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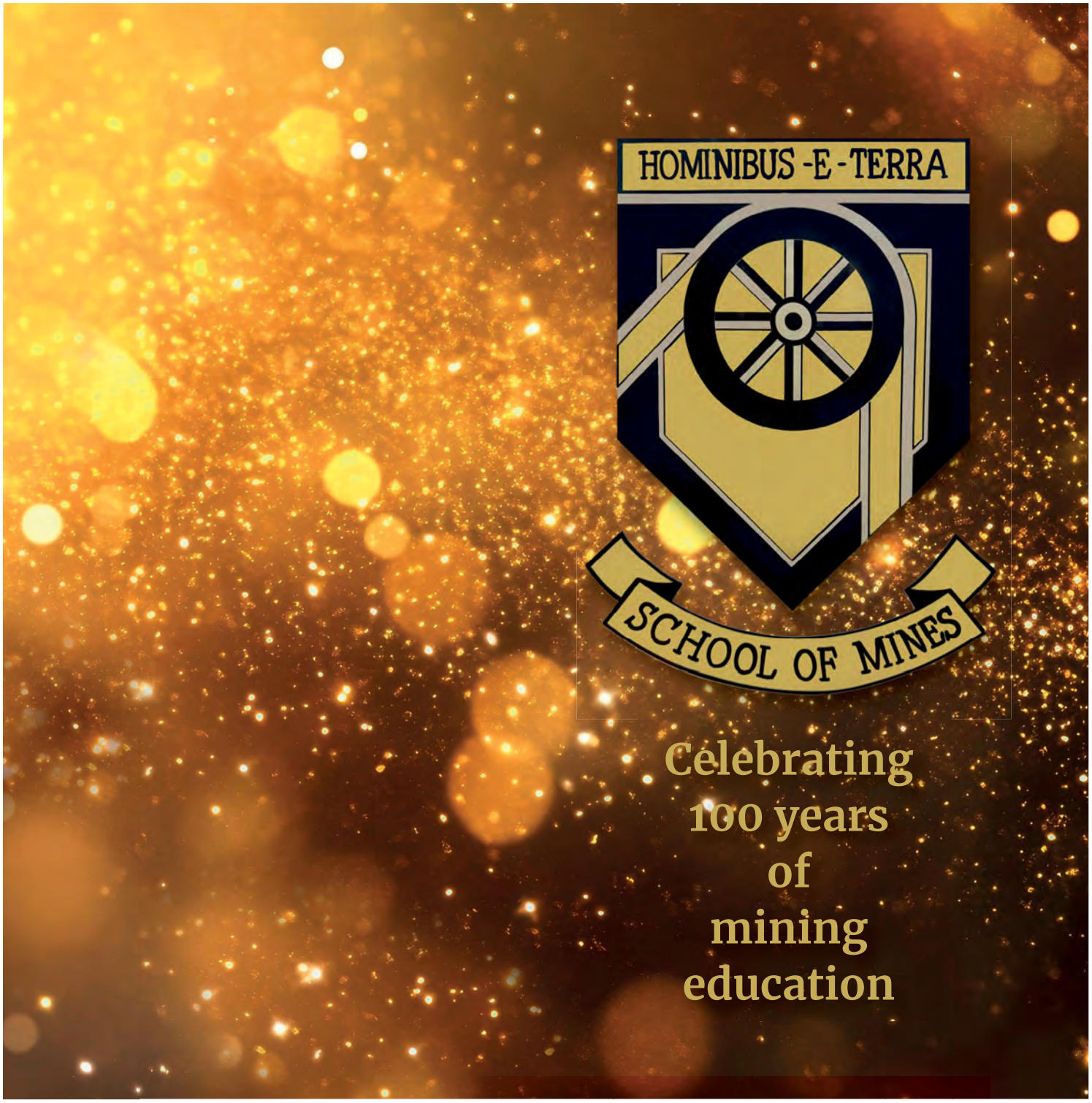
Digital and Sustainable Mining Digest



Department of Mining Engineering & Mine Surveying
Faculty of Engineering and the Built Environment
University of Johannesburg
South Africa

UNIVERSITY OF JOHANNESBURG
20 YEARS 2005-2025

Contents

From the Editor-in-Chief

A Century of Mining Education Leadership
University of Johannesburg – Department of Mining Engineering and Mine Surveying

I am delighted to welcome you to the inaugural edition of the Digital and Sustainable Mining Digest of the Department of Mining Engineering and Mine Surveying at the University of Johannesburg, South Africa. This publication has been conceived as a reservoir of knowledge—capturing both our rich heritage over the past century and our collective vision for the next hundred years. Within these pages, you will discover our historical milestones, profiles of distinguished alumni, and the lecturers who are shaping knowledge and innovation within the department. You will also find thought-provoking scholarly perspectives on the future of mining, insights into health, safety, and sustainability, and highlights of our ongoing research and strategic industry collaborations. As we stand at the intersection of tradition and transformation, embracing both digitalisation and sustainable practices, this digest reflects our commitment to shaping a mining industry that is not only innovative and efficient, but also safe, responsible, and future-focused.

In 2025, the Department of Mining Engineering and Mine Surveying at the University of Johannesburg (UJ) celebrates its centenary—marking 100 years of continuous contribution to the mining industry's technical, educational, and societal advancement. Established in 1925 amid the post-war, post-pandemic recovery, the department has evolved from modest facilities in central Johannesburg to a global leader in sustainable and digital mining education and research. Throughout this journey, it has remained anchored in UJ's core values—**Impact, Innovation, Inclusivity, Integrity**—and aligned with the UN Sustainable Development Goals.

Timeline of Key Milestones

Year	Milestone	Notes
1886	Gold discovered on the Witwatersrand	Catalyst for mining education in South Africa
1895	School of Mines established in Kimberley	Early institutional foundation
1903	Relocation to Johannesburg – Transvaal Technical Institute	Served growing gold-mining industry
1925	Department of Mining founded at Witwatersrand Technical Institute	Centenary origin date
1932	*Witwatersrand Mining Practice* textbook published	Set national mining standards
1946	*Problems and Solutions for Mine Surveyors* released	Supported returning WWII servicemen
1979	Transition to Technikon Witwatersrand	Expanded applied mining programmes
2005	Formation of University of Johannesburg (UJ)	Merger of Technikon Witwatersrand and Rand Afrikaans University
2017	Launch of modern Bachelor's degrees and postgraduate programmes	Mining Engineering Technology, Mine Surveying, Sustainable Mining
2024	Inauguration of Sibanye Stillwater Centre for Sustainable Mining	Featuring Simulacrum mine simulation facility
2025	Centenary celebrated alongside UJ's 20th anniversary	Strategic focus on Industry 4.0 and global leadership

About Us

By: Prof Hendrik Grobler
Head of Department

The department operates under this motto - "de terra pro bono humanitatis" Meaning: "from the earth for the good of humanity"

All the resources used by humankind can be categorized into two very basic formats. If a commodity cannot be grown, it must be mined. Therefore, all the modern technology used in the Industrial revolution 4.0, in its most fundamental form has its origin in a mine. Mining is crucial to the development of our economy and our society. The programmes in Mining Engineering and Mine Surveying are the backbone of the mining industry both on the continent but also world-wide.

We are very proud of our history and our contribution to the development of the mining industry in South Africa. The Department of Mining Engineering and Mine Surveying can trace its origins back over 125 years to the School of Mines that was established in Kimberly in 1896. The current School of Mines at the University of Johannesburg will turn 100 in 2026. If you start working on any mine in South Africa, the chances are good that some of your supervisors will be alumni from UJ. UJ has a hard-earned international reputation for developing practical, "hands-on" Mining Engineers and Mine Surveyors that are immediately employable and productive after graduation. It is exciting to know that the graduates from these new programmes will continue this legacy in times to come. We have a very proud history with a number of well-known figures within the mining industry that have graduated from this institution.

As a forward-thinking department, prepared and shaping the future of the Mining Industry, Our vision is "*to be the leader in the 4th industrial revolution through applied research and development of realistic mining related applications that guides our teaching and learning focused on safe, sustainable exploitation of our continent's mineral wealth.*"

Our Mining Engineering and Mine Surveying graduates are designing and operating mines that are up to 4000 metres underground and the ore they need to mine is only one metre high. To put that in perspective, imagine a book that is 4 000 pages thick. Our graduates are trained to develop a safely mine down to that one specific page. Graduates will work as a team of Surveyors, Mining Engineers, Rock engineers, Geologists and other experts to ensure the optimal extraction of a mineral resource to the benefit of both the shareholders and the local community.

Our department use GPS, drones, laser scanning technology and 3D printing to visualize these complex 3D structures at all stages of the mining process in our undergraduate teaching. The Minerals industry is adapting to the IR4.0 and our students are now introduced to VR training, the safe operation of Drones (RPAS) and Laser scanning amongst others. Our lecturers are involved in research in the fields as diverse as underground navigation systems that will ultimately guide autonomous mining machines, holo-lens applications and the impact of Women in Mining on the productivity of the industry.

In our department, we are committed to training students across the various professional cadres of the mining industry, equipping them with the knowledge, skills, technologies, and foresight needed to responsibly extract wealth from the earth for the benefit of humanity—while ensuring the safety and well-being of people in both the short and long term.

We prepare specialists for diverse roles in the sector:

- Mining Engineering Technologists are involved in daily production activities such as designing excavations, developing drilling patterns for explosives, cleaning broken rock, and supporting excavations.
- Mine Engineers, often appointed as Mine Managers, oversee all mine operations, which include financial management, mechanical and electrical engineering, mineral beneficiation, and mining operations—roles that carry extremely high levels of responsibility.
- Mine Surveyors plan and design excavations based on ore deposit valuations, providing production teams with spatial controls to ensure excavations align precisely with the 3D design. Legally appointed under the Mine Health and Safety Act, they are responsible for maintaining accurate spatial control of mining operations and updating detailed mine plans (maps) for all underground and surface workings.

Importantly, the University of Johannesburg offers the only accredited and formally recognized degree in Mine Surveying in South Africa.

Moreover, in the last 100 years, the department's research focus has evolved in step with the changing needs of society, ensuring relevance and impact in every era. In the context of South Africa's economy, where mining remains a cornerstone of growth and development, our research work has consistently addressed the sector's most pressing challenges. From pioneering safer, more efficient extraction methods to advancing sustainable mining practices and embracing the latest in digital and automation technologies, our research has been instrumental in shaping industry standards. This century-long legacy reflects our unwavering commitment to driving innovation, supporting economic resilience, and contributing to the responsible stewardship of the nation's mineral wealth

At the University of Johannesburg, where we reimagine the future, the Department continuously adapts to the evolving needs of a society shaped by the Fourth Industrial Revolution. This commitment means our students engage with cutting-edge technologies not only in the classroom and laboratory but also through regular industry exposure. We proudly host one of the first Virtual Reality (VR) training systems at a university in South Africa, enabling students to immerse themselves in realistic mining scenarios while remaining in a safe laboratory environment. In this VR environment, learners can perform critical tasks, such as the precise placement and use of explosives, that would otherwise require access to active mining sites with potentially challenging and hazardous conditions. Central to this innovation is the Sibanye Stillwater Simulacrum, generously sponsored by Sibanye Stillwater. This facility incorporates a highly realistic mine tunnel complex within a dedicated building, offering a fully integrated Mixed Reality (MR) experience where physical infrastructure blends seamlessly with virtual simulations. Acting as a digital twin mine on campus, the tunnel complex allows students to experience authentic mining operations in a safe, controlled setting. It also serves as a foundation for developing a comprehensive Extended Reality (XR) programme that will redefine mining education and research for the digital age.

Furthermore, the increased qualification profile of staff and the introduction of the Honours and master's programmes will increase research outputs to an acceptable level. Research focus areas will focus on Sustainable mining, Resource optimization, Extended Reality Technology in Engineering Education.

Consequently, the Department continues to advance its innovation and collaboration agenda through several ongoing initiatives. Our work in Small-Scale and Artisanal Mining continues to make significant strides, addressing both community development and sustainability goals. The Department is also at the forefront of technological innovation, spearheading geological and structural mapping using advanced laser scanning.

