

Limpopo Branch Event 2025



SAIMM
THE SOUTHERN AFRICAN INSTITUTE
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Mining for Intelligent, Open and Responsible Organisations: Enhancing the Role of Innovation for a Sustainable Mining Future

Abstract Book

28 NOVEMBER 2025

Zebula Golf Estate & Spa, Farm 534KQ, Bela Bela, Limpopo

**THE SOUTHERN AFRICAN INSTITUTE OF MINING AND
METALLURGY JOHANNESBURG 2025**

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Responsible Organisations:
Enhancing the Role of Innovation
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FOREWORD

Dear Participants and Guests,

It is a great pleasure to welcome you to the SAIMM Limpopo Branch Technical Conference of November 2025, held in Zebula Lodge, Bela-Bela. As a group of over 150 participants from most parts of South Africa, we represent the mining industry community in its unity as well as its diversity.

The SAIMM Limpopo branch is committed to disseminating – to all disciplines of the mining industry – information on the most recent and relevant research, and theories and practices in the mining industry. It is our belief that good research and technical achievements deserve to be heard, widely-read and published.

SAIMM Limpopo Branch conferences link researchers and practitioners from different disciplines of the mining industry countrywide. The theme for the November 2025 Technical Conference is **Mining for Intelligent, Open and Responsible Organisations: Enhancing the role of Innovation for Sustainable Mining Future.**

This theme is meant to assist in disseminating, to all branches of the mining industry, information on the most recent and relevant research, and theories and practices in technological innovations.

The advent of digital technologies for advanced mining has resulted in a rapid transformation in the industrial world. In the mining sector, dynamic technologies largely aim to transform production agents from fully physical systems to

FOREWORD (CONTINUED)

cyber-physical systems. This is achieved by integration of various technologies such as the Internet-of-Things, Artificial Intelligence (AI), big data, edge computing, cyber-security etc., to bridge the digital and physical worlds.

In this respect, a strong necessity to increase productivity through automated means while avoiding redundancy of human workers has led to great challenges for the global economy.

Please take this opportunity to attend presentations and imagine your contribution to the future in mining and related industries.

Wishing each one of you a successful technical conference to catch up on the latest developments in the mining industry, expand your network and seek inspiration to use your technical knowledge towards the solution of mining challenges.

M.S. Zulu
Branch Chairperson

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Branch Chairperson CV



Steven Zulu, Siyanda Bakgatla Platinum Mine, South Africa

Mxolisi Steven Zulu is an accomplished Metallurgical Technical Manager with extensive expertise in extraction metallurgy and technology management. He holds a National Diploma and a B.Tech. in Extraction Metallurgy from the University of Johannesburg, as well as an M.Sc. and a B.Sc. (Hons) in Technology Management from the University of Pretoria. Currently, he is pursuing a Ph.D. in Management of Technology & Innovation.

Steven's career is marked by significant contributions to the mining and metallurgical sectors. As a legal appointee for Safety, Health, and Environmental compliance, he has overseen critical operations including production, budgeting, and cost reduction initiatives. His leadership in metallurgical optimisation and recovery improvement projects has yielded substantial results, including the successful design and commissioning of the MIG and Chrome Recovery Plants at Modikwa Concentrator.

In academia, Steven is deeply involved in mentoring and supervising graduate students, chairing career development panels, and collaborating with various academic institutions. He has organised multiple colloquia and symposia for professionals in the mining and metallurgy fields.

His research interests have culminated in several published papers, focusing on the strategic competitiveness of the South African mining industry in the context of the Fourth Industrial Revolution. Steven's publications highlight the importance of organisational capabilities in adopting new technologies and advancing the sector.

A member of multiple professional organizations, including the SAIMM and the Mine Metallurgical Managers Association, he currently serves as the Chair of the SAIMM Limpopo Branch. Steven's commitment to professional development is evident in his active participation in workshops, courses, and conferences.

Metallurgical slags: A drive to circularity and search for a new research agenda

E. Matinde

Mintek, South Africa

Most of the critical metals and alloys can only be economically extracted and refined via pyrometallurgical approaches. Pyrometallurgical processes utilise high temperatures to extract and refine metals and alloys from their primary ores and secondary resources. Although most pyrometallurgical processes have matured and employ optimised flowsheets and technologies, these processes generate huge amounts of residual and hazardous waste streams, such as process slags and metallurgical dusts, in addition to the toxic and greenhouse gas emissions which are being extensively investigated by many researchers. Notwithstanding the impact of other waste streams on ecosystems and communities near smelters and refineries, metallurgical slags are increasingly drawing the attention of researchers due to the high volumes produced and the high ecotoxicity posed by transition metals and their oxides inherently present in discard slags. The need to mitigate the environmental impact therefore increases the urgency to explore ways to increase the valorisation potential of slags, with the ultimate objective of eliminating slag dumps in the near future. This presentation provides a brief overview of the production and properties of typical metallurgical slags. Expanding on previous discussions on the valorisation of slags, this presentation will explore the potential of deliberately engineering the slag properties during solidification in order to increase their valorisation potential. The ultimate objective is to improve the industrial ecology of smelters by considering slags as secondary sources of metals and other critical raw materials.

