DSI-NRF CIMERA Annual Research

COLLOQUIUM'22

cimera

DSI-NRF CIMERA
Centre of Excellence for
Integrated Mineral and Energy
Resource Analysis

ABSTRACT BOOKLET

science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

Image supplied by Jeremie Lehmann. Western margin of the Kunene Complex, Angola.

DSI-NRF CIMERA
Centre of Excellence for Integrated Mineral and Energy Resource Analysis

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

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

UNIVERSITY OF JOHANNESBURG

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
1922 2022

University of Cape Town

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

TU Delft
Delft University of Technology

RHODES UNIVERSITY
Where leaders learn

University of Fort Hare
Together in Excellence

Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREYSTATA
UFS
UV

University of Venda

Council for Geoscience

Helmholtz Institute Freiberg for Resource Technology
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF
TU BERGAKADEMIE FREIBERG

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF KWAZULU-NATAL

秋田大学
Akita University

DSI-NRF CIMERA ANNUAL RESEARCH COLLOQUIUM

21- 22 November 2022

Hybrid Event

Nadine Gordimer Auditorium (Level 5)

Auckland Park Kingsway Campus Library

University of Johannesburg

DISCLAIMER: This event may be photographed and video recorded for marketing, social media and media purposes. By attending this event, you grant DSI-NRF CIMERA, University of Johannesburg and the University of the Witwatersrand permission to use and publish any recorded material.

DSI-NRF Centre of Excellence for Integrated Mineral and Energy Resource Analysis – CIMERA
Department of Geology
University of Johannesburg | Auckland Park Kingsway Campus [APK]
PO Box 524 | 2006 Auckland Park | South Africa
+27 11 559 4728 [tel] | +27 11 559 4702 [fax]
cimera@uj.ac.za | www.cimera.co.za

Dear All,

We extend a warm welcome to the 2022 DSI-NRF CIMERA Colloquium, hosted at the University Library, University of Johannesburg. 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:

- **Monday 21 November @15:50: Mr Douglas Silver**. Mr Silver is an economic geologist with expertise in exploration, mineral economic and finance; essentially a go-to-expert on critical resource assessment and economic valuation. Mr Silver hales from the USA, is a frequent keynote speaker, and has received numerous awards.
- **Tuesday 22 November @12:00: Professor Nic Beukes**. Prof Beukes is well known to us all. He holds an Emeritus Professorship in the Department of Geology, UJ, is a NRF A-rated scientist, and has received many national and international awards as recognition for his career.

We look forward to their respective keynote presentations: "Supply and demand in the green economy", and "Contributions of four DSI-NRF CIMERA managed scientific drilling projects to advancement of geoscience outreach activities and unravelling of major geological questions".

This booklet contains the presentation and poster abstracts. A total of 30 presentations will be given over the next two days, as well the 10 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 10 poster presentations generally show preliminary results, and we look forward to the final presentation of results in 2023 by these students. We congratulate the students on moving forward and completing their research under the constraints of the international COVID-linked lockdowns in previous years.

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 70 postgraduate students hosted at 11 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 are a backbone 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) for more information on our goals, research focus areas, and activities.

Congratulations to all students on your 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 21th of November, a time to network and socialise.

Regards,

Professor Nikki Wagner
Director: DSI-NRF CIMERA
nwagner@uj.ac.za

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

PROGRAMME

DAY 1: **MONDAY 21 NOVEMBER 2022**			
	08:00 – 08:45	REGISTRATION AND TEA	
	08:45 – 09:00	**Prof N Wagner** (UJ)	OPENING
	09:00 – 09:10	**Prof Meijboom** (UJ)	WELCOME NOTE
SLOT	TIME	PRESENTER	TOPIC
1	09:10 – 09:30	**Gharlied Abrahams** (WITS)	Structural setting, emplacement controls and evolution of selected pegmatites in the Orange River Pegmatite Belt, Namaqua Metamorphic Province, southern Africa.
2	09:30 – 09:50	**Fatima Chitlango** (UJ)	Rare earth elements in South African coals: concentration and mode of occurrence in density fractionated samples from the Waterberg Coalfield.
3	09:50 – 10:10	**Thabo Kgarabjang** (UL)	Temperature of mineralization and source of ore-forming fluids at the Stibium Mopani Gold-Antimony Mine, Murchison Greenstone Belt, South Africa: constrains from arsenopyrite geothermometry and oxygen isotope signatures.
4	10:10 – 10:30	**Thangeni Mphanama** (UV)	Coal occurrence and quality at Mushithe Area, Soutpansberg Coalfield, South Africa.
5	10:30 – 10:50	**Welhemina Langa** (UJ)	Testing the capability of core scan hyperspectral imaging to characterise South African coal, its functional groups and associated inorganic matter.
	10:50 – 11:10	TEA BREAK	
6	11:10 – 11:30	**Mpofana Sihoyiya** (WITS)	Depth imaging of the western limb of the Bushveld Complex through focusing Prestack Depth Migration of 2D legacy reflection seismic data.
7	11:30 – 11:50	**Aleck Mkhabela** (WITS)	Mineralisation controls on the ultramafic sequence and T Zone of the Waterberg Project, north of the Hout River Shear Zone, Bushveld Complex, South Africa.
8	11:50 – 12:10	**Justine Magson** (UFS)	Constraints on the Nd-isotopic composition and nature of the last major influx of magma into the Bushveld Complex.

9	12:10 – 12:30	**Sinikiwe Ncube** (UJ)	Petrological, geochemical and geochronological constraints on the Kameel Complex, Northern Cape, South Africa: implications on the Hartley Large Igneous Province.
10	12:30 – 12:50	**Samer Mashhour** (WITS)	The origin of the Merensky Reef, western Bushveld Complex, South Africa: Evidence of reactive melt flow in the petrogenesis.
	12:50 – 13:35	LUNCH	
11	13:35 – 13:55	**Tshepiso Sekhula** (UJ)	Preliminary results on the tectonic evolution of the Zebra Lobe, Kunene Complex, Namibia using structural geology and geophysics.
12	13:55 – 14:15	**Marina Yudovskaya** (WITS)	Role of contamination on formation of magmatic sulfide deposits – Bushveld vs Norilsk.
13	14:15 – 14:35	**Lebogang Madisha** (WITS)	Seismic imaging the deep structure under the Bushveld Complex.
14	14:35 – 14:55	**Khensani Moses** (UCT)	Mineralogical and geochemical characterization of the Gamsberg zinc deposit sulphide minerals, South Africa.
	14:55 – 15:10	COMFORT BREAK	
15	15:10 – 15:30	**Robyn Ormond** (UJ)	Collision or collapse? What the rocks of the Namibfontein-Vergenoeg dome can tell us about the thermal and structural evolution of the Damara Orogen.
16	15:30 – 15:50	**Sinelethu Hashibi** (UCT)	Imaging the evolution of the subcontinental lithospheric mantle using Kimberlite indicator minerals and insights from Sp receiver functions.
	15:50 – 16:35 Virtual presentation	KEYNOTE SPEAKER 1: **Mr Douglas Silver** (Exploration Geologist and Mineral Economist) **Supply and demand in the Green economy**	
	16:35 – 17:00	POSTER PRESENTATION AND VIRTUAL VIEWING	
	17:00 – 19:00	DRINKS AND SNACKS – NETWORKING SESSION	

PROGRAMME

DAY 2: **TUESDAY 22 NOVEMBER 2022**			
	08:00 – 08:45	REGISTRATION AND TEA	
	08:45 – 09:00	**Prof N Wagner** (UJ)	OPENING
SLOT	TIME	PRESENTER	TOPIC
17	09:00 – 09:20	**Sarafina Mandevhu** (UWC)	Two generations of dolerite intrusions within iron ore of the Maremane Dome: implications for the tectonic evolution and mineralization within the Dome.
18	09:20 – 09:40	**Maropeng Mailula** (UJ)	Petrography, geochemistry and age of the intrusive units of the Leinster deposit, Northern Cape.
19	09:40 – 10:00	**Mabatho Mapiloko** (WITS)	Magmatic Sulphide Mineralization in Lower Zone and Platreef offshoot intrusions on the Uitloop Farm, Limpopo South Africa.
20	10:00 – 10:20	**Ansahmbom Yong Nke** (UCT)	Impact of the Great Oxidation Event on South African basins.
21	10:20 – 10:40	**Jaganmoy Jodder** (UJ)	Insights into the age of iron formations in the Singhbhum Craton, India.
	10:40 – 11:00	TEA BREAK	
22	11:00 – 11:20	**Luyanda Mayekiso** (UWC)	The use of gaming software and HIVE technology in the construction of virtual field education of the Tanqua Karoo.
23	11:20 – 11:40	**Emmanuel Onyebueke** (WITS)	Integrated geophysical methods for mine workings investigation: case study at the Blaauwbank and Tharisa Gold Mine.
24	11:40 – 12:00	**Ramphabana Khethani Tom** (UV)	Geochemical and mineralogical characterisation of the Waterberg Coalfield: implications for provenance and acid generation potential.

	12:00 – 12:45	KEYNOTE SPEAKER 2: **Prof Nic Beukes** (UJ) **Contributions of four DSI-NRF CIMERA managed scientific drilling projects to advancement of geoscience outreach activities and unraveling of major geological questions**	
	12:45 – 13:30	LUNCH	
25	13:30 – 13:50	**Phumudzo Munyai** (UV)	Phytoremediation of metals from Klein Letaba gold mine tailings, Limpopo Province, South Africa.
26	13:50 – 14:10	**Sikelela Gomo** (WITS)	Investigating potential surface and groundwater mixing near a tailings dam and contamination potential using integrated geophysical methods.
27	14:10 – 14:30	**Tariro Mombe** (WITS)	A machine learning approach for assessing sedimentological data's potential for in-situ gold grade prediction in the Witwatersrand Basin, South Africa.
28	14:30 – 14:50	**Salizwa Plaatjie** (WITS)	Using numerical modelling to analyse seismic waves in the vicinity of in-mine tunnels.
29	14:50 – 15:10	**Joshua Pillay** (WITS)	Accurate automatic first-break picking.
	15:10 – 15:30	CLOSING AND PRIZES	
		DEPARTURE	

Image: ICDP BASE (Moodies) Scientific Drilling Project, Barberton, South Africa.

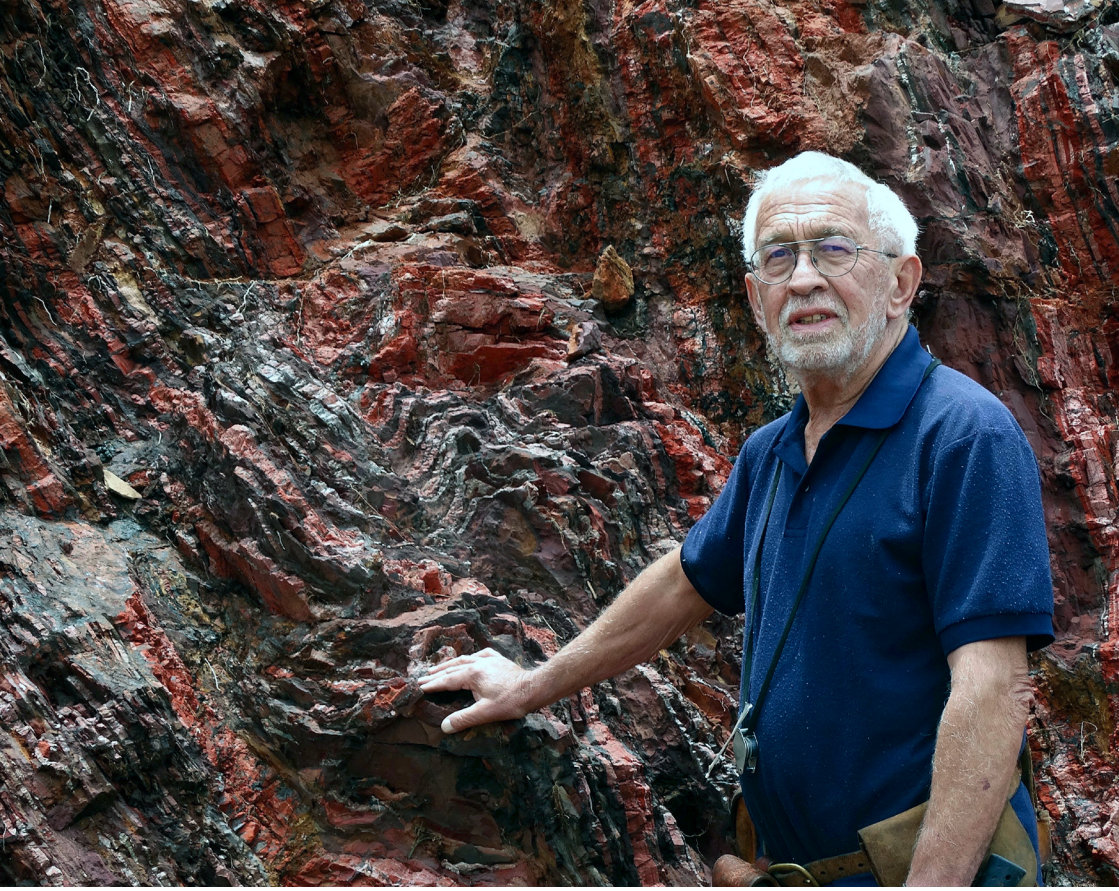
VIRTUAL POSTER PRESENTATIONS

16:35 – 17:00 **MONDAY 21 NOVEMBER 2022**		
PRESENTER	TOPIC	CONTACT
Ben Whit (UCT	Rayleigh Wave Group Velocity Maps near Leeu Gamka, southern Karoo.	whtben003@myuct.ac.za
Gbenga Olamide Adesola (UFH)	El I Resistivity Survey for groundwater ex on in the University Of Fort Hare Alice Campus, Eastern Cape, South Africa.	201813490@ufh.ac.za
Tuhin Cl orty (	The timing and orogenic context of Pan-African gem bearing pegmatites in Malawi: evidence from Rb-Sr and U-Pb geochronology.	t.chakraborty@ru.ac.za
Steve Ch ru (SU)	Invisible gold in the Archean detrital sulphides of the Witwatersrand tailings dumps: a large and under-exploited gold resource.	20206771@sun.ac.za
Bruno Ba neu (W ST)	Mineralogy and Ni potential of the Molopo Farms Complex in the area of Jwaneng-Makopong shear zone.	brunobartolomeu96@gmail.com
Jim Pau o Vila (UJ)	P–T–T–D record of the contact metamorphic aureole of the Kunene Complex in Angola.	jimiv@uj.ac.za
Mfuneko Sihlezana ( )	The limits of beneficiation of high-grade BIF hosted iron ores as deduced from geochemistry, mineralogy and mineral chemistry of ore forming hematite.	sihlezana45@gmail.com
Maponya J apula (U	Mode of occurrence and origin of iron ore deposits: a case study of iron ore in Ga-Nchabeleng area, Sekhukhune District, Limpopo Province, South Africa.	mapulajulia4@gmail.com
Merril Tau (UC)	Testing the use of olivine as a diamond indicator mineral and in defining kimberlite/orangeite sampling depth and craton margins.	txxmer002@myuct.ac.za
Rene Booysen (WITS)	Innovative remote sensing for the exploration of critical raw materials.	rbooysen411@gmail.com

Image: Baryte, Barberton (Nikki Wagner)

KEYNOTE SPEAKER 1: Mr Douglas Silver

BIOGRAPHY ■ Douglas Silver is an explorationist turned mineral economist. He has worked in many different fields within the mining industry ranging from exploration geologist to Chairman of the Board. Along the way, Mr. Silver undertook his own independent research on the global mining industry to educate himself and others. His biggest achievements include being a co-discoverer of the Silver Creek porphyry molybdenum deposit (Colorado, USA), conceptualizing and founding the Denver Gold Group – the world's largest gold investor forum, founding and building International Royalty Corporation into the fourth largest mineral royalty company and being a founding manager of Orion Resource Partners – the world's largest mining private-equity firm. Mr. Silver has written extensively about the industry, given hundreds of presentations, including more than 30 keynote speeches, and has won numerous awards. Douglas was inducted into the U.S. National Mining Hall of Fame in 2018 and will be inducted into the Canadian Mining Hall of Fame in 2023.