The introduction of sponsored chairs to support the Post-Graduate and Research

activities in Sustainable mining supported through Sibanye Stillwater.

As a department, we are committed to deepening our engagement with the mining industry through strategic collaborations, groundbreaking research partnerships, and the co-creation of innovative solutions. Our focus is on developing sustainable, digitally driven mining applications that enhance operational efficiency, promote environmental stewardship, and contribute to the long-term prosperity of the economy. By integrating advanced technologies such as automation, artificial intelligence, virtual/augmented reality, digital twins, and data analytics into mining processes, we aim to shape a future where the industry not only generates wealth, but does so responsibly, safely, and sustainably for generations to come.

A Century of Mining Engineering Excellence at the University of Johannesburg

By: The Department

Introduction

South Africa's abundant natural resources represent a significant portion of global reserves, yet only a fraction has been exploited. Mining education and research are essential for the sustainable development and management of these resources, enhancing beneficiation and fostering regional prosperity. The Latin phrase *"Aut crescit, aut foditor"* – "Either it grows, or it is mined" – underscores mining's pivotal role in technological advancement and community development. A quotation attributed to Max Planck summarizes it aptly: "*Mining is not everything, but without mining everything is nothing*."

In 2025, the Department of Mining Engineering and Mine Surveying at the University of Johannesburg (UJ) commemorates its 100th anniversary amid a dynamic landscape of economic and social transformations. Drawing lessons from its history, the department is committed to a sustainable future where mining advances education, research, and societal well-being.

Historical Foundations

The department's lineage begins with the 1886 gold discovery on the Witwatersrand. The School of Mines of South Africa was established in Kimberley in 1895 but was disrupted by the South African War (1899–1902). Relocating to Johannesburg in 1903, it merged with the Transvaal Technical Institute (TTI), housed in the iconic "Tin Temple" at Rissik and Plein streets, to address the gold-mining industry's needs.

However, challenges persisted, including the 1913 mining strike and World War I (1914–1918), which caused labour shortages and rising costs. By 1916, the SA School of Mines and Transvaal University College offered part-time classes for mining engineers and surveyors. Post-war, the 1918 influenza pandemic claimed over 250,000 lives in South Africa, followed by the 1922 Rand Revolt amid economic pressures, reducing active mines to 40.

In this turbulent aftermath, the Witwatersrand Technical Institute (WTI) was established in 1925 under a 1923 Act of Parliament, with the Department of Mining forming its core. The WTI evolved into the Witwatersrand Technical College (1930), Witwatersrand College for Advanced Technical Education (1968), and Technikon Witwatersrand (1979). It contributed to the founding of the University of the Witwatersrand (1922) and University of Pretoria.

Academic and Industry Contributions

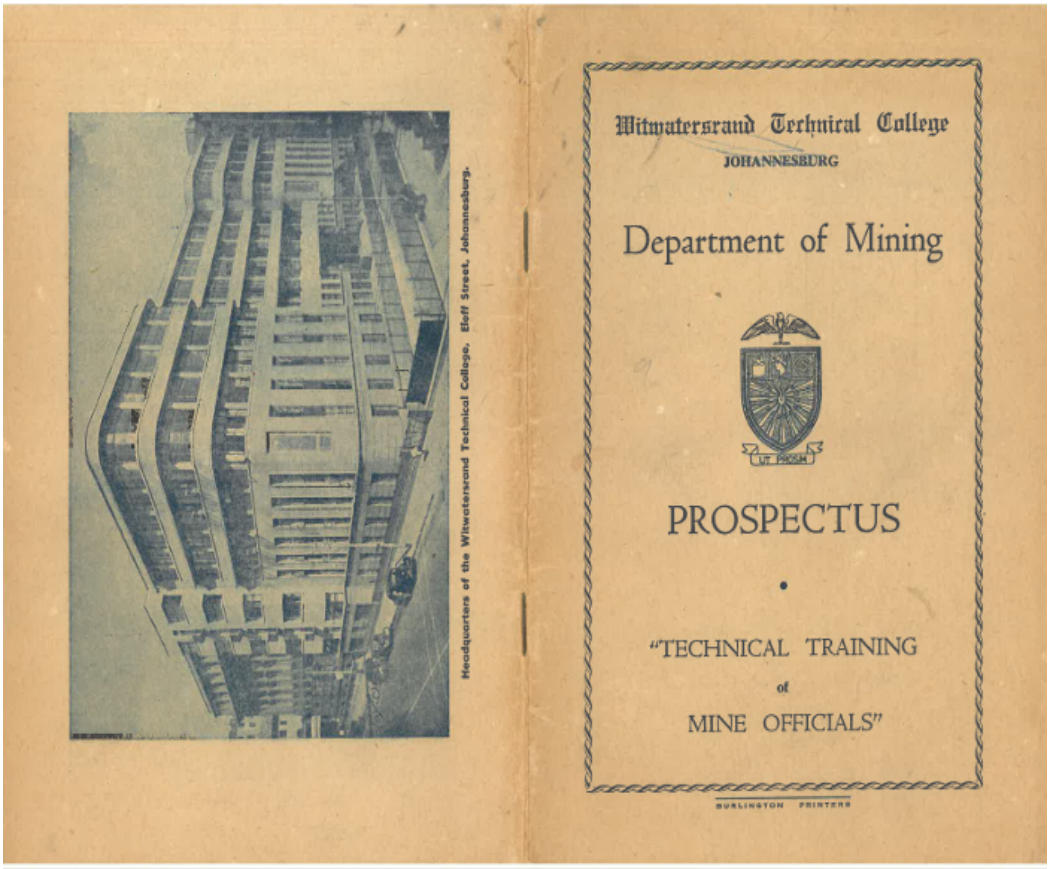
The department's scholarly impact is evident in key publications. Watermeyer and Hoffenberg's 1932 "Witwatersrand Mining Practice" included mine surveying, drawing from institute journals. C.B. Jeppe's 1946 "Gold Mining on the Witwatersrand" followed, omitting surveying due to the concurrent publication of "Problems and Solutions for Mine Surveyors", aiding ex-servicemen's reintegration after world war 2. Clare Storrar, a lecturer (1936–1937), authored "South African Mine Valuation", revised in 1987 with Professor Danie Krige's statistical chapter. Lesser-known works include Janisch and Hamilton's "Section Drawing from Simple Geological Maps". In 2022, Professor H. Grobler authored Chapter 25 on "Sub-surface surveying" in the Society of Mining Engineers' Mining Engineering Handbook.

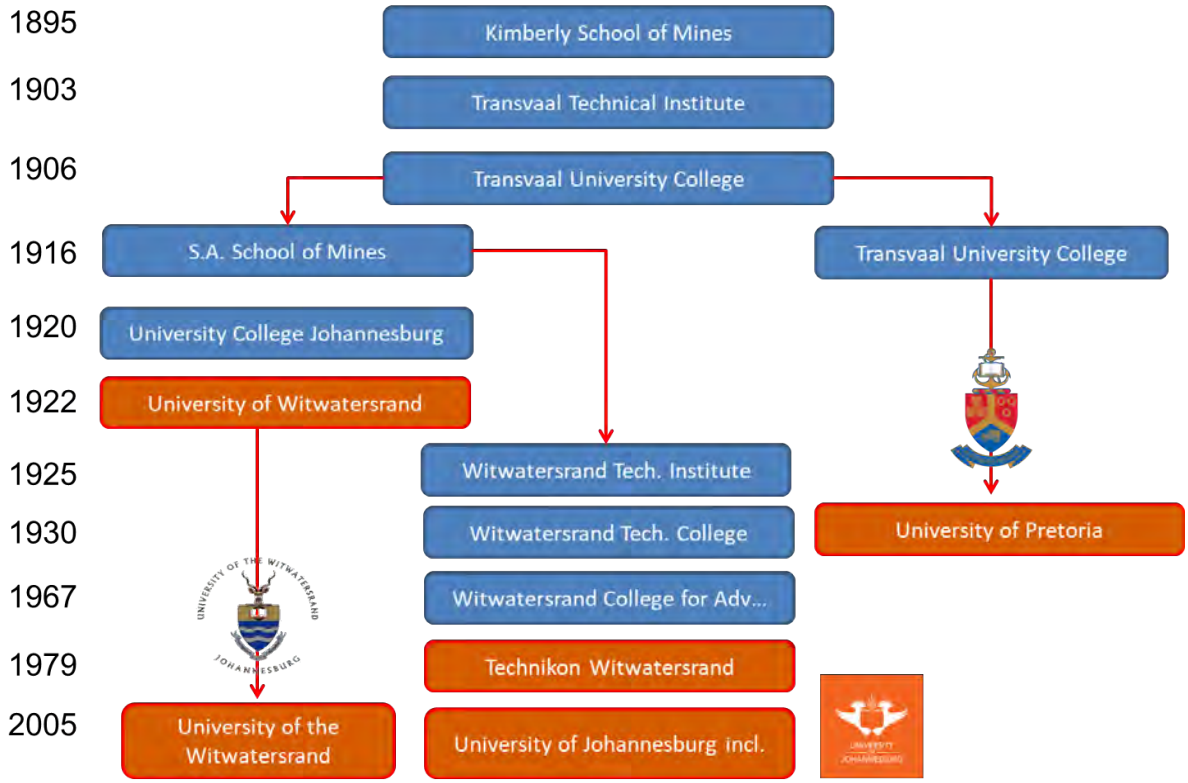
Historical documents like the "Wits Tech College 1951 Prospectus" with front page shown below, emphasize part-time, industry-aligned education, while the "TWR 1925–1975 Tin Temple History" chronicles the institute's adaptability during industrialization. The 1951 Prospectus can be downloaded via this link: https://drive.google.com/file/d/1d99Wvl5NtryohFIktaY487SQ_V57blQH/view?usp=sharing

Institutional Evolution

The 2005 merger of Technikon Witwatersrand and Rand Afrikaans University, directed by Minister Kader Asmal in 2002, formed the University of Johannesburg (UJ), integrating academic and technological programs. The department, now in the Faculty of Engineering and the Built Environment, phased out diplomas (2015–2017) for Bachelor of Engineering Technology degrees in Mining Engineering and Mine Surveying, plus Honours, Masters, and PhDs in Sustainable Mining and Mineral Resource Governance.

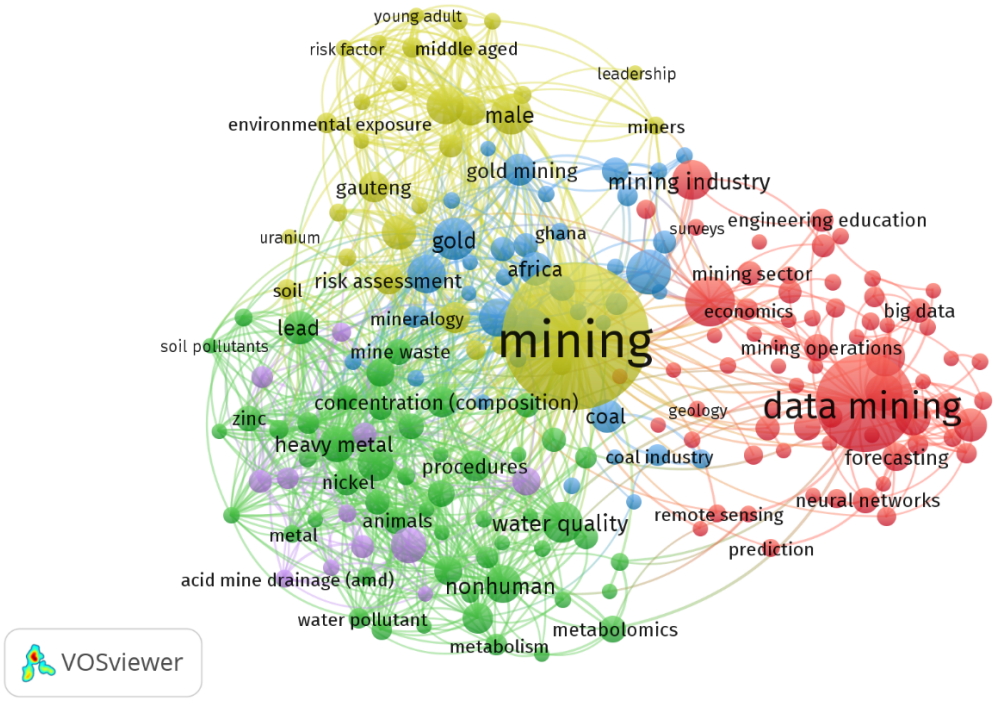
The image on the following page depicts this evolutionary journey of the department.