This presentation follows up on the plenary talk I gave during the SAIMM AGM 2024. A more detailed review paper was published in the Journal of SAIMM, September 2024 edition (available saimm.co.za/Journal/v124n9p491.pdf).



Elias Matinde

Executive Manager
Pyrometallurgy Division
Mintek

Elias holds a PhD in Metallurgical Engineering from Tohoku University in Japan, an MBA and a Bachelor of Science degree Metallurgical Engineering from the University of Zimbabwe.

Elias is a Professional Engineer and is a Fellow and Past President of the Southern African Institute of Mining and Metallurgy (SAIMM). Elias has over 20 years of experience in academic and applied research, including more than 5 years at mid-senior to senior management levels leading multidisciplinary research, development, and innovation teams in extractive metallurgy. He is currently employed as the Executive Manager of the Pyrometallurgy Division at Mintek

Elias specialises in the development of sustainable pyrometallurgical processes. His current research activities are focused on developing integrated pyrometallurgical flowsheets and technologies to recover critical metals from both primary and secondary resources. He is an avid reader of scholarly works on technological and economic catch-up.

Geopolymers in sustainable engineering: Enhanced building material, water purification, CO₂ sequestration, and thermal resistance: A review

M.J. Mvita

University of Johannesburg, South Africa

Geopolymers have emerged as a transformative alternative to traditional cementitious materials, offering significant advantages in sustainable engineering. This paper explores the advancements and applications of geopolymers, focusing on their role as enhanced building materials, their potential in water purification, CO₂ sequestration, and thermal resistance. Introduced by Joseph Davidovits in the 1970s, geopolymers are synthesised through the alkali activation of aluminosilicate sources such as metakaolin, fly ash, and slag, which are activated using alkaline solutions. The unique amorphous three-dimensional structure of geopolymers imparts notable mechanical and thermal properties, making them ideal for various construction applications.

Geopolymers significantly reduce CO₂ emissions compared to ordinary Portland cement, with studies indicating emissions reductions of 26% to 80%. This is largely attributed to their reliance on industrial by-products, which not only diverts waste from landfills but also conserves natural resources and promotes circular economy principles. The incorporation of waste materials, like fly ash and slag, enhances the mechanical properties of geopolymers, enabling them to outperform traditional materials in terms of durability and thermal stability.

The paper reviews the synthesis and processing techniques of geopolymers, emphasising the role of alkaline activators and the influence of various raw materials on their properties. Recent advancements, such as the integration of nanomaterials and the development of hybrid geopolymer-cement composites, further enhance their mechanical strength and durability. Applications of geopolymers in environmental remediation are also highlighted, showcasing their effectiveness in immobilising heavy metals and radionuclides, as well as their high adsorption capacities for pollutants in water purification.

Despite their potential, the widespread adoption of geopolymers faces challenges, including raw material variability, the lack of standardised

specifications, and issues related to workability and setting control. The paper identifies these challenges while proposing future research directions to optimise mix designs and enhance the performance of geopolymers in practical applications. In conclusion, geopolymers represent a promising pathway toward sustainable construction and environmental protection, with the potential to mitigate climate change impacts through reduced carbon footprints and effective waste management strategies. Through advancing the understanding and application of geopolymers, this paper aims to contribute to the development of innovative solutions in the field of chemical engineering and sustainable development.

Keywords: geopolymers, sustainable construction, CO₂ sequestration, water purification, alkaline activation, environmental remediation



Jonathan Mvita

Researcher and Part-time lecture
University of Johannesburg

Meta Jonathan Mvita is a dedicated PhD candidate in Chemical Engineering at the University of Johannesburg, expected to complete the program in 2026. Before this, he pursued a Master of Engineering (MEng) in Extraction Metallurgy from 2023 to 2024. He holds a Bachelor Honours degree in Metallurgy, also from the same institution, completed in 2022. Since 2023, Jonathan has served as a research assistant, contributing to significant advancements in the field of engineering. Over the years, he lectured on modules including Coal Processing, Refractory Technology, Advanced Reaction Engineering, and Multi-Stage Operations, demonstrating a strong commitment to education. Jonathan has authored 12 peer-reviewed journals and conference proceedings, showcasing his research contributions and expertise in metallurgy and chemical engineering. The work focuses on sustainable practices and innovative solutions within the field, positioning him as a promising researcher and educator. Fascinated by Artificial intelligence concepts, programming, and statistics, MVITA believes in imparting the skills developed in relation to the use of intelligent systems.

