DSI-NRF CIMERA Annual Research

# COLLOQUIUM'23

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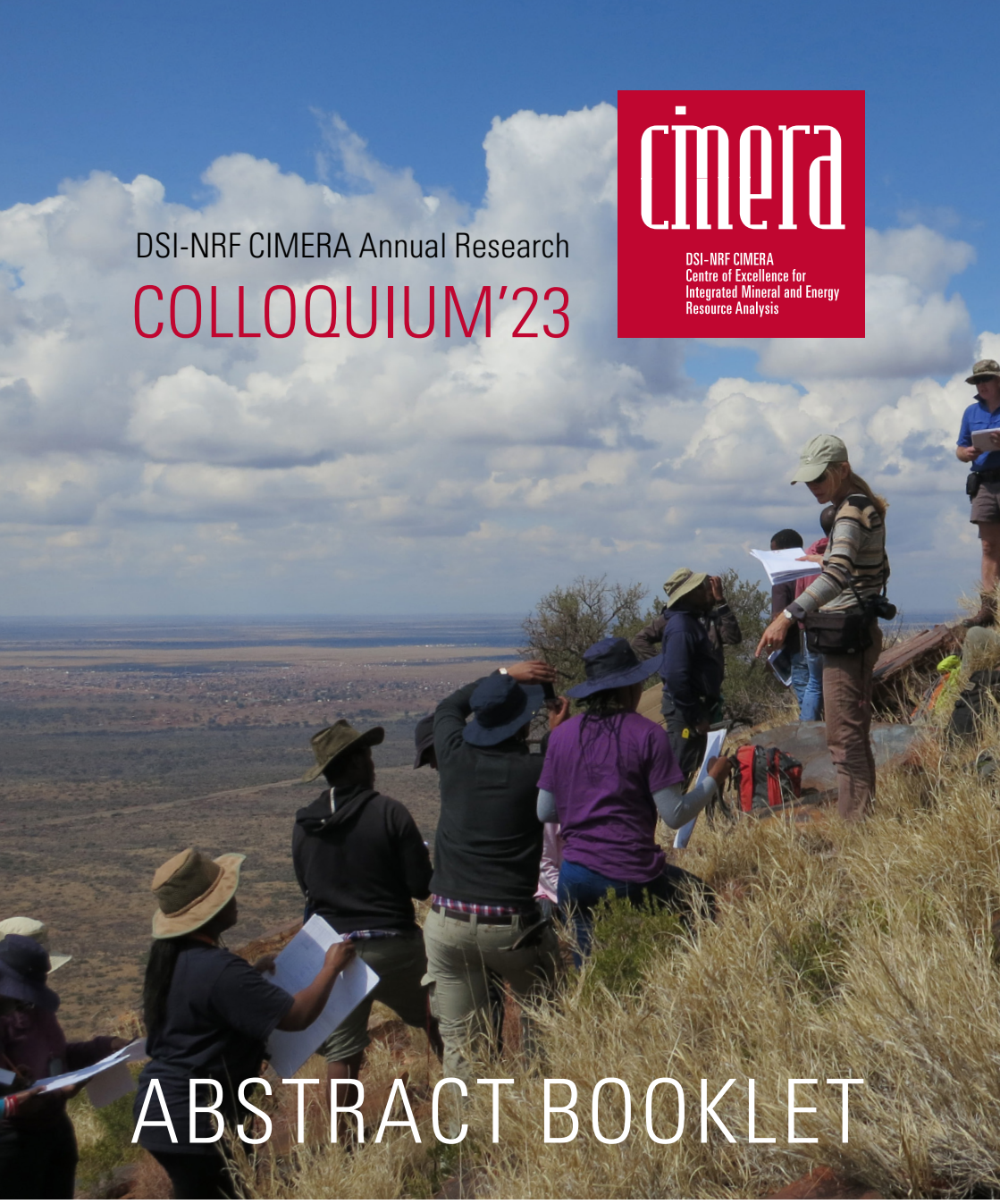
Centre of Excellence for
Integrated Mineral and Energy
Resource Analysis



# ABSTRACT BOOKLET

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | RISA Research and Innovation Support and Advancement

UNIVERSITY OF JOHANNESBURG

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Banded Iron Formation at Kuruman Kop (UJ Honours students). Northern Cape Province, South Africa. Image by George Henry.

DSI-NRF CIMERA ANNUAL RESEARCH COLLOQUIUM

27 & 28 November 2023

A hybrid event hosted

at the

University of the Witwatersrand

Auditorium 024

Emthonjeni Building

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Dear All,

We extend a warm welcome to the 2023 DSI-NRF CIMERA Colloquium, hosted by CIMERA at the University of the Witwatersrand. The Colloquium provides the opportunity for the DSI-NRF CIMERA-supported postgraduate students, researchers, and academics from across South Africa to come together. We hope to meet many of our collaborators in person, although this event is hybrid to allow for virtual attendance. Ongoing and completed research will be presented, and we actively encourage discourse.

We are extremely pleased to welcome two keynote speakers Mr Robert Kaemba, a seasoned Economic Geologist, and Dr Sarah Gordon, co-founder and CEO of Satarla Sustainability and Risk Management.

We look forward to their respective keynote presentations, *"Approaches to Innovation in Geoscience for Academia and Industry, for a Circular Economy"* and *"Environmental Social Governance (ESG) in the context of the Low Carbon Economy: what does it mean?"*, respectively.

This booklet contains the presentation and poster abstracts. A total of 24 presentations will be given over the next two days, as well 6 poster presentations, and the 2 keynote presentations. The students will present their research results stemming from the economic geology projects supported by DSI-NRF CIMERA. The poster presentations generally show preliminary results, and we look forward to the final presentation of results in 2024 by these students.

DSI-NRF CIMERA is a virtual Centre of Excellence (CoE) that brings together research excellence, capacity, and resources to enable collaboration across geoscience disciplines and institutions on long-term projects of economic and/or societal benefit in geology, that are locally relevant and internationally competitive. The DSI-NRF funded CoE provides direct and indirect funding support to over 50 postgraduate students hosted at 12 geology departments across South Africa. The outputs of the research in economic geology benefit the region and the continent, as does the pool of skilled graduate students. Geology and the mining industry is a back-bone of the South African economy, and geoscientists play a vital role in the development of the low carbon economy. Please visit our website (www.cimera.co.za) and follow us on LinkedIn for more information on our goals, research focus areas, and activities.

Congratulations to all students on the achievements in your studies to date, and we look forward to interacting with you over the next two days. We hope to see as many people as possible at our networking evening event on the 27th of November, a time to network and socialise.

Regards,

Professor Nikki Wagner
Director: DSI-NRF CIMERA
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Professor J. Kinnaird
Co-Director: DSI-NRF CIMERA
Judith.Kinnaird@wits.ac.za

Image: Deformed metamorphic rocks in quarry near Upington (geological hammer for scale) – George Henry

# KEYNOTE SPEAKER 1: Mr Robert Kaemba

BIOGRAPHY ■ **Robert Kaemba is an Economic Geologist**, completed his BSc (Hons) in Applied Geology at the University of Leicester, U.K. in 2007 and was the recipient of the Institute of Materials, Minerals, and Mining (IOM3) award. He has spent the majority of his career working on sediment-hosted copper exploration in the Central African Copperbelt initially as an Exploration Geologist and later as an Exploration Manager in Zambia. As a result, he has worked on several exploration projects from inception to completion, at different scales. Robert is a Fellow of the Society of Economic Geologists (FSEG) and was an invited speaker at the SEG2022 conference in Denver, U.S. He was also an invited speaker at the EU Commission Science summit in 2021 as well as a participant at the UKRI-NERC sustainability in reaching net zero workshop at University of Oxford, U.K. in 2022. He is an MSc (Economic Geology) Candidate at the University of the Witwatersrand and has interests in the nature, occurrence, and characteristics of sulfide mineralization.

# KEYNOTE SPEAKER 2: Dr Sarah Gordon

BIOGRAPHY ■ **Dr Sarah Gordon is the co-founder and CEO of Satarla Sustainability and Risk Management**. She is also co-founder of the not-for-profit Responsible Raw Materials and production company Critical Productions. Having started her career as an exploration geologist before moving into risk management and sustainability, Sarah has always been passionate about ensuring that we make sustainability a reality.

Sarah was delighted to represent The Geological Society at COP26 and be a member of the UK Government Expert Committee on Raw Materials. She is also a Trustee of Geology for Global Development, Women in Mining UK, is an Industry Advisor to iCRAG, and lectures at Imperial College London.

# PROGRAMME

| DAY 1: **MONDAY 27 NOVEMBER 2023** | | | | |
|---|---|---|---|---|
| | | 08:00 – 08:45 | REGISTRATION AND TEA | |
| | | 08:45 – 09:00 | **Prof Nicola Wagner** (UJ) CIMERA Director | WELCOME |
| | | 09:00 – 09:10 | **Prof Annah Moteetee** Executive Dean, Faculty of Science, UJ | WELCOME NOTE |
| | | 09:10 – 09:20 | **Prof Nithaya Chetty** (Wits) Executive Dean, Science Faculty | WELCOME NOTE |
| | | 09:20 – 10:00 | KEYNOTE SPEAKER: **Mr Robert Kaemba** Approaches to Innovation in Geoscience for Academia and Industry, for a circular economy | |
| SESSION 1 & 2 CHAIR: **Bjorn von der Heyden** | | | | |
| | SLOT | TIME | PRESENTER | TOPIC |
| SESSION 1 | 1 | 10:00 – 10:20 | **Minenhle Maphumulo** (UJ) | Potential source for NYF pegmatites from the Orange River pegmatite belt |
| | 2 | 10:20 – 10:40 | **Borbor AKK Gibson** (Wits) | Application of automated and semi-quantitative mineralogy techniques in the development of alternative pre-treatment flowsheet for PGE recovery from flotation tailings |
| | | 10:40 – 11:00 | TEA BREAK | |
| SESSION 2 | 3 | 11:00 – 11:20 | **Bjorn von der Heyden** (SU) | Characterization of refractory gold behaviour in Witwatersrand mine tailings: implications for gold recovery |
| | 4 | 11:20 – 11:40 | **Mpofana Sihoyiya** (Wits) | Legacy seismic data processing for mineral and coal exploration in the Evander Basin |
| | 5 | 11:40 – 12:00 | **Kwame Fynn** (UJ) | The geology of gold mineralization in the Nangodi greenstone belt, NE Ghana |
| | 6 | 12:00 – 12:20 | **Rutger La Cock** (SU) | Geochemical controls on high-grade gold mineralisation in the Barberton Greenstone Belt |
| | 7 | 12:20 – 12:40 | **Salizwa Plaatjie** (Wits) | Physical property studies to investigate the source of orebody seismic reflectivity at South Deep gold mine |

# PROGRAMME (cont.)

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|---|---|---|---|---|
| | | 12:40 – 13:00 | POSTER PRESENTATIONS (2-minute elevator pitches) | |
| | | 13:00 – 14:00 | LUNCH AND POSTER VIEWING | |
| SESSION 3 CHAIR: **Lorenzo Milani** | | | | |
| SESSION 3 | 8 | 14:00 – 14:20 | **Senamile Dumisa** (Wits) | Constraints on the genesis of the orbicular rocks and sulphide mineralization in the Koperberg Suite, Namaqualand Metamorphic Complex, South Africa |
| | 9 | 14:20 – 14:40 | **Khensani Moses** (UCT) | Paragenetic sequence of sulphide minerals at the Gamsberg zinc deposit, South Africa: An LA-ICP-MS study of pyrite, sphalerite |
| | 10 | 14:40 – 15:00 | **Dimakatso Hlahla** (Wits) | Investigation of the ore mineralisation styles and alteration zones of Messina Copper deposit |
| | 11 | 15:00 – 15:20 | **Matthew Hales** (Wits) | Late orogenic, competency-controlled copper sulfide mineralisation at the Onganja Mining District, Namibia |
| | | 15:20 – 15:35 | COMFORT BREAK | |
| SESSION 4 CHAIR: **Christopher Baiyegunhi** | | | | |
| SESSION 4 | 12 | 15:35 – 15:55 | **Moyagabo Rapetsoa** (Wits) | Multi-geophysical methods for characterizing fractures in an open pit mine, western Bushveld Complex, South Africa |
| | 13 | 15:55 – 16:15 | **Monica Oghenekome** (UWC) | Petrophysical and sedimentological characteristics from the Reservoir sediments of the Pletmos Basin, South Africa |
| | 14 | 16:15 – 16:35 | **Eric Saffou** (Wits) | Enhancing core sampling with machine learning and petrographic analyses: a case of study from a tight gas reservoir in Bredasdorp Basin, South Africa |
| | 15 | 16:35 – 16:55 | **Bopape Malesela Meshaclick** (Wits) | Mapping the Whitehill Formation and Karoo dolerite intrusions for shale gas potential in the southeastern Main Karoo Basin |
| | | 17:00 – 19:00 | NETWORKING SESSION | |