In the last 100 years, the department's research spans the full spectrum of modern mining science as shown in the below Vosviewer analysis of Scopus publication of the department. Key focus areas include mine modernization through digital mining technologies, big data, the Internet of Things (IoT), and advanced data analytics to optimize the mining value chain, enhance life cycle assessments, and support evidence-based policy and strategy development. Expertise extends to mine planning and design, geomechanics, rock fracture mechanics, geohazard mitigation, ventilation engineering, mine logistics, and both vertical and horizontal transport systems. Cutting-edge work in mineral resource management, mine valuation, mineral economics, and critical energy minerals is complemented by studies on artisanal and small-scale mining, mine closure, abandoned mines, repurposing of ghost towns, and mining's role in the energy transition. The department also advances applications of machine learning, deep learning, and geo—including GPS, GIS, gyroscopic surveying, and spatio-temporal analysis—for mineral evaluation, tailings storage monitoring, slope stability assessment, and climate change adaptation. Environmental initiatives focus on wastewater remediation using biological waste, environmental geochemistry, and sustainable extraction of rare earth elements, alongside research in solar energy integration and mining-caused subsidence prevention. Additional strengths lie in safety and health systems, legal and regulatory frameworks, mining engineering education, and the assimilation of emerging technologies to create a future-ready mining industry.

Over the past century, the department's legacy of educational, research, and industrial excellence has been deeply rooted in strong global collaborations. This global footprint is reflected in partnerships with 81 countries, as highlighted in the Vosviewer analysis of our publication network. These collaborations span every continent and encompass both developed and emerging economies, underscoring the truly international nature of our work. Our network includes the United Kingdom, United States, Germany, India, Australia, Canada, South Korea, Nigeria, Netherlands, China, Denmark, Sweden, Italy, Finland, Brazil, Spain, Pakistan, Switzerland, Portugal, Botswana, Hong Kong, Zimbabwe, Turkey, Hungary, Egypt, France, Japan, Indonesia, Tunisia, Malaysia, Saudi Arabia, Costa Rica, Ghana, Iraq, Mexico, Norway,

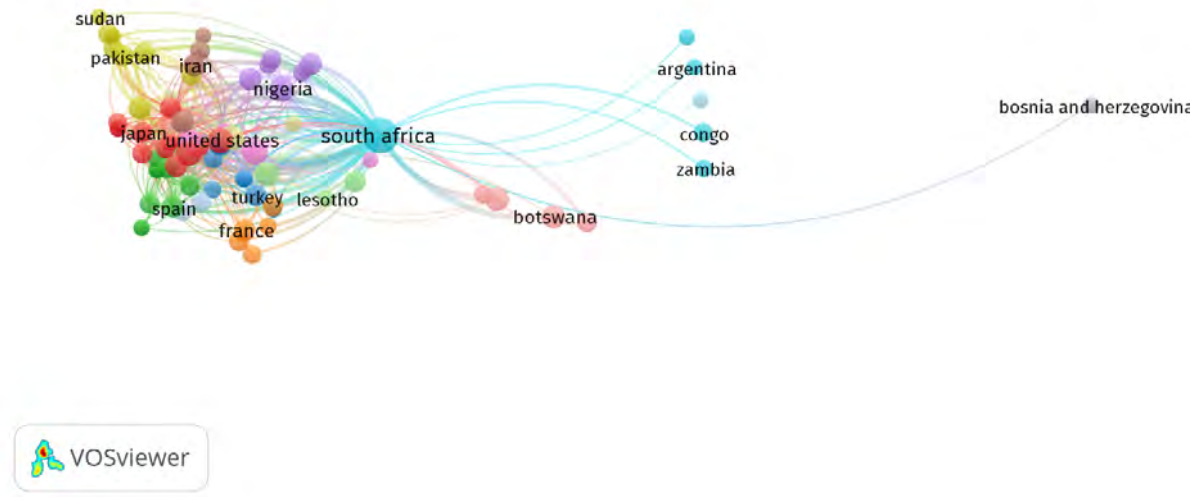


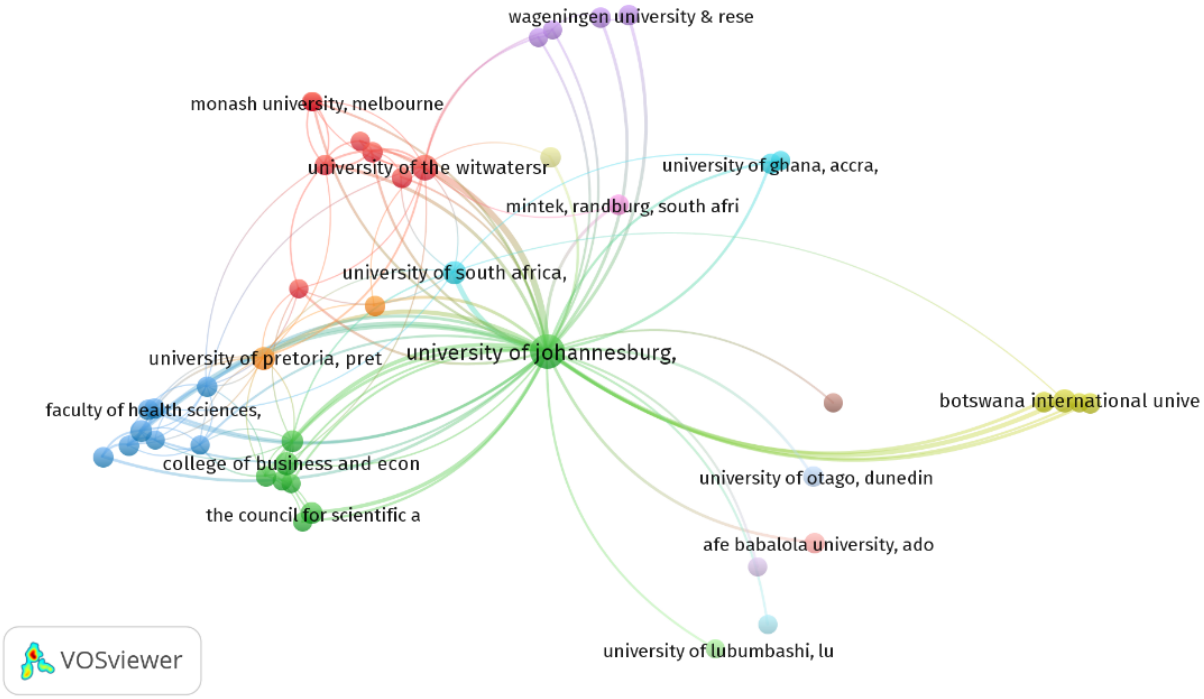
Iran, Russian Federation, Belgium, Czech Republic, Israel, New Zealand, Uzbekistan, United Arab Emirates, Democratic Republic of Congo, Vietnam, Poland, Austria, Bulgaria, Greece, Kenya, Lithuania, Serbia, Armenia, Croatia, Namibia, Bangladesh, Peru, Somalia, Tanzania, Yemen, Ireland, Malawi, Singapore, Jordan, Qatar, Congo, Ethiopia, Bosnia and Herzegovina, Central African Republic, Kazakhstan, Lesotho, Rwanda, Senegal, Slovenia, Sudan, Zambia, Argentina, Cameroon, and Thailand.

These partnerships have enabled a rich exchange of knowledge, technology, and expertise, enhancing our research impact and driving innovations in mining engineering and mine surveying. Together, we continue to advance solutions that address both local and global challenges in sustainable resource development.

Looking to the Future

The department proudly hosts the Sibanye Stillwater Centre for Sustainable Mining and the





Strategic Minerals Research Group, serving as hubs for cutting-edge research and innovation. These initiatives align seamlessly with the University of Johannesburg's core values and the United Nations Sustainable Development Goals (UN SDGs), particularly in fostering mineral-driven economic prosperity that is socially inclusive and environmentally responsible.

Through robust partnerships with industry leaders, the department will continue to advance continuous learning and upskilling in Industry 4.0 technologies. This includes expertise in mine information systems, digital twins, remote operations, augmented and mixed reality for enhanced safety training, real-time health and environmental monitoring, and other emerging digital solutions. By integrating sustainability principles with digital transformation, the department not only enhances operational efficiency in mining but also supports safer, cleaner, and more sustainable extraction practices for the future.

Conclusion

Marking its centenary in 2025 alongside UJ's 20th anniversary, the Department of Mining Engineering and Mine Surveying reflects on a century of perseverance, excellence and innovation. From humble beginnings in the "Tin Temple" to leadership in sustainable practices, it continues to equip professionals for responsible resource stewardship, ensuring mining's positive legacy for South Africa and beyond.

Mining Department @ 100: Photo Speaks

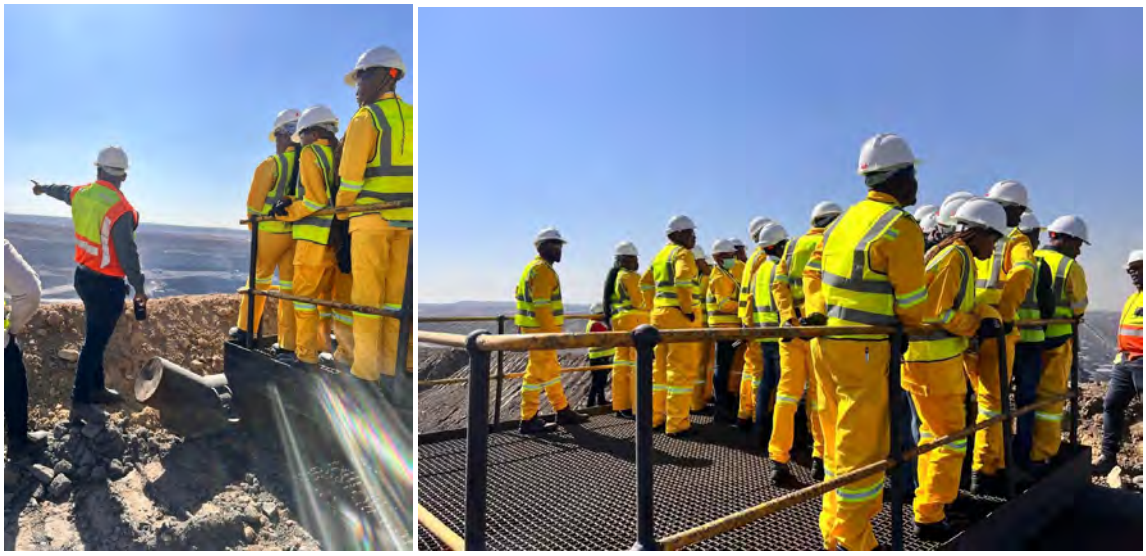
First mining commission in Johannesburg 1886

1909 Teachers in front of the Transvaal University College in which the School of Mines was housed on Eloff street

Witwatersrand Technical College members of the second council 1928 including Prof. John Orr and John "Jock" Glen Finlay (School of Mining)