Unlocking flotation circuit stability at Palabora mining company through froth sensing and computer vision

K. Machaba, E. Mualusi, R. Moagi, T. Ramakobya, T. Mokalapa,
K. Mashilo

Palabora Mining Company, South Africa

Flotation stability is critical for consistent metallurgical recovery, yet it remains one of the least quantified aspects of concentrator performance. At Palabora Mining Company, a data-driven initiative was launched to link froth behaviour to process outcomes using computer vision and froth sensor technologies. Exploratory data analysis revealed strong correlations between airflow, froth depth, and feed density fluctuations – key drivers of recovery variability. Vision-based froth sensors now provide real-time measurements of bubble size and mobility, offering a quantitative view of froth stability. By combining these data streams, new analytical models are being developed to predict recovery trends and optimise reagent use. Early insights show that computer vision and froth sensors can significantly improve flotation consistency, enabling proactive control and enhanced recovery without relying on complex APC systems. This approach demonstrates how sensor-enhanced froth analytics can unlock new levels of flotation intelligence, advancing both recovery and sustainability in modern concentrators.

Keywords: computer vision, froth sensors, flotation recovery, data analytics, process stability, sustainable mining.



Kabelo Machaba

Metallurgist
Palabora Mining Comoany

Kabelo Machaba is a metallurgist and data scientist with extensive experience in mineral processing and digital transformation within the mining industry. As a Metallurgist at Palabora Mining Company, he focuses on flotation performance improvement and advanced process analytics. Kabelo is currently pursuing a Postgraduate Diploma in Data Science, reflecting his commitment to integrating artificial intelligence and ethical data governance into sustainable mining practices. His passion for leveraging technology to drive operational excellence highlights the growing role of innovation and data-driven decision-making in modern mineral processing.

Mine closure challenges and the need for innovation to crack the closure certificate conundrum

H. Coetzee

Owl Mountain Earth Science, South Africa

The formalisation of the closure of mines in South Africa has developed in parallel with global trends requiring the implementation of programmes to address the biophysical and socio-economic effects of mine closure, as resources become depleted and mining operations cease. Since the implementation of the 'One Environmental System' in 2014, mining and mine closure is regulated under both mining legislation – the Mineral and Petroleum Resources Development Act; environmental legislation; the National Environmental Management Act – and the regulations promulgated under these acts. Unfortunately, the mining sector – comprised of mining companies, regulators and affected communities – has not been able to find sufficient common ground to enable the consistent certification of mine closure processes.

The solution to this conundrum cannot lie in a 'business as usual' approach but will require an innovative approach. Innovation, closely related to creativity and invention, refers to both the introduction of new products and services, and the identification of new ways of doing things. While the product development life cycle is well understood, with concepts such as technological readiness levels developed and accepted, new ways of doing things are often by their nature disruptive and difficult to adopt. However, they present a means to navigate the complexities of the realities of modern mine closure, which must include:

- Mine closure planning which evolves throughout the mining life cycle, responding to the way a mine develops over time, as well as changes in the broader environmental, socio-economic, legislative and technological context in which the mine exists. Legislation requires rehabilitation to support an 'agreed-to post-closure land-use'. Mine closure planning must lay out a programme towards this land-use, providing an input into operational decision-making and concurrent rehabilitation, without losing sight of changes in the environment over the life-of-mine;

- The acknowledgement of the role of external stakeholders in the mine closure process, in particular local communities who will, ultimately, take over land stewardship after mine closure;
- The need to develop a substitutive economy, to sustain post-closure economic activity and development concurrently with mining;
- The centrality of water to mining processes and the post-mining biophysical and socio-economic landscape; and
- The need for broader cooperation between mines, in situations where environmental and socio-economic effects are integrated over a shared geographic area,

Achieving these objectives will require creative and innovative thinking as well as the application of appropriate technical solutions. Conceptual closure plans already exist in some areas and are being developed in others, addressing these concerns and offering long-term financial sustainability.



Henk Coetzee

Director
Owl Mountain Earth Science

Dr Henk Coetzee is a geoscientist with more than 30 years of experience dealing with environmental management issues in the mining sector. He recently retired from the Council for Geoscience, where he held the position of Specialist Scientist and founded Owl Mountain Earth Science, a company with a focus on ESG questions in the mining sector, with a strong emphasis on water management, environmental management, sustainability and mine closure. In recent years he has worked extensively on resolving problems related to the management of mine water in the Witwatersrand Goldfields, was a member of the Team of Experts that developed the recommendations that led to the pump-and-treat plants currently operating in the Witwatersrand, and co-led the team that has been drafting the National Strategy for Mine Closure and the Management of Derelict and Ownerless Mines together with the Department of Mineral and Petroleum Resources. Other projects have looked at CO₂ sequestration using alkaline wastes from the construction industry, remote sensing applications in the management of the environmental and social impacts of mining, resource recovery from mining and other mineral wastes and a range of geoscientific fields.

He holds a PhD in geophysics from the University of the Witwatersrand and has authored and co-authored more than a hundred papers, conference abstracts, book chapters and technical reports.