KEYNOTE SPEAKER 2: Prof Nicolas Beukes

BIOGRAPHY ■ Nic Beukes is a Professor of Geology at the University of Johannesburg. He is a field geologist, specializing in sedimentology and stratigraphy, with emphasis on understanding the origin of Precambrian iron formations, manganese ore and carbonate deposits. Prof. Beukes is the recipient of several awards, of which the Jubilee and Draper Medals of the Geological Society of South Africa and the National 2017 NSTF-South 32 Life-time Award are the most significant. He was also recently elected as International Member of the US National Academy of Sciences. He has authored/co-authored 215 refereed scientific articles, three books, over 300 conference abstracts and 100 technical reports to the mining industry.

TITLE:	**Structural setting, emplacement controls and evolution of selected pegmatites in the Orange River Pegmatite Belt, Namaqua Metamorphic Province, southern Africa.**
PRESENTING AUTHOR:	**Gharlied Abrahams**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	1789615@students.wits.ac.za or gharlied@gmail.com
SUPERVISOR/S NAME/S:	Paul Nex and Roger Gibson
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Energy Resources
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

The Kakamas Domain (KD), located along the eastern portion of Namaqua Metamorphic Province, has been the subject of debate. This investigation aims to model the pegmatite mineral system across the KD by use of modern GIS techniques, field mapping, structural analyses, and petrography.

The KD is composed of approximately 15 known major structural lineaments. These structures are characterized by high magnetic field ratios ranging between 142-322nT and -23 to 322nT. The greatest variation in magnetic intensity is seen across the Straussheim subarea. The western extent of the Straussheim subarea is dominated by folds ranging from moderately-plunging-upright-gentle-folds to moderately-plunging-moderately-inclined-tight-folds (sheath fold) to moderately-plunging moderately-inclined-closed-folds to steeply-inclined-moderately-plunging-open-folds. The axial planes range in strike from NNW/SSE to ESE/WNW to NNE/SSW, whilst the stretching lineations across the Straussheim subarea trend predominantly NE. The NE and NW dipping fabrics along the limbs of the fold characterized as phyllonites, blastomylonites, protomylonites, and mylonites change to a sub-vertical NE dipping fabric along the Straussheim shear zone (SSZ). In addition to the series of en echelon Straussheim pegmatites emplaced between the SSZ and Boven Rugzeer shear zone (BRSZ), the bulk of the pegmatites was emplaced concordant to the main high-strain fabric. In places, the relationship between the sub-vertical and moderately dipping foliations was seen as S-C fabrics. A heterogeneous mixture of meta-pelite, semi-pelite and schist, meta-psammite, dirty-calcsilicate, skarn, greenstones, amphibolite, meta-basalt, and epidosite are found west of the BRSZ. A comparison between maximum deposition age with distance from the western boundary of the KD revealed a sawtooth curve representative of sedimentary recycling, underplating, and rear wedge exhumation. Exhumation is further supported by retrograde metamorphism from the 800–900°C;~5.0 kbar upper granulite facies (Bial et al.,2015) to the greenschist facies (von Backstrom.,1964) dominating the KD. A series of tectonic discrimination diagrams revealed that granites plot within the volcanic-arc, syn-collisional, and within-plate fields. The remnant ophiolites and heterogeneity across the various facets of geoscience indicate that the KD is a suture zone. Since pegmatites were emplaced between 966,9±3,5Ma to 1042,7±5,0Ma (Maphumulo., 2020) it might have fractionated from nearby granitic magma emplaced around 1014±36Ma (Colliston et al., 2015). However, they could have also been sourced from a pressurized solute-rich magmatic volatile phase (Troch et al., 2022). →

REFERENCES

1. Bial, J., Buettner, S.H., Schenk, V. and Appel, P., 2015. The-long-term-high-temperature-history-of-the-central-Namaqua-Metamorphic-Complex: Evidence-for-a-Mesoproterozoic-continental-back-arc-in-southern-Africa. Precambrian Research, 268, pp. 243-278.
2. Von Backstrom., J.W., 1964. The-geology-of-an-area-around-Keimoes, Cape-Province, with-special reference to phacoliths of charnockitic adamellite-porphyry. Mem. Geol. Surv., Dep. Min. S.Afr., L111, 35-51
3. Maphumulo., M. S., 2020. Mineralogical and geochemical characterization of mineralised and regular NYF-type pegmatites from the Namaqualand pegmatite belt, Northern Cape, South Africa
4. Colliston, W.P., Cornell, D.H., Schoch, A.E., Praekelt, H.E., 2015. Geochronological-constraints-on-the-Hartbees-River-Thrust-and-Augrabies-Nappe: new-insights-into-the-assembly-of-the-Mesoproterozoic-Namaqua-Natal-Province-of-southern Africa. Precambrian-Res. 265, 150–165.
5. Troch, J., Huber, C., Bachman, O., 2022. The-physical-and-chemical-evolution-of-magmatic-fluids-in-near-solidus-silicic-magma-reservoirs: Implications-for-the-formation-of-pegmatites. American Mineralogist, 107, pp. 190-205

TITLE:	**Rare Earth Elements in South African coals: concentration and mode of occurrence in density fractionated samples from the Waterberg Coalfield.**
PRESENTING AUTHOR:	**Fatima Chitlango**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	zonkechitlango@gmail.com
SUPERVISOR/S NAME/S:	Prof Nicola Wagner
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Critical Raw Materials, Energy Resources
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The increased demand for rare earth elements (REEs) in recent years for use in technology, health care, renewable energy, oil refining, and electronics has led to increased interest and research in coal deposits being considered as an alternative source for these critical raw materials. Several countries, including South Afric,a are looking for coal and coal by-products for the extraction of REEs. However, before extraction, one needs to understand the concentration of REE in the host rock. South Africa has extensive coal resources, but the understanding of the mode of occurrence and distribution of REEs in coal and associated sediments is limited. The Waterberg Coalfield is estimated to contain 40 to 50 % of South Africa's coal resources, but this coalfield is underexplored and there is currently no available information pertaining to REE concentration. The recovery methods for critical elements (including REEs) include preconcentration, activation, extraction, enrichment, and purification. Among these recovery methods, preconcentration has a direct effect on extraction efficiency and energy consumption. The density fractionation of coal is considered as a preconcentration method.

The study aimed to assess density-fractioned coal samples from the Waterberg Coalfield to determine the concentration and mode of occurrence of REEs and to establish whether there is a relationship between REE concentration and density fractionation. Thirty density-fractionated coal samples selected from zones 8H, 8I, 7B, 4B, and 3C were characterized using proximate analysis, petrography, X-ray diffraction (XRD), and X-ray fluorescence (XRF). The concentration of REEs was determined using ICP-MS (after microwave digestion). The mode of occurrence of REEs was determined using Pearson's correlation (indirect) and Tescan Integrated Mineral Analyzer (TIMA) (direct).

The coals are classified as medium-rank C bituminous coals. The dominant REE-bearing minerals determined include calcite, hematite/magnetite, pyrite, and kaolinite. The REEs, including scandium and yttrium (REY) concentrations, range from 52.51 to 400.28 ppm. The values are higher than that of world coals, except for sample 8H F1.30 (REY concentration of 52.51 ppm) and generally a higher average sum of REE concentration in Chinese coals. Float densities 1.40 to 1,80 show anotablye higher degree of differentiation (different REY enrichment in the selected horizons) of LREY compared to MREY and HREY. Density fractions F1.30 and sink 1.80 show no distinct type of REY enrichment as the differentiation degrees between the different zones differ significantly. The results suggest that there is a relationship between the concentration of LREY with float densities 1.40 to 1.80 and therefore, preconcentration may be beneficial for these coals. The Pearson's correlation identified positive correlation coefficients of REY with organic matter and mineral matter, suggesting that the REY in the density fractionated coal samples have a mixed organic and inorganic affinity. The TIMA image analysis revealed that REEs in these samples have both an organic and inorganic mode of occurrenc,e particularly associated with phosphates, silicates, aluminosilicates, iron-bearing, and sulphur-bearing minerals. The REE occurring in these coal samples may have occurred due to inputs of volcanogenic hydrothermal solutions and sediment input from the Bushveld Complex. The results suggest that the Waterberg Coalfield is unpromising for REY and unlikely to be economically viable for extraction.

Keywords: Rare Earth Elements (REEs); Waterberg Coalfield; density fractionation; concentration; mode of occurrence.

TITLE:	**Temperature of Mineralization and Source of Ore-forming fluids at the Stibium Mopani Gold-Antimony Mine, Murchison Greenstone Belt, South Africa: Constrains from arsenopyrite geothermometry and oxygen isotope signatures.**
PRESENTING AUTHOR:	**Thabo Stephen Kgarabjang**
AFFILIATION:	University of Limpopo
EMAIL ADDRESS:	kgarabjangts@gmail.com
SUPERVISOR/S NAME/S:	Prof NQ Hammond
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Base Metals, Critical Raw Materials, Gold
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The Antimony Line in the Murchison greenstone belt hosts several gold-antimony mineralisations within massive, fractured talcose and carbonate host rocks. Samples from three orebodies, Beta, Athens and Monarch at the Stibium Mopani Mine were studied to characterize the ore mineral assemblage and geochemical distribution of the mineralisation in the host rocks and the source of the mineralizing fluids. Predominant ore minerals identified in the deposits include ullmannite (Ni0.98 Sb0.82 As0.17 S0.50), gersdorffite (Ni0.63 Fe0.24 Co0.10 Sb0.02 As0.96 S0.51), arsenopyrite (Fe0.93 As0.89 S0.55), stibnite (Sb0.69 S1.44), and Pyrrhotite (Fe0.85 S1.18). The geochemical data from the host rocks along the Antimony Line shows several characteristics distinctive to schists of basaltic origin, but exhibiting some degree of differentiation from andesitic to alkaline basalt.

Mass-balance studies of the hydrothermally altered assemblage indicated a variable degree of enrichment of the trace and pathfinder elements (Au, As, Sb and Ag) in the deposits. In particular, Au enrichment is highest at Monarch with an average enrichment of 9761%, while antimony recorded the highest enrichment at Beta with 7167%. Antimony generally shows an increasing trend of enrichment from Monarch to Beta, while gold enrichment increases from Beta to Monarch. A combination of arsenopyrite geothermometry and oxygen isotope quartz-dolomite pair from mineralizing quartz-carbonate vein and indicated temperatures of the ore formation ranging from 242oC in Athens to peak temperatures of 420°C at Monarch. The isotopic composition of the mineralizing fluids indicate δ18Owater range from +2.54 to +8.27‰ (Athens: δ18Owater range from +2.54 to +2.96‰, Beta: δ18Owater range from +5.15 to +5.68‰ and Monarch: δ18Owater range from +7.32 to +8.27‰). This range is consistent with fluids of crustal origin, typically magmatic and metamorphic hydrothermal fluids that may be evolving from a homogeneous fluid source during ore fluid migration or discrete fluid regimes associated with each the deposits.

TITLE:	**Coal Occurrence and Quality in Mushithe Area, Soutpansberg Coalfield, South Africa.**
PRESENTING AUTHOR:	**Mphanama Thangeni**
AFFILIATION:	University of Venda
EMAIL ADDRESS:	thangeni95@gmail.com
SUPERVISOR/S NAME/S:	Dr HR Mundalamo, Emeritus Professor JS Ogola and Dr LR Kone
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Energy Resources
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	ORAL

Coal remains South Africa's major energy source and will be for a foreseeable future due to its low cost and relative abundance. The Mushithe coal occurrence, which is located within the Pafuri sub-basin of the Soutpansberg Coalfield, has received less attention as compared to other coal occurrences in the Tshikondeni area, which previously hosted the Exxaro Tshikondeni Coal Mine. This is due to complex geology, insufficiently developed infrastructure, and severe water shortages, resulting in inadequate data and information available, especially regarding the geological architecture, and coal quality. Coal occurrence at Mushithe outcrops along Mbodi riverbank.

The study aims at investigating the chemical and petrological properties of coal in the Mushithe area to contribute knowledge on the geology and to complement future studies on coal quality and coal use in the area. Six coal samples were sampled from the outcrop to a depth of one metre using auger drilling method. Chemical analyses (including proximate, ultimate analyses, and Calorimetry), and petrographic analyses (maceral point, and vitrinite reflectance) were conducted on the samples. Based on ash yield (25.20 wt. %) and total sulphur (0.3 wt. %), Mushithe coals are classified as low-grade, low sulphur coal. Calorific value ranges between 12.97 – 23.35 MJ/kg and graded below grade D based on ESKOM's domestic coal specifications. The petrographic characterisation revealed that vitrinite and inertinite are the dominant maceral groups. Vitrinite range from 36.50 – 90.60 vol. % and inertinite from 9.4 – 63.5 vol. % on a mineral matter-free basis. Various coal weathering features such as cracks, fissures and oxidation rims were noted. Clay, quartz, pyrite, and carbonate minerals were identified petrographically. The mean random vitrinite reflectance values range between 0.80 – 0.82%, placing the coals in the Bituminous Medium Rank C category based on the United Nations Economic Commission for Europe coal classification (UN-ECE) coal classification scheme.

Keywords: Soutpansberg Coalfield; Mushithe coal occurrence; Macerals; Vitrinite reflectance

TITLE:	**Testing the capability of core scan hyperspectral imaging to characterise South African coal, its functional groups and associated inorganic matter.**
PRESENTING AUTHOR:	**Welhemina Langa**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	welheminasito@gmail.com
SUPERVISOR/S NAME/S:	Prof Nicola Wagner and Dr P Harris
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Energy Resources
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

Hyperspectral imaging is a non-destructive technique that measures the spectral response caused by vibration or electronic processes of molecular bonds within mineral crystals. Minerals are characterised based on their unique spectral properties within specific infrared ranges and are presented as a function of reflectance vs wavelength. Several studies have shown that core scan hyperspectral imaging (CSHI) has been successfully applied in exploration of other inorganic rocks but its application on organic rocks such as coal is not clear. Therefore, it is significant to test and demonstrate the use of CSHI in coal exploration. A borehole core from Zibulo Colliery, Witbank, south Africa was examined within the visible and near- (350 - 1000 nm), shortwave (1000 - 2500 nm), and longwave (8000 to 12000 nm) infrared ranges. To assess the capability of hyperspectral imaging to characterise coal and associated inorganic matter. The core scan hyperspectral imaging data was compared to x-ray diffraction (XRD) data, supported by proximate analysis and x-ray fluorescence (XRF).

Organic matter was identified within the VN-SWIR (visible and near-shortwave infrared) spectral region, indicated by low reflectance and a gradual increase of reflectance towards the shortwave infrared region. The positive slope of the coal spectra is influenced by the presence and the amount of very fine-grained clay and Fe-rich minerals associated with organic matter. Hyperspectral imaging identified the coal functional groups as aliphatic, aromatic rings and oxygenated groups. However, the absorption features are weak and overlap with bands of inorganic matter, resulting in uncertainty in the accuracy of data interpretation. The VN-SWIR identified kaolinite, gypsum, smectite, calcite, and magnesite. The LWIR identified quartz, kaolinite, illite, calcite, barite, and chlorite as inorganic phases.

The XRD data confirmed quartz, kaolinite calcite, gypsum and smectite, and further identified dolomite, pyrite, microcline, muscovite, plagioclase, siderite, and alunite. Microcline, muscovite, and plagioclase were not identified by hyperspectral imaging, but illite was; illite forms by degradation and weathering of feldspars and muscovite. Hyperspectral imaging did not identify pyrite, which is the most significant inorganic phase within South African coal seams due to pollution concerns.

This study established that hyperspectral imaging can rapidly indicate the presence of organic matter within the borehole core but cannot adequately separate data on coal functional groups. The technique is able to characterise most inorganic phases within the borehole core, however more research on inorganic phases such as pyrite is required.

TITLE:	**Depth Imaging of the Western Limb of the Bushveld Complex through focusing Prestack Depth Migration of 2D Legacy Reflection Seismic Data.**
PRESENTING AUTHOR:	**Mpofana Sihoyiya**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	1284606@students.wits.ac.za
SUPERVISOR/S NAME/S:	Musa Manzi and Michael Westgate
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

To improve the delineation of complex geological structures that host the platinum-bearing horizon (known as the UG2 Reef; a chromitite horizon) on the south-eastern edge of the western limb of the Bushveld Complex, we reprocessed the 50 km long, 16s two-way time, legacy 2D reflection seismic profile acquired in 1986 by the geological survey of South Africa (now known as the Council for Geoscience). The pre-stack seismic data quality was improved through careful processing, including modifying the predictive deconvolution algorithm to simulate spiking deconvolution.