1966 School of Mines final year group including Prof "Jos" Lurie

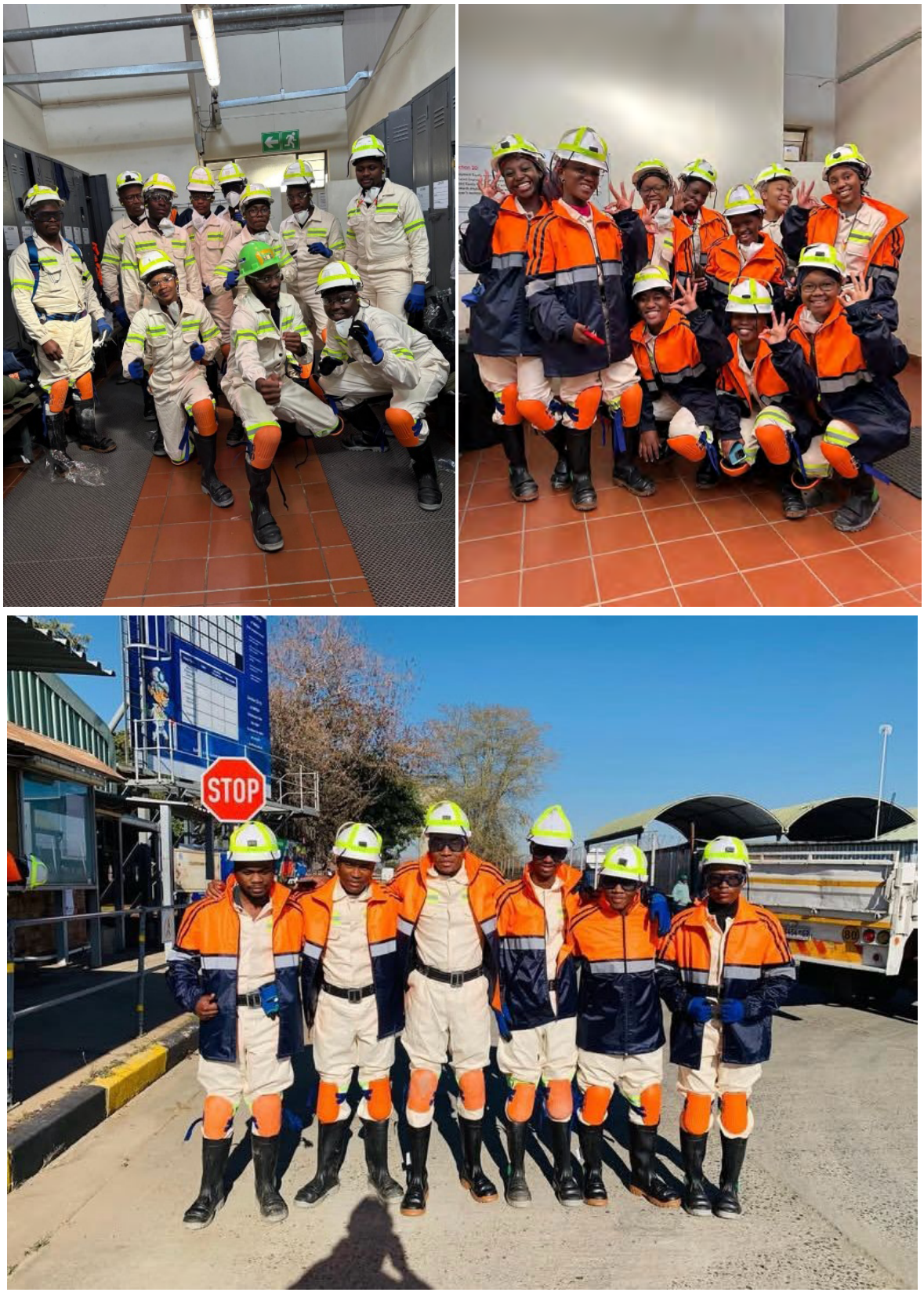
The "Tin Temple" (1915-1933) on Plein square between Eloff and Joubert streets, that was the point of origin for the Witwatersrand Technical College and The University of the Witwatersrand



2025 Mine visit to Glencore Goedgevonden (GGV) Colliery.
Captured: UJ Mining Forum

2025 Mine visit to Harmony Gold Mining Company Limited.
Captured: UJ Mining Forum

2025 Mine visit to Seriti Khutala Colliery.
Captured: UJ Mining Forum



2025 Mine visit to Impala Platinum.
Captured: UJ Mining Forum

2025 Mine visit to Khanye Colliery – Canyon Coal.
Captured: UJ Mining Forum

2025 Mine visit to Exxaro Resources Grootegeluk.
Captured: UJ Mining Forum

2025 Mine visit to Dwarsrivier Chrome mine
Captured: UJ Mining Forum

Our Alumni

Name: Benedict Bosman
Position: Chief Executive Officer, Meerust Operations
Class: 2009
UJ Memory: I remembered one day that I was adamant that my answer to a support layout was also right. I headed to Mr Knottenbelt and explained to him why I should get full marks for the question. After all he agreed and gave me what I deserved. That memory lasted up to today. If you feel strongly about something, do not hesitate and seek clarity to align your thinking in all you do. That will fuel you with commitment once it makes sense in your brain.

Name: Phiwa Khumalo
Position: General Manager
Class: 2012
UJ Memory: Mine Visits

Name: Thando Matanzima
Position: CEO XS plant and Rigging
Class: 2012
UJ Memory: Mr Knottenbelt encouragements.

Name: Muneiwa Lorraine Nndwambi
Position: Production manager
Class: 2012
UJ Memory: In my first year at UJ, we were introduced to a little book called Who Moved My Cheese? — a simple story about change and adaptability. At the time, I didn't realise how much it would stick with me. Years later, working in the ever-changing world of mining, I still find its lessons relevant: be ready for change, embrace it, and keep moving forward.

Name: Mpho Kgadima
Position: Principal Mining Engineer - Operational Excellence
Class: 2012
UJ Memory: My undergraduate years in Mining Engineering remain some of my most treasured. I am deeply grateful to the then-Head of Department and faculty who believed in me, gave me the chance to lead my class, and helped me secure a study sponsorship with the company I have proudly served since graduating in 2012 (Anglo American). I am also proud of my classmates, with whom I co-founded the UJ Women-in-Mining substructure — an initiative that continues to thrive and empower women in the industry today.

Name: Nomzamo Zwane
Position: BI Projects Specialist
Class: 2017
UJ Memory: The mining test week

Name: Kethusitswe Jeffrey Mokgatlha
Position: Project Executive
Class: 2007
UJ Memory: Visit to the mock up mine.

Name: Matete Malatji
Position: Key Accounts Manager
Class: 2012
UJ Memory: Obtaining the Faculty of Engineering and the Built Environment (FEBE) Dean's Honour Roll award for exceptional achievement in 2012. Honoured with the UJ Blazer for 2012 top performing student in the 4th year (BTech). Chosen to represent UJ Mining Department at the Colloquium held by SAIMM in 2012. Awarded a certificate for Highest Academic Achievement in BTech Engineering (all disciplines) for ladies at University of Johannesburg in 2012. I was a class rep back in 2012 during my final year and also active member in the mining forum where I held the Training & Development role and these opportunities helped in honing my leadership skills. Our department was very supportive, and they nurtured and recognised great talent and academic achievement, and this was a motivation to carry me throughout the years.

Name: Shale Masindi
Position: Senior Mining Consultant at Deswik
Class: 2012
UJ Memory: I have so many fond memories of my time at UJ, but one that stands out was in 2010 — the World Cup year in South Africa. I had just completed my in-service training, and my sponsors asked me to stay at the mine for another year. I wasn't too keen on the idea, so I went ahead and registered for my 3rd and 4th semester courses. What I didn't know was that my sponsors had quietly contacted the HOD at the time, Mr. Knottenbelt. He sat me down for a pep talk, explaining why returning to the mine would be beneficial for my career. In the end, I had little choice but to agree. Looking back, that year turned out to be one of the best of my student life — a mix of personal growth, unexpected turns, and the unforgettable atmosphere of the World Cup. Our Lecturers

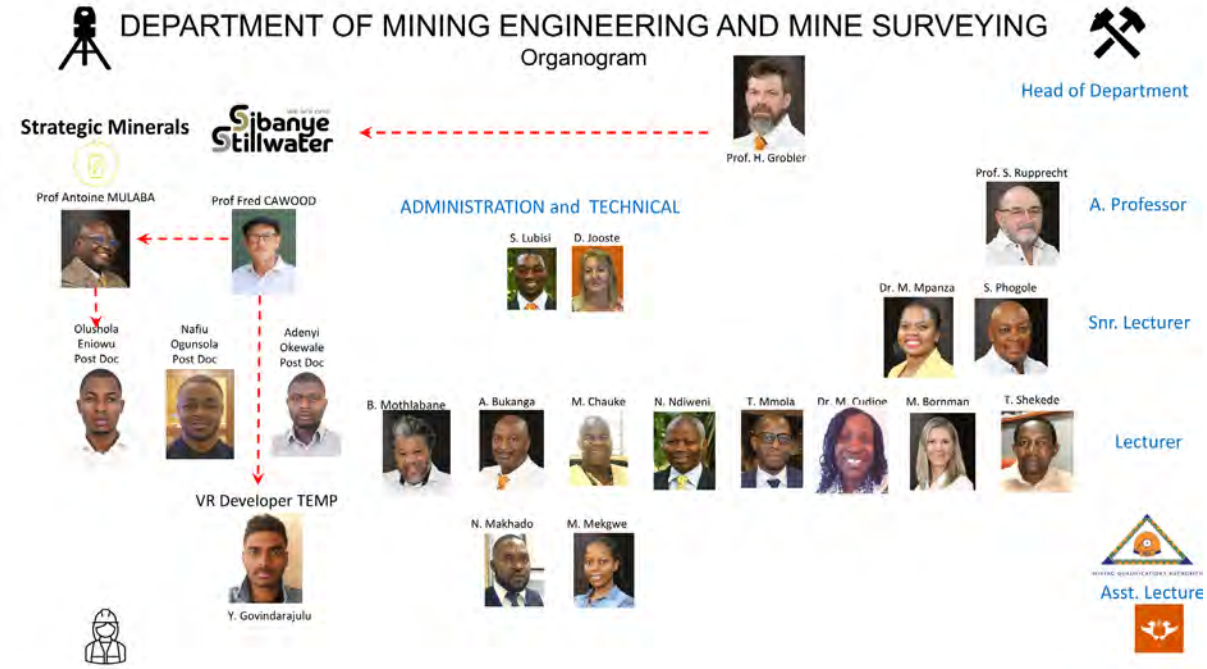
Our Lecturers

Introduction

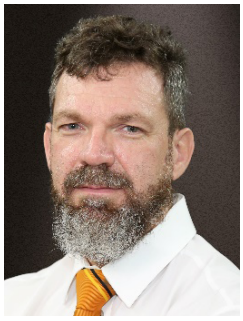
In the last 100 years, the Department of Mining Engineering and Mine Surveying has been dedicated to producing graduates who are not only technically competent but also industry-ready, adaptable, and visionary. Every module, laboratory session, and field exercise are designed with clear learning outcomes that align directly with the diverse career paths our graduates pursue, from Mine Managers, Rock Engineering Managers, and Health and Safety Leaders to Project Managers, Mineral Resource Specialists, Geospatial Engineering Consultants, and Technical Services Managers. Whether stepping into roles in open-pit or underground mining, coal or mineral resources, artisanal or large-scale operations, our graduates carry with them a breadth of knowledge and a depth of practical skills shaped by a team of world-class academic staff.

Our faculty are more than lecturers, they are innovators, industry collaborators, and researchers whose work spans the full spectrum of modern mining science, engineering, and policy. Their expertise drives advancements in mine modernization through digital mining technologies, artificial intelligence, and advanced analytics to improve the mining value chain, life cycle assessments, and policy development. They bring cutting-edge insights into mine planning, geomechanics, ventilation engineering, logistics, mineral economics, and the sustainable management of critical energy minerals. Students benefit from exposure to research in artisanal and small-scale mining, mine closure, repurposing of abandoned sites, and mining's role in the global energy transition. They also engage with frontier applications of machine learning, deep learning, and geospatial systems for mineral evaluation, slope stability monitoring, climate change adaptation, and tailings management.

Through this rich academic and research environment created by our staff, enhanced by industry partnerships and emerging technology integration, our graduates leave not just with a qualification, but with the competence, adaptability, and foresight to lead the mining industry toward a safer, more sustainable, and digitally driven future.