Evaluation of the recovery potential of weathered oxidised open pit UG2 ore at Modikwa concentrator

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Modikwa Platinum Mine, South Africa

The depletion of sulfide-rich platinum group metal (PGM) ores in the Bushveld Igneous Complex (BIC) has increased interest in exploiting near-surface oxidised ore deposits. These oxidised ores pose significant metallurgical challenges due to altered mineralogy and poor response to conventional xanthate collectors. Oxidation modifies the surface chemistry of PGM-bearing minerals, reduces metal liberation, and increases the presence of slime-forming gangue minerals such as talc and serpentine, which interfere with flotation performance. At Modikwa Platinum Mine, initial treatment of oxidised open-pit UG2 ore using the existing flotation circuit achieved only 54% PGE recovery, compared with 86% from underground UG2 ore, highlighting the need for alternative strategies to improve recovery.

The objective of this paper is to investigate the recovery potential of oxidised open-pit UG2 ore at Modikwa Platinum Mine by testing multiple reagent combinations and determining their optimum performance conditions to enhance flotation efficiency. Numerous studies and batch test works were conducted using a variety of reagents to evaluate their effect on PGE recovery. Among these, alkyl hydroxamate (AM) collectors and sodium silicate (NaSiO_2) in combination with conventional collectors, co-collectors, depressants, and frothers were identified as the most effective reagents, producing significant improvements in recovery and selectivity.

Hydroxamate collectors improve hydrophobicity of oxidised PGM surfaces through chelation under neutral to mildly alkaline conditions, while sodium silicate acts as a dispersant and depressant for phyllosilicate gangue minerals, reducing slime coating, froth entrainment, and pulp viscosity. Batch flotation testwork was conducted on representative oxidised UG2 ore samples from the open pit. Reagent dosages were varied systematically to assess both individual and combined effects on recovery, grade, and selectivity. Flotation performance was evaluated using time-recovery

curves, 4T PGE grade-recovery relationships, mass pull-recovery trends, Cr_2O_3 grade-recovery data, and reagent-cost analysis. The introduction of AM improved PGE recovery from 54% to 61%, with further gains observed with NaSiO_2 . Improvements were associated with enhanced mineral hydrophobicity, reduced slime effects, and better froth stability. However, due to the lower inherent floatability of the oxidised ore, frother dosage had to be doubled and depressant dosage reduced.

A notable challenge is the elevated chromite content in the ore, resulting in Cr_2O_3 levels in the concentrate nearly twice that of standard UG2 concentrate. Despite this, the combined use of hydroxamate collectors and sodium silicate demonstrates a promising and economically viable approach to improving recovery and selectivity. The results highlight the potential for efficient processing of oxidised open-pit UG2 ore and contribute to sustainable PGM beneficiation practices in South Africa, aligning with national objectives for responsible resource utilisation and metallurgical innovation.

Keywords: oxidised ores, flotation reagents, altered mineralogy



Constance Sebota Mabitla

Graduate Metallurgist
Modikwa Platinum Mine

Sebota Mabitla holds a Btech in Agriculture (Animal Production) and Bachelor of Engineering Technology in Extraction Metallurgy. She is currently completing a Bachelor of Engineering Technology Honours in chemical Engineering at the University of Johannesburg. She began her career at Sovereign Foods where she completed two years experiential learning in large-scale animal production and agribusiness operations. After obtaining her agricultural qualification, she established her own mixed farming enterprise focusing on poultry and crop production.

Sebota later transitioned in to mining sector and is currently employed as a graduate metallurgist at Modikwa Platinum mine, where she contributes to metallurgical test works, process optimization, and recovery improvement studies. Her work focuses on sustainable mineral recovery and process efficiency. Her pursuit of Chemical Engineering is driven by a desire to deepen her understanding of process systems, reaction engineering and environmental management. Skills that will strengthen her professional capacity to design and optimise metallurgical processes.

An explorative study on monitoring and evaluation of HR policies and procedures in the mining industry: A governance truce and a case study of Palabora mining company

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The mining industry is still considered a pillar of the economic development of the resource-endowed countries; however proper human resource (HR) management has always been a serious governance issue. This paper discusses the mechanisms of monitoring and evaluating (M&E) HR policies and procedures used in Palabora Mining Company (PMC) in order to assess their probability to ensure compliance, operational effectiveness, and workforce sustainability. Although HR policies are crucial in upholding labour relations and employee's well-being, compliance with regulatory requirements is also crucial. The research has not explored how the policies are effectively tracked and assessed in the context of the organisation's policies and procedures. The lack of well-organised governance systems on HR practices may lead to inefficiencies, undermined labour relations or practices, and restricted legal compliance. Employing a qualitative case study approach, this paper focuses on the current HR policies in PMC by using semi-structured interviews with HR managers, employees, and governance experts, and supplemented by research analysis of compliance reports and best practices in the industry. The paper utilises thematic analysis to identify key governance challenges, policy enforcement mechanisms, and compliance effectiveness. Initial research indicates essential information regarding the positive and negative aspects of the HR M&E system used by PMC and the possibility of improving the quality of governance. The paper gives practical suggestions on how HR policy monitoring and evaluation can be enhanced to make compliance mechanisms more effective and create compelling governance frameworks that can be applied throughout the mining industry. The paper is valuable to the theoretical background as well as practical use in the HR governance field, providing the mining companies with evidence-based policies in managing their workforce sustainably and in compliance with regulatory standards. The next phase of this research work will look into developing an integrated governance framework for monitoring and evaluating HR

policies and procedures that aligns with both organisational objectives and regulatory standards. This phase will further explore how evidence-based M&E practices can encourage accountability, sustainability of the workforce, and improve compliance in the South African mining industry.

