Group (Nvq_2), both showing pahoehoe surfaces.

From Moir Hut the route turns southwards, recrossing the phonolites and basal beds, and in succession the Rhomb Porphyry Group (Nvx_1) and the Upper Rectangle Porphyry Group (Nvq_2), following the contact between these two rock types

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where the trail from Moir Hut joins the trail from Shira II Camp. The route then crosses onto the Lent Group (Nvpt), back onto the Upper Trachyandesite Group (Nve), and finally encountering the Lower Rectangle Porphyry Group (Nvq_1) at Lava Tower. These are the oldest Kibo lavas encountered on the trail.

From Lava Tower the trail stays on the Lower Rectangle Porphyry Group (Nvq_1) until encountering the Rhomb Porphyry Group (Nvx_1) close to Barranco Camp. Spectacular lava flows of the Lower Rectangle Porphyry Group (Nvq_1) are exposed on the Barranco Wall, crossing back onto Rhomb Porphyry Group (Nvx_1) interfingered with sediments and lava flows of the Caldera Rim Group (Nvnx) until reaching Karanga Camp. Spectacular views of Kilimanjaro can be seen along this route, especially if the weather is favourable.

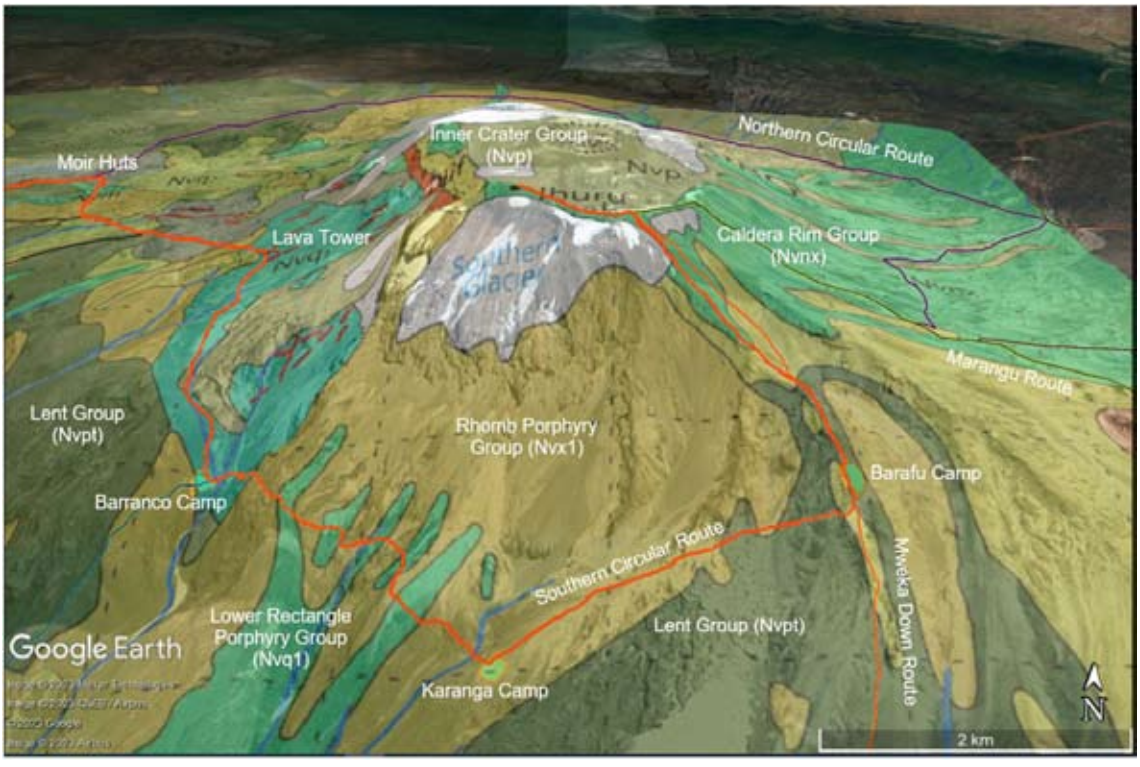
Between May to October a dry northeast wind blows at altitudes above about 4,000 m. As this wind swirls around the mountain, it sucks up warmer clouds from below, resulting in much of the snowfall falling on the peak being from this moisture. If this wind is blowing strongly, the morning cloud cover is dissipated leaving the mountain clearly exposed to trekkers hiking the southern and northern circular routes. The cloud cover will frequently reappear in the afternoon and will blanket the mountain from view.

From Karanga the trail follows the Rhomb Porphyry Group (Nvx_1) and crosses onto the Lent Group (Nvpt) close to Barafu Camp, where spectacular ersional deposits are encountered. From Barafu the trail follows the Lent Group (Nvpt) upwards, and onto the Caldera Rim Group (Nvnx) lavas until the summit.

The Lemosho Route thus crosses an almost complete succession of Shira and Kibo volcanics, although not necessarily in chronological order. The juxtaposition of certain rock types, and the lack of exposure of others, is largely due to the cycles of deposition and erosion that characterised the Kilimanjaro lavas.