# PROGRAMME (cont.)

| DAY 2: **TUESDAY 28 NOVEMBER 2023** | | | | |
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| | | 08:00 – 08:45 | REGISTRATION AND TEA | |
| | | 08:45 – 09:00 | **Prof Nicola Wagner** (UJ)<br>CIMERA Director | WELCOME |
| SESSION 5 CHAIR: **Linda Laccheri** | | | | |
| SESSION 5 | 16 | 09:00 – 09:20 | **Glenance Ngomane**<br>(UP) | Petrogenesis and geochronology of mineralised pegmatoidal pods hosted in the Kunene Complex anorthosites, Angola |
| | 17 | 09:20 – 09:40 | **Marina Yudovskaya**<br>(Wits) | Ni-PGE mineralization of the Molopo Farm Complex in the area of the Jwaneng-Makopong shear zone |
| | 18 | 09:40 – 10:00 | **Mabatho Mapiloko**<br>(Wits) | Chromite composition in the Ni sulphide mineralised Uitloop Lower Zone and Platreef offshoots in the northern limb, Limpopo, South Africa |
| | 19 | 10:00 – 10:20 | **Ben Hayes**<br>(Wits) | Clues to the petrogenesis of the platiniferous of Merensky Reef from the textures and compositions of its pegmatites |
| | | 10:20 – 10:50 | KEYNOTE SPEAKER: **Dr Sarah Gordon**<br>Environmental Social Governance (ESG) in the context of the low carbon economy: what does it mean? | |
| | | 10:50 – 11:10 | TEA BREAK | |
| SESSION 6 CHAIR: **Karen Smit** | | | | |
| SESSION 6 | 20 | 11:10 – 11:30 | **Thoriso Lekoetje**<br>(Wits) | Petrocronology of the layered Zebra Lobe of the Kunene Complex (Namibia) |
| | 21 | 11:30 – 11:50 | **Karadzandima Casper Soul** (UJ) | Hybrid geological mapping of the Kunene Complex, Red Granite Belt, SW Angola |
| | 22 | 11:50 – 12:10 | **Ntando Ngwenya**<br>(UJ) | Plume–lithosphere interactions and LIP-triggered climate crises constrained by the origin of Karoo lamproites |
| | 23 | 12:10 – 12:30 | **Busisiwe Khoza**<br>(Wits) | Sr-Nd isotope evidence for depleted mantle sources in the Bushveld Complex |
| | 24 | 12:30 – 12:50 | **Merrily Mathume Tau**<br>(UCT) | Olivine as a diamond indicator mineral |

# PROGRAMME (cont.)

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| | 12:50 – 13:15 | CLOSING AND PRIZES |
| | 13:15 – 14:00 | LUNCH |
| | 14:15 – 16:30 | **Science Writing Workshop** facilitated by Prof. Hoogendoorn (UJ)<br>Students only (in person) |
| | 14:15 – 16:00 | **ICDP Brainstorming Session** facilitated by Prof. Nicola Wagner (UJ)<br>Academics and interested people only (hybrid) |
| DEPARTURE | | |

# POSTER PROGRAMME

| 12:40 – 14:00 **MONDAY 27 NOVEMBER 2023** | |
|---|---|
| PRESENTER | TOPIC |
| **Jena Moldenhauer**<br>(UCT) | Volcanology, petrology, and geochemistry of selected kimberlites from the Lulo kimberlite field, Angola |
| **Danielle Visagie**<br>(UCT) | Automatic earthquake detection via Machine Learning in Leeu Gamka, Karoo, RSA |
| **Itumeleng Matlala**<br>(UJ) | The importance of petrography in understanding the role of mode of occurrence in reducing mineral matter during coal beneficiation |
| **Mahlatse Manthepeng Ntake**<br>(UL) | Textural Characteristics and Depositional Environment of the Permian Sandstones of the Ecca Group in Borehole KWV-1: Evidence from Grain Size Analysis |
| **Mphanama Thangeni**<br>(UV) | Genesis and Mineralisation Processes of Copper Deposits in the Mutale Copperfield, Soutpansberg Group, South Africa |
| **Kananelo Letete**<br>(Wits) | Age and origin of the lithospheric mantle below the Ancient Gneiss Complex (Eswatini) |

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| TITLE: | **Potential source for NYF pegmatites from the Orange River pegmatite belt** |
| PRESENTING AUTHOR: | **Minenhle Maphumulo** |
| AFFILIATION: | University of Johannnesburg |
| EMAIL ADDRESS: | minniem@uj.ac.za |
| SUPERVISOR/S NAME/S: | Prof. M.A. Elburg, Dr. C. Ballouard and Dr. M. Mayne |
| DSI-NRF CIMERA FOCUS AREA: | CRITICAL RAW METALS |
| REGISTERED DEGREE: | PhD Geology |
| ORAL OR POSTER: | Oral |

The 450 km long Orange River pegmatite belt consists of > 30 000 pegmatite dykes or lenses that intruded various tectonic domains and subprovinces of the Mesoproterozoic Namaqua Sector of the Namaqua-Natal Metamorphic Province in Southern Africa at ca. 1 Ga. The Kakamas Domain, located in the central part of the Namaqua Sector, is dominated by the occurrence of niobium-, yttrium-, and fluorine-enriched (NYF) pegmatites, with economic potential for REE and Th. The NYF pegmatites consist of (i) simple relatively homogeneous dykes with low concentrations of REE-Y-Th-U-rich minerals, contrasting with (ii) complex variably zoned dykes or lenses characterized by a higher proportion of monazite, thorite, and xenotime. The age and origin of simple and complex NYF pegmatites, including processes of REE-Th enrichment, remain poorly understood. The study therefore aims to better constrain their source and tectonic-magmatic context of emplacement and to establish rare-metal enrichment and/or depletion of host-rocks as a result of pegmatite emplacement.

The U-Pb geochronology of simple and complex pegmatites yield crystallization ages from 1043 ± 5 Ma to 1025 ± 6 Ma and from 985 ± 4 Ma to 969 ± 5 Ma, respectively. They were emplaced during the main stage of pegmatite emplacement in the Orange River pegmatite belt, which occurred after peak granulite-facies metamorphism from 1200-1100 Ma and A-type granitic magmatism from 1100 to 1080 Ma (e.g., Keimoes Suite) in the Kakamas Domain. The Nd isotopic compositions of titanite and monazite from simple (εNd(t) -6 to -3) and complex εNd(t) -4 to -3) pegmatites, respectively, were determined by laser ablation multi- collector inductively coupled plasma mass spectrometry (LA-MC-ICPMS). Simple and complex pegmatites have average two-stage depleted mantle model ages ($T_{2DM}$) of 2.1 to 1.9 Ga and 1.9 to 1.8 Ga, respectively, which overlap with mantle extraction ages of granitoids and orthogneisses in the Kakamas Domain from 1.9 to 1.5 Ga. Therefore, the parental magma for both pegmatite types may have been sourced from the melting of Proterozoic rocks from the Kakamas Domain. At the scale of the Namaqua Sector, the beginning of NYF pegmatite magmatism in the Kakamas Domain was contemporaneous with the emplacement of REE-Th-rich veins and granitoid dykes in the Bushmanland Subprovince, including the REE-Th Steenkampskraal deposit (1050-1025 Ma), which formed in association with mafic magmas of the Koperberg Suite. REE-Th-rich rocks from the southern Bushmanland Subprovince have Nd isotopic compositions (εNd(t) ~ -5.9 to +0.9) similar to NYF pegmatites from the Kakamas Domain, suggesting possible petrogenetic similarities between REE-Th mineralising melts in the two regions. Whole-rock analyses of fresh and metasomatized country rocks shows that metasomatized country rocks are marked by significant rare metal enrichment (e.g., Nb, Li, Cs, Ta), with metasomatism across pegmatites and their country ocks suggesting the exsolution of a high amount of rare metal-enriched aqueous fluids at the end of pegmatite crystallisation. Although this highlights the influence of magmatic-hydrothermal processes in rare metal enrichment and/or loss during pegmatite emplacement, the enrichment in lithium, caesium and tantalum in metasomatized country rocks is unexpected for NYF pegmatite melts and raises questions regarding the nature of their parental magma.

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| TITLE: | **Application of Automated and Semi-Quantitative Mineralogy Techniques in the Development of Alternative Pre-treatment Flowsheet for PGE Recovery from Flotation Tailings** |
| PRESENTING AUTHOR: | **Borbor A.K.K. Gibson** |
| AFFILIATION: | Economic Geology Research Institute (EGRI), School of Geosciences University of the Witwatersrand, Johannesburg 2000, South Africa |
| EMAIL ADDRESS: | 2051925@students.wits.ac.za |
| SUPERVISOR/S NAME/S: | Prof. Glen Nwaila and Prof. Jochen Petersen |
| DSI-NRF CIMERA FOCUS AREA: | CRITICAL RAW MATERIALS (GEOMETALLURGY) |
| REGISTERED DEGREE: | PhD |
| ORAL OR POSTER: | Oral |

The rapidly declining head grade of platinum group minerals (PGMs) in ore resources, more so concentrators' feed grade, has led to increasing attention to recovering the economic valuable minerals (PGMs and base metal sulfides) from tailings. The current industrial route for repurposing flotation tailings, via tertiary flotation circuits, involves ball mill and/or ultrafine stirred mills unit stages suggesting an energy and cost intensive process. Moreover, the value mineral are yet rejected to the tailings in tenors that are significant given the volume of materials processed annually. As apart of a larger investigation aimed at developing an alternative flowsheet for recovering PGMs from flotation residues, this contribution demonstrates the influence of SEM-based characterization coupled with other semi-quantitative mineralogy techniques on the flowsheet development. In this investigation, Tescan automated mineral analyser (TIMA), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS), X-ray diffraction (XRD), Fourier-Transform Infrared Spectroscopy (FTIR) and Raman Spectroscopy were techniques used to inform the development of an acidic pre-treatment unit process. Leaching time, temperature, and lixiviant (with/without additive) were the parameters evaluated in the pre-treatment stage and characterized with the aforementioned mineralogical techniques. TIMA mineral phase identification for the feed and leached residue was accompanied with XRD and Raman Spectroscopy data. The presence/disappearance of hydrous mineral functional group in the material was achieve with FTIR and Raman, while the material surface and inherent chemistry were investigated under SEM-EDS.

The SEM-based characterization revealed that the tested lixiviants had a significant influence on the tailing starting material mineralogy and surface morphology in the order of sulfuric acid>ammonium hydrogen sulfate>nitric acid. Amorphous silica showing no definite crystal spectra in the FTIR analysis was confirmed in the Raman Spectroscopy result of the leached residue. The amorphous material was potentially characterized in the TIMA mineral classification as quartz (>50 wt%). However, XRD phase quantification showed that quartz composition was only ~0.6 wt% of the residue. SEM images further validated the change in the material surface morphology after leaching with the three lixiviants, while the EDS chemistry showed major depletion of cations from the feed: most noticeable was magnesium disappearance in the sulpfuric acid and ammonium hydrogen sulfate residues. The FTIR, Raman, and SEM-EDS results confirmed the dominance of the amorphous silica phase identified by the TIMA classification in the leached residue.

The mineralogical characterization techniques revealed that the chemical pre-treatment stage disrupted the crystal structure of the host minerals, but orthopyroxene was present. The host gangue mineral lattice embrittlement led to (a) the release of the PGMs and BMS minerals from their locked gangue host and (b) the creation of cracks and fissures in host particles, thereby increasing the accessibility of lixiviants (to be used in subsequent stages) to attack the PGMs and associated BMS – i.e. in the larger project ongoing flowsheet development. The combined mineralogical techniques used in this investigation have shown to play a significant role in evaluating the application and efficicency of the chemical pre-treatment process as a potential alternative route for PGM upgrading and recovery from flotation tailings.

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| TITLE: | **Characterization Of Refractory Gold Behaviour In Witwatersrand Mine Tailings: Implications For Gold Recovery** |
| PRESENTING AUTHOR: | **Dr Bjorn von der Heyden (on behalf of Steve Jason Chingwaru)** |
| AFFILIATION: | Stellenbosch University |
| EMAIL ADDRESS: | 20206771@sun.ac.za |
| SUPERVISOR/S NAME/S: | Dr Bjorn von der Heyden and Dr Margreth Tadie |
| DSI-NRF CIMERA FOCUS AREA: | GEOMETALLURGY |
| REGISTERED DEGREE: | PhD Earth Sciences |
| ORAL OR POSTER: | Oral |

The Witwatersrand basin, the world's largest gold province (53 000 Au), has produced over 6 billion tons of mine tailings after more than a century of mining. Due to the basin reaching maturity in gold production, the mine tailings are metallurgical processed simultaneously with primary gold ores by traditional cyanidation techniques to extract gold. Despite this process, the tailings remain strongly refractory with an estimated 1325-1855 tons of gold still present in tertiary tailings. The full mineralogical deportment of this remaining gold is not well understood. This study focuses on an in-depth characterization of the refractory behaviour of the Witwatersrand tailings material gold obtained from different spatially varying goldfields, by physical separation with mineralogical and chemical analysis. The results show that the heavy mineral concentrate has a higher gold concentration of 0.71-10.12 ppm, while the light (< 2.95 g.cm-3) and slimes (< 10 µm) fractions have 0.05-0.22 ppm and 0.17-0.76 ppm concentrations of gold, respectively. Further detailed in-situ analyses and leach tests of the different mineral fractions suggest that the gold is encapsulated by tailings mineralogy in the form of 'invisible-' or 'solid-solution' gold, mainly in pyrite and arsenian pyrites, ranging from 0.01 to 2730 ppm, accounting for up to 420 ton of gold (up to 31 % of total gold). Furthermore, the tailings sulphides host a substantial concentration of deleterious and critical heavy metals (as, ni, co etc.). The identification of invisible gold represents a potentially under-exploited resource, as it accounts for a weighty proportion of the refractory nature of 50-70% of gold. The primary Witwatersrand ores are known for their native liberated gold, which explains the refractory behaviour of remaining re-dump gold during traditional extraction. The study's results have implications for mining, economics, environment, optimization of flowsheets, and the origin of the Witwatersrand.