Keywords: Human Resource Management, Monitoring and Evaluation, Mining Industry, Governance, Palabora Mining Company, Policy Compliance



Octave Patel

Superintendent Value Improving Practices
Palabora Mining Company

A results-driven and strategically professional currently serving as Superintendent Value Improving Practice at Palabora Mining Company, where I lead strategic initiatives aimed at enhancing operational efficiency, cost optimisation and long-term project value. I am pursuing a Master of Management in Governance, specialising in Monitoring and Evaluation, as well as a Bachelor of Commerce in Human Resource Management. I bring strong interests in governance, evidence-based decision-making and organisational effectiveness. Recognised for my analytical approach, problem-solving ability and dedication to continuous improvement, I contribute to building high-performing, sustainable and well-governed organisations.

Nanostructured functionalised sewage sludge adsorbent: Utilising ANN and RSM for optimised wastewater remediation

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University of Johannesburg, South Africa

Heavy metal contamination in industrial wastewater poses substantial environmental challenges and threatens both ecosystems and human health. Metals such as iron (Fe), manganese (Mn), chromium (Cr), and aluminium (Al) can cause toxic effects, bioaccumulation, and long-lasting ecological harm. Conventional methods for treating wastewater laden with heavy metals often lack efficiency and sustainability, necessitating innovative solutions to improve removal processes. This paper explores the optimisation of heavy metal adsorption using a combination of Artificial Neural Networks (ANN) and Response Surface Methodology (RSM). It specifically focuses on the adsorption capabilities of sewage sludge ash (SSA) as an economical and sustainable adsorbent for removing Fe^{2+} , Mn^{2+} , Cr^{3+} , and Al^{3+} ions from water. SSA is particularly attractive due to its availability as a by-product from wastewater treatment, contributing to sustainable waste management. To systematically analyse the adsorption process, a Box-Behnken Design (BBD) consisting of 25 experimental runs was employed. The paper investigates three critical factors: temperature (25 to 45°C), solid load percentage (1 to 10%), and contact time (1 to 10 hours). Experimental results showed excellent removal efficiencies, achieving 97% for Fe^{2+} , 89% for Mn^{2+} , 97% for Cr^{3+} , and 92% for Al^{3+} in mono-metal solutions. These outcomes highlight the effectiveness of SSA as an adsorbent for heavy metal ions. The functionalised SSA demonstrated a significant surface area of 7.79 m²/g before adsorption, categorising it as a mesoporous material. Its nanoporous characteristics greatly enhance its adsorption potential, allowing for improved interaction with metal ions. The integration of ANN and RSM revealed a strong predictive capability, with an R^2 value near 0.95 and a root mean squared error (RMSE) of 0.086, validating the model's effectiveness in predicting adsorption results based on varying parameters. A sensitivity analysis identified temperature as the primary factor influencing adsorption efficiency, followed by contact time and solid loading percentage. This indicates the importance of controlling these parameters to optimise the adsorption process. The research

underscores the potential of combining ANN and RSM to deepen the understanding of heavy metal adsorption mechanisms and to enhance remediation strategies effectively. In summary, this paper highlights the effectiveness of using sewage sludge ash as a sustainable adsorbent for heavy metals in wastewater treatment. Through the integration of ANN with RSM, the research provides valuable insights into optimising adsorption processes and lays the groundwork for future studies aimed at improving heavy metal remediation strategies. The findings have important implications for developing cost-effective and environmentally-friendly solutions for wastewater treatment.

Keywords: Heavy metal pollution, industrial wastewater, sewage sludge ash (SSA), adsorption, Artificial Neural Networks (ANN), Response Surface Methodology (RSM)



Jonathan Mvita

Researcher and Part-time lecture
University of Johannesburg

Meta Jonathan Mvita is a dedicated PhD candidate in Chemical Engineering at the University of Johannesburg, expected to complete the program in 2026. Before this, he pursued a Master of Engineering (MEng) in Extraction Metallurgy from 2023 to 2024. He holds a Bachelor Honours degree in Metallurgy, also from the same institution, completed in 2022. Since 2023, Jonathan has served as a research assistant, contributing to significant advancements in the field of engineering. Over the years, he lectured on modules including Coal Processing, Refractory Technology, Advanced Reaction Engineering, and Multi-Stage Operations, demonstrating a strong commitment to education. Jonathan has authored 12 peer-reviewed journals and conference proceedings, showcasing his research contributions and expertise in metallurgy and chemical engineering. The work focuses on sustainable practices and innovative solutions within the field, positioning him as a promising researcher and educator. Fascinated by Artificial intelligence concepts, programming, and statistics, MVITA believes in imparting the skills developed in relation to the use of intelligent systems.