To improve the delineation of complex geological structures and investigate the continuity of the reef below the thick cover, we applied Kirchhoff Pre-Stack Depth Migration (KPRESDM) and Coherency-Based Fresnel Volume Migration (CBFVM) techniques. Both imaging techniques provide good imaging of the platinum deposit and its hanging wall and footwall rocks. In particular, the CBFVM technique has provided better imaging in complex faulted regions, yielding a better understanding of the interrelationship between fault activity and platinum deposit distribution, and the relative chronology of tectonic events. Moreover, we clearly mapped the regional geological structures (Crocodile River Fault and Chaneng structure) that crosscut the profile.

TITLE:	**Mineralisation controls in the Ultramafic Sequence and T Zone of the Waterberg Project, north of the Hout River Shear Zone, Bushveld Complex, South Africa.**
PRESENTING AUTHOR:	**Aleck Mkhabela**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	1234066@students.wits.ac.za
SUPERVISOR/S NAME/S:	Glen Nwaila, Judith Kinnaird and Marina Yudovskaya
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The Waterberg Project magmatic sequence rests unconformably on granite-gneiss of the Southern Marginal Zone of the Limpopo Belt north of the Hout River Shear Zone. The succession is composed of basal Marginal pyroxenite sills, the Ultramafic Sequence (UmS), the Troctolite-Gabbronorite-Anorthosite sequence (TGA) and the Upper Zone. The entire succession is covered by the Waterberg Group sedimentary rocks, which are intruded by dolerite sills linked to the Umkondo Igneous Province. Platinum-group element (PGE)-Au-Cu and Ni sulphide mineralisation within the succession is confined to both the UmS and the upper portion of the TGA (the T Zone). This mineralisation is associated with blebby and disseminated chalcopyrite, pentlandite and pyrrhotite. Within the UmS, the mineralised interval varies from 3 to 100 m in thickness with grades occurring in both the lower feldspathic pyroxenite (FP) and the upper feldspathic harzburgite (FH). As for the T Zone, the highest-grade mineralisation is within the lower subzone (T2) gabbronorite, transgressing up-dip from west to east and along strike from SW to NE into the Lower Pegmatoidal Anorthosite (LPA). Both the T2 and the LPA are well endowed with mineralisation while the upper subzone (T1) and Upper Pegmatoidal Anorthosite (UPA) mineralisation is spatially restricted. Overall, no upward reduction in PGE tenor (PGE content in 100% sulphide) is revealed through the UmS. Instead, tenors are lower at the base of the UmS (FP), increasing upwards to higher values towards the top of the FH, implying that multiple UmS magma influxes were already rich in PGE-bearing sulphides when entering the resident magma chamber. Both the lateral PGE tenor and Cu/Pd variations favour a westerly/SW feeder zone for the UmS magma influxes. There is some variability in both tenors and Cu/Pd trends within the T Zone. However, the trends favour a westerly/SW feeder zone with higher tenors in both T2 and the LPA. Unlike the UmS, there are higher levels of lateral anti-correlations between PGE and Au tenors, implying that the anomalously high Au abundances observed within the T Zone were derived from a distinct source.

TITLE:	**Constraints on the Nd-isotopic composition and nature of the last major influx of magma into the Bushveld Complex.**
PRESENTING AUTHOR:	**Justine Magson**
AFFILIATION:	University of the Free State
EMAIL ADDRESS:	Markramj1@ufs.ac.za
SUPERVISOR/S NAME/S:	Freddie Roelofse, Grant Bybee and Robert Bolhar
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

The Pyroxenite Marker, a thin, orthopyroxene-dominated marker horizon, is observed towards the top of the Main Zone of the Bushveld Complex, where the last voluminous influx of magma into the Bushveld Complex is thought to have occurred. In an attempt to constrain the Nd- isotopic composition of the magma added at the level of the Pyroxenite Marker, a total of 21 whole-rock samples from a borehole (BH7771) drilled on the Central Sector of the Eastern Limb of the Bushveld Complex were analyzed for their Sr-Nd isotopic ratios. The magma added at the level of the Pyroxenite Marker had a unique Sr and Nd isotopic composition not seen in any of the layered rocks occurring below the level of the Pyroxenite Marker, with an 87Sr/86Sr ratio of 0.7063-0.7067 and an εNd value on the order of -5.9. The magma added at the level of the Pyroxenite Marker records evidence for a lesser degree of crustal contamination compared to the resident magma.

Dispersion of data points around the modelled isotopic (melt-melt) mixing curves is interpreted to reflect the incorporation of minerals derived from either the incoming or resident magmas into individual rock layers occurring across the Pyroxenite Marker interval, either in response to the mixing of minerals settling through a stratified magma column, or potentially through the intrusion and mixing of crystal-laden magmas with unique isotopic compositions from a sub-Bushveld staging chamber.

TITLE:	**Petrological, geochemical and geochronological constraints on the Kameel Complex, Northern Cape, South Africa: implications on the Hartley Large Igneous Province.**
PRESENTING AUTHOR:	**Sinikiwe Ncube**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	sinikiwen@uj.ac.za
SUPERVISOR/S NAME/S:	Dr Trishya Owen-Smith and Dr Herve Wabo
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICs) and Large Igneous Provinces (LIPs)
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

The Kameel Complex (KC) is a mafic intrusion located in the western part of the Kalahari Craton in South Africa. It occurs within the Paleoproterozoic Keis Supergroup rocks overlying the Transvaal Supergroup in the Griqualand West area. The KC, which has never been studied before, is completely covered by Cenozoic Kalahari sediments and is only known from drill core. The KC can be subdivided from the base to top into a Lower Zone (LZ) and Upper Zone (UZ). The LZ is made up of gabbros composed of cumulate plagioclase and clinopyroxene, while the UZ (mostly magnetite gabbros) is composed of cumulate plagioclase, clinopyroxene and Fe-Ti oxides. The UZ is marked by the appearance of the Fe-Ti oxides as a cumulus phase. In terms of geochemistry, the KC rocks become more evolved upward and follow a tholeiitic differentiation trend with enrichment of Fe and Ti upward. There is an enrichment in light REE relative to heavy REE and also a negative Nb, Ta and Ti anomalies (for the gabbros) and positive Zr and Ti anomalies (for the magnetite gabbros). The most plausible parental magma is a tholeiitic liquid that was emplaced at shallow depth. Differentiation of KC was most likely driven by the fractionation of an assemblage of plagioclase + clinopyroxene ± titanomagnetite. New 39Ar/40Ar step-heating biotite ages obtained for the KC reveal ages ranging from 1901 ± 11 Ma to 1950 ± 12 Ma. The younger 1901 ± 11 Ma age is affected by alteration and interpreted as a minimum age. However, the older 1950 ± 12 Ma age, obtained from primary biotite, is interpreted as a cooling age. Our ages overlap within error with the existing U-Pb zircon ages of 1.93–1.91 Ga for the Hartley Basalt Formation, placing the KC into the context of the Hartley Large Igneous Province. The KC may constitute the bulk of the 1.9 Ga Hartley magmatism which was so far only recognized from lavas and dykes. Further dating with the U-Pb technique on apatite and ongoing paleomagnetic investigation will refine our results.

TITLE:	**The origin of the Merensky Reef, western Bushveld Complex, South Africa: Evidence of reactive melt flow in the petrogenesis.**
PRESENTING AUTHOR:	**Samer Mashhour**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	samer.mashour@gmail.com
SUPERVISOR/S NAME/S:	Dr Ben Hayes
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Mantle and crustal processes, and associated metallogenesis including kimberlites
REGISTERED DEGREE:	PDRF
ORAL OR POSTER:	Oral

The fossilized mafic layered intrusions are the main host of the platinum-group metals in the Earth's crust. In a number of these intrusions, mineralization is associated with textural, mineral chemistry and isotopic anomalies. Merensky pegmatoid reefs of the Bushveld Complex are exploited for platinum group elements for a century. However, their metallogenesis is remained elusive. We present mineral chemistry (both major and trace), textural and high precision 87Sr/86Sr isotopic analyses from within 10 meters across the stratigraphy of the Merensky Unit (Merensky reef and its immediate foot- and hanging wall-rocks) on four drill cores that are 10 kilometers apart along the strike. Textural observations include peritectic olivine-orthopyroxene and dynamic recrystallization textures that are indicative of the percolation of a hot reactive melt within the mush. Mineral chemistry and 87Sr/86Sr isotopic ratio recorded kilometer-scale lateral variations and heterogeneity, which indicate melt flow and percolation from northeast to southwest of the study area. These observations suggest that reactive melt percolation events were important during crystallization of the Merensky pegmatoid and the formation of the platinum-group metals.

TITLE:	**Preliminary results on the tectonic evolution of the Zebra Lobe, Kunene Complex, Namibia using structural geology and geophysics.**
PRESENTING AUTHOR:	**Sekhula Tshepiso**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	sekhulatm96tt@gmail.com
SUPERVISOR/S NAME/S:	Jérémie Lehmann and Grant Bybee
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The Kunene Complex (KC), a massif-type anorthosite extending from SW Angola to NW Namibia, is one of the largest in the world yet the least studied. At the periphery of the complex are mafic-ultramafic bodies dominantly consisting of peridotites and norites documented to contain Ni-Cu-PGE mineralization (Maier et al., 2013). The complex has a surface exposure of 18 000 km^2 and an estimated total areal extent of over 45 000 km^2 when the concealed parts under Kalahari cover are considered. At least three different structural components are observed in the KC. The two Angolan KC anorthosite bodies are NNE-trending, with an isotropic northernmost part and a central part made of multiple NNE- to N-trending magmatic layers. Instead, the southern component in Namibia (i.e., the Zebra Lobe, ZL) is characterized by ENE-trending magmatic layers. Understanding when and how the components formed and evolved is still limited and under investigation. The Namibian and Angolan components of the KC are supposedly separated by a major NE-trending highly tectonized zone referred to as the Serpa Pinto Lineament. This study gives insights into the tectonic history of the Zebra Lobe, which is described in the literature as an ENE-trending antiform with a domal structure. The architecture of the ZL is attributed to compressional forces associated either with the Kibaran tectonism or the Pan-African Orogeny.

We combine structural data with processed aeromagnetic maps (reduced to pole, vertical derivative and analytical signal maps) to unravel the tectonic evolution of the ZL and constrain its architecture. The deformation history points to four deformation phases. The amphibolite facies S1 forms a steep NE-striking gneissic foliation and stromatic layering in the basement rocks (i.e., Epupa Metamorphic Complex, EMC) containing a steep SE-plunging hornblende lineation. D2 consists of high temperature subsolidus steep N-S-striking gneissic foliation with a steeply plunging pyroxene mineral lineation. S2 overprints S1 into poorly exposed S-plunging F2 folds and this foliation is observed in both basement rocks and anorthosites. Subsolidus S2 foliation is parallel to the magmatic foliation in KC anorthosites, and the parallelism is suggestive of syntectonic emplacement of the KC during an E-W shortening event. D3 results in ENE-WSW-striking high temperature subsolidus fabrics, a network of anastomosing shear zones all compatible with NNW-SSE shortening. D3 structures crosscut both primary and S2 structures in the anorthosites by deflection along shear planes associated with top to the NW kinematic indicators. We interpret the ZL as a D3 inclined fold plunging to the SW with a steeply SE-dipping axial plane associated with a fold axial planar cleavage in the core of the ZL. A later event D4, formed a steep NW-striking cleavage that overprints the EMC, KC and the Neoproterozoic clastic sedimentary rocks of the Nosib Group at greenschist facies. D4 probably formed during the Pan African Orogeny. Associated with D4 are NW-striking quartz veins and fault planes that mark tectonic contacts between the EMC and ZL units. These faults are delineated as structural lineaments indicated by sharp changes in amplitude along the ZL-EMC contacts and within the ZL. The 1100 Ma post-KC dykes and marginal units of the ZL are marked by strongly positive magnetic anomalies. The marginal positive magnetic anomalies coincide with sites of mafic-ultramafic intrusions at the periphery of the ZL.

Structural analysis and processing of aeromagnetic maps confirm that the ZL acquired its architecture during NNW-SSE shortening event, possibly during Kibaran tectonism. This regional fold and associated fold axial planar ENE-striking fabrics reworked earlier D2 fabrics, which are concordant with the NNE trend of the KC in southern Angola. A localized D3 event in the Zebra Lobe, therefore, explains the orientation difference between the NNE-trending Angolan and ENE-trending Namibian components of the KC.

TITLE:	**Role of contamination at formation of magmatic sulfide deposits – Bushveld vs Norilsk.**
PRESENTING AUTHOR:	**Marina Yudovskaya**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	Marina.yudovskaya@wits.ac.za
SUPERVISOR/S NAME/S:	N/A (Staff Member)
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	N/A
ORAL OR POSTER:	Oral

Bushveld and Norilsk PGE-Cu-Ni sulphide deposits represent two most remarkable events of chalcophile metal super-accumulations in the Earth's history that were formed after a time interval of ~1800 m.y. Despite their uniqueness and the significant age difference, implying dissimilar geodynamic situations of the ancient and more modern continents, these ore reserve repositories share major common features that can be considered necessary and sufficient ones to create a magmatic sulfide deposit. Both ore clusters occur within the largest continental LIPs on Earth in the intrusive facies associated with voluminous volcanism. This conjoint melt volume of an entire province may help to resolve a balance problem as each specific ore-bearing intrusion or influx contains much more metals than its magma volume can dissolve. Whereas PGE-Cu-Ni mineralization is related to a Mg-rich derivate, either komatiitic or picritic in composition, an accompanying series of more evolved melts and cumulate-rich magmas reflect prolonged differentiation and inevitable contamination in mushy melting–assimilation–storage–hybridization (MASH) zones (Hildreth and Moorbath, 1988) at crustal depths. At the upper crustal level, the problem of space is hard to reconcile unless the intrusive bodies replace wallrocks by ripping off and dissolving xenoliths so that the eroded strata are missing from the host volcano-sedimentary successions. Due to hybridization and contamination at these two levels, none of ore-bearing magmas show pristine mantle characteristics: their Sr-Nd isotope systems show mixing trends of deep crustal and local contamination. However, if the former is unanimously recognized as a major factor, a significance of the latter process is hotly debated. Sulfur isotope systematics of Norilsk deposits help to distinguish the local S contribution showing (i) distinct S isotope compositions of sulfides from intrusions hosted by different wallrocks; (ii) positive correlation between an amount of sulfides and a proportion of heavy 34S isotope; (iii) progressive enrichment in heavy isotope from rear facies towards intrusion's front. The similar correlations and tendencies could be recognized in the separate sills and chonoliths of the composite northern limb of the Bushveld Complex, suggesting that sulfide-rich mineralization requires an addition of local S.

TITLE:	**Seismic imaging the deep structure under the Bushveld Complex.**
PRESENTING AUTHOR:	**Lebogang Madisha**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	1348766@students.wits.ac.za
SUPERVISOR/S NAME/S:	Prof. Raymond Durrheim and Dr Fenitra Andriampenomanana
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

Widely known for being one of the world's largest layered mafic-ultramafic intrusions, the Bushveld Complex (BC) is one of South Africa's most impressive geological marvels. Hosting an extensive range of minerals, viz; platinum, rhodium, palladium, vanadium, chromium and nickel, this marvel is of great economic importance to the country. The BC was initially modelled as a single-layered laccolith by Jorrisen (1904). In 1954, Du Toit proposed a lopolith model, which was proceeded by Cousin (1959)'s dipping model that suggested the idea of separate intrusions making up the grander BC structure. These postulations were finally followed by the most recent model, proposed by Cooper and Webb (1998), of a connected Bushveld Complex. The progression of the models proposed is a clear testament to the evolution of geological and geophysical methods along with the increase in data availability. The latter of which has come to change dramatically very recently as the US array experiment was concluded.

