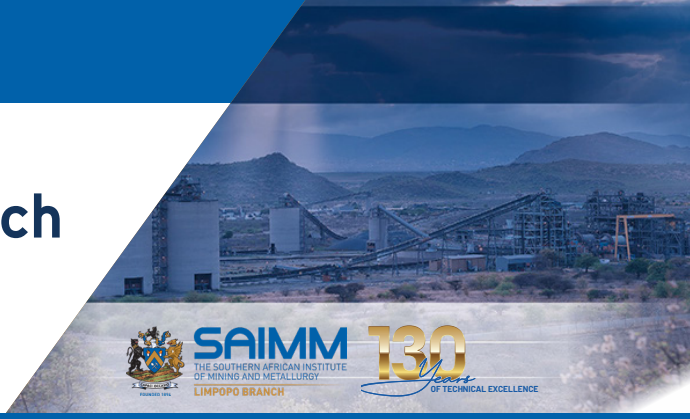
Limpopo Branch Event 2024



Embracing the 'Mine of the Future' through Adoption and Implementation of 4IR/5IR technological innovations

Abstract Book

8 NOVEMBER 2024

Cajori Hotel, 39 Palm Street, Phalaborwa, Limpopo

THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY JOHANNESBURG 2024

Limpopo Branch Event 2024

Embracing the 'Mine of the Future' through Adoption and Implementation of 4IR/5IR technological innovations

8 NOVEMBER 2024

Cajori Hotel, 39 Palm Street, Phalaborwa, Limpopo

SAIMM PUBLICATIONS

THE MONOGRAPH SERIES

Ml **Lognormal-De Wijsian Geostatistics for Ore Evaluation**
(2nd ed 1981) D.G. Krige

M2 **An Introduction to Geostatistical Methods of Mineral Evaluation**
(2nd ed 1981) J.-M.M. Rendu

M3 **Principles of Flotation**
(1982) (3rd imp. 1986) Edited by R.P. King

M4 **Increased Underground Extraction of Coal**
(1982) Edited by C.J. Fauconnier and R.W.O. Kersten

M5 **Rock Mechanics in Mining Practice**
(1983) (3rd imp. 1986) Edited by S. Budavari

M6 **Assay and Analytical Practice in the South African Mining Industry**
(1986) W.C. Lenahan and R. de L. Murray-Smith

M7 **The Extractive Metallurgy of Gold in South Africa,**
2 volumes (1987) Edited by G.G Stanley

M8 **Mineral and Metal Extraction — An Overview**
(1994) L.C. Woollacott and R.H. Eric

M9 **Rock Fracture and Rockbursts—an illustrative study**
(1997) Edited by W.D. Ortlepp

THE SPECIAL PUBLICATIONS SERIES

SPI **Proceedings, Underground Transport Symposium**
(1986) Edited by R.C.R. Edgar

SP2 **Backfill in South African Mines (1988)**

SP3 **Treatment and Re-use of Water in the Minerals Industry (1989)**

SP4 **COREX Symposium 1990**
(1990) Edited by H.M.W. Delport and P.J. Holaschke

SP5 **Measurement, Control, and Optimization in Mineral Processing**
(1994) Edited by H.W. Glen

SP6 **Handbook on Hard-rock Strata Control**
(1994) A.J.S. Spearing

SP7 **Rock Engineering for underground coal mining**
(2002) J. Nielen van der Merwe and Bernard J. Madden

SP8 **Second Edition: Rock Engineering for underground coal mining**
(2010) J. Nielen van der Merwe and Bernard J. Madden

SP9 **Theoretical Rock Mechanics for Professional Practice**
(2016) M. Handley

SP10 **Johannesburg and its Holey Mining Heritage 2021**
(2021) T.R. Stacey

SP11 **Mineral and Metal Extraction — An Overview**
(2021) L.C. Woollacott and R.H. Eric

SP12 **The Fall of a Giant: The story of the disintegration of the South African Mining -Industry** (2022/2023) Dr I. Robinsoin

SP13 **COMRO's Legacy: Research and Development of Stoping Mining Machinery and Technologies** (2023) B. Protheroe

SUPPLEMENT TO THE SAIMM JOURNAL

The Metals and Minerals Industry in South Africa - Part 1 (1989)
Edited by H.W. Glen

THE SYMPOSIUM SERIES

S1 **Mathematical Statistics and Computer Applications in Ore Valuation (1966)**

S2 **Planning Open Pit Mines** (1970) (4th imp.) Edited by P.W.J. van Rensburg

S3 **Application of Computer Methods in the Mineral Industry** (APCOM 1973) Edited by M.D.G. Salamon

S4 **Infacon 1974** Edited by H.W. Glen

S5 **Proceedings of the 12TH CMMI Congress** 2 volumes (1982) Edited by H.W. Glen

S6 **Rockbursts and Seismicity in Mines** (1984) Edited by N.C. Gay and E.H. Wainwright

S7 **The Planning and Operation of Open Pit and Strip Mines** (1986) Edited by J.P. Deetlefs

S8 **GOLD 100: Proceedings of the International Conference on Gold (1986)**

Volume 1: Gold Mining Technology Edited by H. Wagner and R.P. King

Volume 2: Extractive Metallurgy of Gold Edited by C.E. Fivaz and R.P. King

Volume 3: Industrial Uses of Gold Edited by G. Gafner and R.P. King

S9 **APCOM 87: Proceedings of the Twentieth International Symposium on the Application of Computers and Mathematics in the Mineral Industries (1987)**

Volume 1: Mining Edited by L. Wade, R.W.O. Kersten and J.R. Cutland

Volume 2: Metallurgy Edited by R.P. King and I.J. Barker

Volume 3: Geostatistics Edited by I.C. Lemmer, H. Schaum and F.A.G.M. Camisani-Calzolari

S10 **International Deep Mining Conference (1990)**

Volume 1: Innovations in Metallurgical Plant Edited by G.A. Brown and P. Smith

Application of Materials Engineering in the Mining Industry Edited by B. Metcalfe

Volume 2: Technical Challenges in Deep Level Mining Edited by D.A.J. Ross-Watt and P.D.K. Robinson

S11 **Infacon 6 (Incorporating Incsac) (1992)** Edited by H.W. Glen

S12 **Massmin 92** Edited by H.W. Glen (out of print)

S13 **Minefill 93** Edited by H.W. Glen

S14 **XVTH CMMI Congress Publications (1994)**

Volume 1: Mining Edited by H.W. Glen

Volume 2: Metals Technology and Extractive Metallurgy (1994) Edited by H.W. Glen

S15 **Surface Mining 1996** Edited by H.W. Glen

S16 **Hidden Wealth (1996)** Edited by H.W. Glen

S17 **Heavy Minerals 1997** Edited by R.E. Robinson

S18 **The 8TH International Platinum Symposium (1998)**

S19 **Mining in Africa '98**

S20 **Extraction Metallurgy Africa '98**

S21 **Sixth International Symposium for Rock Fragmentation by Blasting (1999)**

S22 **Metallurgy Africa '99**

S23 **Heavy Minerals 1999** Edited by R.G. Stimson

S24 **Tunnels under Pressure** Technical Editor T.R. Stacey

S25 **Mine Hoisting 2000**

S26 **Coal–The Future (2000)**

S27 **The Fifth International Symposium on Rockburst and Seismicity in Mines (RaSim 5) (2001)**

S28 **6TH International Symposium on Mine Mechanization and Automation (2001)**

S29 **XIV International Coal Preparation Congress and Exhibition**

S30 **Surface Mining 2002—Modern Developments for the New Millennium**

S31 **IFSA 2002, Industrial Fluidization South Africa**

S31a **APCOM 2003—Application of Computers and Operations Research in the Minerals Industries**

S32 **ISSA/Chamber of Mines Conference—Mines and Quarries: Prevention of Occupational Injury and Disease**

S33 **ISRM—Technology Roadmap for Rock Mechanics**

S34 **Heavy Minerals Conference 2003**

S35 **Safety in Mines Research Institutes (2003)**

S36 **VII International Conference on Molten Slags, Fluxes & Salts (2004)**

Tenth International Ferroalloys Congress INFACONX 2004

S37 **Deep and high stress mining 2004**

S38 **'Platinum adding value' 2004**

S39 **Base Metals—Southern Africa's response to changing global base metals market dynamics 2005**