The Kibo volcanic rocks

Kibo volcanism began in the early Pleistocene and in places the earliest lavas are indistinguishable from the Shira and Mawenzi lavas. Lavas gradually became more undersaturated, culminating in the nepheline-rich Caldera Rim and Inner Crater



The geology of the summit area,[2] draped on a Google Earth terrain image.

Sequence of bedded sand and gravel containing rounded boulders, on the west side of Karanga Valley.

Groups. During the lengthy periods of erosion that separated the episodic volcanism deep valleys were cut, resulting in the cone not growing much from its height in the Lower Pleistocene. Not all the lava erupted from the central vent, and flank fissures, such as the Lent and Lava Tower vents, were prominent.

Periods of volcanic eruption were followed by periods of erosion. In total 10 eruption episodes are recognised, each followed by a period of erosion.[2] The most extensive lavas, named the Rhomb Porphyry Group, erupted about 360,000 years ago, in lava flows about 15 m thick, but extending up to 50 metres thick.[3]

The periods of glacial erosion in between the volcanism sculpted the profile that we see today. About 100,000 years ago a huge landslip breached the south crater wall and carried away about 1,000 m of the cone, thus creating the impressive Barranco valley and wall.

There is little pyroclastic rock associated with any of the erupted groups, with volcanism progressively weakening with time. About 200 or more years ago a mild puff left ash around the rim of the vent, and eruption ceased.

The Lower Trachyandesite Group (Nvq_1)

The Bastion and Umbwe streams have created deep erosional incisions to the southwest of Kibo, exposing these oldest lavas. In the Bastion stream these lavas are exposed immediately east of the Lava Tower. The lava flows are about 4 m thick, with a layer of flow breccia at the base. The lavas are fine-grained trachyandesites with crystals of labradorite 2 to 4 mm in length.

The Lava Tower Trachyte is exposed at Lava Tower itself, and towards the southwest. The lavas are green and fissile, with well-developed flow structures and a green chloritic sheen. Obsidian fragments are common.

The elevation of the base of the Lava Tower is at 4,600 m, the highest point on the southern circular route until the Barafu Camp is reached. The tower has weathered into large mostly blocky and angular boulders at the base.

Kibo shown from Karanga Camp.

The Upper Trachyandesite Group (Nve)

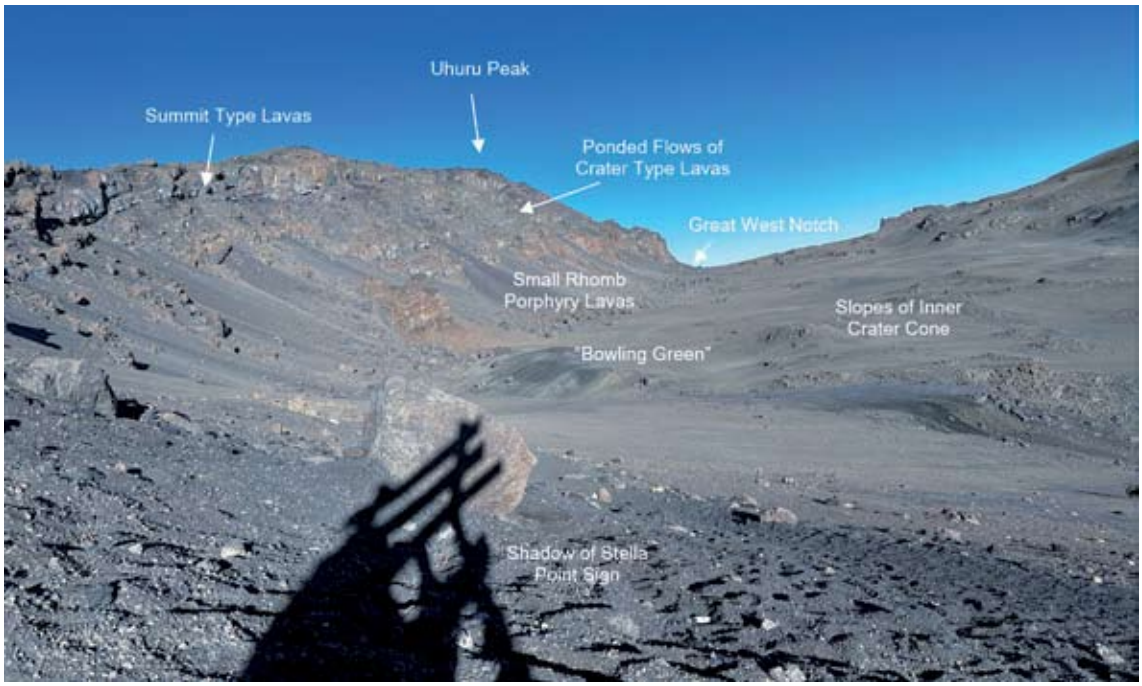
This is the first group of lavas to have a demonstrably wide extent. It outcrops on the upper reaches of the peak, and extends across much of the Shira Plateau, especially in the Oehler and Lent valleys. It also appears on the Machame Escarpment and as inliers in the Lent Group. The lava flows average 3 m thick, with a thin flow breccia at the base.[2]

The Lemosho Trail between Shira I Camp and Moir Hut traverses the Upper Trachyandesite group (Nve) for much of this section of its length. The Shira plain is gently sloping, and is crossed by westerly trending streams, which drain into the Engare Nairobi stream. The vegetation is moorland grasses and small bushes and trees. The path crosses the rescue road, where a turn to the south will take the hiker to the Simba Caves camp and on to Shira II camp. The Upper Rectangle Porphyry group (Nvq_2) is not encountered on this trail.