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| TITLE: | **Legacy seismic data processing for mineral and coal exploration in the Evander Basin** |
| PRESENTING AUTHOR: | **Mpofana Sihoyiya** |
| AFFILIATION: | University of the Witwatersrand |
| EMAIL ADDRESS: | 1284606@students.wits.ac.za |
| SUPERVISOR/S NAME/S: | Prof. Musa Manzi |
| DSI-NRF CIMERA FOCUS AREA: | GOLD METALLOGENESIS AND METALLURGY |
| REGISTERED DEGREE: | PhD |
| ORAL OR POSTER: | Oral |

The Evander Basin stratigraphy has been a target for deep (> 500 m depth) mineral and shallow (< 500 m depth) coal exploration for decades through exploration drilling. In this study, to delineate the subsurface geology and geological structures on the Evander Basin, we have recovered and processed six legacy 2D reflection seismic profiles acquired in 1986 for mineral and coal exploration. We propose contemporary reflection seismic processing workflows that employ new algorithms to provide an improved subsurface image of the structurally complex goldfield. We tested Kirchhoff pre-stack depth migration algorithm and newly developed Kirchhoff-based depth migration techniques called Fresnel volume migration (FVM) and coherency migration (CM).

The profiles were acquired over Karoo Supergroup rocks, with the covered pre-Karoo strata dipping to the north. The preliminary results from the pre-stack processing of the shot gathers show successful attenuation of noise through f-k and bandpass frequency filtering. The processed shot gathers show improved and restored reflections on the data. The legacy seismic lines were collected perpendicular to each other, allowing for pseudo-3D imaging. Further processing improvements on the legacy seismic profile include accurate imaging of the seismic reflective interfaces that can be used as proxies to delineate the mineral and coal deposits and constrain the geometry of the geological structures in the study area.

Even though minimal preprocessing was applied to the data before migration using a constant velocity model, the results successfully imaged the main lithological contacts in the Evander Basin. The reflections from the gold-bearing Witwatersrand Supergroup are clearly mapped and the possible crosscutting geological structures are delineated. An improved migration velocity model will play a major role in improving the imaging of the reflections. Furthermore, iterative static corrections will improve the continuity of the reflections. To better image the near surface reflections associated with the coal seams, the first break mute on the processing workflow will need to be removed, since near surface reflections are very close to the first breaks. Unfortunately, we do not have access to the legacy stacked and migrated sections from the initial processing applied to the data (if any processing was conducted). This would afford us an opportunity to compare both results to better judge the effectiveness of our novel processing workflows.

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|---|---|
| TITLE: | **The geology of gold mineralization in the Nangodi greenstone belt, NE Ghana** |
| PRESENTING AUTHOR: | **Kwame Fynn** |
| AFFILIATION: | University of Johannesburg |
| EMAIL ADDRESS: | kfynn@uj.ac.za |
| SUPERVISOR/S NAME/S: | Prof. Axel Hofmann and Dr. Samuel Nunoo |
| DSI-NRF CIMERA FOCUS AREA: | GOLD METALLOGENESIS AND METALLURGY |
| REGISTERED DEGREE: | MASTERS |
| ORAL OR POSTER: | Oral |

One of the recent gold discoveries in Ghana is the Namdini Gold Project in the northern part of the country situated within the Bole-Nangodi greenstone belt. The Bole-Nangodi greenstone belt consists of Birimian volcanic and volcaniclastic rocks (basalt to rhyolite) and immature sedimentary rocks (greywacke, shale) and is flanked on both sides by extensive granitoid complexes. These rocks have been affected by the 2.1 Ga Eburnean orogeny, which deformed and metamorphosed the rocks under greenschist facies conditions, and was accompanied by gold mineralization. Exploration in the area has led to the estimation of a 5.1 Moz ore reserve. However, the nature of the gold mineralization in this area is poorly understood. In this study, we present U-Pb zircon ages, petrographic analysis, whole rock major and trace element geochemistry, ore mineralogy and mineral chemistry of samples from within belt (including drill cores from the Namdini Gold Project). Gold mineralization is associated with strongly sheared, volcanic arc-type meta-andesite and meta-dacite/-rhyolite. The mineralization is restricted to shear zones characterized by quartz-carbonate veins that acted as hydrothermal fluid pathways for the precipitation of gold-bearing sulphides. Compositional zoning in sulphides is interpreted as due to the evolution of mineralizing fluids from As-poor to As-rich, forming early-stage pyrite/arsenopyrite, followed by the deposition of As-poor, late-stage pyrite. Oriented sulphides, pressure shadows and deformed veins all suggest that the mineralization was coeval to the deformation of the Bole-Nangodi greenstone belt. Zircon ages indicate that the volcanic units were deposited at ca. 2.16 Ga followed by granitoid intrusions at ca. 2.12 Ga and 2.10 Ga respectively.

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|---|---|
| TITLE: | **Geochemical controls on high-grade gold mineralisation in the Barberton Greenstone Belt** |
| PRESENTING AUTHOR: | **Rutger La Cock** |
| AFFILIATION: | Stellenbosch University |
| EMAIL ADDRESS: | 21745889@sun.ac.za |
| SUPERVISOR/S NAME/S: | Dr Bjorn von der Heyden |
| DSI-NRF CIMERA FOCUS AREA: | GOLD METALLOGENESIS AND METALLURGY |
| REGISTERED DEGREE: | MSc in Earth sceinces |
| ORAL OR POSTER: | Oral |

The Barberton Greenstone Belt (BGB) represents one of the oldest and best-preserved fragments of continental crust on Earth and has been intensely studied for over half a century. Like many other greenstone belts, the BGB hosts a number of economically significant gold deposits, with over 350 tons of gold extracted from the belt since 1882 (Agangi et al. 2019). Recent studies have focussed on characterising the structural controls on gold mineralisation within the well-endowed, Sheba-Fairview Complex (Gloyn-Jones & Kisters 2018, 2019; Pintos Cerda et al. 2020; Jones & Kisters 2022). However, the chemical controls on mineralisation are still poorly understood. To better understanding the chemical controls on high-grade gold mineralisation, a detailed petrographic characterisation of ore from the Main Reef Complex (MRC), Fairview mine, was undertaken. This gold ore was classified using conventional light microscopy, scanning electron microscopy (SEM) and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Results show that ore fluids evolved over time and that carbon in the form of carbonates and graphite have an important role to play in gold localisation. A dominance of dolomite-ankerite carbonates are required when seeking high gold grades as these carbonate phases form preferential sites for pyrite depsotion with some of these carbonates being replaced by pyrite (± arsenopyrite). As most of the native gold grains and "invisible gold" are associated with pyrite, the localisation of this sulphide was an important mechanism for gold focussing. Raman spectroscopy on MRC-associated graphite shows that this graphite is composed of nanocrystalline crystals and has a high degree of structural disorder. Graphite Raman geothermometry indicate that this graphite has been exposed to maximum temperatures averaging around 400 ºC. This graphite within the MRC shear zones acts as both a structural and chemical control. Structurally, graphite abundance caused strain localisation (Gloyn-Jones & Kisters, 2019) and acted as a lubricant to promote slip during episodic deformational events. Chemically, graphite acts as a strong reductant resulting in gold (+ sulphides) adsorbing onto its surface in a manner similar to the carbon-in-pulp gold recovery process. Carbon isotope analyses done on carbonates and graphite from the MRC suggest that ore fluids were derived from within the BGB, from the melting of Fig Tree metasediments. Re-Os geochronology on gold-associated pyrite was performed to better constrain the timing of gold mineralisation at Fairview. A Re-Os isochron age of 2913 ± 284 Ma argues in favour of a younger mineralisation age compared to previous studies, although this age has a considerable error margin due to the low Re concentration in pyrite. This research has helped create a more robust ore-forming model for Barberton gold deposits and higlights the important role of carbon in forming one of Earth's oldest orogenic deposits.

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| TITLE: | **Physical property studies to investigate the source of orebody seismic reflectivity at South Deep gold mine** |
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| DSI-NRF CIMERA FOCUS AREA: | GOLD METALLOGENESIS AND METALLURGY |
| REGISTERED DEGREE: | PhD Geophysics |
| ORAL OR POSTER: | Oral |

In this study we attempt to characterize the physical properties of rocks samples collected at depths of up to 3.5 km in a South African gold mine located in the far West Rand. The physical properties derived from this study will give us information on several aspects about the rocks such as (1) the propagation velocity of seismic waves in the rocks (2) the response of the rocks to high stresses at large depths (3) how the mineralogy and structure of the rock reflects seismic waves propagating through them. This subsurface information is correlated with real reflection seismic data from the region in order to better characterize and constrain the orebody. Thus, aiding mine planning and leading to safer and optimized mining.

Due to the great depths and complex nature of the rocks, uncertainty in our measurements becomes inherent. For example, reflection seismic surveys principally rely on the acoustic impedance contrast between the host and surrounding rocks. This contrast is dependent on velocity differences between both rocks and so thorough velocity analysis is crucial in deducing the source of reflectivity of seismic waves during surveys and processing steps. In addition to this, the structure, fracturing, faulting, igneous intrusions in rocks contribute to complicating the velocity measurements. The travel times of the ray paths used in seismic reflecting modelling are also directly dependant on the velocities derived from laboratory measured velocities. Hence, it may be near-impossible to interpret seismic data using a single set of velocity measurements (Nkosi, 2016).

In our research we measure the density, s- and p-wave velocity of host and surrounding rock samples in our study area. We investigate the effects of mineralogy, structure (e.g., anisotropy, porosity micro- and macro-fracturing) and bulk density on seismic velocities of the rock samples. Understanding these effects will assist us in infer information about the source of seismic wave reflectivity in our study area such as its depth, strike and dip. This will further enhance the existing models of the orebody's structure as well as assist in mine planning and the design of future reflection seismic surveys in the region.

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| TITLE: | **Constraints on the genesis of the orbicular rocks and sulphide mineralization in the Koperberg Suite, Namaqualand Metamorphic Complex, South Africa** |
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| DSI-NRF CIMERA FOCUS AREA: | BASE METALS |
| REGISTERED DEGREE: | PhD |
| ORAL OR POSTER: | Oral |

The 1020-1060 Ma Koperberg Suite (KS) in South Africa was emplaced during a localized ductile event that formed the E-W trending steep structures controlling regional Cu-mineralization. The KS rocks contain zones with orbicular textures, thought to form by either magmatic, metasomatic or metamorphic processes. There is no consensus or single mechanism explaining the genesis of these textures both globally and in the KS. Some orbicular zones are also associated with Cu sulphide mineralization, suggesting a possible link between orbicule formation and metallogenesis. This study documents a selection of orbicular localities from the KS to understand their genesis using petrography, in-situ mineral chemistry and isotopic data. Five different orbicule localities are described including Orbicule Koppie (OK), Jubilee Pit (JP), Henderson North (HN), Henderson South (HS) and Hoogskraal Lease (HL).

Orbicules occur in spectrum of lithologies of the KS, ranging from granite to diorite. The orbicules are characterized by coarse-grained (2-6 mm), felsic cores composed of feldspars, biotite and quartz. Sharp contacts mark the transition from cores to the fine-gained (0.2-1 mm) shells. Alternating, fine-grained mafic and felsic shells exhibit polygonal textures. HS and HL orbicules are characterized by radiating textures that are restricted to orbicular shells. Sharp boundaries mark the transition from core to shells and coarse-grained matrices, all of which contain similar mineral assemblages. Some of the orbicule localities contain deformed orbicules trending parallel to steep structures. Plagioclase in the HN ($An_{47-65}$) and HS ($An_{52-62}$) orbicules are more calcic than plagioclase at HL ($An_{35-52}$) and OK ($An_{41-57}$). Biotite in the HN ( = Mg#77) and the OK ( = Mg#75) orbicules are more magnesian than those at HS (=Mg#62) and HL (Mg#68) orbicules. Plagioclase in the HN orbicules are characterized by elevated initial $^{87}Sr/^{86}Sr$ ratios ($I_{Sr}$) (0.709675 to 0.723517) relative to other orbicule localities (0.705608 - 0.724905).

Formation of these orbicules has been attributed to metasomatic processes. However, a variety of textural and geochemical constraints rules out a metasomatic origin. These include chemical similarity between orbicules and the magmatic matrices, as well as a variety of synmagmatic textures. This, along with isotopic data, indicate that distinct pulses of orbicule-forming magmas make up the KS, where variable amounts of magma mixing, mingling and assimilation occurred. These differentiation processes possibly took place during magma ascent and emplacement, possibly triggering the ideal conditions for orbicule and sulphide formation.