S40 **Strategic *versus* Tactical approaches in mining 2005**

S41 **Best practices in rock engineering SARES 2005**

S42 **IFSA 2005, Industrial Fluidization South Africa**

S43 **Southern African Pyrometallurgy 2006 International Conference**

S44 **Stability of rock slopes in open pit mining and civil engineering situations**

S45 **'Platinum Surges Ahead' 2006**

S46 **Hydraulic Transport of Solids - Hydrotransport 17 (2007)**

S47 **Fourth Southern African Base Metals Conference 'Africa's base metals resurgence'**

S48 **Heavy Minerals Conference, 2007**

S49 **Cave Mining Conference, 2007**

S50 **International Symposium on Lead and Zinc processing – Lead & Zinc 2008**

S51 **Surface Mining 2008**

S52 **Platinum in transformation 2008**

S53 **IFSA 2008, Industrial Fluidization South Africa**

S54 **Hydrometallurgy Conference 2009**

S55 **Shotcrete for Africa 2009**

S56 **Base Metals Conference 2009**

S57 **Heavy Minerals Conference, 2009**

S58 **Hard Rock Safe—Safety Conference 2009**

S59 **Sampling and Blending 2009**

S60 **World Gold 2009 Conference**

S61 **Physical Beneficiation Conference 2010**

S62 **Second Hardrock Safe—Safety Conference 2010**

S63 **Platinum in Transition 'Boom or Bust' 2010**

S64 **South African Pyrometallurgy 2011 International Conference**

S65 **Minefill 2011 (10TH International Symposium on Mining with Backfill)**

S66 **Base Metals Conference 2011**

S67 **MineSafe 2011 Conference**

S68 **Iron Ore and Manganese Ore Metallurgy 2011**

S69 **Percolation leaching: The status globally and in Southern Africa 2011**

S70 **IFSA 2011, Industrial Fluidization South Africa**

S71 **Southern Hemisphere International Rock Michanics Symposium 2012**

S72 **Platinum Conference 'A catalyst for change' 2012**

S73 **Ferrous 2012—Ferrous and Base Metals Development Network Conference**

S74 **Diamonds - Source to use 2013**

S75 **Sampling and analysis: Best-practice in African mining 2013**

S76 **Base Metals Conference 2013**

S77 **Precious Metals 2013 Conference—The Precious Metals Development Network (PMDN)**

S78 **Physical Beneficiation 2013 Conference**

S79 **21st Century challenges to the southern African coal sector 2014**

S80 **Furnace Tapping Conference 2014**

S81 **Platinum Conference 'Platinum—Metal for the Future' 2014**

S82 **IFSA 2014, Industrial Fluidization South Africa**

S83 **Copper Cobalt Africa 2015**

S84 **The Danie Krige Geostatistical Conference 2015 - Vol. 1**

The Danie Krige Geostatistical Conference 2015 - Vol. 2

S85 **World Gold Conference 2015**

S86 **Slope Stability 2015**

S87 **2nd Annual Young Professionals Conference 2015**

S88 **AMI–Nuclear Materials Development Network 2015**

S89 **MPES–23rd International Symposium on Mine Planning & Equipment Selection 2015**

S90 **Diamonds still Sparkling Conference 2016**

S91 **The SAMREC/SAMVAL Companion Volume Conference 2016**

S92 **New Technology and Innovation in the Minerals Industry Colloquium 2016**

S93 **Theoretical Rock Mechanics for Professional Practice**
(Special Publications Series 9)
by M. Handley - 2016

S94 **Hydrometallurgy Conference 2016**

S95 **10TH Heavy Minerals Conference 2016**

S96 **MineSafe Conference 2016**

S97 **AMI-Ferrous and Base Metals Development Conference 2016**

S98 **3rd Young Professionals Conference 2017**

S99 **Proximity Detection and Collosion Avoidance Systems in Mining Colloquium 2017**

S100 **6TH Sulphur and Sulphuric Acid Conference 2017**

S101 **Mine Planning Colloquium 2017**

S102 **Chrome Colloquium 2017**

S103 **4TH Mineral Project Valuation Colloquium 2017**

S104 **Water Conference 2017**

S105 **Rapid Underground Mine and Civil Access Engineering 2017**

S106 **MineSafe Conference 2017**

S107 **Uranium 2017 International Conference 2017**

S108 **IFSA 2017–Industrial Fluidization Conference 2017**

S109 **AfriRock 2017–ISRM International Symposium 2017**

S110 **AMI Precious Metals 2017–The Precious Metals Development Network (PMDN) Symposium**

S111 **7TH International Platinum Conference 2017**

S112 **Infacon XV: International Ferro-Alloys Conrgress 2018**

S113 **SOMP–Society of Mining Professors 6TH Regional Conference 2018**

S114 **Digitalization in Mining Conference 2018**

S115 **Diamonds – Source to Use 2018 Conference 2018**

S116 **The 9TH Southern African Base Metals Conference 2018**

S117 **Geometallurgy Conference 2018**

S118 **Mine Safe Technical Conference and Industry Day 2018**

S119 **ASM Conference 2018**

S120 **4TH Young Professionals Conference 2018**

S121 **Furnace Tapping 2018 Conference 2018**

S122 **7TH Sulphur and Sulphuric Acid Conference 2019**

S123 **Mine Planner's Colloquium 2019**

S124 **9TH International Conference on Deep & High Stress Mining 2019**

S125 **New Technology Conference and Trade Show 2019**

S126 **Smart Mining Smart Environment Smart Society Conference 2019**

S127 **The Eleventh International Heavy Minerals Conference 2019**

S128 **Surface Mining Masterclass 2019**

S129 **International Mine Health and Safety Conference 2019**

S130 **Tailings Storage Conference 2020**

S131 **IMPC2020 XXX International Mineral Processing Congress**

S132 **Johannesburg and its Holey Mining Heritage**
(Special Publications Series 10)
by T.R. Stacey - 2021

S133 **Mineral and Metal Extraction — An Overview**
(Special Publications Series 11)
by L.C. Woollacott and R.H. Eric - 2021

S134 **Diamonds - Source to Use - 2021 Online Conference 2021**

S135 **WorldGold Online Conference 2021**

S136 **APCOM 2021 Minerals Industry4.0-The next digital transformation in mining**

S137 **5TH Young Professionals Online Conference 2021**

S138 **Southern African Rare Earths International Online Conference 2021**

S139 **SAMCODES Conference 2021**

S140 **Global Tailings Standards and Opportunities`For the Mine of the Future Conference 2022**

S141 **The Fall of a Giant: The story of the disintegration of the South African Mining Industry**
(Special Publications Series 12)
by I. Robinson - 2022/2023

S142 **Battery Materials Conference 2022**

S143 **32ND SOMP Annual Meeting and Conference 2022**

S144 **SDIMI (Sustainable Development in the Minerals Industry) 10TH International Conference 2022**

S145 **THANOS International Conference 2022**

S146 **Mine Impacted Water Online Conference 2022 (Abstract Book Only)**

S147 **8TH International PGM Conference 2022**

S148 **SANCOT Symposium 2022**

S149 **8TH Sulphur and Sulphuric Acid Conference 2023**

S150 **Southern African Hydrogen and Fuel Cell Conference 2023**

S151 **COMRO's Legacy: Research and Development of Stoping Mining Machinery and Technologies**
(Special Publications Series 13)
by B. Protheroe - 2023

S152 **Copper Cobalt Africa in Association with The 10TH Southern African Base Metals Conferenc 2023**

S153 **Digital Transformation in Mining Conference 2023**

S154 **Diamonds Source to Use 2023 Online Conference**

S155 **12TH International Heavy Minerals Conference 2023**

S156 **Geometallurgy Conference 2023**

S157 **Next Generation Tailings Opportunitiy or Risk? Conference 2023**

S158 **6TH Young Professionals Conference 2023**

S159 **Southern African Pyrometallurgy 2024 International Conference**

S160 **The 11TH World Conference on Sampling and Blending Hybrid Conference 2024**

S161 **SANIRE Symposium 2024 Technical Applications in Rock Engineering**

S162 **2ND International Conference 2024 Souther African Rare Earths**

S163 **2ND Battery Materials Conference 2024**

S164 **Hydrometallurgy Conference 2024**

S165 **Environmental Social Governance Sustainability Conference 2024**

S166 **Mine Health and Safety Conference 2024**

Published by The Southern African Institute of Mining and Metallurgy
Minerals Council South Africa, 7th Floor, Rosebank Towers, 19 Biermann Avenue,
Rosebank, 2196, Republic of South Africa

The abstracts in this volume have been for the most part prepared from Word documents supplied by the authors, with additional typesetting and formatting by The Southern African Institute of Mining and Metallurgy.