At 5.3 km from Shira I the path follows (for 2.6 km) the contact between the Upper Trachyandesite group (Nve) and the Rhomb Porphyry group (Nvx_1) to the south. The path then encounters Lent Group phonolites, basalts and debris flows, before passing back onto Upper Trachyandesite lavas for the last 500 m. A 140 m climb at 10% gradient northwards from Moir Hut along the Northern Circular Route takes the hiker onto the Lent Group lavas, with excellent views of the Lent Peak and associated lava towers.

The Shira Plateau is scattered with outcrop and discrete boulders and rocks of the Upper Trachyandesite group. Some of the rounded boulders can be quite large, and along the trail measure up to 3 m x 3 m in size. The rock is porphyritic and the frequently aligned and clustered rhombohedral feldspar crystals are set in a fine-grained greyish groundmass. The crystals are 3 mm to 5 mm in length, and the rock is frequently covered by greenish and dark yellowish lichen. Grasses are ubiquitous on the gently undulating plateau.

The lavas of the Upper Rectangle Porphyry Group (Nvq_2) are exposed in the Lent valley to the south and southwest of Lent Peak. They form prominent 3 to 10 m thick lava flows with pronounced pahoehoe surfaces and terminations. The lavas are visible from the hike up the northern route towards Lent Peak.



Panorama of Uhuru Peak and the Inner Crater lavas, taken from Stella Point.

The Rhomb Porphyry Group (Nvx_1)

The Rhomb Porphyries are the flows most characteristic of Kibo. East of Kibo the flows crossed the saddle and were diverted north and south of Mawenzi. Westwards they reached the Shira caldera floor and overlapped the Shira volcanics to the north and northwest. The lavas extend up to 40 km northwards and a similar distance to the south. In the south the lava flows are confined between two upstanding arches situated to the east and west, limiting their lateral extent to about 15 km wide in the upper reaches of the mountain.

The Rhomb Porphyries are remarkably uniform massive lavas. The matrix is dark grey and fine-grained. The rhombohedral feldspar phenocrysts are typically 30 to 40 mm in length, constitute 30 to 60% of the rock, and are frequently sub-horizontally aligned. Lava flows are typically 8 to 30 m thick, with pahoehoe surfaces. The rocks are dark coloured, and occasionally vesicular.

In the photo of Kibo the Rhomb Porphyry extends from the ridge on the right, to the ridge at the top, and to the Big Breach glacier situated to the left of the photo. The colour and slope angle change marks the change from the Rhomb Porphyry to the Caldera Rim Group.[2]

The porphyry is covered by moraine scree at the concave knickpoint half-way down. Rivulet incisions in the moraines attest to previous and ephemeral water flows from glacial melt.

Horizontal lava flow layering is apparent in the immediate face, with slightly southeasterly dipping lava flow layering apparent on the right-hand side of the photograph. The rock face is incised with narrow, erosion cracks. The rocky Karanga Camp, from which the photo is taken, is on Rhomb Porphyry rocks, and good exposures can be examined.

The pre-Lent Group erosion

Before the Lent Group there was a period of erosion during which the Rhomb Porphyries were eroded and considerable sediment deposits accumulated. Erosion removed the Rhomb pPrphyries from the lower Lent Valley, in some valleys to the north, and in some areas around the Oehler Valley and the Barranco at higher altitudes. In these places the Lent Group rests directly on Rectangle porphyries and trachyandesites.

This erosion was partly glacial with glacial and tillite beds noted beneath the Lent trachytes at a number of localities. These were recorded on the Machame escarpment, at the Galuma Caves, and

View of Mawenzi from Barafu Camp, looking eastwards.

at the Karanga outwash. The latter deposits can be viewed in the valley immediately to the west of Barafu Camp, where a great thicknesses of sand and boulder sediment fills U-shaped depressions in the Rhomb Porphyry. Here the boulders, largely comprising Rhomb Porphyry rocks, reach diameters of 3 m across, although the sediment is largely composed of bedded sand and gravel. Along the path large boulders of lava can be seen delicately balanced on weathered coarse-grained sediments.

The Lent Group (Nvpt)

The Lent Group consists of a widespread group of trachytes and phonolites, spread over the northern, northwestern, and southern flanks of the mountain, and emanating from four main vents.