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| TITLE: | **Paragenetic sequence of sulphide minerals at the Gamsberg zinc deposit, South Africa: An LA-ICP-MS study of pyrite, sphalerite** |
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| REGISTERED DEGREE: | PhD |
| ORAL OR POSTER: | Oral |

The Gamsberg zinc deposit is one of four Cu-Pb-Zn-Ag Broken Hill-type deposits of the Aggeneys-Gamsberg ore district. It is accepted that Gamsberg was transformed, through amphibolite facies metamorphism, from an originally Sedimentary Exhalative Deposit. However, the exact mechanisms by which the current textural configurations of sulphide minerals at the Gamsberg zinc deposit were achieved have received little attention. Using petrography, QEMSCAN, EMPA and in situ ICP-MS techniques, the paragenesis-evolution of sulphide minerals at the Gamsberg zinc deposit has been described.

A detailed mineralogical study of sulphide minerals shows that there are at least three major phases of pyrite formation recorded at the Gamsberg zinc deposit. The first is syn-sedimentary to diagenetic pyrite (Py1) typically inclusion-rich pyrite cores as well as disseminated pyrite microcrystals. The second is prograde to peak metamorphic pyrite (Py2) that is inclusion-free, subhedral to euhedral and granoblastic pyrite. And the third is retrograde metamorphic pyrite (Py3) which is mottled, often intergrown with honey-coloured sphalerite. The last is Py4, cataclastic and associated with ball-ore or durchbewegung textures of fractured pyrite porphyroblasts infilled by pyrrhotite and sphalerite. Pyrite has a preferential incorporation of Ni, Co, As, Se, Pb. Time resolved depth profiles through Py1b overgrown by Py2 reveal zoning in with elevated As content in the inclusion-rich core, and a dramatic decrease in As from the core to the inclusion-free rims. The mottled Py3 also shows zoning, with a bell shaped As profile.

Sphalerite has a preferential incorporation for Mn, Cd, Hg, Cu, Ga, Te and Mo. At the Gamsberg North ore body, sphalerite characterized by zoning (higher Fe and Mn in the cores), typical of re-equilibration diffusion during retrograde metamorphism. Sphalerite from the West and South ore bodies is characterized by two contrasting compositions, one of higher Zn and Hg and the other of higher Fe, Mo and Mn. Both sphalerite types vary from disseminated to semi-massive and remobilized. At the East ore body sphalerite generally contains alabandite inclusions as well as the highest MnS mole% of all the sphalerite types.

The impact of metamorphic overprinting (recrystallization, remobilization, and sulphide mineral conversions) becomes more pervasive from the Gamsberg North, to South, West and ultimately East. The pyrite-dominated ore's pyrite and sphalerite textures and trace elements are comparable to SEDEX deposits that have experienced regional metamorphism above greenschist facies.

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| TITLE: | **Investigation of the ore mineralisation styles and alteration zones of Messina Copper deposit** |
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| REGISTERED DEGREE: | MSc Economic Geology |
| ORAL OR POSTER: | Oral |

Messina deposit is a unique copper deposit with its distinct style of mineralisation and alteration. The deposit was emplaced within granulite metamorphic rocks of the Central Zone of the Limpopo Mobile Belt. Mineralisation and associated pervasive alteration of the wall rock are thought to be of post-Karoo age. Four types of ores can be distinguished: Mineralised breccia, disseminated, vein/fissure, and massive ore. The sulphides and alteration sequences define the characteristic concentric zoning: Pyrrhotite–pyrite and sericitisation in the outer zone; an increase of chalcopyrite and bornite concomitant with chloritisation towards the centre; bornite–chalcocite associated with epidote and zoisite in the inner zone. Two models were proposed for the origin of Messina deposit: A magmatic – hydrothermal plumbing system and meteoric water circulation process. No consensus has yet been reached regarding copper mineralisation and the source of hydrothermal fluids.

To investigate the relationship between ore, gangue, and Fe-oxide minerals, SEM-EDS (Tescan Integrated Mineral Analyser – TIMA) was employed specifically to identify and assess secondary minerals and trace elements associated with the minerals. These minerals enable comparison of the deposit with other known copper deposits. For example, Co enrichment in magnetite, pyrrhotite, and pyrite is not a unique phenomenon to Messina because it is common in other deposits, for instance, porphyry deposits of Northern Greece and Cu-Co deposits of Zambia. This provides an opportunity to explore the economic potential of Messina Cu deposit.

Unlike typical copper deposits, Messina hydrothermal fluids underwent retrogressive cooling to produce concentric zonation of sulphide and alteration minerals. That is, low temperature minerals are found at the core of the ore body, whereas high temperature minerals occur in the outer parts of the ore body, indicating falling temperature gradient inwards. Moreover, most of the breccia body is not exposed at the surface, but rather buried below the surface.

Optical microscopy and TIMA observations reveal that mineralisation zoning ranges from pyrrhotite–pyrite and/or molybdenite associated with sericite + chlorite + quartz, to chalcopyrite–bornite with chlorite + quartz ± minor epidote ± sericite, and chalcopyrite–bornite–chalcocite with epidote + zoisite + quartz ± chlorite in the centre of the ore body. These Cu-sulphides are associated with iron oxides (magnetite and hematite) and indicate increasing oxidation with increasing alteration intensity inwards. Alteration close association with copper sulphides suggests that mineralisation occurs within immediate zones of alteration. Alteration zones show overlapping and overprinting of minerals within the zones and suggest that the hydrothermal fluid experienced episodic compositional changes at different stages. In this sense, mineralisation occurred by means of subsequent element replacement during exchange of Fe, Cu and S, whereas alteration involved exchange of $SiO_2$, $K_2O$, $Al_2O_3$, $Fe_2O_3$, MgO, and CaO with increasing hydration during increasing alteration intensity. These associations are closely related with brecciated secondary quartz in inter-fragmental spaces, as cement between altered minerals, in veins/veinlets, as well as irregular to subhedral grains that overprint other minerals and terminates mineralisation and alteration. It is concluded that a silica-saturated alkaline-metal bearing hydrothermal fluid resulted in the formation of Messina Cu deposit. The hydrothermal breccia pipe acted as a feeder for the formation of ore and alteration zones. Based on the consistent occurrence of sulphides and iron-oxides within alteration zones, the deposit shows similarities with porphyry copper systems and greisen deposits.

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| TITLE: | **Late orogenic, competency-controlled copper sulfide mineralisation at the Onganja Mining District, Namibia** |
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| DSI-NRF CIMERA FOCUS AREA: | BASE METALS |
| REGISTERED DEGREE: | PhD |
| ORAL OR POSTER: | Oral |

The Onganja Mining District, ~60 km due NE of Windhoek, is a structurally controlled copper deposit within the Southern Zone of the Damara Orogen. The district is recorded to have produced copper concentrates between 1904 and the early 1970s. The recent discovery of two copper-rich orebodies has regenerated interest in the economic potential of the district. This research moves towards providing a comprehensive genetic model by combining structural, petrographic, whole-rock chemistry, mineral chemistry, and geochronology datasets.

Most of the mined-out orebodies at Onganja were chalcopyrite-chalcocite infill breccias and veins associated with a N-S trending quartz-albite vein system which crosscuts the metabasite-metapelite country rock lithologies, while the two recently discovered orebodies have a spatial association to amphibolite-bearing units and comprise massive to disseminated sulphides that are stratiform to the regional $S_2$ axial planar foliation. These orebodies consist of chalcopyrite and magnetite with minor pyrite and molybdenite. Furthermore, geochemical analysis (fire assay) of the ores indicates Au, U, and REE enrichment occurs with the copper mineralisation.

Cream white to pinkish-red albitisation of the schists occurs throughout the district as both foliation-bound bands and as haloes around quartz-albite veins. Locally, subhedral albite grains are observed in cavities adjacent to quartz veins. Likewise, mica growth is approximately foliation parallel to the $S_2$ or formed mica books within the same cavities as the albite crystals. Magnetite and hematite are closely associated with albitisation; the former is associated with amphibole-bearing units while the latter is associated with metapelites. Locally, hematite is potentially converted to mushketovite within the quartz-albite veins but is also found as euhedral grows in late calcite veins.

Given the alteration, ore, and elemental assemblages, the district bears some similarity to those of Iron Oxide-Copper-Gold deposits, providing a potential basis for a genetic model. However, several lines of evidence suggest that the district shows deviation from typical IOCG deposits. These include the abundance of quartz, lack of regional albitisation, undifferentiated alteration and metamorphic mica compositions, and both magnetite and ore chemistry that is distinct from those of IOCGs. Furthermore, U-Pb age dating of monazite (~440 Ma) suggests that REE enrichment post-dates orogenesis and sulphide mineralisation (517-518±3 Ma; Moore, 2010) by at least 80 My.

Rather than being an IOCG sensu stricto, the genesis of the Onganja orebodies is possibly related to the scavenging and mobilisation of sulphides associated with the amphibolite-bearing units by sodium-rich brines. These brines likely migrated along shears that developed along bands of $F_2$ axial planar schistosity before migrating up through fractures that developed in the more competent fold hinges and pre-existing vein system. The upward migration of the fluids resulted in the albitisation of the wall rock and precipitation of the sulphides into the fracture spaces producing the veins and breccias observed.

Moore, J.M., 2010, Comparative study of the Onganja copper mine, Namibia: a link between Neoproterozoic mesothermal Cu(–Au) mineralization in Namibia and Zambia: South African Journal of Geology, v. 113, no. 4, p. 445–460.

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| TITLE: | **Multi-geophysical methods for characterizing fractures in an open pit mine, western Bushveld Complex, South Africa** |
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| DSI-NRF CIMERA FOCUS AREA: | CRITICAL MINERALS |
| REGISTERED DEGREE: | PhD |
| ORAL OR POSTER: | Oral |

In the Bushveld Complex (BC), South Africa, open pit mines are faced with a challenge of rock slope stability due to geological structures (fractures, faults and dykes) that compartmentalise the rock mass. Geophysical surveys (seismics, magnetics and electrical methods) were conducted in a 0.2 $km^2$ area at Tharisa mine, with the goal to delineate fractures that may be potential conduits for water migration into the pit. Special processing techniques were applied to the dataset to obtain good quality seismic, magnetic and resistivity models. The P-wave velocity models show distinct low velocities in the center of the seismic profile, indicating the presence of weak zones associated with faulting or fracturing. Seismic reflection method was used to image the deeper discontinuities and mineralization contacts. Near surface reflections are observed throughout the profiles and are correlated with the contact between the chromitite and host rock. Ground magnetic surveys were conducted to delineate dykes and fractures. De-trending and de-culturing techniques were applied on the magnetic data for correcting regional and temporal variations. The low magnetic regions indicate the presence of fracture systems in the subsurface, while the high magnetic region is correlated with the dolerite dyke that crosscuts the pit. The electrical resistivity tomography exhibits linear low resistivity contrast zones that differentiates between the fractured and undisturbed hard rock at an estimated depth of 4 – 10 m. Resistivity shows discontinuities that suggests the presence of fracturing and dyke-host rock contacts. Correlation between magnetics, P-wave velocity models, resistivity section and seismic data is evident when overlaying the different datasets, implying that the low magnetic regions are highly weathered and prone to fracturing. The integration of geophysical data is encouraging, because it was able to image the depth to the bedrock, fractures within the host rock and dyke in a complex mining environment.

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| TITLE: | **Petrophysical and sedimentological characteristics from the Reservoir sediments of the Pletmos Basin, South Africa** |
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| DSI-NRF CIMERA FOCUS AREA: | ENERGY RESOURCES |
| REGISTERED DEGREE: | Postdoctoral |
| ORAL OR POSTER: | Oral |

A fundamental reservoir characterization begins with lithology identification and petrophysical evaluation. It often enables accurate prediction of the reservoir system and fluid association. The present study aims to characterize the reservoir lithofacies and rock physical properties for assessment of the reservoir quality. This study involves the integration of well logs and conventional core data using sedimentological and petrophysical approach. The depositional facies and sediments variation were determined from delineating the lithological units by integrating the well log and conventional core description analysis that was further validated by various cross plots. The reservoir petrographic code was accurately determined by integrating the sediment and rock physics properties. To discriminate the minerals, hydrocarbon content and water zones, Lamé rho and mu-rho parameters (k and μ) and M-N lithology plot were employed. The reservoir rock properties in relation with the historic porosity-permeability values, indicated the Pletmos Basin as a prolific reservoirs system that developed from a turbidity fluvial deposit system with permeable and porous sand with an excellent segment of predominantly gas sand, oil sand and shale units. There is a progressive increase of sand succession with higher shale density value across the field. There are a few sections with a low compressibility sediment framework and lesser density values indicating the gas zone. The study reconstructs an electrolithofacies model which represents a more reliable estimate of the reservoir's petrophysical properties and lithological succession that precisely revealed the pitfalls from gamma ray lithology with any ambiguity for uncertainties.