Organised by

Desktop prepared by SAIMM

FOREWORD

Dear Participants and Guests

We are pleased to welcome you to the SAIMM Limpopo Branch Technical Event of November 2024.

The month of November is a special month for SAIMM Limpopo Branch as it was in the same month, two years ago, that this branch came to life. As the first Chair of the SAIMM Limpopo Branch from its inception, it gives me a great thrill to see how the SAIMM Limpopo Branch has grown from the 'cradle' to where it is now.

The theme for the November 2024 Technical Event is Embracing the 'Mine of the Future' through Adoption and Implementation of 4IR / 5IR Technological Innovations. With the advent of 4IR and 5IR phenomena the economy, mining industry and society are changing radically from what they have been. Thus, while we harness the incredible power of 4IR/5IR technological innovations for the good of humanity, it is crucial that we develop safeguards to protect against the intentional or non-intentional misuse of that technological power and make sure there will be no damage to society.

Technical events like these are crucial as they link researchers and industry practitioners from different disciplines and branches of mining industry from around South Africa, to discuss common problems and pave a way into the future.

SAIMM is a highly distinguished organization, dedicated to advancing the state-of-the-art in education, research, networking and technical integrity in mining, metallurgy and other mining industry-related fields. SAIMM is a non-governmental, non-profit organization that has served the Southern African mining industry for over 130 years.

It accomplishes this purpose through various activities including coordination of conferences, technical webinars; publishing newsletters/periodicals, conference proceedings, books and special issues of scholarly journals, and recognising academic programmes. The SAIMM should be viewed as an information exchange hub on teaching and research issues in mining industry. It is amongst the leading Southern African forums that disseminate, to all disciplines of mining industries, information on the most recent and relevant research, theories and practices pertaining to the mining industry.

M.S. Zulu
Branch Chairperson

Contents

Page No

Contents *(continued)*

Page No

The organizers of the event wish to thank the following sponsors for their support

AECI MINING CHEMICALS

kemtec Africa FLOTATION INSPIRATION

FLOTATION REAGENT TECHNOLOGIES

MAGOTTEAUX

MAKURUNG PROCESS SOLUTIONS PTY LTD

MetSoP METALLURGICAL SOLUTIONS & PRODUCTS

PROJECT ADVISORY PARTNERS

tega

WILSUM MINERALS PROCESSING AND CONSULTING

MILL LINERS | CASTINGS | GRINDING MEDIA

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.

Heat transfer through siceraria cucurbitaceae lagenaria material: A python coding approach

S.G. Bhongoza, T. Matamela, M. Ramaboea, and A.F. Mulaba-Bafubiandi

University of Johannesburg, South Africa

Using python analysis, this paper discusses the thermal properties of Lagenaria siceraria, a member of the Cucurbitaceae family, as a natural insulating material for thermal energy preservation. African traditional practices utilise natural materials, like calabash for food storage. However, there is a significant lack of empirical data and scientific understanding regarding the thermal performance of these materials, specifically Lagenaria siceraria. With an aim of providing a comprehensive analysis of the thermal properties of Lagenaria siceraria and to model its heat transfer behaviour using Python-based tools, the paper focusses its content around: (1) developing a Python-based model to simulate heat transfer processes within this material; (2) the validation of the model with laboratory collected and generated experimental data to assess its accuracy (3) the evaluation of the effectiveness of Lagenaria siceraria to conserve the temperature of contained food. The findings as discussed in the paper show that within the calabash heat is transferred by conduction, while from the outer surface of the calabash heat is transferred by convection. In the paper, the developed Python's code shows visualisation of heat transfer model between the contained pap, the calabash container and its surroundings. A systematic literature review was conducted to understand the existing body of knowledge on the thermal properties of natural materials and the application of computational models in heat transfer studies. Experimental methods were employed to measure the thermal properties of Lagenaria siceraria. Python's extensive libraries were utilised to develop and visualise the developed heat transfer model.

Keywords: Calabash material, food conservation, heat transfer, Python coding

Samkelo Gift Bhongoza
Research Student
University of Johannesburg

Samkelo Gift Bhongoza is a highly motivated BEng Tech Extraction Metallurgy student with a passion for improving recovery of metals and their applications. Through his academic coursework and practical experience, he has developed a strong foundation in metallurgical principles, including mineral processing, hydrometallurgy, and pyrometallurgy. He has learned to put those skills to practical use by learning how to build small basic python programs that run simulations.

Enhancing flotation process efficiency through data-driven insights: A comprehensive approach

K. Machaba, M. Facela, E. Mualusi, D. Zambukere, and R. Moagi

Palabora Mining Company, South Africa

The complex and dynamic nature of flotation processes in mineral beneficiation presents significant challenges in achieving optimal recovery rates and concentrate grades. At Palabora Mining Company, leveraging data science methodologies has offered a transformative route to address these challenges. This study employs a structured data science approach, encompassing Exploratory Data Analysis, data preprocessing, Principal Component Analysis, and predictive modelling to enhance flotation process performance.

The analysis begins with an extensive Exploratory Data Analysis, which reveals key trends and distributions within process parameters such as head grade, flotation feed density, air rate, froth depth, and reagent dosages. Using sophisticated visualizations, relationships between these parameters and operational outcomes are explored, enabling the identification of threshold levels that correlate with improved concentrate grades across different flotation cells, including roughers, cleaners, and re-cleaners.

Critical to the methodology is rigorous data preprocessing, which includes handling missing values through advanced imputation techniques and normalizing variables to ensure model integrity. Principal Component Analysis is then employed to reduce the dataset dimensionality, distilling complex interactions into independent principal components. This dimensionality reduction facilitates easier detection of hidden patterns influencing recovery rates and aids in simplifying further analysis.

Building on these insights, robust predictive models are developed using linear regression and advanced machine learning algorithms to forecast recovery rates. These models incorporate key process drivers identified during Principal Component Analysis and Exploratory Data Analysis, allowing for precise adjustment of operational parameters to enhance process efficiency. Evaluation of the models demonstrates a significant improvement in predictive accuracy, with variance explanations exceeding industry benchmarks.

The findings underscore the pivotal role of data science in refining flotation processes, offering profound insights that drive operational improvements. By combining rigorous statistical analysis with machine learning techniques, the project not only identifies optimal operational settings but also provides actionable recommendations for ongoing process enhancement.

This research contributes to the growing body of knowledge in mineral processing and provides a replicable framework for similar applications across the industry. As the demand for improved metallurgical performance intensifies, adopting data-driven methodologies proves indispensable for achieving superior efficiency and productivity in flotation operations.

Keywords: data science, flotation process, principal component analysis, predictive modelling, mineral beneficiation, process optimization

Kabelo Machaba
Metallurgist
Palabora Mining Company

I am a metallurgist at Palabora Mining Company, working in the Concentrator Division. My role involves overseeing the technical aspects of metallurgical processes, including optimizing copper mineral recovery, conducting metallurgical testing, and ensuring quality control. Additionally, I am responsible for data analytics, research, and metallurgical accounting within the division. Passionate about the intersection of metallurgy and data science, I leverage advanced data analytics to drive innovation and efficiency in our operations.

Effects of stemming length and inter-hole delay timing on rock fragmentation and crusher throughput at a typical quarry

S.A. Madanda and F. Mulenga

University of South Africa, South Africa

The efficiency of rock fragmentation and crusher throughput is critical in optimizing quarry operations. This study investigates the influence of stemming length and inter-hole delay on rock fragmentation and crusher throughput at a quarry exploiting granite in South Africa. Stemming length determines the amount of loose aggregate material used to cap the explosive column loaded in a blast hole. This parameter is crucial for controlling the explosive energy release and the size distribution of the resulting fragmented rocks. Similarly, the timing between explosive detonations affects the distribution of energy and plays a key role in influencing rock fragmentation. Optimizing these two parameters can significantly enhance both rock fragmentation and downstream crusher throughput.