An almost unbroken field of phonolite covers the northwest flanks of Kibo covering a triangular area of about 310 km^2. The field widens downwards and below the forest it extends northwards and to the northwest, reaching about 32 km from the Lent Peak. Several outliers of Rhomb Porphyry are exposed in river valleys. Glacial erosion in the Lent Valley has isolated an outcrop of Lent Group lavas along the southern side of the valley. The Lemosho Trail traverses this outcrop within a kilometre of Moir Hut.

On the southwest slopes of Kibo the Lent Group can be traced from the lower Barranco across the Bastion Stream to beyond the Oehler Valley. The exposures are limited by an almost continuous cover of glacial deposits. These lavas extend down into the forest zone and are last seen near Machame.

On the southeast slopes of Kibo, the Lent Group is apparent immediately east of the Karanga Camp and is traversed on the steep path leading up to the camp, which is itself situated on the Lent Group lavas. Upslope the lavas disappear under the Rhomb Porphyries and under the Caldera Rim Group. The lateral extent of the lavas increases down slope and becomes dissected by valleys where underlying rocks are exposed. The Lent Group extends to just beyond the southern boundary of the park, where it merges with the flows down the southwestern slopes, to form an almost continuous lateral strike of 18 km.

The Machame Route ascent is almost entirely on Lent Group lavas, as is the Umbwe Route, until these reach the Southern Circular path.

On the northeast slopes of Kibo phonolites of the Lent Group appear below the Caldera Rim Group. The distribution appears to be limited, but isolated flows can be seen along the Rongai Route.
The Lent Group lavas are similar wherever they occur, consisting of fine-grained phonolites and phonolites with occasional sparse small feldspar phenocrysts. The flows are invariably accompanied by quantities of obsidian occurring at the sides or base of flows. The flows vary from 3 to 10 m thick and flow structure is strongly marked.

The flows appear to have occupied shallow valleys and show a pattern of narrow meandering lava fingers. On occasions the flows occupy deeper valleys and these exhibit tunnel collapse structures.

The four phonolite fields appear to have different sources, with the northwest and southwest fields being from flank fissures. The northeast and southeast lavas are probably also from flank fissures.

The Caldera Rim Group

The Caldera Rim Group consists mainly of flows of rhomb porphyry with visible nepheline phenocrysts. It is of recent formation, the flows retain their original form, and they are well exposed in the cliffs of the present caldera. Gillman's Point, Stella Point and Uhuru Peak itself are located on these lavas. The caldera is rimmed by these lavas, and individual flows can be traced to the east, north and northwest. On the northeast they completely cover the underlying rocks. The Caldera Rim Group can be subdivided into three distinct units as follows:

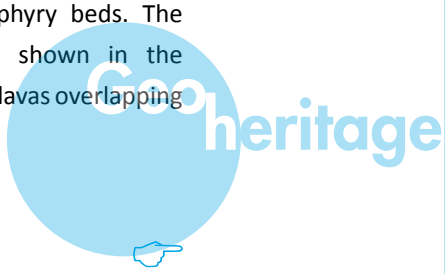
- The basal beds are an impersistent and variable set of beds comprising tuffs, agglomerate, pumice and boulder beds.
- The Camp and Crater lavas are generally nepheline poor, contain rhomb-anorthoclase phenocrysts, and reach a thickness of about 30 m.
- The Summit lavas in turn comprise three distinct lava groups based on the composition of the feldspar phenocrysts: sanidine type, prismatic orthoclase type and rhomb orthoclase type. The lava flows followed radial valleys that do not coincide with the present-day valleys and are more likely to form ridge cappings. Only the Klute and Lent valleys have persisted since this period.

Close to Moir Huts the path follows the base of a debris flow, mapped as Caldera Rim Group rocks. In this deposit, which is roughly 6 to 10 m thick along the outcrop that we traversed, rounded to sub-rounded to angular lava boulders and lighter-coloured angular fragments are jumbled together in a matrix consisting of fragments of a variety of sizes and compositions. It is underlain by the lighter-coloured phonolites mentioned earlier and is overlain by a 5 to 8 m-thick massive lave flow.

Subsequent to the eruption of the Small-Rhomb Porphyries, which overlie the Lent Group, a period of erosion followed, which reached depths of up to 30 m. Ice is thought to be the main erosion agent.
The nepheline rhomb lavas ring the caldera on the southern side but are obscured by ice on the northern rim. On the southern rim the scarp follows the caldera rim fault in a slightly northeastern direction resulting in the lava sequence being exposed looking northwards.

The photo of Uhuru Peak is taken from Stella Point (the shadow of the sign is shown in the immediate foreground) looking towards Uhuru Peak. The crater itself is to the right of the photo.

The scarp shows Summit-type lavas gently dipping to the southeast, underlain by Camp and Crater lavas, and by Small-Rhomb Porphyry beds. The Great West erosional notch is shown in the background, with the Inner Crater lavas overlapping in the centre of the photo.



The upper edge of part of the southern glacier. Taken half-way between Stella Point and Uhuru, looking south.

In this photo the Inner Crater lavas dip outward at 10˚ towards the south.

The underlying Small-Rhomb Porphyry Group forms the base of the scarp, but it is largely obscured by talus. It forms the rim and floor of the basin in which the flat-lying Inner Crater lavas accumulated.