Improving the control of explosives through technology: A framework for safe and accountable mining

T.J. Bogopa

University of South Africa, South Africa

This abstract, drawn from Thabang Joy Bogopa's ongoing doctoral study in policing, explores the use of technology to strengthen the control and management of explosives within South African mining. The research identifies major challenges such as insufficient traceability, manual record systems, fragmented databases, weak enforcement of the Explosives Act, and the Mine Health and Safety Act. These weaknesses contribute to diversion risks, unsafe practices, and limited oversight across the explosives value chain. The paper proposes a technology-driven control framework integrating digital tracking, blockchain-based inventory management, real-time scanning, and smart blast design systems. These technologies can enhance accountability, ensure end-to-end visibility, and enable real-time monitoring from manufacturing to end use and disposal. Comparative case studies from technologically advanced mining jurisdictions are analysed to demonstrate effective models adaptable to South Africa's mining and security environment. The paper highlights how adopting Fourth Industrial Revolution tools—such as the Internet of Things, data analytics, and automated compliance reporting—can optimise the explosives regulatory process, improve safety standards, and reduce operational risks. The findings emphasise that digital transformation in explosives control is not only a compliance requirement but a strategic necessity for national security, efficient mining operations, and sustainable resource management. This paper contributes a practical framework and policy recommendations to guide law enforcement, regulatory authorities, and industry stakeholders toward safer, transparent, and technology-enabled explosives governance in mining.

Keywords: Explosives control; Technology integration; Blockchain; Policing; Mining safety; Digital monitoring



Thabang Joy Bogopa

Lecturer
University of South Africa

Thabang Joy Bogopa joined the University of South Africa (UNISA), where he studied Diploma in Security Management, BTech in Forensic Investigation, and Masters in criminal justice and became active in applied research. By the time he reached his late twenties, Bogopa had already positioned himself at the meeting point of academic research and practical crime prevention. Bogopa is a seasoned law enforcement and security professional with over 15 years of combined experience in policing and mining security. His career includes six years as an Investigator in the SAPS, six years as an Inspector of Explosives under SAPS, and three years as an Explosives Officer in Mining. Thabang Bogopa's professional path blends postgraduate study, research awards and public-facing analysis. He was a Master's student in Criminal Justice at UNISA when he developed the idea for a software tool to manage explosives more carefully in mining environments. In 2019 he won UNISA's Research & Innovation Challenge. His most notable technical work is the Explosives ICT Control System, an information and communication technology platform designed to improve how mines track, control and account for explosives. The system is built to be practical: it aims to integrate biometric checks, access control and geographic information so that mines can know who handled explosive materials, how much was issued for a specific rock type, and where remaining stockpiles are stored. Beyond the explosives system, Bogopa has contributed to public discussion on forensic and security policy. He appears in media as a crime expert and forensic scientist.

Energy and cost optimisation in underground mine dewatering at Palabora mining company: A pump scheduling approach for block cave operations under inflow variability and off-peak power usage

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Efficient dewatering is essential for sustaining underground block cave operations at Palabora Mining Company (PMC), where water accumulation poses risks to infrastructure stability and operational continuity. This paper introduces an innovative, time-based pump scheduling strategy designed to reduce energy consumption and operating costs. By leveraging off-peak electricity tariffs and accounting for variable water inflows, the model optimises pump operation based on real-time site conditions. Key inputs include inflow patterns, pump capacities, and dynamic power pricing. When applied to PMC's dewatering system, the strategy achieved reliable water control while significantly lowering energy usage and costs. The results demonstrate a practical, intelligent solution that supports more sustainable and responsible mining practices. This approach offers valuable insights for other deep-level mining operations seeking to enhance efficiency and environmental performance through innovation.

Keywords: Underground mining, block cave mining, dewatering, energy efficiency, pump scheduling, power management, cost savings.



Chuene Ramashala

Graduate Metallurgist
Palabora Mining Company

A metallurgist is often described as a custodian of equipment specifications and process parameters. Chuene, a metallurgical engineer in training who is currently in the minerals processing industry at Palabora Mining Company aims to demonstrate that through his cumulative knowledge and exposure to other industries such as the refractories industry and pyrometallurgical industry at a smelter that specializes in the use of an electric arc furnace. Chuene possesses a Bachelor of Engineering in Metallurgical Engineering degree from the University of Pretoria. He is currently within the department that deals with the water reticulation of the process water for operations and tailings management (Auxiliary Services Technical). Chuene currently performs duties that are aligned with that of a process engineer through data-driven modelling, process design and development and collaboration with different engineering disciplines on plant optimisation and availability.