The research involved a detailed onsite testing of various stemming lengths and inter–hole delays in six controlled blasts. The blasts were categorised into two experimental groups, with each group consisting of three separate trial blasts. The initial group concentrated on the inter-hole delay timings, designated as blasts 1, 2, and 3 with respective delay intervals of 17, 9, and 6 milliseconds. The subsequent group of experimental blasts focused on stemming length, with parameters set at 2, 1.5, and 1 metrs for blasts 4, 5, and 6 respectively. The resulting fragmentation sizes were estimated using WipFrag, a software specializing in the analysis of the images collected on blast muckpiles. On the other hand, crusher performance was measured in terms of throughput, defined as the quantity of material processed per hour, measured in tonnes(t/h). This throughput was monitored using a conveyor belt scale.

Results showed that shorter stemming lengths (≤1.5 m) led to finer fragment sizes and improved crusher throughput. Conversely, longer stemming length (>1.5 m) reduced fragmentation quality, resulting in oversized fragments (>450 mm) that subsequently hindered on throughput. An optimal stemming length of 1-meter was identified, with 50% of material under 450 mm and a crusher throughput of 300 t/p. In relation to inter-hole delay timing, too-short (<6 ms) or too-long (>16 ms) delay detonations created excessive oversize fragments. The experimental results indicated that optimal rock fragmentation is achievable within a window delay interval of 6 to 16 milliseconds. Finally, two widely used fragmentation models were tested against the Wipfrag-based muckpile size distributions for future predictive work. The models considered for the purpose were the Kuz-Ram model and the Kuznetsov-Cunningham-Ouchterlony model. The following statistical indicators of prediction adequacy included the Mean Absolute Error, the Mean Square Error, the Root Mean Squared Error, and the Pearson coefficient of determination (R2). The statistical analysis showed that the KCO fragmentation model worked best for the granite quarry investigated. This model has been retained for refinement and for future planning of mining activities.

Keywords: fine chrome recovery, PGM, chrome grade, metallurgical performance, spiral, silica rejection

Samuel Alpheus Madanda
Junior Lecturer
University of South Africa

I hold a Bachelor of Science in Engineering (Honors in Mining Engineering) from the University of the Witwatersrand. I have five years of experience in opencast mining, with a thorough grounding in construction material (aggregate) industry. Additionally, I have two years of experience as a junior lecturer, responsible for designing, implementing, and developing high-quality learning experiences for students in alignment with the university's purpose, values, and ethics.

Safety for future mines in South Africa: Navigating through an interplay of factors affecting the adoption of the fourth industrial revolution

L.A. Maseko

Modikwa Platinum Mine, South Africa

Mining throughout history has been associated with dangerous activities which resulted in loss of life, equipment and in some cases, property. As such, governments around the world have passed legislation aimed at enforcing the identification and elimination of hazards in the workplace. The aim of this study is to understand the challenges faced by the South African mining industry to improve safety. Indeed, the mining industry indicated to the four mining engineering universities (i.e., the University of the Witwatersrand, the University of Pretoria, the University of Johannesburg, and the University of South Africa) in South Africa that safety education in its current form is not adequate to meet the needs of the industry. It is therefore difficult for the industry to navigate the fifth industrial revolution without an appropriate safety plan.

The methodology to approach this study was based on literature reviews to ascertain facts about the key factors involved. Each factor was then analyzed to determine its influence on safety. The information was synthesised to understand the implications in terms of the way forward to address this issue adequately. Given that there are other stakeholders who influence safety education, a holistic approach was used. Factors considered included safety education offered by private institutions and national universities, the role of professional bodies and public entities.

In terms of safety education offered by both private institutions, the following were considered: the National Occupational Safety Association and OHSE Resolved (Pty)Ltd. In addition to this, safety curricula offered at the University of South Africa was reviewed. As for the role of professional bodies, two entities were selected: the South African Institute of Occupational Safety and Health, and the Association of Mine Safety Professionals of South Africa. These were supplemented by the Mine, Health and Safety Council.

Based on the analysis of the above selected factors, moving to the fourth and fifth industrial revolution will require adjustment in the current safety education provided for the mining industry. This will also depend on the contributions of other stakeholders based on a shared understanding of the challenges. The mine of the future that embraces new technology will have to deal with increased risk, changes in existing risk and the introduction of new risks in the mines. This risk can only be addressed adequately if safety education and training are appropriate for this change. Finally, the role of the safety professional in the context of the mining industry will require attention if there is acknowledgement that changes bring along complexity in the operations. Furthermore, past research indicates the need for a paradigm shift in the mining industry to navigate the required change in future.

Keywords: mine safety, mine safety education, system safety, occupational health, industrial revolution, mining education

Lucky Albert Maseko
Senior Lecturer
University of South Africa

Lucky Maseko has worked at different mining companies as a mining engineering graduate in various positions. Companies worked for include Johannesburg Consolidated mines (JCI), South Deep Project, Anglo Coal (Greenside Colliery, New Vaal Colliery) and Mpumalanga Education Department. Before joining the University of South Africa in 2006 as a lecturer where he handled a variety of modules including curriculum design work. He is currently a Senior Lecturer.

Effect of electrochemical potential on the copper metal recovery of the floatation plant at Palabora Mining Company

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

Palabora Mining Company

Froth flotation is a chemical process used to separate minerals from gangue by exploiting the difference in their hydrophobicity. These differences are increased through the use of reagents, mainly collectors while frothers are used to stabilise the froth. Collector dosage during froth flotation is important to increase hydrophobicity of copper sulfide minerals by absorption into the particle surface. Palabora Mining Company uses froth flotation for the beneficiation of sulfide ore using a dual collector system of thiano-carbamates and dithiophosphate collectors supplied by Kemtec.

Electrochemical potential (measured as Eh) is one of the best measures to indicate the presence of the dissolved oxygen in the pulp. A high concentration of oxygen in the pulp is indicated by a more positive Eh, which inhibits collector absorption and adversely affects recovery. Palabora Mining has embarked on a two phased test work: firstly, to assess how reagent dosing points affect recovery and secondly to evaluate the effects of different grinding media on the Eh of the ore inside the mill, and ultimately the recovery. The grinding media which were evaluated are the high chrome balls, low chrome cylpebs and stainless-steel rods.

The milling was succeeded by laboratory batch flotation tests using Denver flotation cells. The Eh and pH were measured before milling, after milling and after the collection of each set of concentrate during the batch flotation (RC1-RC4).

The results showed that the sulfide ore experienced lowest electrochemical potential directly after milling with the stainless-steel rods giving the lowest potential at -126 mV, followed by the low chrome cylpebs at -116 mV and the high chrome balls at -114 mV. Within two minutes after milling, the Eh was seen to be increasing closer to -100 mV for all the test conditions. This indicates the presence of dissolved oxygen which may adversely affect reagent absorption and ultimately the recovery if the reagents are not added inside the mill. The results also showed that dosing the collectors before milling vs after milling yielded a higher copper recovery at a higher grade. This paper discusses the positive effect of reagent dosage before milling vs after milling using electrochemical potential of the sulphide ore.

Keywords: Recovery, collector, electrochemical potential, grinding media and reducing

Karabo Mashilo
Metallurgy Intern
Palabora Mining Company

Karabo Mashilo is a Metallurgy Intern at Palabora Mining company. She is eager to apply theoretical knowledge to practical challenges in the company. Karabo is currently learning skills of quality control and process optimization where she collaborates with experienced professionals to develop innovative solutions to improve copper recovery.

Assessment of interest shown by Phalaborwa mining community to advance educational level at a university to embrace the mine of the future

A.A. Mkonde, I.P. Dikgwatlhe, and L.N. Makhanya

University of South Africa, South Africa

Phalaborwa is known as a mining town with three major mining operations: Palabora Mining Company (PMC), Foskor, and Stibium. These three operations make up as much as 80% of the economic output in the area. Technology and innovation shape the future of the mining industry. Educated and skilled employees are needed towards embracing the mine of the future to adopt and implement technological innovation. The purpose of this study is to assess and weigh the interest of the mining community of Phalaborwa towards advancing their educational status at the University of South Africa (UNISA). This is because education is generally regarded as the 'key to success' while being the fourth sustainable development goal according to the 2030 Agenda of the United Nations. Education also provides the relevant knowledge and skills that are the foundations for improving peoples' lives. A learned community with technical skills therefore allows for the easy employment of local community members instead of importing technical skills. This ensures growth and sustainability in the mining community.