The Staff



Prof. Hendrik Grobler

Head of Department

Inspirational Quote: "The obstacle is the way."
- Marcus Aurelius

Research Interest: Inertial navigation and orientation (gyroscopes) and network adjustments. Virtual and Augmented Reality applications for the education of Mining Engineers and Mine Surveyors. Mine Surveying Education, Mineral Resource Management, and Applications of Gyroscope

Dr. Mbalenhle Mpanza

Senior Lecturer (Deputy Head of Department)

Research Interest: Mineral Resource Evaluation, mine tailings storage facilities, mapping of abandoned mine tailings using deep learning techniques, Mining engineering education, and Sustainability in Mining

Prof. Frederick Cawood

Visiting Professor and Acting Director: Sibanye-Stillwater Centre for Sustainable Mining

Research Interest: Mine modernization for responsible mining, mining value chain and life cycle analysis, mine modernization through digital mining technologies, and generative artificial intelligence for mining policy and strategy development.

Prof. Antoine F. Mulaba-Bafubiandi

Emeritus Professor and Director research Group. NRF Rated (C)

Research Interest: Strategic and critical minerals, mine closure, abandoned mines, ghost towns and repurposing, mineral for energy transition, Tourism and mine, Artisanal and small-scale mining, mining caused subsidence.

Prof. Steven Rupprecht

Senior Lecturer

Research Interest: Mine Planning and Design, and Artisanal Smal Scale Mining. Mine planning and design. Mineral Reserve reporting

Dr. Monica Naa Morkor Cudjoe

Lecturer

Inspiration Quote: "Whether you think you can or think you can't, you're right." – Henry Ford

Research Interest: Mineral Resource Management; Mineral Resource Evaluation; Mine and Land Surveying; GPS and GIS systems; Mine Planning and optimization

Mr. Maelani Chauke

Lecturer

Inspirational Quote: Mintirho ya vulavula

Research Interest: Mine Modernization; various topics of in underground Mine Ventilation Engineering; Mine Logistics; Vertical and Horizontal Mine Transport; Engineering Education, particularly Workplace-related Engineering Education. Technology Assimilation (TA) in the South African Mining and Minerals Industry (SAMMI); Several Topics in Subsurface Mine Ventilation Engineering; Technical Entrepreneurship; Revolutionary Engineering and Innovation

Mr. Amuli Bukanga

Lecturer

Inspiration Quote: Life is not about waiting for the storm to pass, but learning to dance in the rain

Research Interest: Open pit mine planning and design, Mine Planning, Mineral Processing (Comminution, Classification, Mine Engineering)

Mr. Shekede Tafadzwa

Lecturer

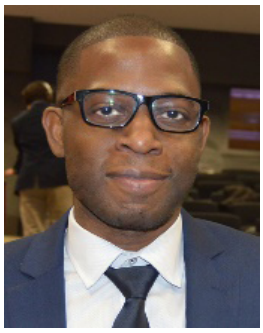
Research Interest: Waste water remediation using biological waste

Mrs. Monique Bornman

Lecturer

Inspirational Quote: "It always seems impossible until it is done."

Research Interest: Slope Stability Monitoring and Ground Subsidence with Special Interest in Abandoned Mines, Safety and sustainable mining, collapse of mine shafts, alteration of groundwater flow, and degradation of geological materials, and Deformation Surveys.



Mr. Tshepo Mmola

Lecturer

Research Interest: Mine Design, Planning and Optimisation; Mine Valuation and Financial Modelling; Operations Research and Artificial Intelligence in Mining

Mr. Ntabiso Ndiweni

Lecturer

Research Interest: Mining Law, Mine Health and Safety Act in mining operations.

Ms. Keabetswe Mmolotsi

Lecturer

Inspirational Quote: It is not hard until you try it

Research Interest: Laser Scanning, Environmental and legal in mining

Mr. Basimane Motlhabane

Lecturer

Research Interest: Mining and Geotechnical

Ms. Melia Mekgwe

Lecturer

Inspirational Quote: I can do all things through Christ who strengthens me (Phillipians 4:13)

Research Interest: NERB utilisation in the mining industry, sustainability of mining by improving the efficiency of rock breaking, evaluation of sensitive areas, geologically difficult, and legally prohibited areas to be exploited for sustainability.

Ms. Tiisetso Kekana

Lecturer

Inspirational Quote: "There's no shortcut to a place worth going"

Research Interest: Spatio-Temporal Analysis of Informal ASM Using Integrated Geospatial Techniques. GIS for mapping artisanal small-scale mining operations

Mr. Nyadzeni Makhado

Lecturer

Mr. Silence Lubisi

Lecturer

Inspirational Quote: "In the age of technology, safety is not just a priority, it is a revolution waiting to be engineered"

Research Interest: 4IR and the occupational health and safety in the mining industry.

Dr. Eniowo Olushola

Postdoctoral Research Fellow

Research Interest: Mineral Economics, Small-scale Mining, Critical Energy Minerals (CEM), Environmental geochemistry, Application of Machine Learning (ML) in mining, Rare earth elements (REEs)

Dr. Nafiu Olanrewaju Ogunsola

Postdoctoral Research Fellow

Research Interest: Geomechanics, Rock fracture mechanics, computational intelligence of rocks and geomaterials, geohazard mitigation, Rock dynamics, Sustainable mining and geomechanics, Artificial intelligence application to mining and geomechanics

Department of Mining Engineering and Mine Surveying 2024 Annual Report

Advancing Sustainable Mining Education and Research: Highlights from the University of Johannesburg

In a year marked by resource constraints and global shifts toward sustainable resource management, the Department of Mining Engineering and Mine Surveying at the University of Johannesburg (UJ) demonstrated resilience and innovation. Led by Head of Department Professor Hendrik Grobler and Head of School Professor Peter Olubambi, the department navigated challenges, accreditation demands, and industry partnerships to advance mining education and research. This summary draws from the department's 2024 Annual Report, highlighting key achievements, challenges, and strategic contributions that align with UJ's mission to "*transform and serve humanity through innovation and the collective and collaborative pursuit of knowledge*," and its vision of being "*an international university of choice, anchored in Africa and the global South, dynamically shaping a sustainable future*." The department's efforts embody UJ's core values—Impact, Innovation, Inclusivity, and Integrity—while supporting broader imperatives, including the United Nations Sustainable Development Goals (SDGs). Notably, the focus on sustainable mining practices aligns with SDG 9 (Industry, Innovation, and Infrastructure) through technological advancements in resource extraction, SDG 4 (Quality Education) via enhanced learning opportunities, and SDG 17 (Partnerships for the Goals) through collaborative initiatives, without overstating direct impacts.

Key Achievements and Strategic Initiatives

The department's 2024 accomplishments reflect a decade-long trajectory of building industry-academia synergies, particularly with partners like Sibanye Stillwater and

the Mines Qualification Authority (MQA), embodying UJ's value of Innovation through pioneering collaborations and Inclusivity by prioritizing historically disadvantaged South Africans (HDSA) in talent development. A standout achievement was the successful accreditation of the Bachelor and Honours degrees in Mine Surveying by the South African Geomatics Council (SAGC). This milestone enables graduates to register as Geomatics Professionals in Mine Surveying, enhancing their employability and addressing industry needs for skilled professionals—demonstrating Integrity in upholding rigorous standards and Impact in bolstering workforce readiness. Over the past five years, similar accreditations and program reviews have ensured alignment with Engineering Council of South Africa (ECSA) standards, preparing for the next ECSA visit in 2026, in line with UJ's mission to foster transformative knowledge.

Another highlight was the launch of the Sibanye Stillwater Research Centre in Sustainable Mining (CSM), including the SS Simulacrum mine simulation facility. This state-of-the-art simulator provides hands-on training in underground environments, supporting practical education and research in areas like real-time monitoring of deformation, airflow, and contaminants—critical for safer, more efficient deep-level mining. The CSM's establishment builds on a 10-year partnership with Sibanye Stillwater, which has funded undergraduate and postgraduate students, research, and infrastructure, reflecting UJ's value of Impact by driving societal benefits through sustainable practices anchored in Africa's resource challenges.

Internationally, Professor Grobler's election as President of the International Society of Mine Surveyors (ISM) elevated the department's profile, aligning with UJ's vision of a global footprint in the global South. The hosting of an ISM Praesidium meeting with 20 global organizations laid groundwork for the 2026 ISM Congress in South Africa, fostering cross-border collaboration and Inclusivity in diverse knowledge exchange. These efforts underscore trends over the last five years, where international engagements—such as visits to mining universities in Ghana and hosting delegations from Germany, China, and Poland—have strengthened global networks, embodying Innovation in collaborative pursuits.

Research outputs surged in 2024, with over 20 publications and conference papers on topics ranging from tailings stability and rock burst prediction to sustainable mineral exploitation. Notable works include studies on the mechanical behaviour of gold tailings and machine learning for pillar stress prediction in platinum mining, contributing to SDG 12 (Responsible Consumption and Production) by promoting efficient resource use and waste minimization. The department also formed a Strategic Minerals research group, targeting high-impact areas like underground navigation in GPS-denied environments and mapping old mine workings to prevent infrastructure damage from illegal mining—initiatives that indirectly support SDG 11 (Sustainable Cities and Communities) through risk mitigation in urban mining contexts, while upholding UJ's Integrity in ethical research practices.

Looking ahead, opportunities abound in leveraging digital technologies for mining, such as intelligent dashboards for equipment effectiveness, as explored in staff research. Strategic interventions could include expanded partnerships with the Mining Education Trust Fund (METF) to retain talent and integrate SDG-aligned curricula, ensuring graduates drive sustainable practices in an industry facing environmental scrutiny, thereby advancing UJ's vision of shaping a sustainable future.

Contributions to UJ's Strategic Objectives and Broader Impacts

Aligned with UJ's six strategic objectives, the department made targeted contributions in 2024, weaving in its core values. In "Excellence in Research and Innovation", the CSM and Strategic Minerals group amplified outputs, supporting SDG 9 through innovations in sustainable mining and embodying UJ's Innovation value. Excellence in Teaching and Learning was bolstered by the Simulacrum's monthly industry visits and student mine excursions, enhancing practical skills and work readiness—key to SDG 4 and reflecting Impact on student outcomes.

The department's International Profile shone through ISM leadership and collaborations, aligning with UJ's global vision. Student and Staff Friendly Environments benefited from bursaries and visits funded by industry partners, promoting Inclusivity. National and Global Reputation Management was advanced via roles in SAIMM, MEESA, and SOMP, and Fitness for Global Excellence through delegations and MOUs, all underpinned by Integrity in professional engagements.

Employee profiles show a diverse team of 21 staff (including MQA temporaries), with three pursuing PhDs and six Master's degrees. Predominantly HDSA, the staff blend academic qualifications with GCC and professional registrations, though vacancies persist—efforts here support Inclusivity. Student demographics reveal steady growth, from 414 in 2020 to 641 in 2024, with 99% African students and a focus on throughput via credit reviews and industry relevance, aligning with UJ's mission to serve humanity through education.

In Research Footprint and Impact, emerging areas like social responsibility in mining (including conflict minerals) and subsidence monitoring address SDG 13 (Climate Action) by tackling environmental risks in arid regions, demonstrating Innovation and Impact. Internationalization included staff engagements in global societies and visits, with programs holding international accreditation. Community Service and Stakeholder Engagement featured senior staff supporting Industry in council positions at the Institute of Mine Surveyors of South Africa (IMSSA), South African Institute of Mining and Metallurgy (SAIMM), public lectures, and industry partnerships, reinforcing SDG 17 and UJ's collaborative ethos.

Resource Management secured external funding for sustainability. Emerging risks include funding volatility and the need for updated infrastructure, addressed through external grants totalling R4.25 million from Sibanye Stillwater and R1.4 million annually from MQA, supporting UJ's mission of collaborative knowledge pursuit.

Transformation initiatives, supported by MQA and METF, developed HDSA staff, promoting equity in line with SDG 10 (Reduced Inequalities) and UJ's Inclusivity value.