Keywords: *Sandstone, reservoir, lithofacies, lithology and petrophysics.*

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| TITLE: | **Enhancing Core Sampling with Machine Learning and Petrographic Analyses: A Case of Study from A Tight Gas Reservoir in Bredasdorp Basin, South Africa** |
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| REGISTERED DEGREE: | Postdoctoral |
| ORAL OR POSTER: | Oral |

This study demonstrates the application of machine learning, specially k-means clustering, to optimize rock sampling for rock mechanics testing in sandstone reservoirs. By utilizing K-means clustering, the study aims to capture the heterogeneity of the reservoir and identify distinct cluster units based on their similarities. The research focuses on a tight reservoir sandstone in the Bredasdorp Basin and applies petrological and petrophysical analyses to investigate the unique characteristics of each cluster. The cluster analysis based on gamma-ray logs identifies six significant clusters: Red, Yellow, Light Blue, Green, and Brown. The Folk classification categorizes the Dark Blue cluster as clastic sedimentary rock sublitharenites, while the Green, Red, and Brown clusters exhibit lithic arkose composition. The Light Blue and Yellow clusters are classified as feldspathic litharenites. However, modal analysis reveals variation in texture within each lithology group identified by the Folk classification. Reservoir quality assessment involves various analyses, including petrographic thin section, scanning electron microscope (SEM) analysis, diagenesis studies, and experimental petrophysics. The findings indicate that the Yellow cluster exhibits the highest reservoir potential, characterized by a porosity of 13% and a well-developed intergranular network of pores protected by clay lining, preventing quartz cement growth. In contrast, the Red cluster displays very poor reservoir potential, with 8.71% porosity due to carbonate cement(ferroan calcite and dolomite) and clays(illite and chlorite) reducing porosity. Furthermore, triaxial testing and velocity measurements demonstrate that the Red cluster exhibits the highest values for unconfined compressive strength (172 MPa) and Young's modulus(32.82 GPa), while the Yellow cluster has the highest Poisson's ratio(0.23). This suggests that clusters with low porosity tend to be stiffer, whereas those with a high Poisson's ratio are softer. Hence, elastic properties correlate with porosity and reservoir potential on sandstone reservoirs. The study concludes that K-means clustering effectively highlights the small-scale heterogeneity of reservoir and overburden lithology, providing valuable insights for sampling optimization. Additionally, the method shows promise for reservoir characterization, hydraulic fracturing optimization and sweet spot prediction in shale formations. However, it is important to note that exploring and comparing the performance of alternative machine learning techniques, such as hierarchical clustering or density clustering, may offer different insights and results..

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| TITLE: | **Mapping the Whitehill Formation and Karoo dolerite intrusions for shale gas potential in the southeastern Main Karoo Basin** |
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| REGISTERED DEGREE: | MSc Geophysics |
| ORAL OR POSTER: | Oral |

The Main Karoo Basin is a vast region spanning 700,000 km$^3$ in South Africa and hosts the hydrocarbon-rich Whitehill Formation that is believed to host economically viable shale gas. The Whitehill Formation is easily identifiable on seismic data as a highly reflective marker horizon and on electromagnetic data as a conductive marker. The presence of a network of interconnected dolerite dykes and sills can affect the amount of shale gas in the Karoo Basin. Therefore, evaluating the extent of these high-temperature dolerite intrusions is essential to target potential 'sweetspots' for shale gas exploration

Our main objective is to map the depth of the Whitehill Formation and Karoo dolerite intrusions in the southeastern region of the Karoo Basin. This region of the Main Karoo Basin has few drilled boreholes and limited scientific studies on mapping depth seismic marker horizons. We have digitised old paper reflection seismic images from the 1960s Southern Oil Corporation (SOEKOR) surveys to estimate the depth of the Whitehill Formation and dolerite intrusions in the southeastern Karoo Basin. We have also used magnetic data to observe the regional distribution of distinct magnetic bodies in the study area.

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| TITLE: | **Petrogenesis and Geochronology of Mineralised Pegmatoidal Pods hosted in the Kunene Complex Anorthosites, Angola** |
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| DSI-NRF CIMERA FOCUS AREA: | Early Earth Mineral Systems and Metallogenesis + Base, Critical Metals, Gold and Other Deposits |
| REGISTERED DEGREE: | MSc (Geology) |
| ORAL OR POSTER: | Oral |

Proterozoic massif-type anorthosites occurred at a specific time in Earth's history, between 2.7 and 0.5 billion years ago. The Mesoproterozoic AMCG suite of the Kunene Complex (KC) is one of the world's largest massif-type anorthosite complexes, with an inferred extent of > 42,500 km$^2$, and is situated along the southern part of the Congo Craton, in northern Namibia and southern Angola.

Anorthosites often host mineralised pegmatoidal enclaves primarily composed of coarse-grained high-aluminium orthopyroxene megacrysts (HAOM), Fe-Ti oxides (magnetite and ilmenite), apatite and plagioclase, with minor amounts of olivine, zircon, and sulphides. A zircon age at ca. 1500 Ma measured on one such enclave represents the oldest available age for the KAC rocks, pre-dating by ca. 60 Myr the maximum age obtained for an anorthosite s.s. (1440 Myr).

No combined dates on enclaves and the surrounding anorthosites are available, and this study aims at filling this gap, presenting new ages on enclaves and host anorthosite sampled in the Chibemba and Graniserra quarries, from the central region of the KC.

Mineral mapping using the Tescan Integrated Mineral Analyser (TIMA) was performed on polished thin sections for in-situ datable mineral identification and sulphide characterisation. Cathodoluminescence (CL) and backscattered electron (BSE) images allowed us to study the morphology and internal structure of the zircons. Magmatic zircons in the two enclaves typically form rims around Fe-Ti oxides. U-Pb ages were acquired via Laser Ablation Multi-Collector Inductively Coupled Plasma Mass Spectrometry (LA-MC-ICP-MS) on the identified zircons. In each enclave, two concordant age groups were obtained: at Chibemba 1488±20 Ma (MSWD=2), and 1424±16 Ma (MSWD=1.5), at Graniserra 1499±2 Ma (MSWD=2.3) and 1407± 11 Ma (MSWD=3.8).

Additionally, mineral separation and U-Pb zircon dating was performed on two anorthosites from Graniserra in contact with the dated enclave. One sample yields an age at 1473±19 Ma (MSWD=3) and 1493±11 Ma (MSWD=2.7), and the second sample dates at ca. 1408±7 Ma (MSWD=1.8).

Our results show that individual batches of anorthositic magma were emplaced as early as 1500 Ma, crystallising simultaneously with the evolved liquid pockets that formed the enclaves. The dates also suggest that the 1500 Ma anorthosite was affected by a second episode of magmatism between 1400 and 1440 Ma, that reset part of the zircon population.

Sulphides (massive or disseminated) are minor constituents of the pods. Pyrite is the main mineral, followed by chalcopyrite and pyrrhotite. Pentlandite is rare. Sparse sphalerite and galena were detected. Secondary pyrite, covellite and millerite are also present. Sulphide trace element geochemistry was obtained through LA-ICP-MS, mainly on pyrite, chalcopyrite, pyrrhotite and millerite. Pyrrhotite from Chibemba is enriched in Cu and in Ru, Rh, Pt, Pd, and is comparable with other Cu-Ni deposits (Lac de Iles, Aguablanca) associated with convergent settings. Pyrite from Chibemba again shows PGE enrichment, while at Graniserra two main pyrite types have been identified, the first mainly euhedral-subhedral and the second anhedral, interstitial, sometimes replacing other minerals. The Graniserra pyrite indicates a predominant magmatic origin for the sulphide (e.g., Co/Sb vs. Se/As; Co vs Ni), with lower T (hydrothermal?) effects producing element enrichment (Ni, As), together with precipitation of covellite and millerite.

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| TITLE: | **Ni-PGE mineralization of the Molopo Farm Complex in the area of the Jwaneng-Makopong shear zone** |
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| DSI-NRF CIMERA FOCUS AREA: | Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICs) and Large Igneous Provinces (LIPs) |
| REGISTERED DEGREE: | PhD |
| ORAL OR POSTER: | Oral |

Serpentinized peridotites and pyroxenite of the Molopo Farm Complex in the area of Jwaneng-Makopong-Werda Kgare shear zones underwent a later metasomatic event, which resulted in the wide development of secondary amphiboles, crystallization of newly formed chromite, olivine and pyroxenes, and formation of the Ni sulfide-alloy-arsenide assemblage indicative of reduced and low-S fugacity conditions. Platinum group elements liberated during dissolution of primary magmatic sulfide assemblages were selectively included into secondary Ni minerals. LA-ICP-MS analysis shows that the highest PGE concentrations are observed in Ni arsenides, particularly in maucherite, $Ni_{11}As_8$, which may carry up to ~2300 g/t Pd, 44 g/t Pt and 6 g/t Au due to a favorable isomorphic substitution scheme. Relic Co-rich pentlandite is enriched in Ir-subgroup PGE and Rh with (g/t): <13.4 Ru, 7.7 Rh, 1.9 Os, 1.2 Ir and 3.5 Pd. Awaruite, $Ni_3Fe$, shows elevated concentrations of up to (g/t) 44 Ru, 2.6 Rh, 13.8 Pd, 2.5 Os and 7.8 Au whereas heazlewoodite, $Ni_3S_2$, which replaces pentlandite, is poorer in PGE. The LA-ICPMS maps demonstrate heterogeneous diffusion-type distribution of PGE in Ni arsenides indicating that equilibrium was not achieved during hydrothermal redistribution. Platinum group elements in the Molopo Farm mineralized zones are predominantly present as solid solutions in relic sulfides and secondary arsenides and alloys as no discrete platinum-group minerals were found except for nano-sized relics of laurite and Pd tellurides. Whole-rock PGE fire-assay data suggest that PGE, Cu and Ni mobility was spatially limited to the zones of the primary magmatic PGE enrichment. The PGE distribution patterns closely match the PGE patterns for mineralised ultramafic rocks of both the Molopo Farms Complex and Lower Zone of the Bushveld Complex suggesting that the PGE abundances were not drastically changed during metasomatic alteration. Nickel mineral balance (Bartolomeu, 2023), however, is distinct from that of its magmatic precursor: secondary mineralization is enriched in Ni, which is mostly contributed by ore minerals, especially in intervals with elevated grade, whilst only a minor portion is hosted within the primary and secondary minerals.

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| TITLE: | **Chromite composition in the Ni sulphide mineralised Uitloop Lower Zone and Platreef offshoots in the northern limb, Limpopo, South Africa** |
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| DSI-NRF CIMERA FOCUS AREA: | Metallogeny and paleogeographic implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS). |
| REGISTERED DEGREE: | PhD Economic Geology |
| ORAL OR POSTER: | Oral |

The Bushveld Complex is the largest layered intrusion globally, with the Critical Zone boasting a substantial share of the world's Cr, Ni, Cu and Platinum group elements reserves. The Lower Zone (LZ) chonolith-like bodies in the northern limb are recognized for hosting economically significant deposits of these metals whereas ultramafic rocks found elsewhere in the Complex's Lower Zone are generally barren and occasionally exploited solely for exogenous magnesite. Grasvally in the southern portion of the northern limb hosts high-quality chromite and Ni deposits (Hulbert and von Gruenewaldt, 1982; 1985). This study is centred around chrome mineralization hosted by the LZ and Platreef offshoot intrusions on Uitloop farm in the central sector of the northern limb. Understanding the relationship between the Platreef and LZ lithologies in this region poses a challenge due to the intricate interfingering contacts and composite structure of the Platreef offshoot, which incorporates ultramafic subunits.

Chromitite seams serve as valuable markers to establish stratigraphic correlation and reveal the nature of their parental magmas. Chromite composition varies in correlation with degree of magmatic differentiation in the Lower and Critical zones. Massive chromitite layers are used as regional stratigraphic markers (Scoon and Teigler, 1994; Naldrett et al., 2009). However, disseminated chromite undergoes compositional changes due to interactions with percolating or trapped liquid, as well as postcumulus recrystallization. Chromium number Cr# = Cr/(Cr+Al) (mol.%) and magnesium number Mg# = Mg/(Mg+$Fe^{2+}$) (mol.%) reflect Cr-Al and Mg-$Fe^{2+}$ substitutions in chromite which depend both on the initial magma composition and its changes during fractional crystallization (Irvine, 1977; Barnes and Roeder, 2001) and contamination (Langa et al, 2021). Various models have been proposed to explain the formation of the massive chromitites: 1) magma mixing, which involves silica contamination due to the assimilation of country rock into residual melt (Irvine, 1975; Kinnaird et al., 2002) or mixing between resident and new magma (Irvine, 1977; Naldrett et al., 2009; 2012), 2) pressure changes (Cameron, 1977; Cawthorn, 2005), 3) in-situ growth at the base of the influx (Latypov et al., 2015), and 4) the injection of crystal-rich slurries containing suspended chromite and silicate crystals (such as orthopyroxene ± olivine) into the magma chamber (Eales, 2000; Mondal & Mathez; 2007; Eales & Costin, 2012). Yudovskaya and Kinnaird (2010), suggested that formation of the Platreef chromitites can be attributed to the magma mixing model proposed by Irvine (1977). In this model, chromite oversaturation occurs because of the mixing of two magmas, with each magma being near or just at chromite saturation.

To obtain a comprehensive understanding, this study aims to conduct a detailed analysis of chromite, focusing on its textures and mineral paragenesis in both uncontaminated and contaminated rocks. The objective is to reconstruct the primary magmatic chromite signature by examining its chemistry and associations. A total of 290 analyses were performed on chromite grains from the Uitloop LZ and Platreef lithologies using a wavelength dispersive electron microprobe Cameca SX-100 at the Department of Earth, Environmental and Planetary Sciences at Rice University, USA. The analyses were conducted on massive chromitite seams (>50% chromite), as well as disseminated chromite in silicate-dominated stratigraphic intervals within both the LZ and Platreef in boreholes Z03, Z027, and Z028. Additionally, 2285 inclusions within some of the chromite grains were analysed. These inclusions consist of mainly amphibole, phlogopite, pyroxenes and sulphides (pentlandite and pyrrhotite). They are generally confined to the core of the chromite grains and vary in size from a few microns to the first millimetres in diameter.