Improving safety and reducing risk by introducing a breathable air backup system for permanent emergency refuge bays underground

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Palabora Mining Company (PMC) operates an underground block-cave copper mine next to the town of Phalaborwa in the Limpopo province. Mining activities have been concentrated at a depth of 1200 m below surface (Lift I) since transitioning from open pit to underground mining. As the current production level is nearing end of life, the mine has been constructing the next production level at 1600 m below surface (Lift II). Access to the new mining area is via an approximately 3000 m long decline system comprising of a men and material barrel and a conveyor barrel. Permanent emergency refuge bays underground (also referred to in short as refuge bays, refuge chambers or refuge stations) are situated at predetermined distances down the decline and on the Lift II production level. These emergency refuge bays (ERBs) are supplied as per industry standard with compressed air from surface to create a breathable atmosphere inside an ERB during an emergency and to pressurise it to prevent ingress of toxic gasses. The compressed air supply line from surface to the ERBs is installed in haulages and conveyor declines. Damage by mining or transport activities can cause a loss of compressed air supply, as can a power failure. To drastically reduce the risk of an ERB breathable atmosphere supply becoming unavailable during an emergency, PMC, with BBE Consulting and the OEM (MineARC Systems) developed and installed a breathable air backup system. Developing a backup system required clear design criteria, including people capacity, minimum duration, oxygen supply safety factor, maximum CO₂ and CO levels, and minimum oxygen level. This paper will describe the original compressed air supplied ERB system, the risks associated with it, the option analysis for a backup system, the selected system and its design, the implementation phase, and the outcome.

Keywords: safety, emergency, escape, refuge, breathable atmosphere, backup system



Riaan van der Westhuizen

Senior Engineer
BBE Consulting

Riaan is an internationally published professional with an impressive academic and industry background. Riaan graduated in 2004, earning a Bachelor of Technology degree in Mechanical Engineering. He is registered as a Professional Engineering Technologist in South Africa. With over two decades of experience in project management and consultancy, he has made substantial contributions to the mining, construction, and business sectors.

Riaan's career began in the HVAC and industrial ventilation industry, where he specialized in designing complex systems, including dust extraction, refrigeration, pumping, and fire safety. This foundational work paved the way for his later achievements in the field of mine ventilation and refrigeration. Riaan has successfully managed numerous EPCM projects both in South Africa and internationally. His portfolio includes the design, construction, commissioning, and performance testing of main fans, surface refrigeration plants, and underground cooling systems. He has led various studies including conceptual, pre-feasibility, and feasibility studies, as well as compliance audits.

Bio-desilication of UG2 tailings using *Paenibacillus mucilaginosus* for enhanced liberation and pre-concentration of Platinum Group Metals

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The platinum group metals (PGMs) supply chain faces growing challenges from ore depletion, complex mineral associations, and environmental constraints. South Africa's UG2 reef, a major PGM source, suffers from high chromite and silicate content, leading to poor flotation recoveries and substantial PGM losses to tailings. This paper investigates a green processing route through bio-desilication using *Paenibacillus mucilaginosus* to enhance PGM liberation from UG2 tailings. Bioleaching was performed in a 50% w/v slurry for 12 days at 30°C and 150 rpm. Characterisation (XRF, XRD, FTIR, SEM, AAS) confirmed significant dissolution of silicate and chromite minerals, with reductions in Si, Al, Cr, and Fe, and increased solubilisation of Fe and Si. XRD and FTIR indicated silicate breakdown, while SEM showed improved exposure of Pd and Pt grains. Optimisation using RSM-CCD revealed that lower pulp densities (50–65%) enhanced desilication, while higher densities (>70%) enriched Cu and Ni sulfides. These findings validate bio-desilication as a sustainable pre-concentration step for PGM recovery from UG2 tailings.

Keywords: Bio-desilication, *Paenibacillus mucilaginosus*, UG2 tailings, Platinum group metals, Bioleaching, RSM-CCD, Sustainable metallurgy



Nokubonga Given Zulu

Business development metallurgist
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Nokubonga Given Zulu is a business development metallurgist at Metsop (PTY) LTD. she holds a master's degree in extraction metallurgy (cum laude) from the University of Johannesburg, specializing in the biometallurgy of PGMs-bearing BMS (biomodification and bioactivation). Currently, she is pursuing a PhD in Metallurgical Engineering, focusing on biometallurgy. As an author of various research outputs, Nokubonga is passionate about exploring the integration of machine learning and artificial intelligence in optimizing PGM-related concentration processes. She actively participates in conferences organized by the SAIMM Limpopo branch and Minerals Engineering (MEi). Notably, she presented her master's research at SAIMM Limpopo branch conference in Palaborwa, Biomining'23 in the United Kingdom, Flotation'23 in Cape Town, and IEOM conferences showcasing her commitment to advancing knowledge and innovation in her field. Nokubonga work reflects her dedication to enhancing metallurgical practices through cutting-edge technologies.