From 2015 to 2020, the US array experiment, through the AfricaArray program and the Council of Geoscience (CGS) deployed 23 broadband stations across the BC. The data was retrieved from the IRIS Data Management Center and earthquake signals were appropriately selected using the CGS earthquake catalogue. The window of selection included a period of 10 minutes prior to the event and 30 minutes post its occurrence to make it easier to identify the P seismic wave arrivals and coda. Phase picking processes and other pre-processing steps (e.g., filtering) were carried out for events greater than Ml1 using the SEISAN, seismic analysis software. PyVelest, a python code for running VELEST, has so far produced a plot showing Vp/Vs ratio after the removal of outliers from the dataset, which will ultimately be used in establishing the synthetic models and the final 1-D velocity model. Once this is completed, FMTOMO will be used to compute a topography of the deep structure beneath the BC. The findings from this project will be studied jointly with results from previous geophysical studies (e.g., gravity and receiver function) to produce a lateral and vertical mapping of the discontinuities in the crust and upper mantle beneath the Bushveld.

This project not only offers the opportunity to better understand the underlying structure of the BC and the quantity of the untapped ores but will also provide access to a processed seismic catalogue that can be used to analyse the geohazard related to natural and mining-induced events within the Bushveld and its surrounding regions.

TITLE:	**Mineralogical and geochemical characterization of the Gamsberg zinc deposit sulphide minerals, South Africa.**
PRESENTING AUTHOR:	**Khensani Moses**
AFFILIATION:	University of Cape Town
EMAIL ADDRESS:	Khensani.moses@uct.ac.za
SUPERVISOR/S NAME/S:	Geoffrey Howarth
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Base Metals
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

The Gamsberg zinc deposit is hosted within the Gams Formation of the poly-metamorphosed and -deformed Mesoproterozoic Bushmanland Supergroup. The mineralization is present within two ore types, namely pelitic (further subdivided into pyrite- and pyrrhotite- dominant ores) and chemogenic garnet-magnetite ore. Within the Gamsberg zinc deposit, the Gams Formation is laterally discontinuous and divided into four ore bodies: North, South, East and West.

Controversy still surrounds the genetic model of the deposit. HÖhn et al. (2020;2021) argued that the Aggeneys-Gamsberg ore district experienced deep oxidation of the primary sulphides between the Okiepean and Klondikean orogenic events, change into a non-sulphide deposit and development of distinct metal zones. During the Klondikean orogeny, re-sulphidation of the ore and formed the current sulphide ore bodies. The garnet-magnetite ore is characteristic of BHT and not SEDEX deposits, and magnetite most likely formed from oxidized pyrite beds. However, Stalder et al. (2004) proposed a differentiation of the depositional basin into oxygen-deficient basin facies hosting sulphide ore and oxygenated shelf facies, which are composed of manganiferous iron formations.

A detailed study of the textural relations, major, minor and trace elements of sulphide minerals of the Gamsberg zinc deposit showed that there are at least three phases of sulphide mineral formation recorded in the pelitic ore of the Gamsberg zinc deposit. Syn-sedimentary to diagenesis (1) is preserved by anhedral inclusion-rich pyrite and pyrite cores as well as disseminated pyrite microcrystals- Py1. Prograde to peak metamorphism (2) is preserved in inclusion-free, subhedral to euhedral and granoblastic pyrite- Py2. Retrograde metamorphism (3) is preserved in mottled pyrite-sphalerite- Py3. Pyrite1 is richer in lattice-bound trace elements Co, Ni, Se and As, unlike the inclusion-free and granoblastic pyrite. Pyrite3 contains the highest Co and Ni, and the lowest As of all pyrite types. These variable pyrite morphologies occur together with disseminated to semi-massive sphalerite. At the Gamsberg North, sphalerite is also 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 contains alabandite inclusions as well as the highest MnS mole% of all the sphalerite types.

The garnet-magnetite ore exhibits textural and chemical similarities in sulphide minerals throughout the deposit as if it is one giant equilibrium domain. Pyrrhotite and remobilized sphalerite are dominant and sphalerite contains a homogenous distribution of major, minor and trace elements. Mottled pyrite-sphalerite, and pyrite associated with durchbewegt textures are also observed. The mottled sphalerite contains the highest Zn and Hg, and the least Mn and Fe of all sphalerite types in the deposit.

Recrystallization, remobilization, and sulphide mineral conversions associated with metamorphism become 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 regionally metamorphosed sediment-hosted deposits above greenschist facies. The pelitic ore is the proto-ore to the Gamsberg zinc deposit. The pre-Klondikean oxidation must have been limited to the garnet-magnetite ore. Following a typical supergene profile, the boundary between the pyrrhotite-dominated pelitic ore and the garnet-magnetite ore marks a plausible paleo-water table, below which the original SEDEX textures of the deposit are preserved. Above this paleo-water table, a complex combination of mineral facies occurs.

TITLE:	**Collision or collapse? What the rocks of the Namibfontein-Vergenoeg dome can tell us about the thermal and structural evolution of the Damara Orogen.**
PRESENTING AUTHOR:	**Robyn Ormond**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	robyno@uj.ac.za
SUPERVISOR/S NAME/S:	Prof Jérémie Lehmann, Dr Pavlína Hasalová and Prof Marlina Elburg
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Mantle and crustal processes, and associated metallogenesis including kimberlites
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

The Pan-African Damara Orogen formed during the amalgamation of the Gondwana supercontinent between 580-470 Ma and is well-known as a polydeformed and polymetamorphic orogen. The Damara Orogen is richly endowed with mineral resources such as uranium, lithium, tin, copper, and gold, whose varied mineralization mechanisms have been intensely studied. While much work has also been done to understand the structures and peak PT conditions linked to orogenic growth, the overall post-peak P-T-d evolution of the orogen is not as well understood. This is important because debate continues whether the Damara Orogen has undergone orogenic collapse, and what process controls exhumation of rocks in the Central Zone. Orogenic collapse is suggested due to i) juxtaposed areas of varied pressures separated by inferred localized, steep normal shear zones, and ii) detachments between basement and Damara Supergroup cover. Decompression melting in the Damara Orogen is proposed to signal orogenic collapse, whereby rocks are exhumed as large-scale core complexes. However, detailed P-T-d information of important structures assisting exhumation are often missing.

The Namibfontein-Vergenoeg (NV) dome in the southern Central Zone of the Damara Orogen, is a well-exposed area in the deep levels of the orogen, which is cored by the Paleoproterozoic Abbabis Metamorphic Complex basement and flanked by the Neoproterozoic Damara Supergroup cover. We use a combination of detailed field-based structural geology, petrography of syn-kinematic mineral assemblages, and pseudosection modelling to determine the PT conditions under which deformation structures formed, to investigate possible signatures of core complex formation and orogenic collapse in the Central Zone of the Damara Orogen.

However, our study shows that interference between four folding events formed the structural architecture of the NV dome. 1) E-W shortening D1 produced steep to subvertical N-S striking schistosity and stromatic layering in migmatite S1, reworked by 2) broad N-S shortening D2. F2 fold geometries control the main ENE-WSW trend of the NV dome, with moderate to steep E-W striking fold axial planar schistosity and compositional layering S2. F2 folds plunge shallowly, and rarely steeply to the NE. 3) Shallowly inclined to recumbent folds plunging to the W-NW locally fold S1 and S2 fabrics. 4) Moderately NE-dipping schistosity S4, formed as fold axial planar fabrics to NE-plunging F4 folds during D4 NE-SW shortening, overprints all older deformation fabrics. Rocks of the basement and cover sequences share a similar deformation history, with no evidence for detachment between the two.

Rocks of the NV dome are metamorphosed to upper amphibolite facies with migmatite present in both basement and cover sequences. Melt exists within and defines structures of all four deformation phases, suggesting that melt was present throughout the deformation history of the NV dome. All deformation fabrics share a similar mineralogy and are defined by cordierite + sillimanite + biotite + K-feldspar + quartz + melt ± garnet and plagioclase with accessory amount of apatite, monazite, zircon, ilmenite, and magnetite, suggesting similar metamorphic conditions. Sillimanite, garnet, cordierite, and biotite form the matrix. Detailed petrography reveals two stages of garnet growth, i) an earlier phase of large (1-2 mm) poikiloblastic garnet (with sillimanite, biotite, and quartz inclusions) partly replaced by cordierite occurring mostly in D1 and D2 samples, and ii) smaller (up to 1 mm sized), peritectic garnet. Pseudosection modelling of two metapelite samples shows that rocks of the NV dome record HTLP conditions (740-760 °C, 4-4.5 kbar), with poor preservation of earlier prograde PT conditions. However, the composition of biotite inclusions preserved in garnet may record earlier higher pressures of up to ~7.5 kbar. But this interpretation needs more data. The overgrowth of cordierite on early garnet in the presence of melt supports the HTLP conditions along the retrograde path.

When considering the results of the pseudosection modelling with the structural geology of the NV dome from this study, we see a combination of all deformation fabrics forming under similar PT conditions (no metamorphic gap) associated with a lack of detachment between basement and cover sequences, and steep structures developed due to folding in a bulk shortening regime. It therefore seems likely that the rocks of the NV dome, possibly existing at near-peak PT conditions, were exhumed along the steep structures during D1 and/or D2, causing post-peak PT conditions to overwrite the earlier segments of the PT path during decompression at high T. These data suggest that these rocks likely experienced one prolonged thermal regime from ~570 Ma down to ~470 Ma whilst undergoing polyphase deformation and melting in a contractional tectonic setting.

TITLE:	**Imaging the evolution of the subcontinental lithospheric mantle using kimberlite indicator minerals and insights from Sp receiver functions.**
PRESENTING AUTHOR:	**Sinelethu Hashibi**
AFFILIATION:	University of Cape Town
EMAIL ADDRESS:	Hshsin001@myuct.ac.za
SUPERVISOR/S NAME/S:	Dr PE Janney, Dr RA Sloan and Dr DA Quiros
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Mantle and crustal processes, and associated metallogenesis, including kimberlites
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

Mantle xenolith studies have provided key data on the composition and thermal structure of the subcontinental lithospheric mantle (SCLM) beneath southern Africa, but there are relatively few kimberlites from which fresh mantle xenoliths have been recovered. In contrast, almost all kimberlites have yielded fresh mantle xenocrysts (i.e., kimberlite indicator minerals (KIMs), such as garnet, pyroxene and ilmenite). The method of studying the SCLM through the major and trace element compositions of KIMs (e.g., Kobussen et al., 2008; 2009) has proved powerful. The use of single-mineral thermobarometry (especially for garnet, e.g., Ryan et al., 1996) has advanced our understanding of the evolution of the SCLM by enabling the vertical and horizontal mapping of the lithospheric mantle. Recent seismological studies have discovered sharp velocity changes within the lithospheric mantle, between the Moho and the lithosphere-asthenosphere boundary. These Mid-lithosphere discontinuities (MLDs) can either be negative (or positive) velocity gradients (NVG or PVGs), suggestive of decrease (or increase) of velocity with depth. Metasomatism is proposed as a probable reason for NVGs (Krueger et al., 2021).

We present data constraining the thermal and chemical structure of the SCLM beneath the Kaapvaal craton based on the mineral major and trace element geochemistry (and PCr – TNi values calculated from them, Ryan et al., 1996) of peridotitic garnets from the Kimberley and adjacent Barkly West kimberlite clusters (hereafter termed "the Barkly West cluster"). The age difference between older Group II and younger Group I kimberlite magmatism (≈ 25 Myr) allows the evolution of the SCLM over this time interval to be evaluated. Garnets from Group II kimberlites (hereafter termed "Group II garnets" are typically more Cr-saturated and magnesian, and less enriched in incompatible elements (i.e., Zr, Y, Ti) and HREE relative to garnets from Group I kimberlites (hereafter termed "Group I garnets"). Plotting the geochemical data in cross-sections through the Barkly West cluster using depths derived from PCr values reveals a layer of metasomatic enrichment at depths ca. 90 to 150 km. Additionally, the P-T profile shows a layer of thermal heterogeneity at similar depths. We have noted a correlation between increases in temperature and the Ti contents of Group I garnets, while Group II garnets show no such correlation. In order to characterise the thermal and compositional effects of metasomatism in each time interval, we calculated separate paleogeotherms for G10 (cpx-free) and G9 (cpx-bearing) garnets. Boyd (1973) divided the Kaapvaal geotherm into two parts: (1) the shallower conductive limb, characteristic of steady-state conditions and constrained by the low temperature (LT) xenoliths; (2) the deeper 'perturbed' limb, defined by the sheared high temperature (HT) xenoliths.

There are two distinct paleogeotherms at Group II kimberlite time, constrained by the G10 (cooler) and G9 (warmer) garnets. G9 and G10 Group I time paleogeotherms are consistent with the G9-based Group II paleogeotherm. We interpret that the paleogeotherm derived from G10 Group II garnets is characteristic of steady-state conditions, while the rest are snapshots of the 'perturbed' limb, as it evolves thermally and chemically.

Krueger et al., (2021) showed that all Archaean cratons, except for the Kaapvaal craton, have NVGs at depths of ca. 100 km. Despite extensive evidence of metasomatism, the Kaapvaal craton has PVGs rather than NVGs at about this depth. PVGs can be a result of phase transition from spinel to garnet peridotite, presence of (high velocity) eclogites, or storage of significant volumes of carbon as diamond (Krueger et al, 2021). This study aims to resolve a geochemical reason for these PVGs.

REFERENCES

1. Boyd, F.R., 1973. A pyroxene geotherm. Geochimica et Cosmochimica Acta, 37(12), pp.2533-2546.
2. Kobussen, A.F., Griffin, W.L., O'Reilly, S.Y. and Shee, S.R., 2008. Ghosts of lithospheres past: Imaging an evolving lithospheric mantle in southern Africa. Geology, 36(7), pp.515-518.
3. Kobussen, A.F., Griffin, W.L. and O'Reilly, S.Y., 2009. Cretaceous thermo-chemical modification of the Kaapvaal cratonic lithosphere,South Africa. Lithos, 112, pp.886-895.
4. Krueger, H.E., Gama, I. and Fischer, K.M., 2021. Global Patterns in Cratonic Mid-Lithospheric Discontinuities from Sp Receiver Functions. Geochemistry, Geophysics, Geosystems, 22(6).
5. 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.
6. Ryan, C.G., Griffin, W.L. and Pearson, N.J., 1996. Garnet geotherms: Pressure-temperature data from Cr-pyrope garnet xenocrysts in volcanic rocks. Journal of Geophysical Research: Solid Earth, 101(B3), pp.5611-5625.

TITLE:	**Two generations of dolerite intrusions within iron ore of the Maremane Dome: implications for the tectonic evolution and mineralization within the Dome.**
PRESENTING AUTHOR:	**Sarafina Mandevhu**
AFFILIATION:	Department of Earth Science, University of the Western Cape, Bellville, WC
EMAIL ADDRESS:	4106462@myuwc.ac.za
SUPERVISOR/S NAME/S:	Dr Elizaveta Kovaleva and Dr Matthew Huber
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Manganese and Iron Ore Deposits
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The Maremane Dome (MD) in the Griqualand West basin, NC, hosts rich iron ore deposits. The deposits are stratigraphically within the Asbestos Hill of the Ghaap Group (2.5-2.4 Ga) in the Transvaal Supergroup. Multiple dolerite sills intersect the ore at various stratigraphic levels (40 to 300 m subsurface). My research focuses on these intrusions, their textural, mineralogical, geochemical characteristics, and geochronology, in order to understand their origin, emplacement and evolution, and to further constrain the age of ferruginization.

A total of 40 dolerite samples were collected from nine drill cores derived from two locations within the MD. Two cores cross-cut (1) non-ferruginized intrusive rocks (both at ASSMANG exploration camp) and the remaining seven sampled (2) heavily ferruginized intrusions. Representative samples from the non-ferruginized rocks (1) are medium- to coarse-grained and dark-grey to dark-green in color, showing ophitic to subophitic textures. The ferruginized samples (2) are dark-red to brown and are very fine-grained, showing significant alteration and sericitization. QEMSCAN (Quantitative Evaluation of Minerals by Scanning Electron Microscopy) mapping shows the presence of accessory apatite, baddeleyite, and zircon in both series, which makes it possible to conduct isotopic dating of melt crystallization. Non-ferruginized intrusions yielded Pan-African ages (ca. 540 Ma, zircon), not reported from the area previously, while the ferruginized ones yielded an age of ca. 1.5 Ga (zircon), potentially corresponding to the late stages of the Keis orogenic event.