The preliminary findings reveal a regular correlation between the chromite Cr# and Mg# in both the Uitloop Platreef offshoot and those from the main Platreef body, particularly in the central sector of the northern limb. The Uitloop chromites exhibit a broader range and higher Cr# values (0.6 – 0.9), while most of the chromite possess lower Mg# when compared to the main Platreef chromites. These results suggest that although the majority of the Uitloop the chromites have primary composition their Mg# was likely modified by incorporation of Fe due to contamination of their magmas with Transvaal reactive country rock as was suggested by Langa et al., (2021) for the UG-2 chromitites of the northern limb. Moreover, chromites in the Uitloop II LZ body exhibit higher Cr# values (0.92 – 1.0) and lower Mg# values (up to 0.18) compared to the Grasvally Lower Zone chromites. This indicates that the Uitloop LZ Cr-richer magmas underwent contamination at the level of emplacement as suggested for the Platreef-Critical Zone chromitites.

REFERENCES


Barnes, S. J. and Roeder, P. L. 2001. The range of spinel compositions in terrestrial mafic and ultramafic rocks. Journal of Petrology, 42:12, 2279 – 2302.

Cameron, E. N. 1977. Chromite in the central sector of the eastern Bushveld Complex, South Africa. American Mineralogist, 62, 1082 – 1096.

Eales, H.V. 2000. Implications of the chromium budget of the Western Limb of the Bushveld Complex. South African Journal of geology, 103, 141–150

Eales, H. V., and Costin, G. 2012. Crustally contaminated komatiite: primary source of the chromitites and Marginal, Lower, and Critical zone magmas in a staging chamber beneath the Bushveld Complex: Economic Geology, 107, 645 – 665.

Hulbert, L. J. 1983. A petrological investigation of the Rustenburg layered suite and associated mineralisation south of Potgietersrus. Ph.D. thesis, University of Pretoria, 511p.

Hulbert, L. J. and von Gruenewaldt, G. 1985. Textural and compositional features of chromite in the lower and critical zones of the Bushveld complex south of Potgietersrus. Economic Geology 80, 4, 872 – 895.

Irvine, T. N. 1975. Crystallization sequences in the Muskox intrusion and other layered intrusions--II. Origin of chromitite layers and similar deposits of other magmatic ores. Geochimica et Cosmochimica Acta, 39, 6-7, 991 – 1020.

Irvine, T. N. 1977. Origin of chromitite layers in the Muskox intrusion and other stratiform intrusions: A new interpretation. Geology, 5, 5, 273 – 277.

Langa, M.M., Jugo, P.J., Leybourne, M.I. et al. Chromite chemistry of a massive chromitite seam in the northern limb of the Bushveld Igneous Complex, South Africa: correlation with the UG-2 in the eastern and western limbs and evidence of variable assimilation of footwall rocks. Miner Deposita 56, 31–44 (2021).

Latypov, R., Chistyakova, S., Page, A., and Hornsey, R. 2015. Field evidence for the in-situ crystallization of the Merensky reef: Journal of Petrology, 56, 2341 – 2372.

Naldrett, A. J., Kinnaird, J. A., Wilson, A., Yudovskaya, M., McQuade, S., Chunnett, G. and Stanley, C. 2009a. Chromite composition and PGE content of Bushveld chromitites: Part 1 the Lower and Middle Groups. Applied Earth Science: Transactions of the Institute of Mining and Metallurgy, Section B 118, 131 – 161.

Van der Merwe, M. J. 1976. The layered sequence of the Potgietersrus limb of the Bushveld Complex. Economic Geology, 71, 7, 1337 – 1351.

Scoon RN, Teigler B (1994) Platinum-group element mineralization in the critical zone of the western Bushveld Complex; I, sulphide poor chromitites below the UG-2. Econ Geol 89:1094–1121.

Van der Merwe, M. J. 1978. The geology of the basic and ultramafic rocks of the Potgietersrus Limb of the Bushveld Complex. Ph.D., University of the Witwatersrand. 176p.

Yudovskaya, M. A. and Kinnaird, J. A. 2010. Chromite in the Platreef (Bushveld Complex, South Africa): occurrence and evolution of its chemical composition. Mineralium Deposita, 43, 4, 1 – 23.

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| TITLE: | **Clues to the petrogenesis of the platiniferous of Merensky Reef from the textures and compositions of its pegmatites** |
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| REGISTERED DEGREE: | NA |
| ORAL OR POSTER: | Oral |

Abstract (max. 500 words): The origin of the platiniferous Merensky Reef (MR) remains a contentious topic. There is abundant field, geochemical and isotopic evidence that the MR corresponds to a major influx of new magma into the chamber. The metallogenesis of the MR may be a product of two hypotheses: "Downer" and "Upper". The Downer hypothesis is a purely magmatic model in which sulphide liquids are generated (and upgraded) by magma mixing and which then settle out to the MR. The Upper hypothesis is a magmatic-hydrothermal model in which sulphur-saturated Cl-rich brines transport PGE upwards from the solidified cumulate pile to the MR. In both hypotheses, a large liquid-filled chamber is envisaged. Pegmatitic textures are common in the MR and coincide with some of the highest PGE grades, therefore, they provide important clues in understanding the petrogenesis and metallogenesis of the MR. We studied the textures and mineral compositions of MR pegmatites at Royal Bafokeng mine in the Western Limb of the Bushveld Complex to test the validity of the Downer and Upper hypotheses. MR pegmatites are characterised by (i) amoeboid olivine inclusions in orthopyroxene megacrysts, with the molar Mg# of orthopyroxene increasing towards the olivine inclusions; (ii) fine-grained chains of orthopyroxene surrounding orthopyroxene megacrysts; (iii) increasing molar Mg# compositon of orthopyroxene laterally across a 10-km section; and (iv) variable molar An and Sr-isotope compositions of intercumulus plagioclase. We show that all these textural and mineral compositional features can be explained by melt percolation in a crystal mush and we go on to suggest that the PGE-rich sulphide mineralisation formed as a result. Therefore, neither the Downer or Upper hypotheses are required to account for the origin of the plaintiferous MR, and a large melt-filled chamber is not a pre-requistive for the development of stratiform PGE reefs in large layered intrusions.

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| TITLE: | **Petrogronology of the layered Zebra Lobe of the Kunene Complex (Namibia)** |
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| ORAL OR POSTER: | ORAL |

Massif-type anorthosites are plagioclase-dominant plutons that are temporally restricted to the Proterozoic. These batholithic intrusions are constructed over prolonged periods of time (≥100 Myr). Certain domains within massif-type anorthosites are characterised by lithological and mineral layering, but the timescales of layer formation are uncertain. The Zebra Lobe is a layered domain within the Kunene Complex, which is the largest massif-type anorthosite on Earth (>42 500 km$^2$; Rey-Moral et al., 2022). As such, the Zebra Lobe provides an opportunity for understanding the nature and timescales involved in the crystallisation of these layered plagioclase-rich magmatic systems. The layers in the Zebra Lobe are defined by mineral and geochemical variation, forming a rhythmic km-scale ridge and valley topography. Ridge lithologies are mainly composed of unaltered, olivine-dominant anorthosites, while the valley lithologies are variably altered and dominated by pyroxene-bearing anorthosites with varying, but minor olivine. In this study, we present the first high-precision ID-TIMS U-Pb baddeleyite and apatite ages that constrain the crystallisation timescales of the Zebra Lobe and its layering. The samples collected for this study represent lithologies along and across strike within the Zebra Lobe. The textural location and morphology of the baddeleyite and apatite grains were assessed using automated mineralogy (TIMA). Irregular, dark brown baddeleyite, which is intermittently rimmed by euhedral polycrystalline zircon (in some samples), occurs in the interstices between cumulate phases, associated with late-stage Fe-Ti oxides. Well-rounded euhedral zircon grains were separated from four of the samples processed, but all show inherited ages spanning 1581.7 – 1731.21 Ma. Baddeleyite and apatite data show two discrete age groupings, which correlate with lithology and composition. Baddeleyites from two samples of pyroxene-dominant, metasomatised valley anorthosites, separated by a stratigraphic distance of ~5.2 km and at least three ridges of unaltered, olivine-dominant anorthosites, yielded weighted mean $^{207}Pb/^{206}Pb$ dates of 1377.44 ± 0.32 Ma and 1376.70 ± 0.75 Ma. Two olivine-dominant, ridge anorthosites/leucotroctolites (also stratigraphically and spatially separated), yielded weighted mean baddeleyite $^{207}Pb/^{206}Pb$ date of 1369.01 ± 0.56 Ma and apatite weighted mean $^{207}Pb/^{206}Pb$ date of 1367.99 ± 0.86 Ma, respectively. These dates provide the most robust crystallisation ages of the compositionally distinct layers of the Zebra Lobe (1377-1368 Ma) and document, for the first time, that layering in massif type anorthosites may develop of 7-8 million year timescales.

Through this work, we also gain insight into timing associated with layering processes more generally. The timescales of development of layered mafic intrusions have attracted much attention and controversy with opposing hypotheses suggesting that layering either forms rapidly (<1 Ma) from a large, single pulse of magma or can be emplaced over 3-5 Ma through out-of-sequence intrusion of sills and sheets. Although smaller layered intrusions (e.g., Skaergaard) can likely emplace and cool rapidly, our study shows that geochemically diverse layering can develop through sheet-like emplacement of magmas over much longer timescales.

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| TITLE: | **Hybrid geological mapping of the Kunene Complex, Red Granite Belt, SW Angola** |
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| REGISTERED DEGREE: | Masters |
| ORAL OR POSTER: | Oral |

The 80 km-long, max. 3 km-wide NE-SW- to E-W trending Red Granite Belt (RGB), dated at 1411-1370 Ma, divides the NNE-SSW-trending Kunene Complex (KC) anorthosite massif into a 1380 Ma olivine-dominated anorthosite in the north and a central 1412-1400 Ma pyroxene- to olivine-dominated anorthosite. The RGB plays a crucial role in understanding the tectonomagmatic evolution of the KC. This study combines field-based structural analysis with hyperspectral mapping (PRISMA L2D) to investigate the structural, microstructural, and mineralogical characteristics of the RGB.

Field observations reveal variable orientations of the gneissic and shear foliation in the RGB and contacts with surrounding anorthosites. In the SW sector (KC intrusive margin), margin parallel, N-S striking, cm-wide shear zones carry steep plagioclase and corrugation lineations in the otherwise isotropic RGB granite and adjacent KC anorthosites, suggesting vertical stretching during E-W shortening. The KC-basement contact in this sector appears to be intrusive and passive. In the central sector, magmatic layering is steep and strikes N-S in a km-scale basement granite septum; it is transected by dm-wide NE-SW striking shear bands aligned with RGB-parallel gneissosity. These shear bands and gneissosity dip moderately to steeply to the SE and more locally to the NW, carrying down-dip stretching lineations marked by plagioclase and quartz. These solid-state foliations parallel RGB-anorthosite contacts and magmatic plagioclase lamination in the adjacent layered anorthosites to the SE of the RGB. This parallelism suggests a similar shortening direction during RGB deformation and anorthosite crystallisation. The NE tip of the RGB exhibits E-W striking gneissic foliation and tight folds within an LS-mylonite zone, with fold axes parallel to quartz and feldspar stretching lineations.

Kinematic indicators suggest ductile thrusting in different directions: E- and W-block-up in the SW sector, NW- and SE-block-up in the central sector, and NNW-directed thrusting forming folds in the NE tip. Although gneissic foliation changes from NE-SW striking to E-W-striking, the stretching lineations have a stable NW-SE trend over the entire 80 km-long RGB. Quartz recrystallisation microstructures indicate a range of deformation temperatures from high to low (grain boundary migration to bulging, respectively).

Hyperspectral mineral mapping enhances understanding of the spatial continuities of the litho-contacts by correlating spectral signatures with ground data and petrography. Reflectance within the KC anorthosites is mainly a function of metasomatism of the anorthosites and olivine presence/absence. Semi-automatic lineament extraction from a 10 m pixel size digital elevation model and a 5.1 m pixel size PRISMA panchromatic imagery identifies over 32000 lineaments, dominated by NE-SW and N-S orientations, with lesser NW-SE and E-W trends.

The interpretation of the data suggests that the RGB underwent progressive ductile thrusting during NW-SE-directed shortening. The change in trend of the RGB along strike from NE-SW to E-W is interpreted to be controlled by the shape of the less deformed adjacent anorthosite bodies. This shortening may have been active during the emplacement of the SE KC anorthosites, questioning the widely accepted anorogenic setting for massif-type anorthosites and favouring an orogenic environment for KC formation. Hybrid mapping (hyperspectral coupled with ground data) proved invaluable in litho-mapping and extracting lineaments semi-automatically in our study area.