The rocky promontories of Stella Point and Gillmans Point are formed by massive flows of Summit lavas. The cliff beneath is formed from Camp lavas. These tend to fill valley floors and dip outwards at 30˚. No remnants of the Caldera Rim Group are preserved in the 200 m-wide Great West Notch. To the north of this gap, the Caldera Rim lavas can be found on the outer rim, where they pass under ice further north.

On the western slopes of Kibo the lavas can be traced for considerable distances, where they tend to be of Summit type.

Boulder beds, tuffs and agglomerates of the basal beds have been identified in the Lent Valley.

Several large flows of nepheline rhomb porphyry have been mapped on the southern slopes of Kibo, but no basal beds. The east slopes of Kibo are largely covered by nepheline rhomb porphyry extending onto the saddle. They increase in number towards the northeast corner where they completely obscure the underlying lavas.

The Inner Crater Group

The last volcanic episode formed the Inner Crater Group, by which time the Kibo had reached its present topographic form. Where the Inner Crater lavas spilled over the rim flanks, they followed pre-existing valleys, scoured by glaciation.

The Mawenzi volcanic rocks

Mawenzi has been recognised as Kibo's twin, though it is much smaller and it was first ascended by Fritz Klute in 1908. At 5,149 m, it ranks as the third highest peak in Africa. It is deeply eroded with a treacherous and jagged summit crest, and deeply eroded steep slopes. It is believed that the end of Mawenzi volcanism was penecontemporaneous with the early stages of Kibo volcanism, particularly with the Lava Tower trachyte.[2] The later Kibo lavas overlie Mawenzi, particularly in the Saddle area between the two peaks.

The lavas are not characterised by large lava type units, although the lavas gradually change from basalts to trachyandesites. Because of this, and the intermingling of lavas from Kibo, Mawenzi and the many parasitic eruptive centres, it was not possible to separate the lavas. However, two main groups have been recognised: the older Neumann Tower Group is basaltic, non-porphyritic, feldspar-microphyric, or with augite and olivine phenocrysts. The upper Mawenzi Group lavas are younger and overlap in time with the later flows of the Neumann Tower Group. They are trachybasalts

and trachyandesites with large tabular feldspar crystals.

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The full report can be obtained from Matt Mullins on request at matt.mullins@snowdenoptiro.com or matt.mullins10@gmail.com.

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mineral scene

Copper from Namibia

The 1992 Mineral Resources of Namibia[1] publication lists and describes 460(!) known copper deposits in the country, and no doubt more could be added to the list since then. These range in size from minor showings of copper mineralisation to major Cu-Pb-Zn deposits.[2-4] Most of these occurrences are characterised by sulphide mineralisation of oxide facies, but some contain 'native' or pure copper, and it is the latter that are featured here.

Perhaps one of the most well known and most productive copper-specimen-producing localities is the old Onganja Mine in the Khomas region.[5] This deposit produced a prodigious amount of native copper. Extremely large specimens are known, including one solid copper specimen weighing 150 kg on public display at the Geological Survey in Windhoek and a 400 kg specimen is also known to exist. Onganja specimens vary greatly in form and habit from ugly, solid lumps, to others consisting of fine, filigree copper wires and dendritic arborescent varieties such as the one shown here. Associated minerals include calcite, cuprite variety chalcotrichite, quartz, malachite and chrysocolla.

The other famous copper-bearing deposit is the Tsumeb Mine. In contrast to the many Onganja specimens, Tsumeb appears to have produced relatively fewer copper specimens and those that are known differ considerably from the Onganja material. Tsumeb copper is generally far more delicate and sometimes even displays bizarre habits such as some of the ones illustrated here.

The remaining two copper specimens shown here are from Otjihase[6] and Klein Aub[7].

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Twinned featherlike copper with a small calcite enclosing cuprite variety chalcotrichite at the base, 3.2 cm. Onganja Mine, Namibia. (Specimen and photo: Bruce Cairncross)

Bright dendritic copper specimen with a later-formed calcite crystal, 2.1 cm. Onganja Mine, Namibia. (Specimen and photo: Bruce Cairncross)

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Copper, 7 cm. Onganja Mine, Namibia. (Specimen and photo: Bruce Cairncross)

Bizarre smooth wire-like copper, 3.8 cm. Tsumeb Mine, Namibia. (Specimen and photo: Bruce Cairncross)