Conclusion and Outlook

The Department of Mining Engineering and Mine Surveying at UJ concludes 2024 on a high note, despite constraints, with accreditations, research launches, and international leadership paving the way for its centenary in 2025. By integrating sustainable practices into education and innovation, the department not only meets industry demands but also contributes modestly to UN SDGs, particularly in fostering responsible mining that balances economic growth with environmental stewardship—all while embodying UJ's core values of Impact, Innovation, Inclusivity, and Integrity. For senior academics and mining CEOs, this report signals opportunities for deeper collaboration—investing in talent pipelines, co-developing technologies, and addressing shared risks like climate impacts and skills gaps. As the sector transitions toward net-zero operations, UJ's efforts exemplify how academia can drive meaningful change, ensuring a resilient future for South Africa's mining heritage in alignment with the university's transformative mission and sustainable vision.

Opinion Piece

The South African Mining Industry (SAMI)'s current Health and Safety Landscape

By: N Ndiweni

The SAMI has historically experienced a high level of mining-related fatalities; however there has been tremendous improvement in reducing the fatalities from 1993 to 2024. The improvements are attributed to the Fall of Ground Action Plan (FOGAP) and the Transportation and Mining projects. Although the SAMI has observed improvement in safety, it might be at a point where the improvement is reaching a plateau. Unless well-designed sustainable health and safety interventions are introduced, the plateau could be with us for years to come. Hence, immediate interventions should be implemented to focus on health risks, well-maintained mine infrastructure, regulatory compliance, digital transformation and corporate governance issues. Just to share the health and safety landscape of the SAMI as reported by the Mine Health and Safety Council (MHSC) and Minerals Council of South Africa (MCSA), there has been an increase in fatalities related to FOG incidents. According to the MCSA (2024), platinum group metals and gold sectors account for majority of the fatalities and injuries see Figure 1.

Looking at continued future safety improvement, these considerations are not just options, but necessities that need to be gradually adopted so that they become the safety norm. The SAMI should decide to adopt the following effectively:

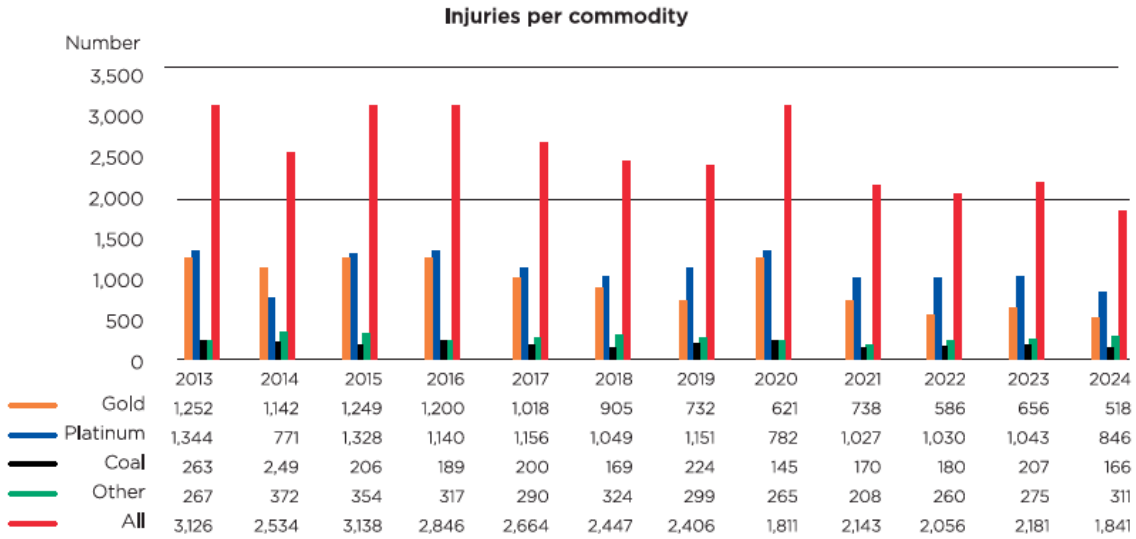


Figure 1: Injuries per commodity (MCSA, 2024)

- Automated technologies and robotics.
- Real-time monitoring systems
- Quality education and training
- Mitigation measures to deal with the impact of mental health on safety
- Evolving the regulatory framework that involves updating safety standards to include new technologies, while also providing support and guidance for small-scale operators to ensure their compliance.
- Adoption of responsible mine closure plans with sustainable rehabilitation and waste management is not just a recommendation, but a commitment to the long-term sustainability of health and safety associated with SAMI.

Our Research Centres

Given the dynamic research landscape of the Department, two dedicated research centres play a pivotal role in advancing the department's vision and extending its impact across the mineral resource sector for inclusive prosperity. These centres are the Strategic Minerals Group (SMG) and the Sibanye-Stillwater Centre for Sustainable Mining (SS-CSM). Both centres serve as hubs for innovation, knowledge creation, and industry collaboration, driving research that aligns with responsible mining, sustainable resource management, and technological advancement. A succinct overview of each research centre is provided below, highlighting their key focus areas, and contributions to shaping the future of mining.

Strategic Minerals Research Group

The Strategic Minerals Group (SMG), based in the Department of Mining Engineering and Mine Surveying at the University of Johannesburg, with Prof. Hennie Grobler as Head of Department, is a dynamic research hub dedicated to advancing knowledge and innovation in the field of critical and strategic minerals in South Africa. Under the leadership of Prof. Antoine F. Mulaba-Bafubiandi, the centre

Prof. Antoine F. Mulaba-Bafubiandi
Director: Strategic Minerals Research Group

brings together a team of skilled academics and researchers committed to addressing the nation's growing need for sustainable mineral resource development. Key members of the team include Dr. Mbalenhle Mpanza, Deputy Head of the Department; Ms. Melia Mekgwe, a Lecturer and experienced mining professional with expertise in mineral resource management; and Dr. Olushola Daniel Eniowo, a Postdoctoral Research Fellow specializing in strategic mineral research and mining sector optimization. In addition to its core research staff, SMG hosts a vibrant cohort of students at undergraduate and postgraduate levels, who conduct research under the group's supervision. This ensures a continuous pipeline of skilled graduates equipped with expertise in critical mineral studies.

The centre's research focuses on the identification, extraction, processing, utilization, and sustainable management of mineral resources critical to South Africa's economic growth, energy transition, and technological advancement. We collaborate closely with industry stakeholders, government agencies, and academic partners to provide cutting-edge research outputs that support informed policy decisions and responsible mineral exploitation. Through training, publications, and innovation, the Strategic Minerals Group plays a pivotal role in shaping the future of mining in South Africa and ensuring the country's competitiveness in the global minerals market.

Sibanye-Stillwater Centre for Sustainable Mining (SS-CSM)

The Sibanye-Stillwater Centre for Sustainable Mining (SS-CSM) is situated within the Department of Mining Engineering and Mine Surveying (MEMS) at the Faculty of Engineering and the Built Environment (FEBE), Doornfontein Campus (DFC) of the University of Johannesburg (UJ). Officially launched on 14 November 2024, the Centre operates under the governance framework of the University of Johannesburg. The Centre is mandated to support and advance the strategic interests of the African mineral and mining industry in promoting sustainable development and facilitating growth within the mining sector. It undertakes multidisciplinary research that contributes to sustainable mining practices, human capital development, and the growth of the mining innovation ecosystem in South Africa. The vision of the Centre for Sustainable Mining (CSM) is to leverage innovation through research and capacity development to positively impact Africa's sustainable mining needs and its reliance on the sector for socio-economic development. The Centre's mission is to drive innovation by addressing the risks and opportunities inherent in sustainable development within the mining industry. A key focus of the Centre is applied research in mining value chain optimization through Fourth Industrial Revolution (4IR) technologies, mining Environmental, Social, and Governance (ESG) practices, licensing to operate, as well as teaching and learning approaches tailored to sustainable mining. While several universities in South Africa host broadly similar facilities, the CSM is unique in its dedicated focus on sustainable mining practices within the 4IR context. The research agenda of the Centre aligns with the strategic priorities of the University of Johannesburg, national development goals, and the broader objectives of the African Union. Considering the accelerated implementation of the United Nations Sustainable Development Goals by 2050, responsible mineral production by the South African and wider African mining sectors is imperative. Equally, minimizing harm to mine employees, surrounding communities, and natural resources constitutes a fundamental prerequisite for mining activities. The CSM is committed to advancing sustainable mining solutions that are developed by Africans, for Africa, and for future generations. The Centre is led by Professor Frederick Cawood, who serves as Director and provides research leadership, supported by Dr. Nafiu Olanrewaju Ogunsola, a postdoctoral research fellow.

Professor Frederick Cawood

Director: Sibanye-Stillwater Centre for Sustainable Mining (SS-CSM)

Opinion Piece

Digitalisation (4IR) and Sustainability of the Mining Industry

By: Thabang Surprise Matlala

Digitalisation goes far beyond simple "digitisation." While digitisation is the conversion of information into digital form, digitalisation is the strategic transformation of processes, decision-making, and operations to harness the full potential of digital technologies and data (Honeywell, 2025). In the context of modern mining, digitalisation is not merely about automation, it is about creating smarter, more integrated systems that optimise resource extraction while safeguarding the environment. As technology advances and high-grade mineral reserves become increasingly scarce, the mining sector must adopt innovative, data-driven methods to maximise the value of each deposit, reduce waste, and minimise the sterilisation of resources. By merging advanced sensing, real-time analytics, and predictive modelling with sustainable mining principles, digitalisation has the potential for responsible extraction that balances economic viability with environmental stewardship, ensuring that the minerals needed for todays and tomorrow's economies are secured without compromising future generations' access to these critical resources.

Notably, for centuries a five percent limit of error on reserve reconciliation has been assumed to be tolerable. Parker (2014) writes a paper which spans over twenty five years of reconciliation experience and data and argues that it is generally accepted that in a base metals mine, a good annual reconciliation between mine and mill would be around five percent and for a precious metals mine, a good annual reconciliation between mine and mill would be ten percent, even so it is useful to examine the impact of such seemingly small estimation errors on the cash flows and net present values of an operation. However, the manner in which beneficiation has been done has changed drastically. The tools utilised to conduct reconciliation has changed drastically, from using tapes to lidar scanning. Could it be that the five percent used as an acceptable limit of error destroys more value than it should, taking into account the advancement of technology and process overhaul the fourth industrial revolution has on mining?