To this end, a questionnaire was designed and administered as part of the existing UNISA-PMC partnership. The study targeted the nine geographical communities of Phalaborwa which are Mashishimale, Makhushane, Maseke, Selwane, Majeje, Lulekane, Namakgale, Phalaborwa Town and others. The questionnaire was administered to the community members who came to the mobile UNISA application and registration center set by PMC through a combination of individual and assisted completion. Trained student advisors from UNISA assisted participants with their individual queries and provided clarification on the questionnaire as needed. Participants were assured of anonymity and confidentiality; information was collected from 169 community members.

The key findings from this study suggest that Namakgale is the most active community in terms of interests to pursue tertiary education. Regarding gender distribution, 53% of females were observed to be more interested in furthering their studies which in South Africa has the potential to contribute positively to equity statistics. The age group mostly interested in education was found to be between 31 and 40 years old with preference for recognition of prior learning. This group constituted 40% of the sample interviewed when slightly more than half from this group representing 22% of the sample already have university education and are seeking to further their studies through distance learning at UNISA. In addition to this, 70% of the respondents are earning a salary and are interested in career growth opportunities. These findings suggest that this mining community has members who are interested in advancing their educational level, qualify for university admission and are able to afford their fees through student funding or own source of income. This information can be used by the mines in their social labour plans for community development, succession planning including training and development plans.

Keywords: mining community, development, education, sustainability

Akhona Amanda Mkonde
Junior Lecturer
University of South Africa

Ms Akhona Mkonde is a Geologist by profession with experience in academic and scientific research. She started her career as an intern for the South African National Biodiversity Institution and moved to the University of South Africa as a Technical Officer working in the Mining Engineering Laboratory. She has upgraded and developed the Mining Engineering Laboratory at UNISA from a classroom state to a laboratory. She has also been involved in several Water Research Commission and National Research Foundation funded projects. She is currently working towards a PhD.

Computational simulation of copper solvent extraction: Modelling and validation

K. Mudzanani, S. Ramatsoma, and T. Phadi

Mintek, South Africa

Solvent extraction (SX) is a crucial hydrometallurgical process to recover valuable metals from aqueous solutions. Mintek's Measurement and Control Division (MCD) conducted audits on SX plants and found inefficiencies due to a lack of advanced process control and instrumentation. In response, MCD developed a prototype instrument and proposed advanced process control strategies. Instead of using costly plant tests, a computational simulator for SX was created using Python and MATLAB Simulink to test these strategies more efficiently. The simulation focused on copper extraction in a Southern African plant, with a feed flow rate between 500 and 700 m^3/h of pregnant leach solution (PLS) and organic feed flow rates 1.3 to 1.5 times the PLS flow. A distribution coefficient between 10 and 50 was used to model copper ion transfer between the aqueous and organic phases, followed by a stripping step with 80% efficiency to transfer copper back to the aqueous phase. The simulation tracked the organic-aqueous interface position in the SX settling chamber and the copper ion concentrations using mass balance principles, and real-time data from industrial copper SX circuits was used to validate the model. Graphs generated from the simulation show the steady flow rates of both the aqueous and organic phases, while the interface height fluctuates due to copper transfer dynamics. Higher KD values improved copper transfer efficiency, significantly affecting interface height. Python and MATLAB were effective tools for simulating SX, with Python offering versatility and MATLAB excelling in numerical computing. The findings, supported by experimental data from an actual copper extraction plant, provide insights into optimizing SX processes for better efficiency.

Keywords: solvent extraction (SX), advanced process control, computational simulation, copper extraction, mass transfer

Khuthadzo Mudzanani
R & D Engineer
Mintek

Dr. Khuthadzo Mudzanani is a chemical engineer at Mintek, leading projects that address key challenges in mineral processing. Working with her team on solvent extraction (SX) control, she has developed simulations in Python and MATLAB Simulink to optimise SX circuits for copper extraction, using real-time industrial data for validation. Dr. Mudzanani is also the lead on projects to develop advanced particle size analysis instruments and improve gold adsorption measurement with Mintek's C2 meter for carbon-in-pulp (CIP) processes. Her work extends to innovative projects like using mine tailings in construction materials, expanding the impact of Mintek's work in both science and sustainability.

Flotation reagents development and application: A case study

M. Lusambo and L. Hoffmann

Kemtec Africa, Zambia and Kemtec Africa, South Africa

Selection and application of flotation reagents are key to optimal metallurgical performance in flotation circuits. Kemtec Africa has been working collaboratively with mines in Zambia to develop tailor-made reagent suites and devise application strategies for optimal copper recovery, concentrate quality improvement and costs optimization and reduction.
The major challenges faced in flotation circuits on these mines are declining ore feed grades, treatment of complex and tarnished ores, increased pyrite, carbon and talc in the ore being processed. These factors have presented challenges in attaining the target copper grade in the final concentrates, recovery as well as keeping pyrite, carbon and talc content in the final concentrate below the smelter thresholds levels, thus not incurring penalties. Kemtec Africa has over the years studied and analyzed mineralogy, ore variability and process plants metallurgical performance data of its major customers in Zambia. The outcomes from these studies and analyses have informed the development of robust reagents suites and plant application strategies. A case study of Kemtec Africa's development of a robust blend of collector chemistries, laboratory testing and dual collector plant application is presented in this work.

Keywords: copper flotation, flotation collectors, efficiency, gangue minerals, optimization.

Martin Lusambo
Technical Sales Manager
Kemtec-Africa Pty Ltd

As Technical Sales Manager for Zambia at Kemtec Africa, I leverage 22 years of expertise in mineral processing to drive process optimization and custom reagent solutions for flotation circuits. Collaborating with mineral processing plant's metallurgical, technical, and operations teams, I identify bottlenecks and implement tailored strategies to enhance concentrate grade, recovery, and gangue minerals rejection.

Utilizing ore mineralogy analysis, plant performance data, and chemical engineering expertise (MSc and BSc), I develop and deploy tailored reagent formulations. My 22 years work experience in mineral processing spans six mine sites, encompassing plant commissioning, debottlenecking, and process optimization.

Phasing in the diploma in mining engineering at the University of South Africa to produce mining practitioners of the future – a historical reflection

F. Mulenga

University of South Africa, South Africa

The Department of Higher Education and Training introduced the updated Higher Education Qualifications Sub-Framework (HEQSF) in 2013. This paved the way for institutions of higher education in South Africa to realign their Programme and Qualification Mix (PQM). In response to this, the University of South Africa (UNISA) initiated the phase-out of the old National Diploma in Mining Engineering. At the same time, the new Diploma in Mining Engineering was introduced in 2020 as an equivalent but restructured replacement for the old National Diploma. This paper reviews the phase-in process of the new Diploma in Mining Engineering over the first five years since inception. This is to ascertain whether UNISA, now the only university in South Africa offering vocational qualifications in Mining Engineering, is able to produce the mining practitioners of the future that the mines in South Africa and on the African continent need.

To this end, the enrolment and subsequent graduation of students have been monitored from 2020 to 2024. A granular statistical analysis of the performance of individual students was then done in terms of the pass rates for individual modules making up the Diploma in Mining Engineering. Graduation rates were also analysed from the year the first students enrolled on the programme till 2024. This was to determine the average number of years it takes for a student to complete the programme and therefore adequately plan for the supply of graduates to meet the demands of the market. In addition to this, an estimate of the average number of modules that students complete per year was determined. Finally, the analysis delved into identifying modules registering low pass rates for effective resource allocation with the aim of ensuring a steady supply of mining technicians.

The historical statistics show that the first cohort consisted of 11 students who successfully enrolled for the Diploma in Mining Engineering in 2020. The enrolment has since steadily increased reaching a total of 433 students in 2024. However, the first two graduates only completed the Diploma in Mining Engineering in 2023. In terms of modules accumulated annually, the statistics show that students so far have been completing an average of six modules per year. And with the 26 modules required before graduation, it is anticipated that it will take students an average of five years to complete the programme usually designed to take three years. Finally, two modules were identified as being the bottleneck to a high conversion of enrolment to graduation. From the above findings, improvement plans on the three-year diploma programme were discussed in terms of the skills required from graduates as the mining industry transitions into the fourth industrial revolution.