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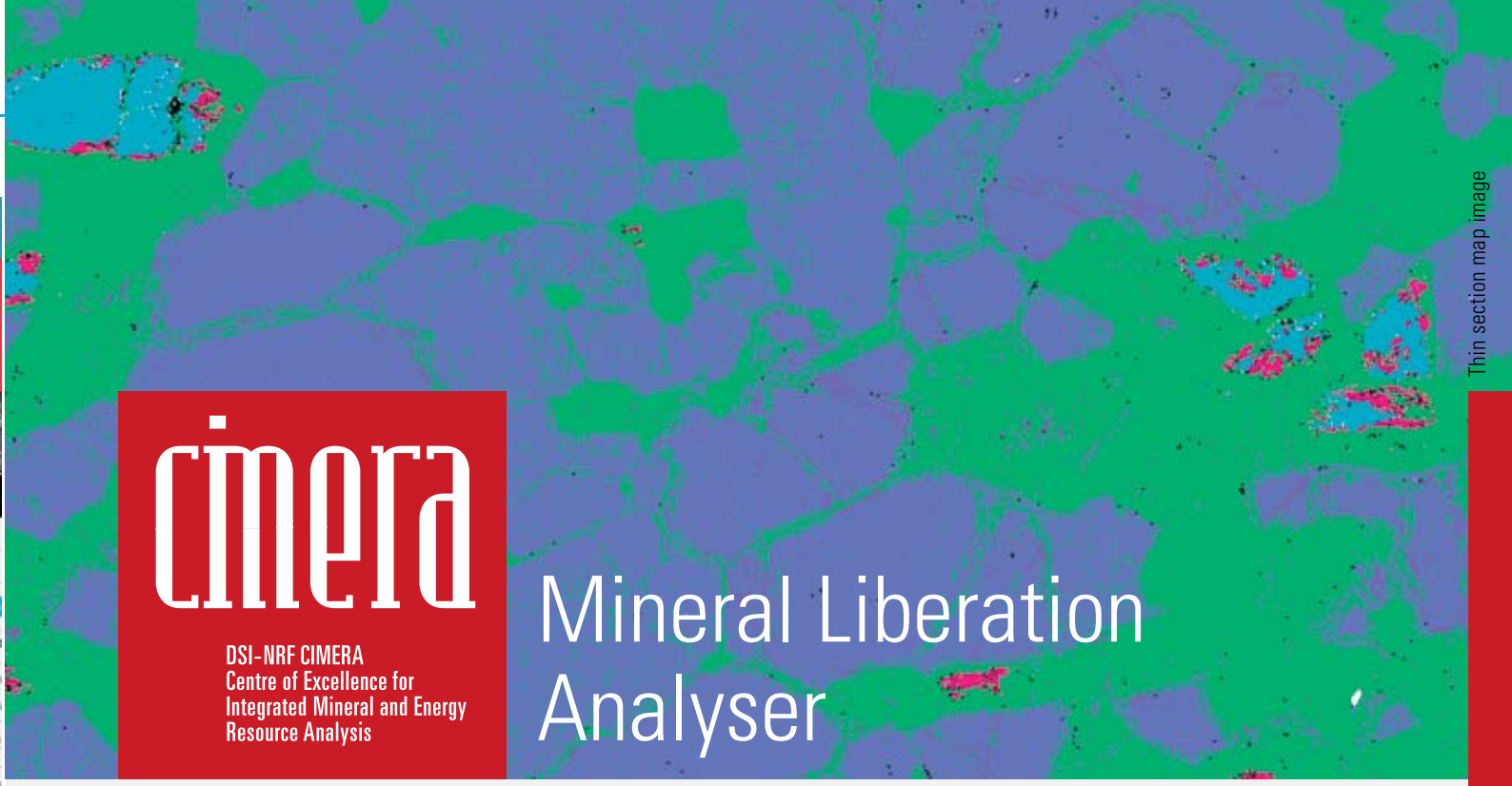
A delicate spray of copper perched on white calcite and associated with yellow mimetite. Field of view is 3 cm. Tsumeb Mine, Namibia. (Specimen and photo: Bruce Cairncross)

A Tsumeb specimen displaying an interesting paragenesis. A large rhombohedral calcite has dendritic copper overgrown. The entire specimen was then coated by a second generation of smaller calcite crystals that partly coat the copper. The field of view is 1.7 cm. Tsumeb Mine, Namibia. (Specimen and photo: Bruce Cairncross)

Flattened platelets of copper partially imbedded in quartz. Field of view is 4 cm. Klein Aub Mine, Namibia. (Specimen and photo: Bruce Cairncross)

Flattened plate-like specimen of copper from the Otjihase Mine, Namibia, 5 cm. (Specimen and photo: Bruce Cairncross)



Thin section map image

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The **MLA (QUANTA 650 FEG SEM)** is an Automated Scanning Electron Microscope equipped with Energy Dispersive X-ray Spectrometry designed for high-resolution imaging, rapid automated data collection, and mineral phase identification. The data is derived from two-dimensional measurements from the exposed surface of either a standard thin section or a 25/30mm diameter polished section. The ability of unattended analysis on multiple sections leads to a larger throughput of data.