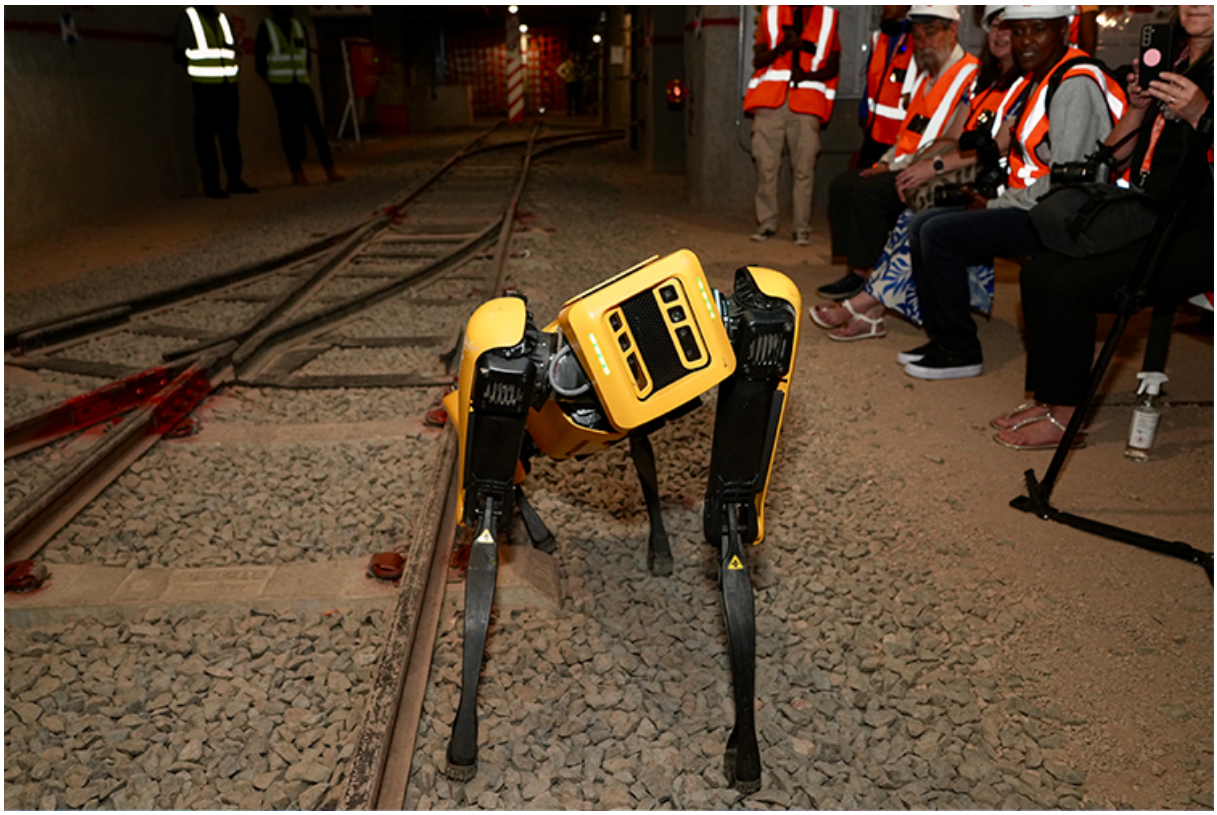
Small scale miners have started mining out old dumps to try and extract value which has been misplaced. The use of modern technology makes this possible. Given these advancements, maintaining a five percent tolerance appears increasingly outdated. Mines equipped with modern digital tools could and arguably should aim for reconciliation variances closer to one or two percent. This heightened accuracy not only improves operational efficiency and resource accounting but also strengthens compliance with Environment, Social, Governance (ESG) reporting and financial governance, where precision builds stakeholder trust. The industry must now question whether clinging to the five rule reflects operational reality or outdated thinking.

Furthermore, the evolution from rudimentary measurement methods to advanced 4IR technologies demands a reassessment of long-standing accuracy benchmarks in mining. While the five percent tolerances once reflected the limits of available tools and operational realities, it no longer represents the potential precision achievable today. Reducing reconciliation variances to one or two percent is not merely a technological possibility, but it is a strategic necessity for safeguarding value, improving sustainability outcomes, and maintaining stakeholder confidence. By aligning industry standards with modern capabilities, mining can unlock hidden value, optimise resource utilisation, and set a new benchmark for operational excellence in the digital era.

Bibliography

Honeywell, 2025. Honeywell.com. [Online] Available at: https://www.honeywell.com/us/en/news/2023/11/what-is-digitalisation-and-why-its-important [Accessed 11 August 2025].

Parker, H., 2014. Reconciliation principles for the mining industry. San Francisco: Scribd.



The Future of Mining in South Africa

By. Dr. Mbalenhle Mpanza

Introduction

The mining industry remains a very complex, high risk and challenging environment. It is inevitable that it requires technological innovation, to remain efficient, effective and sustainable. A recent report by Deloitte (2018) states that mining faces great resistance to change because it relies on legacy technology. Deloitte attributes the decline of production, expansion and development to this resistance. As mineral resources and reserves approach depletion at shallow depths, mining has to go deeper to access and open up ground, this requires cutting edge technology and innovation. According to BDO South Africa (2025), mining companies that execute digital strategies effectively achieve benefits such as a 10% to 20% increase in mining throughput, up to 50% improvement in procurement productivity and a 15% to 30% reduction in emissions.

Technological innovation and sustainability are the future of mining. BDO South Africa (2025) states that technologies will have the biggest impact in mining in the next 15 years. Artificial intelligence (AI), digital solutions, and automation are improving efficiency, while decarbonisation and the adoption of renewable energy are gaining momentum. Investments in green technology and infrastructure continue to fuel a demand for critical minerals, offering new opportunities despite unstable markets. South Africa is a participant in global trade and thus subscribes to the Net Zero carbon emissions goal. The global Net Zero carbon emissions is a pathway for the global energy sector to reach net zero CO_2 emissions by 2050 by deploying a wide portfolio of clean energy technologies, without offsets from land-use measures (International Energy Agency, 2024). Critical Mineral (CM) production in South Africa aligns with the net zero emissions goal and the Just Energy Transition Investment Plan, which has secured $8.5 billion in international funding to support green industrialisation and decarbonisation effort (Zadeh, 2025). Mining companies have set long-term goals, with most aiming to achieve net zero carbon emissions by 2050. In response to regulatory pressures, they are also establishing shorter-term targets for 2030-2035, often aiming for a 30% reduction (BDO South Africa, 2025). To achieve these goals mining companies are required to meet the 2050 targets, prompting mining companies to engage in initiatives such as increasing renewable energy usage and decarbonising their fleets through electrification or green hydrogen. However, for the mining industry this poses a challenge as most operations still depend on fossil fuels for high-energy processes. This means the mining industry is inherently fossil fuel energy intensive. According to a study by Deloitte, the mining industry and manufacturing jointly account for about 60% of national electricity consumption, while their combined GDP contribution is about 22 per cent (Deloitte, 2018).

The future of mining in South Africa is defined by its current and future challenges namely safety in the workplace, high operating costs at relatively low profitability, unstable power supplies, depletion of high-grade reserves, regulatory requirements, and the need to meet sustainable development goals. Majority of these challenges can be resolved by a robust digital transformation in the industry. This commentary focuses on critical minerals (CMs) as a key player in the future of mining because these are relevant in the discussion of

power supply and technological advancement within the mining industry. Furthermore, this commentary explores technological advancement, ESG and skills required for the future of mining.

Critical Minerals (CMs) and the Just Energy Transition

In South Africa, you cannot talk about the future of mining and not mention the increasing demand for critical minerals and the Just Energy Transition (JET). Without stable and sustainable energy solutions, the industry's transition toward decarbonisation remains uncertain. The need for alternative power sources has never been this important and urgent. Some mining companies are already starting to implement strategies and are producing their own power, for instance using solar power. This is an excellent example of innovation and the promotion of sustainability and where the future is headed.

Critical Minerals such as aluminium, copper, lithium, nickel and zinc are essential for the JET, therefore a focus on their exploration and expansion is necessary. South Africa hosts 88% of the worlds' platinum group metal (PGM) reserves making the country a key player in global supply of these minerals. Furthermore, the country is estimated to host 72% chromium, and 80% manganese global reserves. It is ranked second in titanium minerals with a global reserve market share of (10%), zirconium (25%), vanadium (32%), vermiculite (40%) and fluorspar (17%) (DMPR, 2025). According to the International Energy Agency, (2023) the surge in energy transition minerals such as cobalt, copper, aluminium, nickel, zinc, vanadium, REEs and lithium will increase significantly in the coming decade see Figure 1.

Figure 1 shows the projected CMs demand ratio of year 2050 to 2022, it is clear that lithium will be highly in demand in the coming years, followed by vanadium and graphite. Lithium is a high energy density mineral used in battery energy storage. Furthermore, lithium is added to glass and ceramics to enhance heat resistance and durability. By 2035, lithium, iron, phosphate and lithium manganese, iron, phosphate are set to dominate EV cathode chemistries due to their higher energy density. High-nickel chemistries are forecast to drop from 55% of the EV battery market in 2023 to 40% by 2040, displaced by manganese-rich alternatives. This shift can change the demand of nickel in technological innovations (BDO South Africa, 2025). In 2024, copper had high deal values, and the price was exceptional. Copper is vital for use in wind turbines, solar panels, electric vehicles, and energy transmission and distribution infrastructure (PwC, 2024). According to the International Energy Agency (2024), global

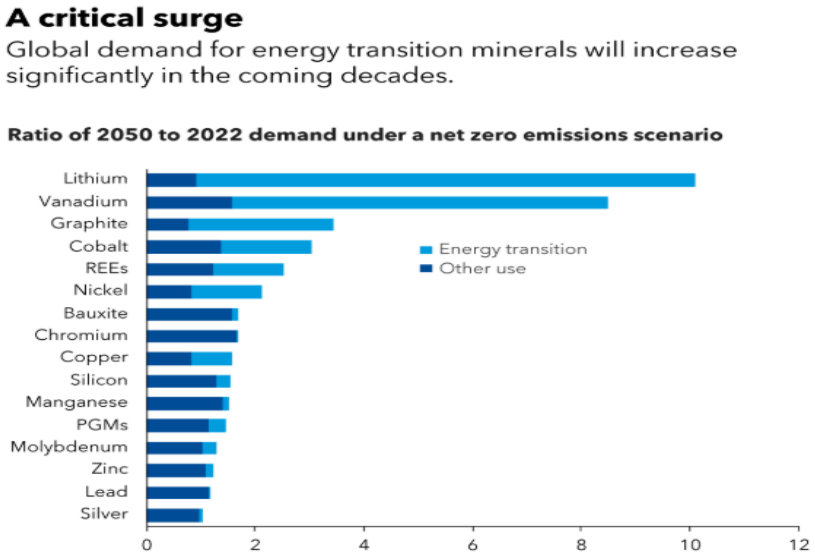


Figure 1: Ratio of 2050 to 2022 projected CRMs demand (International Energy Agency, 2023)

copper demand could double by 2040 under a net zero emissions scenario. South Africa is fortunate to host the majority of what the global market deems as CMs. However, the challenge in South Africa is that most minerals are exported as raw materials and once produced, final products are sold back to the country and are imported as finished high-value products (Dikgwatlhe, 2022). The future of mining should look into various beneficiation strategies for our minerals to be converted into high value-product to avoid unnecessary imports. This is also highlighted by the recently published Critical Minerals and Metals Strategy of South Africa. The CM strategy published in May 2025 by the department of Mineral and Petroleum Resources (DMPR) states that research in battery materials, fuel cells, and advanced beneficiation methods, will unlock the potential to process critical minerals into high-value products (DMPR, 2025).

Technological advancements in Mining

Artificial Intelligence is here to stay; the industry needs to start integrating it to its core production activities. Numerous scholars note that, for the mining industry to be cost-effective and to achieve optimal process efficiencies, technological advances and innovation endeavours are important (Pearce and Robinson, 2007; Mosconi, 2019). Of late, the mining industry has implemented autonomous haulage systems, predictive maintenance, and real-time data analytics. All these are improving productivity while reducing human exposure to hazardous environments. Digital tools such as internet of things (IoT) devices, drones, and remote monitoring systems enable real-time tracking of environmental impact, water usage, and energy consumption (PwC, 2024).

In mine production the use of Trackless Mobile Machines is on the rise. The machines can be operated remotely, have proximity detection, minimise risks and improve safety in incidents and serious injuries. By July 2024, 2,080 autonomous haul trucks were in operation worldwide (BDO South Africa, 2025). Machine learning is currently being explored at Implats in the area of predicting Fall of Ground occurrence ahead of the mining face. Fall of Ground (FoG) related incidents and accidents have been on the rise in the mining industry lately accounting for 30% fatalities (Mine Health and Safety Council, 2024; Minerals Council South Africa, 2024). Although the mining industry struggles with FoG management, the implementation of smart drills at Implats has seen a decrease in the number of FoGs occurrence.

AI-powered predictive analytics enhance resource estimation, mine planning, and energy efficiency, ensuring responsible mineral extraction. Mining companies like BHP, Barrick are already using machine learning and deep learning in the prediction of new mineral resources and their environmental footprint. The application of Artificial Neural Network is growing immensely in the area of mineral resource estimation, and this has provided speed and accuracy in this process. The adoption of digital twins—virtual models of mining operations allow companies to simulate scenarios, optimise decision-making, and mitigate risks. Companies such as Vale have implemented a holistic digital twin for mission-critical connected operations in the mine. Rio Tinto uses AI as a part of its Mine Automation System to generate orebody models, organise equipment dispatch, and predict control blasts.