Keywords: vocational training, Diploma in Mining Engineering, University of South Africa, Higher Education Qualifications Sub-Framework

Francois Mulenga
Professor
University of South Africa

Prof Francois Mulenga is currently the Head of the Department of Mining Engineering at the University of South Africa. He is also a Full Professor of Mining and Minerals Engineering. His research interests specifically cover mine-to-mill optimization, rock drilling and blasting, as well as mine design and planning.

Prof Mulenga has more than 20 years of industrial and academic experience. He has published more than 40 scientific papers and has received several accolades and research grants.

Prof Mulenga is the Principal Investigator and Project Owner of the partnership between the University of South Africa and Palabora Mining Company. The partnership seeks to conduct industry-based research that addresses current challenges faced by the mine for value improvement while also covering student in-service training.

Application of stemming plugs for the reduction of air blast induced during surface mine blasting

T. Mushwana and F. Mulenga

University of South Africa, South Africa

In surface mining, the use of stemming plugs is becoming more common as a means of optimising blast performance and operational efficiency. This is motivated by the ability of stemming plugs to enhance explosive energy retention and reduce the environmental impacts of the blast. The main objective of this study was to assess the potential of stemming plugs in reducing air blasts during blasting at an open-pit quarry mine.

The stemming plugs used for this study are commercially known as the Varistem stemming plugs with 102 mm in diameter used for onsite testing. For this study, 27 blasts were carried out under similar blast design conditions, however with a stemming length ranging between 1.9 to 3 m. The associated air blast levels of these blasts were recorded from two different monitoring stations around the pit. From the test programme, 15 blasts incorporated the Varistem stemming plugs while the remaining 12 were conducted using standard stemming consisting of aggregates. The two stations used to record and monitor the blasts were the Viewpoint and Fish Tank station and were approximately 100 to 700 m away from the blast blocks. Data was collected from the two stations simultaneously for each of the 27 blasts. Using this arrangement, a comparison was carried out between the Varistem blasts and standard blasts. Moreover, blast parameters such as explosive charge weight and the distance from the blast to the monitoring station were used as input parameters to calculate the scaled distances for each blast. The calculated scaled distances were plotted graphically against the recorded air blast levels. A 134dB United States Bureau of Mines (USBM) air blast limit line was introduced on the graph plots to determine if the blasts would surpass the air blast threshold limit.

The results recorded at the Viewpoint station showed that 33.33% of Varistem blasts were above the 134 dB threshold limit in contrast to 58% of the standard blast tests at the same station. At the Fish tank station, all the Varistem blasts were below the threshold while about 16.67% of the standard blasts were above the limit. Lastly, two air blast prediction models, namely, the USBM model and McKenzie's model, were also used to determine which model would be best suited to predict air blasts in the absence of monitoring equipment. The USBM model was found to be the best predictor of air blast for this study with a coefficient of determination (R2) of 1 for both stations compared to McKenzie's model that recorded an R2 of 0.9999 for the Viewpoint station and 0.9992 for the Fish Tank station. The results derived from this study may potentially offer a solution to surface mines of improving blast performance through the incorporation of Varistem stemming plugs.

Keywords: Varistem, air blasts, stemming plugs, blasting, USBM model, McKenzie's model

Talent Mushwana
Junior Lecturer
University of South Africa

Ms Talent Mushwana is a Junior Lecturer in the Department of Mining Engineering at the University of South Africa (Unisa). She is currently pursuing a Master of Engineering specializing in Mining Engineering. Her research interests include rock drilling , blasting and mining engineering.

Ms Mushwana is currently registered as a Candidate Engineer with the Engineering Council of South Africa (ECSA). She is also an Associate member of the Southern African Institute of Mining and Metallurgy (SAIMM).

Optimization of base metals sulfides bio flotation process using particle swarm optimization-artificial neural networks

N.G. Zulu, M.J. Mvita, and B. Thethwayo

University of Johannesburg, South Africa

The urgent demand for critical metals, compounded by the environmental degradation and social challenges posed by conventional mining practices, highlights the necessity for innovative resource recovery solutions. This paper introduces a pioneering, circular economy-driven approach for the sustainable extraction of critical metals from electronic waste (e-waste) through bio-Dense Medium Separation (bio-DMS). Through harnessing the capabilities of iron-oxidizing bacteria, specifically Acidithiobacillus ferrooxidans and Leptospirillum ferriphilum, this research aims to improve metal recovery rates, reduce energy consumption, and diminish environmental impact associated with e-waste processing. The objectives of this study include: (1) evaluating the effectiveness of A. ferrooxidans and L. ferriphilum in bio-DMS for processing e-waste; (2) optimizing bio-DMS operational parameters to maximise metal recovery while minimizing ecological repercussions; and (3) analysing the circular economy advantages that bio-DMS offers for e-waste management. A methodology involving mixed cultures of the aforementioned bacteria will be employed to bio-oxidise e-waste samples, followed by the application of DMS to isolate metal-rich components. Process optimization will utilise response surface methodology and life cycle assessment to gauge environmental and resource efficiency. Expected outcomes of this research include exceeding 90% in metal recovery rates and achieving over 50% reduction in energy consumption. Furthermore, this process aims to enhance environmental sustainability by minimizing waste generation and toxic emissions, ultimately yielding a scalable and economically viable bio-DMS framework for e-waste management. The implications of this research extend towards establishing a sustainable, circular economy-oriented mining model that addresses the environmental and social issues intrinsic to traditional mining approaches. The proposed bio-DMS methodology holds promise for implementation across various sectors, including electronics recycling, mining operations, and waste management initiatives.

Keywords: bio-DMS, circular economy, e-waste, sustainable mining, critical metals, iron-oxidizing bacteria.

Nokubonga Given Zulu
Graduate Metallurgist
Siyanda Bakgatla Platinum mine

Nokubonga Given Zulu is a graduate metallurgist at Siyanda Bakgatla Platinum Mine. She holds a Master's degree in extractive metallurgy (cum laude) from the University of Johannesburg with area of focus in Biometallurgy of PGMs-bearing Base Metals Sulfides (Biomodification and bioactivation). Author of different research outputs, Nokubonga has a passion for research where her target area is on the application of machine learning and artificial intelligence-related technologies in optimisation of many PGMs- related concentration processes. Nokubonga is an active participant to the Minerals industry.

Managing cave-induced seismic hazards at Palabora Block Cave Mine (Lift II)

B.B. Makgate[1], F. Mulenga[2] , V.C. Madanda[2], T.S. Mtshali[1] , T. Chauke[2], and N.M. Chiloane[2]

[1]Palabora Mining Company, South Africa
[2]University of South Africa, South Africa

Palabora Mining Company (PMC) is operating a Block Cave Mine, with Lift I located around 1200 m below the surface. Lift II is currently being developed directly beneath Lift I at approximately 1600 m below the surface. The increased depth of Lift II is expected to result in a higher energy release rate, which will likely lead to increased seismicity compared to Lift I. In addition to this, there are increasing concerns with the greater depth of the cave under development and the anticipated rise in seismic events. It has therefore become clear that an advanced seismic hazard assessment system is essential to improve safety and reduce potential production delays caused by seismic hazards. As mining advances, the cave-induced seismicity increases, presenting greater risks to both safety and production. This required a more effective approach to managing seismic hazards while maintaining productivity.

Previously, Palabora used a primitive polygon system to manage seismic hazards, but this approach often overestimated the risk, which negatively impacted productivity. The system would trigger unnecessary stoppages based on the Trigger Action Response Plan (TARP) requiring a halt in mining production. To address this shortcoming, the mine relies on the Institute of Mine Seismology (IMS) system to monitor seismic activity throughout its operations. A network of geophones has been installed across the mine footprint, feeding real-time data into the IMS system. This allows for continuous monitoring of seismic events. However, as undercutting progresses and production rates increase, the mine experiences a corresponding rise in cave-induced seismicity. This has resulted in increased seismic risks to both safety and production. In response to these problems, in 2024 PMC introduced an intelligent seismic hazard assessment system called the Ground Motion Alert Program (GMAP). GMAP was created to reduce production delays caused by the previous system and improve confidence in safety decision-making around the IMS system. GMAP provides a smarter way of assessing seismic hazards, allowing for better safety decisions while eliminating unnecessarily stoppage of production. This paper highlights how GMAP improved the management of cave-induced seismicity at the Palabora Block Cave Mine. Incoming data have been analysed to show how safety has been enhanced and how production delays caused by seismic risks have been reduced.