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| TITLE: | **Plume-lithosphere interactions and LIP-triggered climate crises constrained by the origin of Karoo lamproites** |
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| ORAL OR POSTER: | Oral |

We identified a ca. 180 Ma diamondiferous lamproite event in Zambia, establishing a link between ultrapotassic volcanism and the early Jurassic Karoo flood basalt province of sub-Saharan Africa. The cratonic lamproites erupted through the Permo–Triassic Luangwa Rift structure, but MgO-rich ultrapotassic magma formation was unrelated to rifting and triggered by plume–lithosphere interactions during the Karoo LIP event. Elevated Li–Zn–Ti concentrations in magmatic olivine (up to 18.5 ppm Li at 86 – 90 mol.% forsterite) and strong Sr–Nd–Hf–Pb isotopic enrichment of the host lamproites ($^{87}Sr/^{86}Sr$ = 0.70701 – 0.70855, εNd = -10.8 to -10, εHf = -20.3 to -19.1, and $^{206}Pb/^{204}Pb$ = 16.8 – 17.5) suggest partial melting of phlogopite-metasomatized lithospheric mantle domains, at approximately 180 – 200 km depth. The mantle-like δ7Li values (+2.8 to +5.7‰) of the most pristine lamproite samples are compatible with source enrichment by asthenosphere-derived melts, without significant involvement of recycled sedimentary components. This geochemical fingerprint stands in sharp contrast to the negative ε7Li compositions of primitive K-rich volcanic rocks from collision zone settings, where the shallow mantle sources contain recycled sediment. Isotope modelling demonstrates that the sub-Saharan lamproites originate from a MARID-style metasomatized peridotitic mantle source that underwent incompatible element enrichment at ca. 1 Ga, during tectonic activity associated with Rodinia supercontinent formation. Plume-sourced basaltic and picritic magmas of the 180 Ma Karoo LIP interacted with such K-rich hydrous lithospheric mantle domains, thereby attaining enriched incompatible element and radiogenic isotope compositions. Nd–Hf isotope mass balance suggests that up to 25% of MARID-sourced lamproite melt component contributed to some of the high-Ti flood volcanic units. Although large quantities of volatiles can be transferred from Earth's mantle to the atmosphere via plume–lithosphere interactions, it is unlikely that outgassing of mantle-sourced sulphur can exceed the climatic impact caused by the release of much more abundant carbon from thick continental roots. Thus, the excess $SO_2$ required to account for transient atmospheric cooling during the early Jurassic, coincident with the Karoo LIP event, must have had a thermogenic origin near the surface of Earth.

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| TITLE: | **SR-ND ISOTOPE EVIDENCE FOR DEPLETED MANTLE SOURCES IN THE BUSHVELD COMPLEX** |
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| REGISTERED DEGREE: | Doctor of Philosophy |
| ORAL OR POSTER: | Oral |

The Rustenburg Layered Suite (RLS) of the Bushveld Complex shows stratigraphic variations in initial (at 2.06 Ga) 87Sr/86Sr and εNd isotopic compositions that are tied to variations in mineralogy and mineral composition. The isotopic variations are interpreted to reflect influxes of variably crustally contaminated mantle-derived magmas into the RLS. The Marginal Zone, at the base of the RLS, is made up of both quenched and cumulate ultramafic-mafic rocks and may represent parent melt compositions to the RLS. The Marginal Zone is subdivided into B1, B2 and B3 groups on the basis of trace elements with each group linked to a particular Zone in the RLS. In this study, we investigated the Sr-Nd isotope compositions of the Marginal Zone in the Eastern Limb of the Bushveld Complex to gain insights into the mantle sources of the RLS. B1 is the most isotopically enriched group in the Marginal Zone, with initial 87Sr/86Sr of 0.720321 to 0.720866 and εNd values of -23 to -8. B2 has an initial 87Sr/86Sr of 0.709235 to 0.719777 and εNd values of -15.9 to -8.4. B3 records the largest range of Sr-Nd isotopic compositions with initial 87Sr/86Sr of 0.702500 to 0.712358 and εNd values of -12.8 to 7.8. Our B3 Sr-Nd isotope compositions are similar to previously published values for the B3 Marginal Zone and the Main Zone (interpreted as cumulates formed from B3 parent magma). Four B3 samples have very depleted Nd isotopic compositions (εNd values of 3.83 to 7.86) that represent the most depleted isotopic compositions ever recorded for the Bushveld Complex. This may imply a very old depleted mantle component in the Bushvelds mantle source although these samples are in the process of being reanalysed before this interpretation is made. Collectively, the Sr-Nd isotopic data for the Marginal Zone is akin to an assimilation fractional crystallisation (AFC) array between a mantle source and a crustal contaminant. Interestingly, the B3 parent magmas record the entire spectrum of Sr-Nd isotopic compositions and show that some uncontaminated pulses of magma were emplaced at high levels in the crust. This work will have important implications for understanding the mantle sources of the Bushveld Complex and will inform future AFC models for its petrogenesis.

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| TITLE: | **Olivine as a diamond indicator mineral** |
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| REGISTERED DEGREE: | PhD Geology |
| ORAL OR POSTER: | Oral |

Olivine is a dominant constituent of kimberlites and Kaapvaal lamproites (formerly Group II kimberlites or orangeites), the primary sources of diamonds in southern Africa, comprising 40-50 vol.% of these rocks. It occurs as anhedral/ rounded macrocrysts (>0.5 mm) and euhedral to subhedral microcrysts (<0.5 mm), the majority of which show sharp compositional zoning between xenocrystic cores and magmatic rims. The xenocrystic cores generally display variable compositions (e.g., Mg# = 75 - 95) corresponding to those that characterize mantle xenoliths, including granular and sheared peridotites as well as the megacryst suite[1]. Due to their abundance, olivine xenocrysts offer great potential for characterizing the subcontinental lithospheric mantle (SCLM) traversed by kimberlites and lamproites of the Kaapvaal craton and to determine whether material from within the diamond stability field was sampled.

We present electron microprobe (EPMA) and laser ablation (LA-ICP-MS) trace element data of xenocrystic olivine cores sampled by five on-craton Kaapvaal lamproites (Finsch, Newlands, Roberts Victor, Star, and Sanddrift). Olivine cores are predominantly Mg-rich with a Mg# range of 90.0 - 94.9, Ni between 2320 and 4564 ppm, Mn = 522 – 1049 ppm, and Ca = 27.4 – 460 ppm. At each locality, Fe-rich olivine cores (with Mg# of 87 – 90) constitute less than 15% of the analysed grains.

While the xenocrystic olivine cores from all five localities were primarily sampled from garnet peridotite lithologies, a smaller population of olivine cores were derived from spinel and/ or spinel-garnet peridotites based on Al/V ratios[2]. The recently calibrated Al-in-olivine thermometer[2] (complemented with pressure from xenolith-based geotherms) is applied to the olivine xenocrysts sampled from garnet peridotite lithologies to further constrain the sampling depth range of each Kaapvaal lamproite.

From Finsch, out of the 89 olivine grains sampled from the garnet stability field, 78 grains (88%) were sampled from the diamond stability field. This is consistent with the high abundance of diamonds at Finsch, with reported diamond grade of 53-77 cpht[3, 4]. Similarly, out of the 66 olivine grains sampled from the garnet window at Roberts Victor, 63 grains (95%) were sourced from the diamond window. Diamond grades of 30-50 cpht have been reported from Roberts Victor[3, 4]. From Star, 26 olivine grains (93%), out of 28 grains from the garnet window, were sourced from the diamond window, which is consistent with the reported diamond grade of 40 -150 cpht[3]. Out of the 68 olivine grains sampled from the garnet window at Sanddrift, 51 grains (75%) were sourced from the diamond window, consistent with the reported diamond grade of 75 cpht[4]. From Newlands, only 22 olivine grains (35%), out of 63 grains from the garnet window, were sampled from the diamond stability field, which is consistent with the much lower diamond grade of 7.5 cpht[3] at this locality.

This work shows promising results for the application of the Al-in-olivine geothermometer in defining lithosphere sampling depths by Kaapvaal lamproites. In all locations, it appears that high temperature olivine from near the lithosphere-asthenosphere boundary (LAB) (depth = 180 – 220 km) is generally missing, which requires further investigation.

REFERENCES


1. Giuliani, A., 2018. Insights into kimberlite petrogenesis and mantle metasomatism from a review of the compositional zoning of olivine in kimberlites worldwide. Lithos, 312, pp.322-342.
2. Bussweiler, Y., Brey, G.P., Pearson, D.G., Stachel, T., Stern, R.A., Hardman, M.F., Kjarsgaard, B.A. and Jackson, S.E., 2017. The aluminum-in-olivine thermometer for mantle peridotites - Experimental versus empirical calibration and potential applications. Lithos, 272, pp.301-314.
3. De Wit, M., Bhebhe, Z., Davidson, J., Haggerty, S.E., Hundt, P., Jacob, J., Lynn, M., Marshall, T.R., Skinner, C., Smithson, K. and Stiefenhofer, J., 2016. Overview of diamond resources in Africa. Episodes Journal of International Geoscience, 39(2), pp.199-237.
4. De Beers Group, Diamond Geology (www.debeersgroup.com)

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| TITLE: | **Mantle and crustal processes, and associated metallogenesis including kimberlites** |
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| DSI-NRF CIMERA FOCUS AREA: | MANTLE AND CRUSTAL PROCESSES, AND ASSOCIATED METALLOGENESIS INCLUDING KIMBERLITES |
| REGISTERED DEGREE: | MSc by dissertation (Geology) |
| ORAL OR POSTER: | Oral |

The Lulo Field, found within the province of Lunda Norte, Angola, contains hundreds of kimberlite targets whereby exploration is currently being undertaken by the Lucapa Diamond company. The importance of these targets is due to their proximity to high-value alluvial diamond deposits currently being mined along the Cacuilo River valley. The diamonds under investigation are euhedral in morphology and show sharp edges with little abrasive signs of travel, indicating that their primary kimberlite source is likely nearby.

To date, 52 targets have been confirmed as kimberlite pipes within the Lulo Field in which one, or multiple drill cores have been drilled within a single pipe. 142 thin sections from representative kimberlite phases have been obtained from these various holes, in order to characterize the internal geology of these kimberlite pipes. The analysis and classification of these individual thin sections help to identify the internal distribution of the pipes within the Lulo Field. In addition, analysing and subsequently describing fresh representative samples of thin sections and obtaining bulk-rock geochemistry of coherent kimberlites allows to put these varying types of kimberlites in context with other worldwide occurrences. This all assists with the overarching aim to help build geological models for the Lulo Field, primarily focusing on whether this area is the likely source of the nearby alluvial diamond deposits.

Petrographic analyses of the thin sections allow for the classifications of the kimberlites, at the most primary form of subdivision (based on kimberlite magma texture), as either coherent or magmaclastic. The magmaclastic samples are then further subdived into mainly Kimberley-type Pyroclastic Kimberlites (KPK); Fort á la Corne-type Pyroclastic Kimberlites (FPK); Resedimented Volcaniclastic Kimberlites (RVK); and additionally Massive Volcaniclastic Kimberlites (MVK). Within the Lulo field, the diverse range of kimberlite deposits found implies that there are various processes contributing to magma fragmentation, pipe formation and infilling – meaning multiple events could have taken place within a single pipe.

The internal distribution of volcaniclastic kimberlite types within the pipes in the Lulo Field varies within each kimberlite. To gain a good understanding of the internal distribution, pipes with many representative thin sections at varying depths provided the best examples. Variations from the typical RVK to PK transition within the crater and diatreme zone will give insight into additional geological processes. Considering the influences of pipe erosion, pipe diameter (with crater facies extending deeper) and pipe shape (pipe vs sheet like morphology).

Magmaclasts, which can be described as fluidal-shaped clasts that are comprised of kimberlite magma that formed through a process of magma disruption (fluidal fragmentation or segregation processes), are used to further identify, and interpret the history of emplacement and geological processes. Magmaclasts found within representative samples of predominantly KPK and FPK's are the primary focus, with the aim of using a standardized descriptive scheme (devised by Webb & Hetman, 2021) to aid in these identifications and interpretations.

Representative samples of KPK and FPK's show distinct variations in texture and magmaclast properties. The KPK's often show a diagnostic kimberlitic rim around the olivine grains with a euhedral-subhedral shape, in addition to a regular-irregular morphology of magmaclasts. Whereas the FPK's show olivine grains with an anhedral shape with sharp edges, in addition to amoeboidal shaped magmaclasts. Other features (texturally and magmaclast related) within the samples, are currently being analysed and will further contribute to the unfolding of the geological processes responsible for the formation of these kimberlite pipes.

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| TITLE: | **Automatic earthquake detection via Machine Learning in Leeu Gamka, Karoo, RSA** |
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| DSI-NRF CIMERA FOCUS AREA: | ENERGY RESOURCES |
| REGISTERED DEGREE: | Masters |
| ORAL OR POSTER: | Poster |

The amount of seismic data available to seismologists has grown tremendously over the years with increasing advancements in instrumentation. In order to accurately and efficiently process and extract information from these large datasets, seismologists have adopted Machine Learning (ML), a combination of supervised and unsupervised learning computer algorithms, that can be trained to identify earthquakes (and potentially yield other geoscientific information) on seismic data. When compared to traditional or other automated methods, ML can process larger datasets within a shorter period while still yielding accurate results and identifying smaller-scale insights.