Both groups (1) and (2) classify as tholeiitic basalts and basaltic andesites (plotted in TAS diagram), compositionally resembling the Karoo dolerites. Both groups are characterised by similar trace element patterns, suggesting a similar source for both series. At least one of the ferruginizations event occurred after 1.5 Ga. The lack of ferruginization in the 540 Ma intrusion suggests that the process was completed by this time. Further isotopic dating of a larger number of samples and, possibly, by means of other mineral phases, is recommended to better constrain the age of ferruginization, and to yield a better understanding of the iron ore mineralization.

TITLE:	**Petrography, geochemistry and age of the intrusive units of the Leinster deposit, Northern Cape.**
PRESENTING AUTHOR:	**Maropeng Mailula**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	mmailula557@gmail.com
SUPERVISOR/S NAME/S:	Dr.Clarisa Vorster, Dr Trishya Owen-Smith and Prof Bertus Smith
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Manganese and Iron Ore Deposits
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The Leinster Deposit is the most northerly of five erosional relics of the Kalahari Manganese Field (KMF). The KMF is the world's largest, land-based source of economically viable Mn, at grades ranging between 20 and 48 wt% Mn (Tsikos et al., 2003; Cairncross & Beukes, 2013). It is associated with the Hotazel Formation of the Griqualand West region, which forms part of the 2650 - 2050 Ma Paleoproterozoic Transvaal Supergroup (Eriksson et al., 2006). The Hotazel Formation is characterized by three Mn ore horizons, the so-called upper, middle, and lower ore beds, which are interlayered with four superior-type Fe formations, as well as hematite-lutite (Cairncross & Beukes, 2013).

Unlike some of the other manganese (Mn) deposits in the KMF, the Leinster deposit has been characterised as a low-grade Mn deposit of which the normal stratigraphic succession has been profusely disrupted by the intrusion of numerous dykes and sills (Kleyenstüber, 1985). The intrusive rocks associated with the Leinster Deposit have in the past been referred to as bostonite: a pink-coloured, fine-grained intrusive rock, rich in alkali-feldspar (Cairncross & Beukes, 2013). However, the mineralogical and geochemical composition of these rocks have not been studied in detail and they are likely incorrectly classified. Kleyenstüber (1985), Gutzmer (1996) and Chisonga (2012) examined the mineralogy and geochemistry of a few of the so-called bostonite samples within the Main Kalahari Manganese Deposit (MKMD) and concluded that they are basalts and basaltic andesites. The intrusions of the KMF commonly appear reddish-brown or pink, not because of the presence of K-feldspar, but due to ferruginization (de Kock et al., 2020). Given the extent to which these intrusions have affected the normal stratigraphic succession in the vicinity of the Leinster Deposit, it is essential that they be adequately investigated and classified.

With the growing need for manganese in the steel-making industry, it is important to understand the effect intrusions might have on the manganese ore if the deposits affected by such events are to be exploited in the future. The purpose of this study is, therefore, to properly classify these intrusions associated with the Leinster Deposit, to investigate their effect on the ore horizons and to adequately constrain their age. The results from such an investigation will further aid to determine how the intrusions associated with the Leinster Deposit compare to other igneous bodies in the Kalahari region in terms of age and composition, in order to place them in a regional context.

In order to achieve this, a petrographical and geochemical study on a representative number of samples of the intrusive bodies associated with the ore horizons of the Leinster Deposit was conducted, in order to properly characterize and classify them. SEM-EDS, XRD, TIMA, and an optical microscope were used to determine the petrography of the intrusions. To determine the whole-rock geochemistry, XRF and ICP-MS were utilized. The samples were investigated for the presence of minerals suitable for geochronology (e.g., zircon, baddeleyite, titanite, apatite, micas) since dating such minerals could aid in constraining the age of these intrusions as well as the timing of any potential hydrothermal influence. Heavy mineral extraction techniques were used to extract heavy minerals from the bulk samples. Thin sections were also investigated for the presence of heavy minerals. →

Four boreholes provided by Anglo American have been sampled for this study. The borehole logs show that Hotazel formation has been intruded by thick sill packages, which are between 20 to 200 m. The intrusive units consist mainly of plagioclase, quartz, and clinopyroxene, with trace amounts of apatite, quartz, ilmenite, magnetite, pumpellyite, titanite, and biotite. Based on geochemistry, the samples classify as tholeiitic basalts to basaltic andesite. The rare earth element chondrite normalized data show enrichment in LREEs over HREEs, with a weak negative Eu anomaly, which is due to the fractionation of plagioclase. The enrichment of LREEs over HREEs can be attributed to crustal contamination (Srivastava and Sinha, 2004). Primitive mantle normalized data show positive U and Pb anomalies, and negative Nb, Sr, and Ce anomalies. It was concluded that the intrusive affecting the Leinster deposit would therefore be better classified as dolerites.

Of the heavy minerals targeted for geochronology (zircon, baddeleyite, titanite, and apatite), only the presence of titanite could be confirmed. Titanite has been identified in thin using TIMA (Tescan Integrated Mineral Analyzer) and an attempt will be made to age date these minerals at a later date. The titanite is suspected to be secondary and will likely reflect the age of an alteration event and not emplacement.

Based on geochemistry and mineralogy, the intrusive units of the Leinster deposit compare well with studies done on the MKMD and Avontuur deposits. Previous studies show similar mineralogy, with plagioclase being the dominant feldspar. The geochemical analysis shows a co-magmatic relationship between the intrusive units of the deposits as the intrusions from all deposits are tholeiitic basalts to basaltic andesites and show similar normalized REE and trace patterns. However, the degree of alteration experience is different between the Leinster deposit and MKMD and Avontuur deposits. The presence of pumpellyite in the intrusive units of the Leinster deposit shows that it experienced a smaller degree of alteration compared to the other two deposits (MKMD and Avontuur), which contain epidote. The presence of epidote indicates that MKMD and Avontuur experienced a higher degree of alteration. There is also a noticeable difference in the size and geometry of the intrusive units between the deposits. The MKMD, which comprises high-grade Mamatwan and Wessels-type ore, is intruded by thin dykes. The Leinster deposit, which is intruded by thick sills contains low-grade ore with Mn content between 17 to 35wt.%. In the Leinster deposit, the Mn ore layers are either displaced or have experienced some degree of metamorphism, resulting in the ore having more iron-bearing minerals than Mn-bearing minerals.

REFERENCES

1. Cairncross, B. and Beukes, N.J. (2013). The Kalahari Manganese Field, the adventure continues. Cape Town: Struik Nature.
2. Chisonga, B.C., 2012. Proterozoic mafic dykes and sills associated with BIF-hosted Iron Ore, South Africa – Implications for the distribution of the Bushveld and Umkondo Large Igneous Provinces. PhD Thesis (Unpublished), University of Johannesburg, South Africa, 281 pp.
3. Erikson, P.G., Altermann, W. and Hartzer, F.J. (2006). The Transvaal Supergroup and its Precursors. The Geology of South Africa, eds Johnson, M.J., Anhaeusser, C.R., Thomas, R.J (Geological Society of South Africa/Council for Geoscience, Johannesburg), 237-260.
4. Gutzmer, J. (1996). Genesis and Alteration of the Kalahari and Postmasburg Manganese Deposits, Griqualand West, South Africa. PhD Thesis, Rand Afrikaans University, May, 490 pp.
5. Kleyenstüber, A.S.E. (1985). A Regional Mineralogical Study of the Manganese-bearing Voëlwater Subgroup in the Northern Cape Province. PhD Thesis, Rand Afrikaans University,November, 328 pp.
6. Tsikos, H., Beukes, N.J., Moore, J.M. and Harris, C. (2003). Deposition, Diagenesis, and Secondary Enrichment of Metals in the Paleoproterozoic Hotazel Iron Formation, Kalahari Manganese Field, South Africa. Economic Geology, 98, 1449-1462.

TITLE:	**Magmatic Sulphide Mineralization in Lower Zone and Platreef offshoot intrusions on the Uitloop Farm, Limpopo, South Africa.**
PRESENTING AUTHOR:	**Mabatho Mapiloko**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	604450@students.wits.ac.za
SUPERVISOR/S NAME/S:	Dr M Yudovskaya and Prof P Nex
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and paleogeographic implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

Magmatic sulphide deposits form from relatively magnesian mantle-derived magmas, as the magma cools it becomes saturated in sulphide liquid, which later segregates and the chalcophile elements partition from the silicate melt into it (Naldrett, 2010). The source of S responsible for the formation of magmatic sulphide deposits such as the Bushveld complex is debatable. Multiple S isotope compositions have been used to constrain the source of S and the timing of S addition in the Bushveld mineralised zone and deposits (e.g., Sharman-Harris et al. 2005; Penniston-Dorland et al., 2008, Smith, 2014; Klemd et al., 2020). Here we present an integrated study of sulphide mineralogy and multiple S isotope composition of the Lower Zone and Platreef as well as footwall rocks at Uitloop, which is located on the eastern periphery of the northern limb, in the southern vicinity to the Ivanplats Platreef project hosting the Flatreef deposit.

Uitloop Lower Zone and the Platreef rocks are well endowed in base-metal sulphides (BMS) (e.g., pyrrhotite, pentlandite and chalcopyrite), which are commonly associated with platinum-group minerals. The sulphide content in these mafic/ultramafic sequences is highly variable and generally increases with proximity to the footwall contact. Underlying metasediments of the Duitschland, Penge and Malmani sequences are also inundated with BMS. These footwall sulphides could be of a sedimentary origin, or derived from adjacent magmatic rocks, or a result of hydrothermal fluid circulation. The addition of external country rock sulphur in a magmatic system can be quantitatively shown by –34S and –33S isotopic signatures, which deviate from the mantle-derived S values. The S isotope compositions of footwall rocks on Uitloop range between the –6.3 to +15.2 ‰ –34S for the Duitschland Formation, –0.4 to –0.7 ‰ for the Penge Formation and +2.1 to +7.1 ‰ in the Malmani Group. The –33S values for these rocks range from –0.26 to 4.15 ‰. Pristine magmatic Platreef rocks show –34S values near-zero –33S values (Penniston-Dorland et al., 2008) whereas Uitloop Platreef rocks show relatively high –34S values ranging between –0.8 and +12.1 ‰ as well as –33S values of –1.8 to +0.13 ‰. On the other hand, Lower Zone sulphides yield –34S and –33S values that range between – 0.3 to +12.8 ‰ and – 0.2 to +0.35 ‰ respectively. These isotopic compositions of sulphur in the Platreef and Lower Zone are indicative of the presence of Archaean surface-derived material in the magma, proving magma-country rock interactions.

TITLE:	**Impact of the Great Oxidation Event on South African basins.**
PRESENTING AUTHOR:	**Ansahmbom Yong Nke**
AFFILIATION:	University of Cape Town
EMAIL ADDRESS:	nkxans001@myuct.ac.za
SUPERVISOR/S NAME/S:	Rosalie Tostevin, Harilaos Tsikos and Xolane Mhlanga
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Manganese and Iron Ore Deposits
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

To constrain the distribution of economically significant ore bodies, and any patterns of contamination, we need to understand the nature of the primary sediments. The mineralogy of primary chemical precipitates is closely linked to the seawater redox state. Although they have undergone multiple, complex phases of alteration since their deposition, marine sediments can preserve information about seawater chemistry during their formation, providing a snapshot of conditions on the early Earth, which in turn, can inform models of sediment generation. The Neoarchean–Paleoproterozoic Transvaal Supergroup, Kaapvaal Craton, South Africa, has only experienced low-grade metamorphism, has a well-documented stratigraphy, and includes a range of lithologies, making it an excellent target. We sampled drill core REX 42 which spans the base of the carbonate-rich Moodraai Formation, through the interbedded banded iron formation-manganese ore units of the Hotazel Formation, to the top of the volcanic Ongeluk Formation. These lithologies are mostly very fine-grained, so several different analytical techniques were used for mineral identification, including (1) transmitted and reflected polarized light optical microscopy; (2) X-ray diffraction analysis (XRD); (3) backscattered electron (BSE) imaging; and (4) major element composition determined by SEM–energy dispersive X-ray spectrometry (EDS). Together, these observations were used to build a detailed paragenetic sequence model. The minerals in the manganese ore beds can be grouped into oxides and oxy-hydroxides, carbonates, and silicates. The oxidation state of manganese in these phases varies between Mn(II), Mn(III), and Mn(IV). Given its very fine grain size and cross-cutting relationships with other minerals, pyrolusite, a Mn(IV)-oxide mineral, appears to be the earliest phase, and potentially precipitated in the water column. However, many other oxide phases formed later, showing early/late diagenesis to metasomatic/hydrothermal origins. The presence of primary, Mn(IV)-minerals implies that oxidation processes were important in the genesis of Mn ore bodies, although this did not necessarily require molecular O2. This is in contrast with recent paragenetic models for iron ore, which suggest deposition of primary Fe(II)-minerals under fully anoxic conditions. If these models are both correct, then these Mn beds may mark the first traces of oxygen in surface environments, with Mn and Fe rich sediments representing deposition above and below a shallow chemocline, respectively.

TITLE:	**Insights into the age of iron formations in the Singhbhum Craton, India.**
PRESENTING AUTHOR:	**Jaganmoy Jodder**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	jaganmoyj@gmail.com
SUPERVISOR/S NAME/S:	Prof Axel Hofmann
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Manganese and Iron Ore Deposits
REGISTERED DEGREE:	PhD completed In 2021
ORAL OR POSTER:	Oral

The Singhbhum craton of India hosts Archaean supracrustal rocks that are richly endowed with iron and manganese mineralization in banded iron formations. Most previous work lumped all iron-formations into a single lithostratigraphic unit, the Iron Ore Group, ignoring the view of a few workers, who argued for distinct iron-formations that formed during different time periods in the Archaean. The Archaean supracrustal succession of the Singhbhum craton has recently been subdivided into the Palaeoarchaean Badampahar Group, a typical greenstone succession, and the Meso- to Neoarchaean Koira Group, a continental cover succession (Hofmann et al. 2022). Here we present new field and geochronological data from iron-formations and associated rocks from these units. We dated a granodiorite intrusive into the iron-formation of the Badampahar Group near Gorumahisani, which provided a weighted 207Pb/206Pb mean date of 3286 ± 10 Ma. This date provides a minimum age for deposition of iron-formations in the study area. Detrital zircon grains from a sandstone intercalated with the iron formation of the Koira Group provided a range of Palaeo- to Neoarchaean ages. The youngest zircon population was dated at c. 2.7 Ga, which we interpret as the maximum depositional age of the sedimentary rocks in the Koira area. Our zircon U-Pb data further confirms that banded iron formations in the Singhbhum craton were deposited at different times and in different geological settings in the Archaean.

REFERENCE

1. Hofmann, A., Jodder, J., Xie, H., Bolhar, R., Whitehouse, M., Elburg, M., 2022. The Archaean geological history of the Singhbhum Craton, India – a proposal for consistent framework for craton evolution. Earth Science Reviews 228, 103994.

TITLE:	**The use of Gaming software and HIVE technology in the construction of virtual field education of the Tanqua Karoo.**
PRESENTING AUTHOR:	**Luyanda Mayekiso**
AFFILIATION:	University of the Western Cape
EMAIL ADDRESS:	3623599@myuwc.ac.za
SUPERVISOR/S NAME/S:	Prof Dirk Frei, Prof Jan van Bever Donker and Dr Mathew Huber
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Energy Resources
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The Tanqua Submarine fan complex is situated in the southwestern Karoo basin of South Africa and consists of four basin floor fans and one slope fan. The basin floor fans of the Tanqua sub-basin are moderately undeformed and characterize an exceptional analogue for hydrocarbon reservoirs in medium to fine-grained turbidite systems characterized by an approximate sandstone-shale ratio of 40-50%. This research aims to develop a preparatory interactive virtual tour of the Tanqua Karoo for teaching and improving student understanding of the depositional processes and facies distribution within fine-grained deep-water fan systems and their association to a reservoir and non-reservoir distribution, heterogeneity, architecture, and quality.