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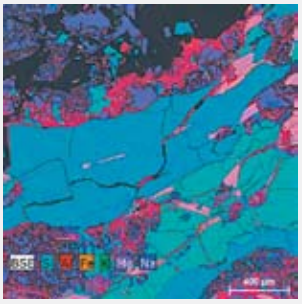
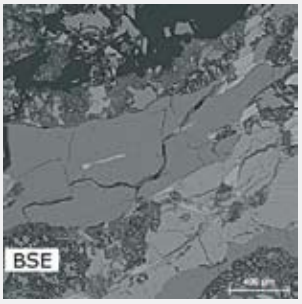
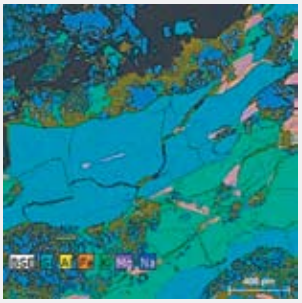
Automated SEM analysis
Detailed mapping of geological material (milled or in-situ)
Determine mineralogical composition
Particle detail:
- Liberation
- Grain Size Distribution
- Mineral Association

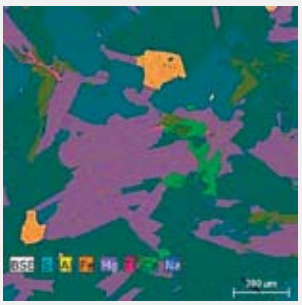
SAMPLE TYPES:
Standard thin section
Milled material set in resin blocks (25/30mm diameter)

ORE TYPES:
Fly ash
Precious metals
Base metals
And other commodities









SEVICES AVAILABLE TO: Academia and Industry

ENQUIRIES: Contact **gabriellef@uj.ac.za** or **cimera@uj.ac.za**

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MINSA
Mineralogical Association of South Africa
A division of the GSSA

Book Prize

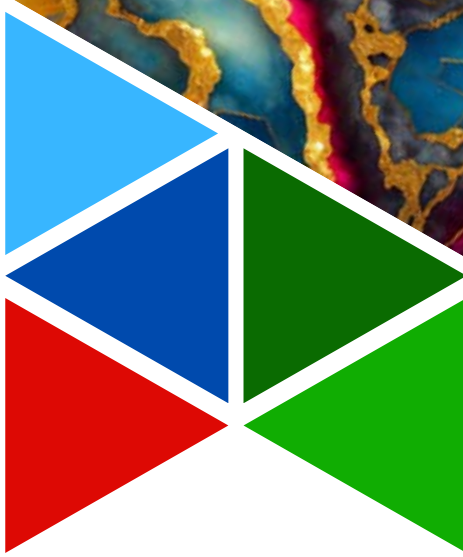
The **Minsa 2024 Book Prize** nomination call is now open!

We kindly request that you promote this opportunity to your institution's relevant stakeholders, or alternatively, you may suggest appropriate candidates yourself. If feasible, we encourage you to forward this email to the relevant Department Heads and/or Faculty Supervisors at your institution/university.

Attached to this email, you will find all the necessary documentation regarding the Book Prize. The 2024 award submission deadline is April 2024. Nominees can be registered by scanning the QR code or clicking on the Nominate button.

Thank you for your cooperation and support.

Nominate



MINSA

Mineralogical Association of South Africa

A division of the GSSA

Mineralogists, Scientists, Students, Enthusiasts.

Who We Are

MINSA was established in 1979 to foster interaction within the mineralogical community of South Africa. We are a specialist division of the Geological Society of South Africa (GSSA) and are affiliated with the International Mineralogical Association (IMA).

MINSA organises various events of interest to both professional and amateur mineralogists, geochemists and petrologists. We promote access to cutting edge developments in the field through meetings, symposia and workshops, the largest of which was the IMA2014 international conference.

Membership Benefits

- Opportunity to interact with peers in the mineralogy, petrology and geochemistry fields
- Reduced fees for attendance of symposia and workshops organised by MINSA
- Free attendance of quarterly topical talks by eminent scientists
- Participation in field trips to exciting and interesting sites, laboratories and factories of mineralogical interest, typically free of charge
- Events at which family participation is encouraged, in stimulating the interest of a new generation of mineralogists
- Quarterly newsletter of MINSA activities (The Geode) and upcoming events of interest to the community. Special themed editions are now a common occurrence
- Opportunity to address issues relating to the mineralogical community

Becoming a member is easy

Scan the QR code or click the sign up button.
Complete the membership form.
WELCOME!

Sign Up

A L Du Toit Memorial Lecture

University of the Free State

Photo credit: Ernest Moitsi

Barberton Branch, GSSA

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Western Cape Branch, GSSA
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University of the Witwatersrand
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Robyn Symons

GSSA events 2024

DATE	EVENT	LOCATION
09 Apr	3D Geological Modelling (TECT)	Online
16 Apr	Advanced Excel for Geoscientists (Earthlab)	Online
TBC	Titans of Industry	Jhb
02-03 May	Sampling & Data Management	Online
25-26 May	KZN Brittle Deformation Field trip	KZN North Coast
04 Jun	GIS for Exploration	Online
24 Jun	Project Management for Geologists	Online
2-3 Jul	Map Making (MINROM)	Online
20 Jul	Marine Geology of Southern Africa	TBD
06 Aug	Intro to Drilling workshop	Online
12 Aug	Vertical trip through the Bushveld	Online
15-18 Aug	100yr Merensky (Roger Scoon)	Rustenburg
19-23 Aug	100yr Merensky Main Event	Hunters Rest (Rustenburg)
3-25 Sep (4 x ½ days)	Drilling Methods and Techniques (Colin Rice)	Online
3 Sep	Professionalism & Ethics	Online
Sep	Data Analytics / Machine learning Hybrid	(Jhb)
01 Oct	ESG Update Workshop	Online
08 Oct	New SACNASP Bill (Webinar)	Online
23-24 Oct	Mineral Economics (MR Classification, financial valuation, sustainability)	Online
07 Nov	Mineralogical Instrumentation (MINSA)	Hybrid (Jhb)
21-22 Nov	African Exploration Showcase	Jhb