Keywords: cave-induced seismicity, block cave mining, seismic monitoring, seismic hazard assessment, GMAP system

Biih Makgate
Rock Engineering Specialist
Palabora Mining Company

Biih is a seasoned Geotechnical professional with eight years' experience in Block Cave mining that includes 1.2 km deep by 9 m diameter ventilation shaft sinking, horizontal developments and undercutting at Palabora Mining Company. I have overseen the successful support design and development of large underground crusher chambers and workshops, and management of cave induced seismicity in deep block cave mining environments. I have extensive knowledge on shotcrete design and quality control, including the efficiency of mine shotcrete process from batching plant to placement site.

SAG mill grinding media stress evaluation – a DEM approach

M.M. Bwalya[1], O.S. Samukute[1], and N. Chimwani[2]

[1]The University of the Witwatersrand, South Africa
[2]University of South Africa, South Africa

The volatility of commodity prices has obligated primary metal producers to continuously seek ways of cutting costs in mineral processing units. Improving the wear characteristics and reducing the probability of grinding media fracture can potentially reduce the production costs. Characterisation of the impact-loading environment and stress induced into the grinding media in SAG mills aids manufacturers in developing grinding media with superior mechanical properties. Such grinding media development emanates from a firm understanding of the SAG process supported by computer modelling tools and well-established engineering designs. The Discrete Element Method (DEM) is a numerical technique for evaluating collision behaviour in particulate systems. This paper discusses application of the DEM to estimate survivability and stress induced into grinding media in a SAG mill.

Keywords: SAG mill, DEM, comminution, grinding media, simulation

Ngonidzashe Chimwani
Senior Lecturer
University of South Africa

Ngonidzashe Chimwani is a Senior Lecturer in the Mining, Minerals and Geomatics Engineering Department at UNISA, who holds a Ph.D. Engineering (University of the Witwatersrand), MBL (University of South Africa), and B-Tech Engineering (National University of Science and Technology). He is a C2 rated researcher by the National Research Foundation (NRF). He has published several articles found on the following link; https://scholar.google.com/citations?user=2J1fWHIAAAAJ&hl=en. He has received 11 awards in his academic life and has supervised several postgraduate students. His research focus is on optimizing comminution circuits. He is expanding his research focus to the treatment of contaminated wastewater, recovery of metals from mineral processing waste and waste extraction for reuse.

Impact of the elutriator on PGMs′ in the scavenger recleaner concentrate stream

P. Nkgadime and R. Malatsi

SIMA Operations (Pty) Ltd, South Africa

The Amandelbult Concentrator includes two UG2 plants, UG2 #1 and UG2 #2, which primarily process UG2 reef, blending it in low ratios with opencast and low-grade waste material. Additionally, the Amandelbult Chrome Recovery Plant (ACRP) operates using either chrome rougher tailings or interstage feed from these concentrators. The ACRP comprises Module 1 and Module 2, producing both metallurgical and chemical grade chromite concentrates. Metallurgical grade chromite is produced from the rougher, middlings, and scavenger recleaner spirals of both modules. The final metallurgical grade product is pumped to the stockpile via cyclones for dispatch to various clients.

When treating interstage feed from UG2 plants, it was anticipated that the final chromite concentrates would have increased platinum group metals (PGM) content. To address this, the goal was to minimise the silicates reporting to the chrome product. The objective of the testwork was also to reduce the PGM's content in the final chromite concentrate and improve the metallurgical grade product. Previous tests indicated that employing an elutriator on the final chemical grade product effectively reduced PGM content. Following this, further tests were conducted on the scavenger recleaner concentrate streams of Module 2, which exhibited high silica levels potentially leading to elevated PGM content in the final product. Consequently, metallurgical grade elutriators were installed to treat the scavenger recleaner concentrates from both modules before combining rougher and middlings recleaner streams. In this research, the impact of the elutriator was evaluated by treating the scavenger recleaner concentrate streams at different conditions to determine:

- The PGMs' content in the scavenger recleaner stream,
- The impact on PGM's reduction, and
- The improvement of the metallurgical grade product quality.

Three distinct feeding conditions were established for the elutriator:

- **Condition 1**: Scavenger recleaner concentrates from banks A and B fed simultaneously.
- **Condition 2**: Concentrate fed solely from scavenger recleaner bank A.
- **Condition 3**: Concentrate fed solely from scavenger recleaner bank B.

Results demonstrated a notable reduction in PGM content (4E) with the elutriator's application. The PGMs for condition 2 & 3 in the underflow stream were reduced by 19% and 4%, while chromic oxide grade improved by 3% & 1% respectively. The $\%SiO_2$ was also reduced by 41% and 40% respectively, as was expected for $\%SiO_2$ to be low in the underflow stream. The installation costs for the elutriators were minimal, while the potential revenue gain from chrome production was approximately 16% per day. Based on these findings, the use of elutriators was recommended for PGM reduction and enhancement of metallurgical grade product quality in the scavenger recleaner concentrate streams.

Keywords: elutriator, PGMs, Cr_2O_3, SiO_2, UG2

Pitoniah Mmabotshwane Nkgadime
Metallurgist
SIMA Operations

My name is Pitoniah Mmabotshwane Nkgadime, and I am currently employed as a Metallurgist at SIMA Operations. I have 14 years of experience in metallurgical processing plants, having held various positions throughout my career. In my current role, I focus primarily on production and technical analysis within the chrome plant. I hold a degree in Extractive Metallurgy from the Vaal University of Technology, where I completed my B-Tech in Metallurgy in 2011. I am currently doing Lean Six Sigma - Black Belt training programme. I prioritise working with honesty and integrity, considering accountability as a fundamental value in my professional conduct. I am eager to participate in a management development programme to further enhance my knowledge and skills in management roles.

Impact of residual mining subsidence on road infrastructure in Merriespruit, Free State Province, South Africa

P.P. Pule, F. Mulenga, P. Dikgwatlhe, and F. Lugoma

University of South Africa, South Africa

Mining subsidence is acknowledged to be a major issue in areas with extensive underground mining activities. This is because mining subsidence leads, amongst others, to surface deformation that threatens the stability and integrity of roads and associated municipal infrastructures. This paper assesses the severity of subsidence and its effects on roads considering the need for improved infrastructure management in mining-affected areas. In particular, the research explores the impact of residual mining subsidence on road infrastructure in Merriespruit, Free State Province, South Africa.

To this end, advanced geospatial technologies including Global Positioning System Real-Time Kinematic methods and a triangulation network are used. These two technologies enabled us to monitor and measure ground movement in the Merriespruit town. In addition to this, PAD – a reference point established by the Chief Surveyor-General of South Africa – functions as a key trigonometric beacon in this study. It serves as a stable benchmark for geospatial measurements. Using PAD as a fixed reference, current ground movements can be compared with historical data while providing a reliable basis for assessing subsidence in the Merriespruit area. A comparison of road design plans drafted in 1984 with elevation data collected around the Merriespruit town in 2024 also highlights the extent of subsidence. The subsidence under investigation is primarily due to the Merriespruit 3 Shaft, which extended to a depth of 1600 m. Although mining ceased before 2012 when the shaft was demolished, the effects of subsidence persist. Visible impacts, such as road cracks and sinking sections, continue to compromise infrastructure, highlighting the need for effective management.

The analysis of the data collected around Merriespruit shows that land subsidence has occurred consistently over 40 years with an average sinking of −0.44 m due to the past underground mining activities. Certain areas exhibit significant subsidence than others indicating localised zones of more severe ground instability. Using a linear regression model based on historical subsidence data, predictions indicate continued subsidence, possibly accelerating to −1.02 m by 2050. Simulated seasonal patterns and visual data reveal varying rates of subsidence across Merriespruit. These findings underscore the importance of ongoing monitoring, particularly in critical areas such as key road intersections and near essential infrastructure.

Based on the findings of the research, there may be a need for regular assessment of infrastructure for timely interventions to prevent further damage. The paper therefore recommends putting in place a long-term monitoring and routine maintenance strategy to protect road infrastructure. Finally, the findings provide a basis for mitigating current damage and addressing future risks in other mining-affected areas.