South Africa tends to be classified as a stable continental region where seismicity is expected to be low, however clusters of tectonic seismic activity are present throughout. One of these clusters occurs near Leeu Gamka in the Karoo, where the International Seismological Centre (ISC) reported anomalous seismicity near the region between 2007 and 2013. The Karoo is currently being explored for shale gas extraction and it is essential to identify any pre-existing structures in the region and determine the potential seismic hazard. For these reasons, scientists from the University of Cape Town deployed a temporary seismic array to identify and locate seismicity in the region near Leeu Gamka.

Previous work done on this dataset focused on creating a seismic catalogue based on visual detection and semiautomated methods such as STA/LTA. The goal of this project is to apply ML algorithms that use different training datasets to the data collected near Leeu Gamka. Here we test the validity of the ML catalogues versus that derived from more standard seismic methods. Preliminary results suggest that PhaseNet, a deep neural network algorithm, with its original benchmark dataset yields the most accurate results, producing the truest detections with minimal false and missed detections. Other algorithms that have been tested are EQTransformer, Generalized Phase Detection, and PhaseNetLight, however, these result in larger numbers of false detections.

Additionally, the ML catalogue shows additional events, not present in the standard catalogue, which are not classified as false detections. These additional events tend to be of smaller magnitude and coherence than those detected with standard methodologies such as STA/LTA.

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| TITLE: | **The importance of petrography in understanding the role of mode of occurrence in reducing mineral matter during coal beneficiation** |
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| REGISTERED DEGREE: | PhD Geology |
| ORAL OR POSTER: | Poster |

Coal heterogeneity causes challenges in linking its properties to utilization. This is partly related to inorganic component, whose behaviour during density fractionation is related to mode of occurrence (i.e., syngenetic or epigenetic). It is sometimes difficult to separate minerals from the organic matter, especially small-sized mineral particles that are syngenetic in their modes of occurrence (detrital and authigenic). In addition to maceral and reflectance analysis, organic petrography provides for the quantification and qualification of the mode of occurrence of minerals. The present study assesses five (5) run of mine (ROM) coal samples from the No. 4 Seam of the Highveld Coalfield. The ROM samples were subjected to density fractionation using relative densities (RD) of 1.7 (F1.7) and 1.9 (F1.9) g/cm$^3$. The study attempts to understand the behaviour of organic and inorganic matter during density fractionation at 1.7 and 1.9 g/cm$^3$. Petrography was undertaken to determine coal type (macerals and microlithotypes) and rank; proximate analysis to determine coal grade, and X-Ray Diffraction (XRD) to understand the mineral matter composition. The mean random vitrinite reflectance (%RoV) ranges between 0.57 and 0.60% (medium rank D bituminous). The parent samples are enriched with inertinite (semifusinite and inertodetrinite) with low vitrinite and liptinite. Reactive macerals (a combination of vitrinite, liptinite, and reactive semifusinite) are generally enriched and ash yields lower in the float products, resulting in increased volatile matter and calorific values. Kaolinite and quartz are slightly high in the F1.9 than the F1.7 samples, though much higher in the sink products. This is related to the microlithotype composition, which shows high carbominerite (an association of organic and inorganic matter) contents (particularly carboargillite, carboankerite and carbosilicates) in the sink products. Some fine-grained syngenetic clays, carbonates (siderite), minor detrital quartz, and pyrite also occur in the float products, including in the F1.7 samples. In contrast, agreater proportion of epigenetic clays, pyrite (occurring as frambroids and cleat-infilling), quartz, and carbonate minerals (particularly calcite) are enriched in the sink products. The partitioning of minerals in the Highveld coals during density fractionation is related to the size of the component, primarily controlled by mode of occurrence.

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| TITLE: | **Textural Characteristics and Depositional Environment of the Permian Sandstones of the Ecca Group in Borehole KWV-1: Evidence from Grain Size Analysis** |
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| REGISTERED DEGREE: | MSc (Geology) |
| ORAL OR POSTER: | Poster |

Grain size analysis is a vital sedimentological tool that is used to unravel the hydrodynamic conditions, modes of transportation, and depositional processes of detrital sediments. The Ecca Group is considered to have exceptional preservation of the stratigraphic sequence, including the sedimentary structures and the varying lithology. However, despite the distinct stratigraphic sequence and lithological variation of the Ecca Group in the southern Main Karoo Basin, up until now, there has not been much information on the grain size parameters of the sandstones. In addition, the few measured statistical parameters were not adequately related to the mode of transportation and deposition. As a result, a total of 35 sandstones from borehole KWV-1 were investigated for their grain size distributions. To unravel the transportation mechanisms, textural characteristics and depositional environment of the sandstones, grain size statistical parameters, binary plots, Visher diagrams, linear discriminant plots and Passega diagrams were used. The grain size parameters indicated that the sandstones were fine- to very-fine-grained and displayed near-symmetrical patterns. Additionally, most of the analysed sandstones displayed mesokurtic distribution patterns. The binary plots indicate that most of these samples were deposited by wind (aeolian action), with a few deposited by river and wave action. The Visher diagrams are indicative of three main transportation modes: traction, saltation and suspension. It is evident that the main transportation mode for these sandstones is saltation, with a few sediments in suspension and traction. Likewise, the Passega diagrams revealed that there were fluctuations in energy levels. Specifically, the sandstones from the Prince Albert Formation were transported through rolling and suspension; the Collingham Formation was transported mainly by saltation; and the sandstones from the Ripon and Fort Brown Formations were transported by graded suspension as well as suspension and rolling. The C-M plot for all the analysed samples shows that they were deposited by tractive currents. The linear discriminant function plots (LDF) revealed that the sandstones from the Fort Brown Formation were deposited by turbidity currents in a deltaic to shallow marine environment, while the Prince Albert, Collingham and Ripon Formations were deposited by turbidity currents in deep marine environments.

Keywords: *Grain size analysis, textural parameters, depositional environment, Ecca Group, sandstones.*

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| TITLE: | **Genesis and Mineralisation Processes of Copper Deposits in the Mutale Copperfield, Soutpansberg Group, South Africa** |
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| DSI-NRF CIMERA FOCUS AREA: | BASE METALS |
| REGISTERED DEGREE: | Doctor of Philosophy in Mining and Environmental Geology |
| ORAL OR POSTER: | Poster |

The Mutale Copperfield, located within the Soutpansberg Group of South Africa, represents a unique geological entity with historical copper mining activities spanning from 1900 to 1970. Despite its historical significance, limited knowledge exists regarding the genesis, mineralisation processes, and current potential of this field a critical copper resource. As the world increasingly relies on copper for the development of green energy technologies, understanding the geological attributes of deposits like the Mutale Copperfield gains paramount importance.

This study aims to address this knowledge gap by pursuing a multifaceted investigation. The primary objectives encompass unravelling the geological setting of copper deposit and identifying prospective exploration targets. Fieldwork entails sampling of old open pit mine workings, drillhole core logging and sampling, geological field mapping and geochemical baseline soil surveys. Remote sensing techniques will be used to identify potential exploration targets, such as altered mineral zones and structural features. Subsequently, comprehensive laboratory analyses encompass fluid inclusion, cathodoluminescence, mineralogical analysis, geochemical analysis, and isotope analysis.

The anticipated outcomes include the development of a comprehensive geological model elucidating the formation and mineralisation processes of the Mutale Copperfield, the identification of prospective copper exploration targets, and an assessment of its potential as a sustainable source of copper.

Keywords: *Mutale Copperfield, Soutpansberg Group, fluid inclusion, cathodoluminescence, green energy.*

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| TITLE: | **Age and origin of the lithospheric mantle below the Ancient Gneiss Complex (Eswatini).** |
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| DSI-NRF CIMERA FOCUS AREA: | MANTLE AND CRUSTAL PROCESSES, AND ASSOCIATED METALLOGENESIS INCLUDING KIMBERLITES |
| REGISTERED DEGREE: | MSc |
| ORAL OR POSTER: | Poster |

The models concerning the formation and stabilisation of cratons are associated with two types of melting. High-pressure melting with magmatic underplating (stagnant lids) and low-pressure melting in mobile settings (subduction processes). To establish tectonic processes governing the start of plate tectonics and formation of the Kaapvaal Craton, many studies have been carried out in the Ancient Gneiss Complex (AGC) and Barberton Greenstone Belt (BGB) of the eastern Kaapvaal Craton (e,g., De Wit et al., 2018). This region experienced tectono-magmatism at 3.2 Ga and there is ongoing debate about whether this event is associated with subduction processes (e.g., Moyen, 2006; Kröner et al., 2018; Wang et al., 2020). To contribute towards a better understanding of the tectonic evolution of the lithospheric mantle beneath the eastern Kaapvaal craton and determine the timing of subduction, we are studying peridotitic and eclogitic mantle xenocrysts from the Dokolwayo carbonate-rich olivine lamproite (previously called Group 2 kimberlites) in Eswatini (previously known as Swaziland).

Analyses of the mantle xenocrysts allow us to elucidate the origin and composition of the lithospheric mantle beneath Dokolwayo. Moreover, we can determine the thermo-barometric conditions of the lithospheric mantle, possible melting regimes and diamond stability at the time of eruption. We consider eclogitic and peridotitic garnets and clinopyroxenes, along with olivines, chromites, ilminites, and eclogitic kyanites. Olivine xenocrysts yield magnesium numbers ($[Mg/Mg + Fe^{2+}] \times 100$) between 89.8 and 93.6. Four of these olivines indicate derivation from depleted dunitic residues produced by primary melt depletion, whereas the majority correspond to lherzolitic and harzburgitic residues. The majority of the analysed peridotitic garnets from Dokolwayo are lherzolitic (CaO 4.2–5.9 wt.% and $Cr_2O_3$ 1.3–7.9 wt.%) and a few are harzburgitic (CaO 2.4–3.6 wt.% and $Cr_2O_3$ 1.2–6.9 wt.%). All eclogitic (n = 72) and some lherzolitic (n = 50) garnets show normal $REE_N$ patterns, with depletion in $LREE_N$, and relatively flat $MREE_N$-$HREE_N$ (where $REE_N$ refers to chondrite normalisation). Harzburgitic garnets (n = 2) have a high degree of sinuosity, with steep slopes of $MREE_N$-$HREE_N$ ($Lu/Gd_N$ ratios of 0.2 and 4.4).

Clinopyroxene xenocrysts yield temperatures between 567 and 750 °C and pressures from 2.3 to 3.4 GPa (Nimis and Taylor, 2000). The FITPLOT geotherm (Mather et al., 2011) produced from the clinopyroxene pressure and temperature estimates shows that the Dokolwayo lithospheric mantle has a thickness around 220-230. The intersection of the geotherm with the graphite-diamond transition (Day, 2012) shows that diamonds are stable above 860 °C. Peridotitic garnet xenocrysts yield Ni-in-garnet temperatures that range from 980 to 1210 °C (Canil, 1999) and when these temperatures are extrapolated onto the clinopyroxene-derived geotherm, they are derived from depths of 150–215/220 km, in the diamond stability field.

Future work will include Lu-Hf isotopic measurements on Dokolwayo`s peridotitic and eclogitic garnets, to constrain the age of the lithospheric mantle below the Ancient Gneiss Complex for the first time. The presence of eclogitic minerals at Dokolwayo allows us to test the subduction hypothesis and potentially date subduction processes that contributed to the formation of the lithospheric mantle in this region.

REFERENCES

Canil, D., 1999. The Ni-in-garnet geothermometer: calibration at natural abundances. Contributions to Mineralogy and Petrology, 136(3), pp.240-246.

Day, H.W., 2012. A revised diamond-graphite transition curve. American Mineralogist, 97(1), pp.52-62.

De Wit, M., Furnes, H., MacLennan, S., Doucouré, M., Schoene, B., Weckmann, U., Martinez, U. and Bowring, S., 2018. Paleoarchean bedrock lithologies across the Makhonjwa Mountains of South Africa and Swaziland linked to geochemical, magnetic and tectonic data reveal early plate tectonic genes flanking subduction margins. Geoscience Frontiers, 9(3), pp.603-665.

Kröner, A., Hoffmann, J.E., Wong, J.M., Geng, H.Y., Schneider, K.P., Xie, H., Yang, J.H. and Nhleko, N., 2019. Archaean crystalline rocks of the Eastern Kaapvaal Craton. The Archaean Geology of the Kaapvaal Craton, Southern Africa, pp.1-32.

Kröner, A. and Hofmann, A. eds., 2019. The Archaean Geology of the Kaapvaal Craton, Southern Africa. Springer.

Mather, K.A., Pearson, D.G., McKenzie, D., Kjarsgaard, B.A. and Priestley, K., 2011. Constraints on the depth and thermal history of cratonic lithosphere from peridotite xenoliths, xenocrysts and seismology. Lithos, 125(1-2), pp.729-742.

Moyen, J.F., Stevens, G. and Kisters, A., 2006. Record of mid-Archaean subduction from metamorphism in the Barberton terrain, South Africa. Nature, 442(7102), pp.559-562.

Nimis, P. and Taylor, W.R., 2000. Single clinopyroxene thermobarometry for garnet peridotites. Part I. Calibration and testing of a Cr-in-Cpx barometer and an enstatite-in-Cpx thermometer. Contributions to Mineralogy and Petrology, 139, pp.541-554.

Wang, H., Yang, J.H., Kröner, A., Zhu, Y.S., Wei, Q.D., Li, R. and Xu, L., 2020. Extensive magmatism and metamorphism at ca. 3.2 Ga in the eastern Kaapvaal Craton. Precambrian Research, 351, p.105952.

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