Geological Society of South Africa

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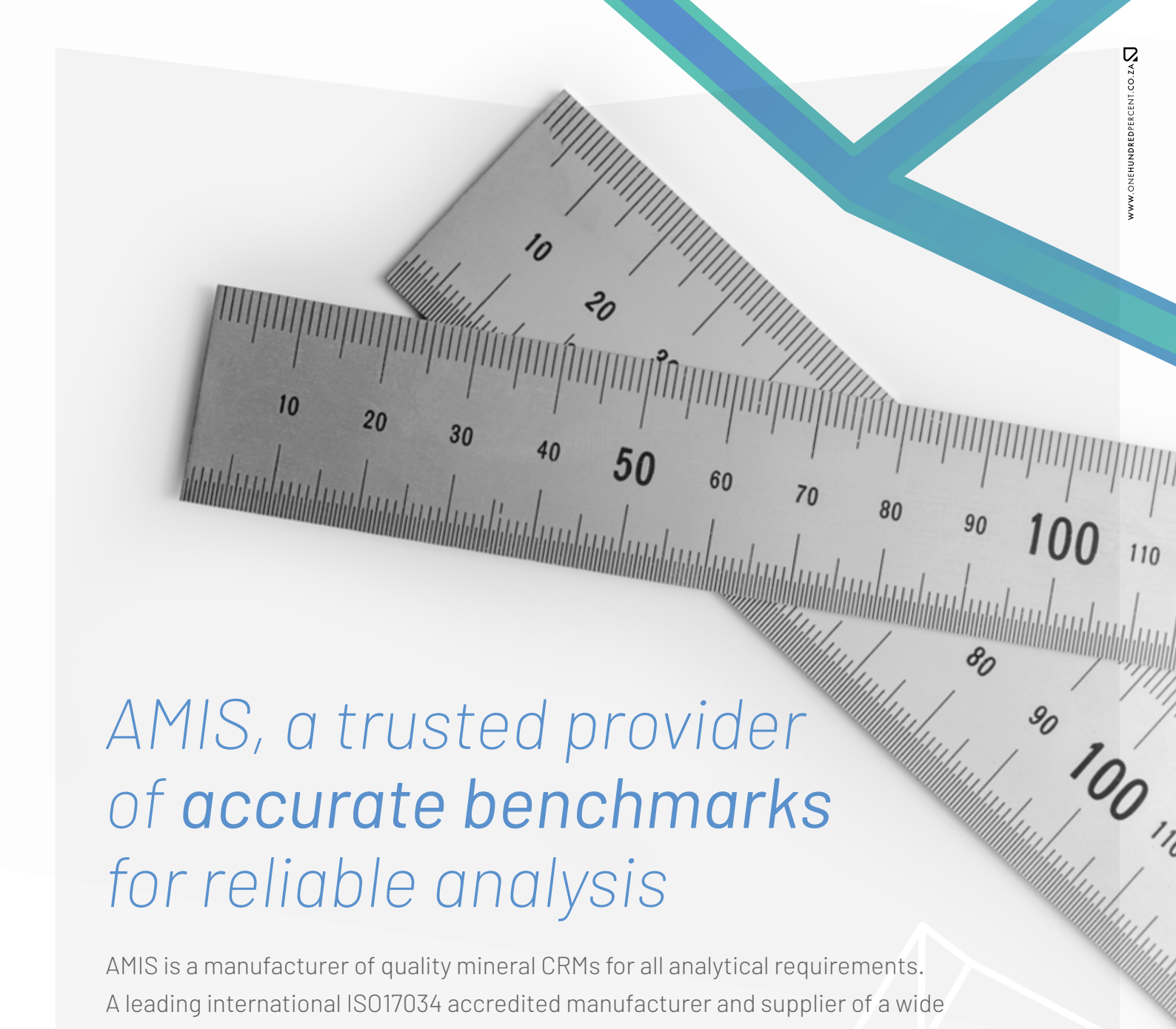

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rates card 2024 incl VAT

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Geobulletin is published by the Geological Society of South Africa (GSSA) and appears quarterly during March, June, September and December each year in digital and print format.

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Banner (horizontal)	R1 250.00	R1 150.00

Special Positions (Front & Back)	Inside Cover F&B R10 000.00	Outer Cover F&B R12 000.00

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June issue:	15 May 2024
September issue:	15 August 2024
December issue:	15 November 2024

5. CANCELLATIONS

At least 4 weeks prior to deadline

6. CIRCULATION

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7. ADVERTISING BOOKINGS AND SUBMISSION

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