Integrating biomass-derived syngas and hydrogen in ferrochrome smelting: A multi-faceted approach to decarbonising the South African metal industry while enhancing economic viability and community resilience

M.J. Mvita

University of Johannesburg, South Africa

The smelting industry, crucial for metal production, faces significant challenges due to its reliance on carbon-intensive processes, leading to substantial greenhouse gas emissions and environmental degradation. This paper investigates the potential of alternative energy sources, specifically biomass-derived syngas and hydrogen from biogas, as sustainable substitutes for conventional fossil fuels in ferrochrome smelting. The need for cleaner and more efficient smelting methods is underscored by the increasing energy consumption associated with traditional practices, particularly in South Africa, where energy costs and supply instability are critical issues. The paper highlights how the transition from fossil fuels to biomass-derived energy sources could mitigate greenhouse gas emissions, improve operational efficiency, and foster community health benefits. Through an in-depth analysis, the proposed solution emphasises the integration of biomass from local agricultural waste and biogas systems into existing smelting operations. Through utilising lignocellulosic biomass and organic waste, the method not only addresses the energy demands of smelting but also enhances the recycling of waste materials, aligning with circular economy principles. The study employs a comprehensive examination of the energy efficiency-gains from implementing biomass-derived syngas in three main smelting applications: as an energy source for sintering furnaces, in the pre-oxidation of iron pellets, and for the pre-reduction of iron oxides in rotary kilns. Energy savings calculations indicate a potential reduction in fossil fuel consumption by up to 40%, alongside significant decreases in carbon emissions, with lifecycle assessments revealing emissions reductions of approximately 40-45% compared to traditional methods. Further, the proposed energy system offers substantial economic advantages, through reduced operating costs and compliance with environmental regulations that are increasingly stringent. A detailed

cost analysis showcases the capital requirements for integrating the new energy systems, alongside potential funding opportunities through initiatives like the Green Fund and SUNREF, emphasising the project's alignment with South Africa's sustainability goals. Furthermore, the adoption of biomass and biogas systems is projected to yield social benefits, such as job creation in local communities and improved health outcomes from reduced air and water pollution. The integration of these cleaner technologies highlights a pathway towards achieving the United Nations Sustainable Development Goals, specifically focusing on industry innovation, sustainable consumption, and climate action. In conclusion, this research underscores the imperative of technological innovation in the smelting industry to combat climate change and promote sustainable industrial practices. The transition to biomass-derived energy systems not only addresses critical environmental and socio-economic challenges but also positions South Africa's ferrochrome production sector as a leader in adopting sustainable practices, enhancing national and global competitiveness in the metal production market while contributing to a greener economy.

Keywords: smelting, sustainable, CO₂ emissions, sustainability, environmental regulations



Jonathan Mvita

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Meta Jonathan Mvita is a dedicated PhD candidate in Chemical Engineering at the University of Johannesburg, expected to complete the program in 2026. Before this, he pursued a Master of Engineering (MEng) in Extraction Metallurgy from 2023 to 2024. He holds a Bachelor Honours degree in Metallurgy, also from the same institution, completed in 2022. Since 2023, Jonathan has served as a research assistant, contributing to significant advancements in the field of engineering. Over the years, he lectured on modules including Coal Processing, Refractory Technology, Advanced Reaction Engineering, and Multi-Stage Operations, demonstrating a strong commitment to education. Jonathan has authored 12 peer-reviewed journals and conference proceedings, showcasing his research contributions and expertise in metallurgy and chemical engineering. The work focuses on sustainable practices and innovative solutions within the field, positioning him as a promising researcher and educator. Fascinated by Artificial intelligence concepts, programming, and statistics, MVITA believes in imparting the skills developed in relation to the use of intelligent systems.

Intelligent and responsible mines: Leveraging innovation for a sustainable mining future

M.J.R. Moloto

University of Limpopo, South Africa

The mining industry is at a crucial crossroads where technological change, environmental responsibility, and social duty converge. As global sustainability goals grow stronger, the way forward for a sustainable mining future depends on how well organisations can become smarter, more open, and more responsible. This paper looks at how innovation – technological, organisational, and social – can drive this transition. It considers the roles of digital intelligence, data transparency, and open innovation ecosystems in transforming mining operations and governance. Using emerging frameworks like Industry 5.0 and responsible innovation, the paper suggests strategies for integrating sustainability principles throughout the mining value chain. Case studies from leading mining regions show how the adoption of advanced analytics, automation, and collaborative innovation networks can improve efficiency, lessen environmental impact, and build trust with stakeholders. This paper argues that the long-term success of the mining industry relies not just on new technologies but on fostering an innovation culture grounded in openness, ethics, and shared values; ending with a framework to help mining organisations move towards an intelligent, inclusive, and sustainable future.

Keywords: Sustainable mining, responsible innovation, digital transformation, open organisations, Industry 5.0