Geology is a field-based profession where it is mandatory for students to travel to distant locations for field-based training. However, in times such as the COVID 19 global pandemic and tight budget constraints, embarking on multiple field trips is challenging to achieve. Currently, computer software and hardware are progressing to a position where "virtual" visits to geological sites could offer some of the information and interactions that are commonly acquired through field excursions. Recent advances in immersive technologies with regards to visualisation and interactions, have made virtual reality (VR) progressively more appealing to scholars. Virtual field trips attempt to portray a real-world environment of a particular location through a compilation of data and photographs. The virtual field trip does not replace the conventional field excursions but introduces students to the basic skills essential to understand their environment prior to going on the field excursion. This research will make use of Pano2VR as it can incorporate large amounts of data, producing a pathway for incorporating data in fine detail into a complex virtual field tour. By developing a method for doing so, a pathway for digitization outcrops is possible. The final virtual tour format is going to be web-based for easy accessibility as it does not need hardware specifics to run. This is going to be demonstrated in the Highly Immersive Visualization Environment (HIVE) for the students to explore the effectiveness of a virtual field tour in preparing for the field excursions.

TITLE:	**Integrated geophysical methods for mine workings investigation: Case study at the Blaauwbank and Tharisa gold mines.**
PRESENTING AUTHOR:	**Emmanuel Onyebueke**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	Emmanuel.Onyebueke.O@gmail.com
SUPERVISOR/S NAME/S:	Prof Musa Manzi
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Geology for Society
REGISTERED DEGREE:	PDRF
ORAL OR POSTER:	Oral

This study presents the use of integrated geophysical methods for mining site investigation and characterization using electrical resistivity imaging, seismic, and ground penetrating radar (GPR) techniques to map mine boulders at the Tharisa mine and old underground mine working at the Blaauwbank Gold mine and, generally, map geological features such as fractures, weathered zones, and bedrock-overburden contacts. The electrical resistivity and refraction tomograms show evidence of weak zones, which were interpreted as weathered and fractured zones. These weak zones could represent groundwater migration pathways and highly weathered zones. The resistivity and refraction tomograms delineated topsoil at 0 – 8 m thick and bedrock-overburden contact at 3 – 12 m depth at the Tharisa mine. The refraction seismic tomography and GPR radargram sections revealed locations where there are changes in p-wave velocity and dielectric permittivity, respectively. The tomograms revealed the variation in near-surface material velocities at different depth and potential weak zones. The electromagnetic wave reflections from the GPR were interpreted as boulders contacts with fractured/weathered zones and bedrock-overburden contacts while the diffracted events were interpreted as signals emanating from isolated boulders at the Tharisa mine.

At the Blaauwbank mine, the resistivity and reflection seismic results correlated well in delineating possible air-filled cavities, saturated weak zones, mineralized Klapperkop Formation package and mined out zones. The reflection seismic results evinced the boundaries of the prevalent geological architectures and have an advantage of deeper penetration when compared to the resistivity tomogram results. The advantage of the resistivity method over the seismic method is its ability to detect between air-filled and water/collapse cavities, and its sensitivity to conductive materials in the area. The research fortresses an undeniable importance of using integrated geophysical methods in environmental and geo-engineering applications for mapping underground mine workings and subsurface geological structures. The acquired results could also serve as a pre-emptive measure to understand the subsurface conditions within an abandoned mine before commencing any infrastructural development in the area.

TITLE:	**Geochemical and mineralogical characterisation of the Waterberg Coalfield: Implications to provenance and acid generation potential.**
PRESENTING AUTHOR:	**Ramphabana Khethani Tom**
AFFILIATION:	University of Venda
EMAIL ADDRESS:	khethanitom@gmail.com
SUPERVISOR/S NAME/S:	Dr HR Mundalamo, Mr R Netshitungulwana and Emeritus Professor JS Ogola
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Environmental Geology
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

Geochemical studies of coal and rocks can be used to determine the provenance and the acid-generating potential. The chemical index of alteration (CIA), chemical index of weathering (CIW), plagioclase index of alteration (PIA), SiO_2/Al_2O_3, and CaO/MgO ratios are important in determining the provenance of sediments. This study focused on geochemical and mineralogical characterisation of coal and host rocks. Geochemical analysis was undertaken for 15 coal and 3 host rock samples collected from a box cut within the Sekoko coal mine using x-ray fluorescence spectrometry. Mineralogical investigation was undertaken for 5 coal and 3 host rock samples using x-ray diffraction spectrometry. Results of major oxides in coal indicate an average mean value in weight % of SiO_2 (14.98), Al_2O_3 (7.58), Fe_2O_3 (1.18), TiO_2 (0.35), ZrO_2 (0.08), K_2O (0.06), CaO (0.02), MgO (0.02), P_2O_5 (0.02), NiO (0.01), SrO (0.01) and Y_2O_3 (0.01) in their order of abundance. While major oxides in clastic sedimentary rocks revealed an average mean value in weight % of SiO_2 (77.43); Al2O3 (13.22); K_2O (0.54), TiO_2 (0.49); Fe_2O_3 (0.45); ZrO2 (0.19); P_2O_5 (0.15); Cr_2O_3 (0.10); MgO (0.05); SrO (0.05) and CaO (0.04) in their order of abundance. The results indicate that sediments are of terrigenous origin. The coal oxide ratio of SiO_2/Al_2O_3 yields values ranging from 2.62 to 10.78 and 1.50 to 3.08 for host rock and coal, respectively. Low values of $SiO2/Al_2O_3$ imply that coal was formed from low land peat with freshwater under stable conditions. The oxides ratio of Al_2O_3/TiO_2 ranges from 20.60 to 56.08 with a mean value of 33.83, this could possibly imply that intermediate to felsic igneous rock was the source rock of the detrital sediments in coal and host rocks. The chemical weathering indices such as CIA, CIW, and PIA indicate that the source rock has experienced extensive chemical weathering to produce secondary minerals such as kaolinite. Mineralogical analysis revealed that all samples except overburden samples contain pyrite mineral phase. Using Abates, the pyrite mineral phase was used to predict the acid generating potential of samples. Results indicate that coal samples from Sekoko coal mine contains a minimum of 17.99 and maximum of 153.69 kg/tonne of sulfuric acid. The study concluded that coal samples from Sekoko are most likely to generate acid mine water through oxidation of pyrite which was possibly introduced through occasional flooding of the peat during coal formation.

TITLE:	**Phytoremediation of metals from Klein Letaba Gold Mine tailings, Limpopo Province, South Africa.**
PRESENTING AUTHOR:	**Phumudzo Gift Munyai**
AFFILIATION:	University of Venda
EMAIL ADDRESS:	munyaip@gmail.com
SUPERVISOR/S NAME/S:	Dr HR Mundalamo, Prof JS Ogola and Prof L Chimuka
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Environmental Geology
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

Phytoremediation is an environmental technique that uses green plants to reduce or remove environmental toxins, primarily those of anthropogenic origin, to restore sites to a condition suitable for private or public use. It is a relatively inexpensive technique and aesthetically pleasing to the public compared to alternate remediation strategies which involve excavation or chemical in-situ stabilization.

This study focused on the Klein Letaba tailings storage facility with metals such as Lead (Pb), Zinc (Zn), Copper (Cu), Arsenic (As), Nickel (Ni), Manganese (Mn), Iron (Fe) and Cadmium (Cd). Fieldwork involved the collection of plants and tailings samples and mapping of the plants distributed on the storage facility. Three different types of native plant species growing on the tailings storage facility were randomly collected which are Combretum imberbe, Cynodon dactylon and Sporobolus africanus. 45 plants and tailings samples were collected. The samples were analysed for metal concentration using inductively coupled plasma-optical emissions spectrometry (ICP-OES). The plants were found to be hyper-accumulators recording maximum values of (ppm); Combretum imberbe Mn (292.5), Fe (195.2); Cynodon dactylon Mn (255.1), Fe (210) and Sporobolus africanus Mn (333.9) and Fe (209.9) respectively.

The expected outcome was to identify suitable plants that have the potential to extract metals from contaminated sites due to the abandoned storage facility which could not be recovered by the mine using physical and chemical techniques. This is an environmentally friendly remediation strategy for metal extraction and stabilisation of the gold mine tailings using native plants. Therefore, this remediation strategy will not only be applied in the studied site but can also be applied to other similar studies.

Keywords: Phytoremediation; Extraction; Klein Letaba Tailings Dam; Metals; Native Plants.

TITLE:	**Investigating potential surface and groundwater mixing near a tailings dam and contamination potential using integrated Geophysical methods.**
PRESENTING AUTHOR:	**Sikelela Gomo**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	1488846@students.wits.ac.za
SUPERVISOR/S NAME/S:	MSD Manzi, GRJ Cooper and RJ Durrheim
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Environmental Geology
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Oral

The mafic/ultramafic rocks of the Bushveld Complex are characterised by intricate fracture networks related to tectonically controlled geomorphic processes (Taylor and Howard, 1994). These fractures enable the formation of shallow unconfined perched bedrock aquifers (intergranular weathered bedrock aquifers) within the weathered zones of the Bushveld Complex (Titus et al. 2009). These aquifers are often at risk of contamination and pollution from adjacent industrialization and urbanization activities, as a result, it is important to characterise the structural geology in an area so as to come up with ways to counteract these issues.

The aim of this study is to characterise the near subsurface weathered aquifer/s in the vicinity of the Tharisa Mine in the western Bushveld Complex. We intend to assess the implications that may be consequential of a leakage/failure of the tailings dam in the region and how contaminants from pollution point sources like landfill sites, agricultural lands could affect the aquifer/s using integrated geophysical methods. Electrical Resistivity Tomography (ERT) and Multichannel Analysis of Surface Waves (MASW) are used to characterise the aquifer/s in the region of interest. ERT is an active source geophysical method based on detecting subsurface features on their ability to transmit electrically charged particles (electrical conduction). MASW is a non-invasive seismic technique that uses the dispersive nature of surface waves (particularly Rayleigh waves) to map the subsurface shear wave velocity profile with depth.

We observed a low overburden protectiveness and high hydraulic conductivity in the study area, which implies that the shallow weathered bedrock aquifer/s in the region are vulnerable to contamination. Thus, if a tailings dam leakage or failure were to occur, the contaminants from the tailings dam are likely to contaminate the shallow bedrock aquifer/s in the region. However, the intensity of the contamination and pollution are also dependent on other factors, such as the type of waste they contain as well as the design of the tailings dam. Hence, we cannot decisively conclude that the underground water in the region is at a high risk of contamination from the nearby tailings dam. The subsurface characteristics observed along the conducted survey lines (i.e., low overburden protectivity, high hydraulic conductivity, and high degree of fracturing and weathering) could be representative of the subsurface features in the nearby agricultural and municipal areas. This suggests that the weathered aquifer/s in the region are vulnerable to contamination from sources such as industrial effluents, acid mine drainage, and agricultural runoff containing unwanted nutrients and pesticides and more.

REFERENCES

1. Taylor, R. and Howard, K., 1994, Crystalline rock aquifers: Their occurrences, use and importance. Applied Hydrogeology, 2, 64-75.
2. Titus, R., Wittüser, K. and Walters, B., 2009, Groundwater and mining in the Bushveld Complex. Abstracts of the International Mine and Water Conference, Extended Abstracts, 178-294.

TITLE:	**A machine learning approach for assessing sedimentological data's potential for in-situ gold grade prediction in the Witwatersrand Basin, South Africa.**
PRESENTING AUTHOR:	**Tariro Mombe**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	tariromombe5@gmail.com
SUPERVISOR/S NAME/S:	Prof Glen Nwaila and Dr Steven Zhang
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Gold Metallogenesis and Metallurgy
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The Witwatersrand Basin has previously been a subject of Au estimation studies; however, very few studies have done so using integrated geological data and machine learning algorithms. This approach serves to identify some of the errors in mineral resource estimation process at the data level, as it will account for imperative attributes that have previously been neglected. Errors in resource estimation have led to lower Au recovery and thus unprecedented revenue losses. This study directly addresses this problem in part because it looks at a more general and flexible estimation approach that will return more accurate and efficient results. Ore reserve estimation has a considerable impact on financial decision-making in mining projects; as a result, reliable estimates of mineral resource grades, along with suitable measures of uncertainty, play an essential role in preventing revenue loss.

This project covers the experimental work and results obtained from attempting to use sedimentological properties for in-situ gold grade prediction. The machine learning algorithms used for predictive modelling were the Random Forest (RF), AdaBoost, K-nearest neighbours (KNN) and Elastic Net (EN) – these were implemented using the Python programming language. The selected subset comprised 10 682 datapoints and four predictive sedimentological properties (Channel Width, Internal Waste, Conglomerate Percentage and Basal Contact). Running the predictive modelling process through this set returned prediction accuracies of 2%, -2%, 4%, and 4% for the RF, KNN, EN and AdaBoost algorithms, respectively. Due to these poor prediction results, the dataset was investigated and segmented using the relative error metric. As a result, the dataset was separated into a well-predicting 'good' set and a poor-predicting 'bad' set. The 'bad' set comprised 8 357 datapoints; and returned prediction accuracies of -1%, -1%, 2% and 1% for the RF, KNN, EN and AdaBoost algorithms, respectively. The 'good' set comprised 2 325 datapoints; and returned prediction accuracies of 84%, 81%, 59% and 81% for the RF, KNN, EN and AdaBoost algorithms, respectively.

The best machine learning algorithm for estimating the Witwatersrand Basin's gold grades is the RF, and the least suitable is the EN. Investigations into the importance of each sedimentological property on gold grade prediction revealed that the Channel Width was the most significant while the Conglomerate Percentage/Internal Waste were the least significant. Removing either the Conglomerate Percentage or Internal Waste increased the prediction accuracy by 3% on average, while removing the Channel Width decreased it by 10% on average. Investigations into the differences between the 'good' and 'bad' sets reveal a prominent data quality issue that may have resulted from errors during the traditional sampling process or poor sampling techniques. This study found that well-predicting samples were extracted on-reef while the low predicting data was largely sampled off-reef. In addition, through a complex methodology, it evidenced the extent to which ML techniques provide more accurate results than traditional geostatistical estimations.

TITLE:	**Using numerical modelling to analyse seismic waves in the vicinity of in-mine tunnels.**
PRESENTING AUTHOR:	**Salizwa Plaatjie**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	810385@students.wits.ac.za
SUPERVISOR/S NAME/S:	Musa Manzi and Lindsay Linzer
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Gold Metallogenesis and Metallurgy
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

In this study, we use numerical modelling to investigate how the presence of in-mine tunnels affects the propagation of seismic waves. In order to do this, we quantify several seismic source parameters from our synthetic waveform modelling and compare them with real in-mine source parameter data. We discuss the characteristics of the datasets using previous studies that have modelled wave-fields in the vicinity of stopes and in-mine tunnels. Our numerical modelling is run on a finite difference code called wave3D, which allows us to model the wave source propagation from its initiation from a specified source right through its reflection and refraction from geological and mining structures e.g., dykes, faults and tunnels.

The preliminary results indicate that tunnels have a complex relationship with the amplification of velocities along the footwall. A low-frequency component was also observed in our data, and we conditionally attribute this to the tunnel presence. Finally, a space-time snapshot analysis of the wave-field reveals that the tunnel refracts and reflects waves travelling through it and this utlimately results in a complex interference pattern.

TITLE:	**Accurate automatic first-break picking.**
PRESENTING AUTHOR:	**Joshua Pillay**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	jaepillay100@gmail.com
SUPERVISOR/S NAME/S:	Prof Gordon Cooper and Prof Musa Manzi
DSI-NRF CIMERA THEME	Gold Metallogenesis and Metallurgy
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Oral

The accurate picking of first breaks is an important and crucial task during the processing of seismic data, as it is necessary for the computation of static corrections and for the building of velocity models via a refraction tomography. Traditional first-break picking methods, such as the manual picking of first breaks, tend to be time-consuming, tedious and difficult, especially when the data being dealt with is noisy in nature. Fortunately, there are numerous advanced machine learning algorithms that provide one with innovative methodologies for accurate automatic picking of big, noisy data in a consistent and objective way. In this study, several machine learning algorithms are trained in MATLAB using approximately 26340 raw (synthetic) traces from which several first-break features are extracted, and tested on an 18-km long 2D legacy seismic profile in the Evander-Kinross area of the Mpumalanga province, South Africa. The survey area is characterised by two geological features, namely the Evander goldfields and the Highveld coalfields, with a Bushveld contact present along the direction in which the data was collected. The Evander goldfield forms part of Central Rand Group on the eastern-most extremity of the Witwatersrand Supergroup, and is dominated by quartzites, conglomerates and shales. The Highveld coalfields form part of the Vryheid formation of the Ecca Group, and is dominated mainly by mudstones, shales, sandstones, and coal beds. Majority of the raw shot gathers exhibit clear first-breaks and some reflections, whereas others required some pre-processing to accentuate the first arrivals. Methodology involves the muting of bad traces on raw shot gathers and an application of an AGC of window length 250 ms to recover attenuated amplitudes. Here, the formulation of the first-break picking problem is treated as a binary classification problem, with logical indicators assigned to events. Synthetic shot records are generated for training the classifier models, with Gaussian noise added in order to generate more noisy traces. The synthetic data is split unevenly, with the smaller of the two being designated for model validation. Once classifiers are trained, the results, after being tested on the aforementioned seismic profile and compared with the first-break picks derived from the manual method, are assessed with typical performance metrics, and an error analysis is carried out. It is envisioned that the modern machine learning algorithm will provide an accurate, faster, less time-consuming technique for the process of first-break picking, where it will ensure the timely delivery of interpretation products, thus allowing for these interpretation products to be readily utilised for updating structurally complex (gold-bearing) orebody models.