Keywords: mining subsidence, road infrastructure, global positioning system real-time kinematic, trigonometric network, surface deformation.

Peace Pule
Junior Lecturer
University of South Africa

Peace Pule is a seasoned academic and industry professional with robust expertise in both civil engineering and surveying. Currently a lecturer at the University of South Africa, Peace specialises in mining subsidence research, module development, and virtual course facilitation. His civil engineering experience spans roles such as Civil Engineering Technician with Raubex Construction and as an intern with the Department of Public Works, where he focused on geotechnical testing, road setting, and precision levelling. He further developed his skills as a Senior Surveyor at Sibanye Stillwater, overseeing comprehensive surveying operations and safety protocols. Holding a Bachelors in Mineral Resource Management and advancing towards a Masters in Engineering, Peace is an active member of the South African Geomatics Council and the Institute of Mine Surveyors of South Africa.

Drone inspection in confined space using computer vision

D.L. Zambukere and L.E. Mualusi

Palabora Mining Company, South Africa

Despite the existing regulations and standards governing confined space work, fatal accidents and injuries occur annually (Botti, *et al*., 2018). Working in confined spaces carries significant risks that can result in highly dangerous situations. Numerous publications, reports, and recent news articles highlight the effects of these risks on workers' safety and health, revealing high accident rates and incidents involving multiple fatalities (Burlet-Vienney, *et al*., 2015); (Sahli & Armstrong, 1992). Inspection reports are crucial for planning and executing necessary maintenance, ensuring both structural integrity and worker safety. However, the size of the facility, difficult access, health risks for inspectors, and other factors make these inspections challenging. This has led companies to increasingly invest in drones as an alternative solution. Drones, being autonomous, can help reduce inspection time and costs. Additionally, they can decrease the number of personnel needed for inspections and enhance safety. Ultimately, drones offer a safe and reliable method for inspecting areas that are hard to reach or hazardous (Nooralishahi, *et al*., 2021).

In the mining industry, particularly in mineral processing, drones can perform two valuable types of inspections: Visual inspections and non-destructive inspections (NDI). Thermography is the technique used in NDI to detect defects such as cracks, voids, delamination, structural damage and corrosion, by observing the component's thermal radiation patterns. Visual inspection involves inspectors using cameras or their own eyes to identify and locate potential defects (Nooralishahi, *et al*., 2021). In both inspections,

object detection through computer vision which has a higher processing speed, consistency and accuracy than humans, can be utilised to improve productivity (Chen, *et al.,* 2024).

Metallurgists at Palabora Mining Company carry out detailed inspections of critical components at the Concentrator to detect abnormalities or assess their condition. During these inspections, they are exposed to several operational hazards, including the risk of steel balls falling into the ball mills from elevated positions and high temperatures within the components. Mill liners are monitored closely for signs of wear, tear, and potential dislodgement caused by steel balls. To minimise exposure to these hazards, drone-based object detection technology is proposed to conduct inspections remotely. Additionally, false bottoms of flotation tank cells are inspected for corrosion by measuring the diameter of the largest false bottom over time. Using drones equipped with thermal imaging systems, the accuracy of corrosion detection can be enhanced while reducing direct exposure to potential hazardous environments.

Keywords: confined space, computer vision, non-destructive inspection, thermography

Dumisani Zambukere
Metallurgical Engineering Intern
Palabora Mining Company

Dumisani Zambukere is a passionate engineer with a keen interest in applying artificial intelligence and remote inspection techniques, particularly through drone technology to enhance metallurgy industry practices. He has experience in coordinating technology-focused events at the University of Witwatersrand, where he emphasised the role of Artificial Intelligence in modernizing and advancing various industries.

From automation to autonomous systems: The next generation of mining

R.G. Thage

University of South Africa, South Africa

From hand operations to sophisticated automated systems, the mining sector has seen notable technological change. Mining is now moving towards autonomous systems that promise to transform efficiency, safety, and sustainability with artificial intelligence and advanced robotics. Mining automation has developed into complex systems allowing minimal human intervention to run operations. By increasing efficiency and lowering the risks connected with human contact to dangerous environments, automated technologies including drilling and haulage systems have transformed the sector. These systems let mining firms operate in remote and dangerous areas, including underwater and underground mines, where conventional activities would be too risky. Though human supervision is still vital in guaranteeing the accuracy and safety of these operations, automation has given the sector tools to increase production and lower labour costs. With an eye towards the advantages, challenges, and future possibilities of autonomous mining systems, this paper discusses the change from automation to autonomy in mining. Supported by present research and case studies, we look at several technologies including smart mining operations, intelligent vehicles, and autonomous haulage systems.

Keywords: autonomous systems, automation, efficiency, artificial intelligence, safety

Rorisang Gomolemo Thage
Lecturer
University of South Africa

Rorisang Gomolemo Thage, 28, is a Mine Surveying lecturer at UNISA in the department of Mining, Minerals and Geomatics Engineering. She is a PhD candidate in Engineering with the focus in Mine Planning. She is a member of the governing council for the Education Committee of the Institute of Mine Surveyors of Southern Africa. She is affiliated with various mining professional bodies and the South African Geomatics Council. She has acquired several awards in the STEMi and academic space over the years, including listing in the Mail and Guardian 200 Young South Africans.

Perspective of mine surveyors on the adoption of new technologies and coding skills in the mining industry

L.L. Yende and T. Chauke

University of South Africa, South Africa

The mining industry is undergoing a digital transformation, driven by the adoption of emerging technologies, data analytics, and automation. As these changes unfold, mine surveyors must acquire new skills to remain relevant. Currently mine surveyors face challenges when it comes to the introduction of new technologies and coding skills at work. These challenges include training, and lack of time to learn new things such as coding. Currently, the University of South Africa is undergoing a full accreditation process for the Diploma in Mine Surveying, while also starting a process of introducing short learning programmes and an advanced diploma in mine surveying. This paper investigates the perspectives of mine surveyors on the adoption of new technologies and coding skills in the mining industry. The motive for the study was to assist the University of South Africa in developing a new curriculum for short learning programmes and an advanced diploma in mine surveying in line with the imperatives of mines of the future. Furthermore, this study is used as a reference to see whether to introduce modules that will cover coding and new technologies being used at the mine for mine surveyors.

A mixed-method approach was used which entailed a structured questionnaire distributed to mine surveyors with different numbers of years of experience and job titles via Google forms. The questionnaire included both closed and open-ended questions, focusing on the adoption of new technologies and the importance of coding skills in mining surveying. It explored current technology use, coding experience, and barriers to adoption. Open-ended questions addressed future technological advancements. Key themes were technology integration, coding proficiency, and institutional support. The quantitative data collected was analysed using descriptive statistics to track trends in coding proficiency. Descriptive statistics were used to calculate frequencies and percentages to show trends in technology adoption and the perceived importance of coding skills. Measures like mean and mode summarised surveyor experience and attitudes. On the other hand, the qualitative responses were thematically analyzed to uncover key barriers and opportunities. Visualizations, including charts and graphs, were generated to present interpreted findings.

The study revealed that 100% of mine surveyors who participated increasingly recognise the importance of coding skills, particularly in automating workflows, data management, and analysis. Despite this, barriers such as limited training, lack of resources, and insufficient institutional support hinder the full integration of these technologies into their work. These insights are crucial in understanding the evolving role of mine surveyors as the industry shifts toward more advanced technology-driven processes. Finally, the 100% of mining surveyors who responded to the questionnaire recommended that universities and training institutions should introduce new technologies and coding skills in mine surveying qualifications.

Keywords: mining surveyors, adoption of technologies, coding skills

Lethuxolo Lindeni Yende
Jnr Lecturer
University of South Africa

Ms Lethuxolo Yende is a passionate professional in Mine Surveying. She is currently pursuing her Master's degree in Sustainable Mining, which underscores her commitment to fostering sustainable practices in the mining industry. Lethuxolo's specialization in Mine Surveying and Photogrammetry complements her role as a Junior Lecturer at the University of South Africa where she contributes to the education and development of future mining professionals. In addition to her expertise, Lethuxolo has a keen interest in coding and game development , demonstrating her enthusiasm for integrating innovative technologies in her work.

SAIMM
THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY
LIMPOPO BRANCH

130 Years
OF TECHNICAL EXCELLENCE