At the 2023 Mining Indaba, we saw Anglo American unveil its first hydrogen-battery powered haul truck as an initiative towards net zero emissions/ decarbonisation. The haul truck was designed for daily operations at Mogalakwena PGMs mine. The 2MW hydrogen-battery hybrid truck, generating more power than its diesel predecessor and capable of carrying a 290-tonne payload, is part of Anglo American's nuGen™ Zero Emission Haulage Solution (ZEHS).

Environmental Social Governance (ESG)

The future of mining pertaining to ESG will ensure that no environmental degradation occurs and that host communities are adequately engaged. Technology will be used to monitor environmental conditions to avoid catastrophic

tailings dams failure. The mining investors are becoming more aware of sustainability goals and will ensure; mining communities and other stakeholders are adequately developed without worsening social inequalities. The future of mining will have responsible mine operators who will conduct progressive mine closure to avoid having to deal with the burden of closure at the end of the life of mine.

Skills of the future in mining and our department's response

The future of mining will involve building skills that will enable the technology to work. Unfortunately, the technology for future mines cannot implement itself it will need skilled individuals to be effective. In the mining industry, a skills gap has been noted in the area of Information Communication and Technology (ICT) (Dragicevic and Bosnjak, 2019). The skills shortage can be attributed to slow technological adoption by the industry and poor ICT infrastructure. Furthermore, culture issues, lack of training, execution and implementation has widened the skills gap.

The skills of the future in mining include the following:

- Competencies in Automation and Robotics, the future courses in universities will need to emphasize automation in drill and blast, hauling, and surveying specific to various mining methods.
- AI and Data Analytics: Predictive maintenance, ore body modelling, and safety analytics will be core.
- Remote Sensing and Drones: Surveying education will heavily include UAVs, LiDAR, and satellite data.
- VR/AR Training: Virtual and augmented reality will be used for safe, immersive training.

To address aspects of sustainability in mining and achieving Sustainable Development Goals, training academies and universities can introduce Phyto mining techniques that can assist in the rehabilitation of tailings storage facilities. Explore opportunities of involving host mining communities in establishing a circular economy in mining where tailings material can be used in brick and tiles manufacturing and these can provide sustainability beyond mining.

The department of Mining Engineering and Mine Surveying at the university of Johannesburg (UJ) has implemented the Virtual Reality to simulate the mining environment and provide training to students for a number of mining activities. For example, at our department we have a Mock Mine which simulates an underground mine tunnel where students do their practicals in mining and mine surveying. The overall curriculum includes courses such as mine planning and design and mineral resource evaluation where students are exposed to software such as Deswik CAD and the Datamine suite of software i.e. StudioRM, StudioOP and StudioUG.

First Year	Second Year
Maths and Science Introductory modules Writing skills	Core Mining and Survey modules (Mock Mine practical, virtual reality and simulation)
Third Year	**Fourth Year**
Automation –introduction of various mining software for the Final year project (Datamine software i.e. StudioRM, StudioUG, StudioOP)	Research and Design Project Mining optimisation (Deswik CAD)

In summary, South Africa is endowed with mineral wealth which include critical minerals, and these are significant to meet the demand of technological advancement and decarbonisation. South Africa has an opportunity to become a future global leader in the supply of these minerals. Through technological advancements, particularly digitalisation, workforce development, community, environmental care the mining industry can contribute to sustainability and economic growth.

References

BDO South Africa (2025). Transforming the Industry with Sustainability, Innovation and Critical Minerals. [Online]. Available: https://www.bdo.co.za/getattachment/45cc7fa0-9cb2-44df-b6a4-d807a210bd1c/Global-__-Annual-Mining-Report-2025-compressed.pdf?lang=en-ZA

Department of Mineral and Petroleum Resources (2025). South African Critical Minerals Strategy. [Online]. Available: https://www.gov.za/sites/default/files/gcis_document/202505/critical-minerals-and-metals-strategy-south-africa-2025.pdf

C. Dodd, "Is there a future boom amongst the gloom?" *AusIMM Bulletin*, pp. 16–19, 2016.

Z. Dragicevic and S. Bosnjak, "Digital transformation in the mining enterprise: The empirical study," *Mining and Metallurgy Institute BOR*, Vol. 1–2, pp. 73–90, 2019. https://doi.org/10.5937/mmeb1902073D

Deloitte. *Tracking the trends 2018: The top 10 issues shaping mining in the year ahead*. 2018. [Online]. Available: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-er-ttt-report-2018.pdf

S. Gao, E. Hakanen, P. Töytäri, and R. Rajala, "Digital transformation in asset-intensive businesses: Lessons learned from the metals and mining industry," *Hawaii International Conference on System Science (HICSS)*, Wailea, HI, 2019. https://doi.org/10.24251/HICSS.2019.593

IEA (2023) *Africa Energy Outlook 2022*.

IEA (2024) *Prohibition of the export of nickel ore*, *Universal Access to Clean Cooking in Africa: Progress update and roadmap to implementation*. Available at: https://www.iea.org/policies/16084-prohibition-of-the-export-of-nickel-ore?

E. Mosconi, K. Crownston, and J.V. Nickerson, "Developing skills to work in the age of intelligent machines: Pre-HICSS workshop," 52nd Hawaii International Conference on System Sciences (HICSS), Wailea, HI, 2019.

Mine Health and Safety Council (2024). Falls of Ground Safety Breakaway Session. [Online]. Available: https://mhsc.org.za/wp-content/uploads/2024/10/Breakaway-Feedback-Falls-of-Ground-Safety-18-October-2024.pdf

J.A. Pearce II and R.B. Robinson Jr., *Strategic management: Formulation, implementation and control,* 10th ed., New York, McGraw-Hill Irwin, 2007.

Price Water Coopers (2024). SA Mining 2024. Beyond Mining. [Online]. Available: https://www.pwc.co.za/en/publications/sa-mine.html

The Presidency Republic of South Africa (2023). Just Energy Transition Implementation Plan 2023–2027. [Online]. Available: https://www.stateofthenation.gov.za/assets/downloads/JET%20Implementation%20Plan%202023-2027.pdf

J. Zadeh (2025). South Africa's Critical Minerals Strategy: Transforming Mineral Wealth. https://discoveryalert.com.au/news/critical-minerals-south-africa-2025-analysis/

Opinion Piece

Geospatial Insights into the Socio-Economic Pulse of High-Risk Artisanal Mining Areas

By MT Kekana

Artisanal small-scale mining (ASM) activities are small-scale mineral extraction operations conducted by individuals, families, or community groups. They often have limited capital investment and simpler methods, basic tools, and minimal machinery compared to large-scale mining. These activities typically occur in informal or semi-formal settings and play a significant role in local livelihoods, but they present significant safety risks, environmental, social, and land-use challenges, particularly in rapidly urbanising and resource-rich areas. Understanding and unpacking their dynamics and impacts is key to striking a balance between sustaining livelihoods and protecting our natural resources. Similarly, by uncovering their actual causes and triggers, developing targeted, research-based interventions and sustainable land management strategies, we can craft smarter solutions that safeguard both communities and the environments they depend on.

Therefore, it is essential to understand the spatial factors driving ASM through integrated geospatial analysis. My study assesses the socioeconomic and infrastructural factors influencing the potential occurrence of high-risk areas for informal ASM activities using an integrated geospatial approach. Informal ASM activities are increasingly associated with negative environmental and social consequences, yet their spatial drivers in urban contexts remain underexplored. In my view, factors such as informal settlements, mine dumps, education levels, unemployment rates, and proximity to railways play a critical role in shaping where informal ASM activities emerge and how likely they are to occur. Analysing these variables is crucial for understanding the complexities of this phenomenon, as well as unpacking their spatial patterns, underlying drivers, and heterogeneity. A combination of geospatial and geostatistical techniques, such as proximity analysis and Random Forest (RF), can be used to capture both the spatial distribution and complex geospatial relationships influencing informal ASM.

Moreover, localised variations in these geospatial relationships can be rigorously established through scientific analysis. This investigation enables the identification of socioeconomic and infrastructural variables that exhibit varying significance of association with the prevalence of informal ASM. Therefore, context-specific interventions are required in informal ASM high-risk areas, as blanket policies often overlook localised socioeconomic and infrastructural dynamics. Geospatial techniques are robust in supporting informed decision-making and sustainable land-use planning to manage the impacts of informal ASM activities across the board. Finally, developing geospatial skills can significantly benefit the future of mining by enabling better planning and monitoring that support environmental protection, social responsibility, and stronger governance practices.

Opinion Piece

The Future of Mining depends on its sustainability

By Dr Monica Naa Morkor Cudjoe

The mining industry has made significant contributions to the global economy by providing jobs for millions of people worldwide and supplying a range of goods to a technologically dependent society. The environmental and social effects of mining the Earth's natural resources have long been overlooked in the name of economic growth, despite these benefits. However, things are starting to change, and as climate change accelerates and minerals become scarcer, the mining industry must decide whether to adapt or go extinct.

A green energy transition requires more mining. Batteries, wind turbines, and solar panels all require lithium, cobalt, copper, and rare earth elements. In summary, mining is necessary for decarbonization. However, mining in the manner that has led to this environmental calamity is also unaffordable.

Sustainable mining is a notion that might have seemed contradictory until recently. The question that comes to mind is how do you mine a finite resource and yet ensure sustainability? In mining, sustainability is more than just cutting emissions or reforesting a slope after blasting. Investing in circular economies, reducing waste, increasing energy efficiency, and—perhaps most importantly—obtaining and preserving social license to operate from local communities are all part of this new way of thinking about the mining lifecycle.

Innovation in technology has a big impact. Automation and AI are reducing the environmental footprint of mining, while increasing productivity and safety. Renewable energy is increasingly being used at mining sites and mining equipment is increasingly being electrified. Geospatial and remote sensing technologies are assisting in ensuring responsible mining.

The mining industry's reputation cannot be saved by technology alone. Beyond merely complying with regulations, mining firms need to respect land rights, communicate openly with indigenous peoples, and make long-term pledges to restore the environment. The days of exploit and exit operations are over.

The role of governments is also important. Green mining incentives, stricter enforcement, and more transparent rules can all help drive the industry in a sustainable manner. The recipients of mining products who are conscious of the origins of their goods are starting to insist on materials that are supplied ethically.

In summary, the future of mining will depend more on how responsibly we can extract than how much we can extract. If mining is to have a future, it must help build one by involving all stakeholders.

Mining Brain Teasers

By: Dr. Kenneth Otasowie

1. I shine deep red and am a corundum prized by jewellers and royalty. What am I? (Ruby)
2. I glint in veins and have long been chased for wealth and ornament. What am I? (Gold)
3. I hide in coal seams and can explode if stirred; I am colourless and flammable. What am I? (Methane)
4. I scoop and lift loose earth and ore with a simple, sturdy blade. What am I? (Shovel)
5. I am thick and tar-like, trapped in sands, used for oil after refining. What am I? (Bitumen)
6. I am the watery waste left after minerals are separated and processed. What am I? (Tailings)
7. I reveal how much metal hides inside a rock sample through testing. What am I? (Assay)
8. I measure shaking and help planners prepare for tremors and faults. What am I? (Richter)
9. I strip away soil and rock above a seam so miners can reach it. What am I? (Stripping)
10. I run through rock carrying minerals, a seam you can follow and mine. What am I? (Lode)
11. I am a clear, crystalline form of carbon prized for rings and brilliance. What am I? (Diamond)
12. I am a dense, malleable heavy metal often recovered from galena. What am I? (Lead)
13. I fizz with acid and make up much of the sedimentary rock used in buildings. What am I? (Calcite)
14. I strap to a miner's head, so their hands stay free while they work. What am I? (Headlamp)
15. I operate beneath waves or on the ocean floor to recover deposits. What am I? (Subsea)
16. I am a reddish iron oxide and a significant source of the iron we use. What am I? (Hematite)
17. I blast sediment with pressurised water to wash gold from gravels. What am I? (Hydraulic)
18. I name the economically mineable portion of a deposit. What am I? (Reserve)
19. I bite and grind big rocks down until they're small enough to process. What am I? (Crusher)
20. I run horizontally through rock to link shafts and work areas underground. What am I? (Tunnel)

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