TITLE:	**Rayleigh Wave Group Velocity Maps near Leeu Gamka, southern Karoo.**
PRESENTING AUTHOR:	**Benjamin Whitehead**
AFFILIATION:	University of Cape Town
EMAIL ADDRESS:	whtben003@myuct.ac.za
SUPERVISOR/S NAME/S:	Alastair Sloan and Diego Quiros
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Energy Resources
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Poster

Leeu Gamka is located in the southern Karoo in a region which has been identified for shale gas exploration. Following a swarm of moderate-low magnitude seismicity in the area between 2007 and 2013, documented in the ISC catalogue, researchers from the University of Cape Town deployed an array of 23 geophones between March and June 2015, for the purpose of more precisely locating further events. Although there is no evidence of a fault at the surface, microseismic epicenters aligned along a NW orientation suggest that there may be movement along a blind fault of the same orientation. The data used for locating earthquakes was reused to calculate Rayleigh wave group velocity maps.

Our preliminary findings suggest that there is an increase in Rayleigh wave group velocities southeast of a linear feature with a similar orientation and location as the previously located earthquakes. This abrupt lateral change in velocity is interpreted to be a consequence of deeper formations with high Rayleigh wave group velocities, having been thrust upwards during the Cape Orogeny juxtaposing them against the generally lower Rayleigh wave group velocity rocks of the Karoo Supergroup.

The anomalous occurrence of earthquakes far removed from an active plate boundary may help improving our understanding of earthquake mechanisms and hazard. Ambient noise tomography presents a low-cost way to identify some potentially seismogenic faults in the region, supporting both exploration and associated hazard identification and mitigation.

TITLE:	**Electrical resistivity survey for groundwater exploration in the University of Fort Hare Alice Campus, Eastern Cape, South Africa.**
PRESENTING AUTHOR:	**Gbenga Olamide Adesola**
AFFILIATION:	University of Fort Hare
EMAIL ADDRESS:	201813490@ufh.ac.za
SUPERVISOR/S NAME/S:	Professor Oswald Gwavava and Professor Ken Liu
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Environmental Geology
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Poster

The University of Fort Hare, Alice campus, was investigated using the electrical resistivity method to evaluate the groundwater potential of the university. The aim of the survey is to assist the university in identifying suitable locations for borehole siting in order to find a solution to the water scarcity problem experienced as a result of its growing population and infrastructure. Twenty-eight (28) Vertical Electrical Sounding (VES) stations were occupied within the campus using the Schlumberger array, with a maximum half-current electrode spacing (AB/2) of 250 m. VES survey was conducted using the ABEM Terrameter SAS 1000C resistivity equipment. Vertical electric sounding curves were obtained from quantitative interpretations involving partial curve-matching using WINRESIST software. The result shows that the curves are composed of HA and HK curve-types, which have 4 subsurface layers. The resistivity of the first layer, which is the topmost layer, has values ranging from 20 - 5752 Ωm and the thickness is between 0.4 – 1.8 m. The second layer has resistivity values varying from 3 - 51 Ωm and thickness varying from 0.8 – 17.5 m. The third layer has resistivity that varies from 136 – 352 Ωm and thickness range from 9.9 – 143.9 m. The fourth layer has a resistivity varying from 44 to 60428 Ωm. The lithology of the area includes clay, mudstone, and sandstone, which are in some places intruded by dolerites. It was indicated that 15 out of the 28 VES stations have been identified as groundwater potential areas. The study reveals that the weathered and fractured sandstone constitute the groundwater potential aquifers. The depth of any borehole should be located between 16 m and 163 m.

Keywords: vertical electrical sounding, Schlumberger array, resistivity, aquifer, groundwater.

TITLE:	**The timing and orogenic context of Pan-African gem-bearing pegmatites in Malawi: evidence from Rb-Sr and U-Pb geochronology.**
PRESENTING AUTHOR:	**Tuhin Chakraborty**
AFFILIATION:	Rhodes University
EMAIL ADDRESS:	t.chakraborty@ru.ac.za
SUPERVISOR/S NAME/S:	Steffen Büttner
DSI-NRF CIMERA THEME:	Mantle and crustal processes, and associated metallogenesis including kimberlites
REGISTERED DEGREE:	PDRF
ORAL OR POSTER:	Poster

The Malawi Basement Complex hosts precious to semi-precious gem-bearing pegmatites, forming at different stages of regional crustal evolution, over ~270 Ma, geographically extending from northern to southern Malawi (Chakraborty et al. 2022). The current study presents U-Pb in zircon and Rb-Sr mineral isochron geochronological and isotope data from the pegmatites. The data suggests gem-pegmatite forming events in Cryogenian (~720 Ma), Ediacaran (~598 Ma and ~550 Ma) and late Cambrian to Ordovician (~515–460 Ma). The relatively older pegmatites consist gem quality zircons and have intruded early in the Pan-African orogenic cycle at 719±5 Ma and 729±4 Ma, during the intra-continental rifting episode, in the eastern part of former Rodinia. The zircon-bearing pegmatite re-appear again during the formation of East African Orogen at 598±15 Ma. Two pegmatite bodies have formed at ~550 Ma, coinciding with the time of final amalgamation of northern and southern Gondwana during the Kuunga Orogeny. The formation of pegmatites in Malawi, during the Kuunga Orogeny is not a tectonically isolated event and similar age pegmatites are reported from southern Tanzania, northern Mozambique, and eastern Zambia (Carranza et al. 2005; Simmons et al. 2012; Ganbat et al. 2021). The post-collisional crustal collapse and extension, culminated in further formation of gem tourmaline, beryl, aquamarine, and sunstone-bearing pegmatites at 520±6 Ma and ~500–460 Ma. A large spread in 87Sr/86Sr initial isotopic ratios between 0.70556 and 0.79018 suggests a variety of magma sources for the Kuunga-related pegmatites with a variably strong crustal affinity.

REFERENCES

1. Carranza et al. 2005, Natural Resources Research, 14, 47-63. 2. Chakraborty et al. 2022, Journal of African Earth Sciences, (under review). 3. Ganbat et al. 2021, Gondwana Research, 91, 286-306, 4. Simmons et al. 2012, Elements, 8, 281-287.

TITLE:	**Invisible gold in the Archean detrital sulphides of the Witwatersrand tailings dumps: A large and under-exploited gold resource.**
PRESENTING AUTHOR:	**Steve Jason Chingwaru**
AFFILIATION:	Stellenbosch University
EMAIL ADDRESS:	20206771@sun.ac.za
SUPERVISOR/S NAME/S:	Dr Bjorn Von der Heyden, Dr. Margreth Tadie
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Gold metallogenesis and metallurgy
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Poster

The Witwatersrand Basin is the world's largest gold province hosting over 53 000 tons of native gold predominantly in quartz pebble conglomerates. The Witwatersrand gold tailings dumps are subjected to secondary mining operations which involve traditional extraction techniques (further comminution and cyanide leaching) that lead to 30-50 % recovery of gold missed by the historical beneficiation. This leaves a projected 1325-1855 tons of refractory gold together with an estimated 30 million tons of sulphide material which reports to the discard stream after secondary mining. The mineralogical deportment of this remaining or refractory gold is not well constrained. The study is a dedicated gold deportment and ore characterization of 200 kg composite Witwatersrand tailings material from the Klerksdorp, Evander, Central Rand and Carletonville Goldfields. The tailings material is subjected to a modified preconcentration to define density fractions. The analysis involves optical microscopy, X-ray powder diffraction, quantitative evaluation of materials by scanning electron microscope, fire assay, aqua regia digestion, inductively coupled plasma mass spectrometry and laser ablation inductively coupled plasma mass spectrometry. Results from the analyses indicate that about 0,89 to 10,5 ppm of gold is distributed in the heavy mineral concentrates which are predominantly made up of sulphides (35,12 - 68,93 %), oxides (8,59 - 20,12 %). Detailed in situ analyses suggest the gold in the concentrate fraction is 'invisible-' or 'solid-solution' gold hosted predominantly in pyrite and arsenian pyrites, Au grades range from 0,01 - 2730 ppm (up to 14 % of total gold in the tailings). Given that the Witwatersrand Goldfield is historically a native gold deposit, identification of invisible gold in detrital pyrites (stable under Archean surface conditions) represents a potentially under-exploited resource (up to 420 tons) which explains a portion of the refractory nature of the gold remaining after secondary mining. The implications of these findings for the economics or tailings remaining and for the genesis of the Witwatersrand goldfields will be discussed.

TITLE:	**Mineralogy and Ni potential of the Molopo Farms Complex in the area of Jwaneng-Makopong shear zone.**
PRESENTING AUTHOR:	**Bruno Miguel Lourenço Bartolomeu**
AFFILIATION:	University of the Witwatersrand
EMAIL ADDRESS:	brunobartolomeu96@gmail.com
SUPERVISOR/S NAME/S:	Marina Yudovskaya; Judith Kinnaird
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Poster

Contemporaneous and likely from the same mantle source as the Bushveld complex (Gould et al., 1987; Reichhardt, 1994; Prendergast, 2012; Kaavera, et al., 2018, 2020), the Molopo Farms Complex, located in Botswana and South Africa, has been an exploration target for Ni-Cu-PGE sulphide mineralization by many companies. This study characterises the mineral assemblages in the mineralised zones of the borehole KKME – 1/6, from the recent exploration project by the Kalahari Key Minerals Exploration, using XRF-XFM data, petrographic observations, electron microprobe and TESCAN integrated mineral analyser (TIMA) analyses of four representative samples. The borehole KKME – 1/6 intersected the alternating sequences of orthopyroxenite and harzburgite, mostly heavily serpentinised. Due to the high degree of alteration, serpentinite is considered a predominant lithology whereas lesser altered neighbouring portions were used to infer the protolith, which is represented by orthopyroxenite, olivine-bearing pyroxenite, poikilitic to granular harzburgite up to dunite including chromite-rich varieties. Veining is common throughout all the lithologies with sporadic magnetite-rich zones as well as amphibole, talc and asbestos-enriched veins. TIMA results indicate the predominance of secondary silicates in the studied samples, with serpentine group minerals, mainly antigorite, predominant followed by chlorite and amphibole group minerals. Orthopyroxene and olivine are major primary silicates whereas clinopyroxene belongs to the superimposed assemblages. Nickel mineralisation is observed in both orthopyroxenite and harzburgite in the relatively narrow zones enriched in interstitial sulphide blebs or dissemination. The ore assemblages are composed of predominant Ni-rich sulphides, mainly pentlandite and heazlewoodite, with minor pyrrhotite, mackinawite, chalcopyrite as well as Ni-Fe alloy, awaruite, and Ni arsenide, orcelite, associated with a disseminated chromitite zone. The calculated Ni mineral balance indicates that the overwhelming proportion of Ni is contributed by ore minerals, especially in the most Ni-enriched samples. The characteristics of the mineral assemblages suggest a significant replacement of primary magmatic mineralisation over the course of later serpentinisation and a superimposed relatively high temperature hydrothermal event.

TITLE:	**P–T–T–D record of the contact metamorphic aureole of the Kunene Complex in Angola.**
PRESENTING AUTHOR:	**Jimi Paulo Vila**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	jvila@uj.ac.za
SUPERVISOR/S NAME:	Trishya Owen-Smith
DSI-NRF CIMERA THEME:	Metallogeny and Paleogeographic Implications of Layered Igneous Complexes (LICS) and Large Igneous Provinces (LIPS)
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Poster

The Kunene Complex (KC) is the largest massif-type anorthosite complex on the planet (Rey-moral et al., 2022). It is located in southern Angola and northern Namibia, at the present-day southwestern margin of the Congo craton. The emplacement and tectonic setting of Proterozoic massif-type anorthosites (including the KC) remains a debate among geoscientists (Ashwal & Bybee, 2017). Massif-type anorthosites crystallize at multiple levels in the crust; however, anorthosites do not contain the ideal mineral assemblages for thermobarometric calculations. Studies of the country rocks may be able to solve the problem, even though other challenges must be considered, such as a lack of exposed contacts, and a complex pre-and post-anorthosite emplacement history that needs to be separated.

We conducted a detailed pressure–temperature–time–deformation (p-t-t-d) study on a suite of supracrustal rocks close to the northwestern margin of the KC in Angola. Our study includes geological and structural mapping, petrographic and geochemical analysis, thermobarometric calculations, microstructural analysis and dating of uranium- and potassium-bearing minerals. By examining the pressure and temperature conditions of the country rocks, the time related to the metamorphic changes, and the deformation events that occurred pre-and post-emplacement, we can obtain several lines of evidence that will help us to understand the emplacement conditions of the kc.

Rock types observed in the study area are represented by an amphibolitic unit, a migmatitic unit (with minor amphibolite, schists, and chert) and granitoids (porphyritic granite and diorite), which present a variable spatial record of metamorphism. Three deformation events are represented in the area, with the oldest deformation event, D1, represented by a steep E-W-striking, low-to-medium-grade metamorphic foliation, which was folded by D2, resulting in a steep N-S-striking medium-to-high-grade metamorphic foliation. D2 was folded by a D3 event, resulting in a shallow medium-to-high-grade metamorphic foliation.

Our preliminary structural and thermobarometric results question existing geological interpretations for the area and provide new constraints on the deformation events and conditions experienced before and during KC emplacement.

REFERENCES

1. Rey-moral, c. Et al., 2022. Recording the largest gabbro-anorthositic complex worldwide: the Kunene Complex (KC), SW Angola. Precambrian Research, 379, p.106790.
2. Ashwal, l.d. & Bybee, g.m., 2017. Crustal evolution and the temporality of anorthosites. Earth-science reviews, 173, pp.307-330.

TITLE:	**The limits of beneficiation of high-grade BIF-hosted iron ores as deduced from geochemistry, mineralogy and mineral chemistry of ore-forming hematite.**
PRESENTING AUTHOR:	**Mfuneko Zukile Sihlezana**
AFFILIATION:	University of Johannesburg
EMAIL ADDRESS:	Sihlezana45@gmail.com
SUPERVISOR/S NAME/S:	AJB Smith, J Krause and J Gutzmer
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Manganese and Iron Ore Deposits
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Poster

Most of the high-grade iron formation (BIF)-hosted hematite (>60% Fe) iron ores being mined in South Africa are found in the Griqualand West Region. They formed within ancient karstic depressions on the Maremane Dome, in the Northern Cape Province [1]. Ancient supergene enrichment of the Asbestos Hills iron formations and associated lateritic weathering along the 2.0-2.2 pre-Gamagara unconformity is thought to be the main ore forming process [2] with only some minor younger hydrothermal modification [3]. These ores are currently being mined at Sishen, Khumani, Beeshoek and Kolomela Mines. Mineable ore types (58.6% ore grade) [4] include laminated, massive, and breccia-textured ores [1]. In all these ore types hematite is the only ore-forming mineral of significance-occurring in various microtextural types such as microplaty, martite or also coarse crystalline and paragenetically late specularite. Given the lateritic origin of the ore deposits it appears likely that at least some of this hematite was formed at the expense of former goethite.

High-grade iron ores deposits from Brazil, India and Australia are thought to have formed or significantly overprinted during extended episodes of lateritic weathering in late Mesozoic and Cenozoic times [5]. In these deposits, both goethite as well as hematite occur as ore-forming minerals. Goethite, in particular, has been shown to vary considerably in minor element composition, depending on its position in the ore-forming system [5]. This study is thus aimed to investigate, if systematic changes in chemical composition and mineral chemistry are preserved in the microtextural types of hematite that constitute high-grade iron ores of Maremane Dome. The different iron ore types as well as altered BIF and Fe-rich lateritic sediments from Gamagara Formation from Sishen and Kolomela Mines were sampled for this purpose.

The whole rock geochemistry of the studied samples did yield no surprise, with ore samples comprising almost exclusively of Fe2O3 (97-100 wt%), with minor amounts of SiO_2 (0,9-2 wt%), P_2O_5, Al_2O_3, TiO_2 (0,05-0,8 wt%) and whereas the Manganore BIF and Gamagara Formation marked by higher concentrations of SiO_2 (20-60 wt%) and Al_2O_3 (2-10 wt%).

Petrographic analysis revealed hematite micro-textures akin to those documented in previous studies [6,7], including microcrystalline hematite, microplaty hematite, specularite, patchy hematite and martite. Detailed studies are still ongoing to study the mineral chemistry of these different microtextural types using electron microprobe analysis (EPMA). The EPMA results on microplaty hematite show low concentrations of SiO_2, P_2O_5, Al_2O_3, TiO_2, MnO (0,03-0,9 wt%) on other ore types, whereas microplaty in high-grade iron ore show MnO concentrations below limit of detection. Martite and patchy hematite show similar pattern in mineral chemistry, with low concentrations of SiO_2, P_2O_5, Al_2O_3, TiO_2, MnO (0,01-0,5 wt%) and MnO concentration below limit of detection in high-grade ore types. Specularite, also show low concentrations of Al_2O_3, SiO_2 (0,1-1 wt%) and TiO_2, MnO, P_2O_5 concentrations below the limit of detection on the EPMA.

Examples of distinct zoning has been observed on the microplaty hematite, patchy hematite and specularite textures, using the EPMA under BSE conditions. High-resolution element distribution maps on different zoned hematite textural types show high Al2O3 concentration distribution around the rims/edges of the hematite grains compared to the core/center of these hematite grains. P_2O_5, MnO, and TiO_2 concentrations on the other hand show high concentration distribution in pore spaces or inclusions that seemed to be associated with different hematite textural types.

The Al_2O_3 concentrations that showed to be slightly higher in the ore types of the Gamagara Fm than of the Manganore IF can be attributed to introduction of additional Al as Al-silicates (muscovite, kaolinite, diaspore) seen in veins and aluminous matrix as the plausible explanation also [6,7]. The high concentration of Al_2O_3 distributed mostly around hematite grain boundary suggest leaching of Al from the hematite grains, with residual concentration around edges. The leaching of Al is outwards rather than inwards and this is supported by the sharp contact observed between the Fe_2O_3 rich center and Al_2O_3 rich outer part of the hematite grains.

Highly detrimental elements to iron ore such as Al, P and Ti are clearly incorporated into the very-fine micro-hematite types that comprise the high-grade iron ores. This indicate that for mechanical beneficiation techniques to remove all these impurities, will be difficult or impossible.

REFERENCES

[1] Smith, AJB and Beukes, NJ (2016). Episodes, 39: 269-284.

[2] Beukes, NJ et al. (2003). Trans. Inst. Min. Metall. B, 112: B18-B25.

[3] Thokoa, M. (2020). Thesis, Rhodes University, pp 24-25.

[4] https://www.angloamericankumba.com/products/iron-ore#:~:text=These%20iron%20ore%20reserves%20are,the%20domestic%20and%20export%20markets.

[5] Spier, CA et al. (2019). Min. Dep., 43: 229-254.

[6] De Kock, MC (2017). Unpublished MSc dissertation, UJ, 185pp.

[7] Ntlhoro, BL (2017). Unpublished MSc dissertation, UJ, 127pp.

TITLE:	**Mode of occurrence and origin of iron ore deposits: A Case study of iron ore in Ga-Nchabeleng Area, Sekhukhune District, Limpopo Province, South Africa.**
PRESENTING AUTHOR:	**Maponya Julia Mapula**
AFFILIATION:	University of Venda
EMAIL ADDRESS:	Mapulajulia4@gmail.com
SUPERVISOR/S NAME/S:	Emeritus Professor JS Ogola and Dr HR Mundalamo
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Manganese and Iron Ore Deposits
REGISTERED DEGREE:	MSc
ORAL OR POSTER:	Poster

The study area falls within the Sekhukhune District Municipality in Limpopo Province. It is situated near the contact between the Bushveld Igneous Complex and the Transvaal Supergroup sedimentary rocks. The Rustenburg Layered Suite, which represents the Bushveld Igneous Complex in this region, consists igneous rock types varying from light gabbronorite to dark gabbronorite.

The aim of the study was to establish the mode of occurrence and origin of iron ore deposits at Ga-Nchabeleng area to ascertain the geological environment and petrological characteristics of rocks and iron within the area.

The outcrops of the iron ore cover mainly the four hills with the host rocks forming mainly contacts between the iron ore. The geological mapping was conducted along traverses drawn across the general strike of the lithology. Iron ore and host rock samples were collected at an exposed area within and around four hills, and a detailed geological map was produced. Ore sampling was done following the trend of the ore deposits. Collected rock and iron samples were characterised and X-ray fluorescence spectrometry method was used for selected samples for geochemical characterisation.

A detailed geological map was produced, which revealed the distribution of the lithologies within the study area and the geological setting of the iron ore in the area. The distribution of the iron ore revealed the stock-work – stringers – finger-like structures wherein geologic structures such as veins acted as conduits. Several lithologies were identified that included varieties of gabbronorite and an iron ore magnetite. The XRF results revealed gabbronorite with minimum and maximum FeO_3 wt% of 1.31% and 44.22%, respectively, while minimum and maximum values of FeO_3 wt% in magnetite ore samples were found to be 43.38% and 54.55% respectively with an average value of 52.36%. The magnetite revealed high concentration values of Zn (221 ppm), Ni (225 ppm), Co (163 ppm), Cr (503 ppm) and V (8981 ppm).

The study concluded that the iron ore is hosted by intermediate to felsic igneous rocks, which were found to be gabbronorite and the magnetite ore formed stringers zones that were randomly oriented veins associated with fractional crystallization of the layered complexes. The magnetite ore within the study area was of good grade with average value above 50% and rich in V, Cr, Ni, Zn and Co.

Petrographic and ore microscopy was used for mineralogy, textural and grain size analysis. Petrographic study revealed the presence of feldspar in the gabbronorite and a high concentration of oxide minerals, and ore microscopy revealed more oxides minerals and little quarts. The oxide minerals were identified as hematite at low content and magnetite at high content. This was done to determine the mode and origin of iron ore deposits at Ga-Nchabeleng.

The study recommends further detailed exploration of iron ore in the area, applying such techniques as geophysical exploration and borehole drilling leading to resource evaluation.

Keywords: Iron Ore, Bushveld Igneous Complex, Rustenburg Layered Suit, Ga-Nchabeleng, Mode of Occurrence, Fractional Crystallisation

TITLE:	**Testing the use of olivine as a diamond indicator mineral and in defining kimberlite/orangeite sampling depth and craton margins.**
PRESENTING AUTHOR:	**Merrily Tau**
AFFILIATION:	University of Cape Town
EMAIL ADDRESS:	txxmer002@myuct.ac.za
SUPERVISOR/S NAME/S:	Geoffrey Howarth
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Mantle and crustal processes, and associated metallogenesis including kimberlites
REGISTERED DEGREE:	PhD
ORAL OR POSTER:	Poster

Olivine is a dominant constituent of kimberlites and orangeites, the primary sources of diamonds on the Kaapvaal craton, comprising up to 40-50 vol.% of the rocks. It occurs as anhedral or rounded macrocrysts (>1 mm) and euhedral to subhedral microcrysts (<1 mm), majority of which show sharp compositional zoning between xenocrystic cores and magmatic rims. In each locality, the xenocrystic cores display variable compositions (e.g., Mg# = 75 - 95) corresponding to those that characterize kimberlite- and orangeite-hosted mantle xenoliths, including granular and sheared peridotites as well as the megacryst suite [1]. Due to their abundance, olivine xenocrysts offer a great potential for characterizing the subcontinental lithospheric mantle (SCLM) column traversed by kimberlites and orangeites. The olivine rims, however, show restricted Mg# with decreasing Ni and Cr and increasing Mn, Ca, and Ti concentrations in each locality, generally associated with evolutionary trends of the host magma.

Here, we present new electron microprobe (EPMA) and laser ablation (LA-ICP-MS) trace element geochemical data of mantle olivine xenocrysts sampled by two on-craton orangeites (Finsch and Robert Victor). Olivine cores from Finsch and Robert Victor are predominantly Mg-rich with Mg# = 90.4-94.7, NiO restricted between 0.3 and 0.5 wt.%, MnO = 0.06-0.15 wt.%, and CaO < 0.07 wt.%. In each orangeite, only one out of 42 and 36 grains, respectively, was found to be Fe-rich, with Mg# = 87- 88.6, NiO = 0.3 – 0.37 wt.%, MnO = 0.14 - 0.16 wt.%, and CaO = 0.02 wt.%. The rims show Mg#'s restricted between 90 and 91.5 with NiO = 0.17 – 0.42 wt.%, MnO = 0.1 – 0.17 wt.%, and CaO = 0.04 – 0.15 wt.%. Finsch olivine cores exhibit higher concentrations of temperature-dependent elements (i.e., Al, Na, V, Cr, and Ca) as well as Cu and lower concentrations of Zn, Mn, Zr, and Ti compared to Roberts Victor cores. Although most of the olivine cores were sampled from spinel peridotites in both localities, only 36% of cores sampled by the Roberts Victor orangeite equilibrated in the garnet stability field compared to 42% for Finsch. Furthermore, Finsch olivine cores mostly show higher temperatures than those from Roberts Victor.

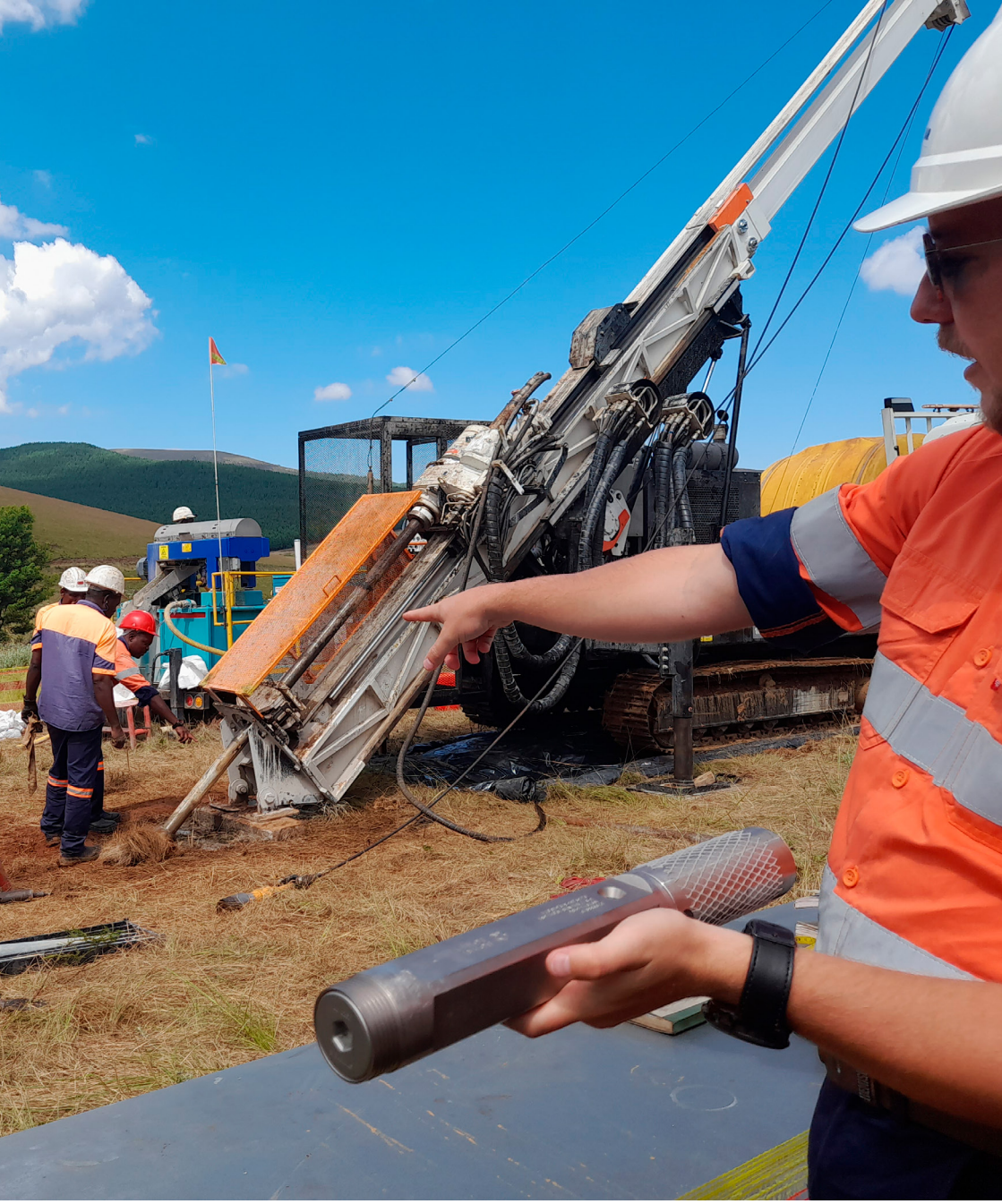
The next step of the project involves applying the recently calibrated Al-in-olivine thermometer [2] to the olivine cores from these localities to constrain their equilibrium P-T conditions, and therefore sampling depths. Ultimately, it will be determined whether material from within the diamond stability window was sampled, thus testing the use of olivine as a diamond indicator mineral.

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.

TITLE:	**Innovative remote sensing for the exploration of critical raw materials.**
PRESENTING AUTHOR:	**René Booysen**
AFFILIATION:	University of the Witwatersrand and Helmholtz Institute Freiberg for Resource Technology (HIF)
EMAIL ADDRESS:	rbooysen411@gmail.com
SUPERVISOR/S NAME/S:	Judith Kinnaird, Paul Nex and Richard Gloaguen
DSI-NRF CIMERA THEME (VISIT WEBSITE):	Critical Raw Materials
REGISTERED DEGREE:	PDRF
ORAL OR POSTER:	Poster

Society is currently in the process of transitioning towards a net-zero economy, which require the use of green technologies such as wind turbines and electric vehicles. The production of these technologies have led to an increased demand in critical raw materials which recycling alone cannot sustain. Thus, a renewed and sustainable approach for the primary exploration of these materials is required. In this project, we suggest innovative and non-invasive remote sensing techniques for the discovery of possible mineral deposits. Conventional remote sensing is the process by which information is acquired of the Earth from a distance, for example by measuring the light reflected off the surface in the visible and non-visible regions of the electromagnetic spectrum. This spectral information can act like a fingerprint whereby we can identify certain minerals. With this project, we propose a multi-scale and multi-source remote sensing approach. We acquired hyperspectral data from multiple platforms, such as satellite, airplane, unmanned aerial vehicles (UAVs) and ground-based, and with the help of advanced machine learning processing methods we plan to identify and investigate critical mineral deposits. Validation is performed by in-situ spectral measurements and sampling for geochemical analysis. We demonstrate our approach in various critical mineral deposits in southern Africa. One such deposit is the Uis pegmatite swarm in NW Namibia, where we integrate hyperspectral data acquired from multiple platforms at varying scales to help disentangle complex mineralogy associated with lithium and tin mineralization. By taking a multi-scale approach, we can benefit from each platform's advantages and improve target detection. This approach uses energy efficient, low-impact technologies that not only decrease the exploration footprint but also improve social acceptance of mineral exploration.



www.cimera.co.za

Image: Core demonstration, ICDP BASE (Moodies) Scientific Drilling Project, Barberton, South Africa. Design and layout: UJ Graphic Design Studio