SANIRE

SOUTH AFRICAN NATIONAL INSTITUTE OF ROCK ENGINEERING

SYMPOSIUM 2026

BALANCING JUDGEMENT, TECHNOLOGY, AND SUSTAINABILITY IN ROCK ENGINEERING PRACTICES

7-8 JULY 2026

EMPERORS PALACE CONVENTION CENTRE, KEMPTON PARK

Abstract Book

SAIMM
THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY

THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY JOHANNESBURG 2026

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G. Nkosi
J. Maritz

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FOREWORD

It is my great privilege to present the proceedings of the South African National Institute of Rock Engineering (SANIRE) Symposium 2026, held at Emperors Palace in Johannesburg, Gauteng, South Africa. The SANIRE Symposium continues to serve as a premier platform for rock engineering practitioners to demonstrate their technical expertise and contribute meaningfully to the advancement of the discipline. Over the course of two days, participants and presenters engage in valuable networking, share insights and experiences, and explore the latest innovations, trends, and challenges shaping the field of rock engineering.

In response to feedback from SANIRE members, the 2026 Symposium introduces enhanced opportunities for broader participation through technical presentations. This initiative is designed to encourage the inclusion of innovative and thought-provoking work that may not typically be showcased, thereby enriching the overall programme and fostering a deeper exchange of knowledge. The Symposium offers a vibrant platform for rock engineering enthusiasts, practitioners, researchers, and industry leaders to engage in meaningful dialogue. Through the sharing of expertise and perspectives, delegates contribute to the collective growth and development of the profession.

Rock engineering remains a distinctive discipline, combining scientific principles, iterative methodologies, empirical knowledge, and sound professional judgment. In an increasingly dynamic global environment – where rising expectations demand excellence, sustainability, and responsible practices – the modern rock engineer must be well-equipped to address complex challenges while balancing technical, human, and environmental considerations. We trust that delegates attending the Symposium in Johannesburg will depart with lasting memories of a successful event, having established new connections and renewed existing relationships. More importantly, we hope the exchange of ideas and knowledge will contribute to the ongoing evolution of rock engineering practices in a VUCA (Volatile, Uncertain, Complex, and Ambiguous) world, where agility, adaptability, and a steadfast commitment to engineering excellence are essential.

On behalf of the organising committee, I extend sincere appreciation to our sponsors for their invaluable support in making this Symposium possible. I also wish to thank the SANIRE and SAIMM Secretariat for their dedicated efforts in the successful organisation of this event.

Obakeng Rakumakoe
Symposium Chairperson

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The organisers of the conference thanks the following sponsors for their support

Conference Chairperson

Obakeng Rakumakoe

Head of Rock Engineering
Harmony Gold

Obakeng Rakumakoe the current SANIRE president who is an accomplished mining professional with a distinguished track recorded in rock engineering, risk management and operational innovation. With over 17 years of experience, he has held key technical and leadership roles at organisations including Anglo Gold Ashanti, the minerals Council South Africa and Harmony where he is currently the Head of Rock Engineering SA Operations the role he assumed from May 2025.

As the head of Rock Engineering he continues to focus on improving the mining culture through innovation in geotechnical risk management systems, cutting edge technology applications and research and development. All this is underpinned by rock engineering knowledge and people development to advance the rock engineering discipline and contributed to all associated industries.

In his previous role as a Rock engineering Manager at Mponeng Mine he developed and implemented processes and systems that have resulted in improved efficiency and safety in the ultra-deep mining environment at Mponeng. At the MCSA as the Adoption Team Manager at MOSH head lead the documentation of the leading on permanent in-stope mesh which has gone to be adopted by many operations and continues to improve safety in the underground mining sector. His leadership extended to national platforms where he contributed to sector-wide advancements through his involvement in SANIRE, member of key technical bodies such as SIMRAC, Mandela Mining Precinct, and ECSA.

Obakeng holds Both a BSc and MSc Engineering degrees from the University of the Witwatersrand. He is a registered Professional Engineering and a Member of SANIRE. His technical credentials are complemented by his strong commitment to research, people development and transformation of the profession and industries.

Keynote Presenters

Floyd Samson Masemula

Group Deputy Chief Executive Officer
Harmony Gold Mining Company Limited

Floyd Masemula serves as the Group Deputy Chief Executive Officer of Harmony Gold Mining Company Limited, a position he assumed on 1 January 2025. In this role, he is responsible for supporting the Group Chief Executive Officer and providing strategic and operational leadership, with a strong focus on Harmony's South African operations, which form the core of the company's production portfolio.

Mr Masemula brings more than two decades of experience in the gold and platinum group metals (PGM) mining sectors, having held a range of senior operational, management, and executive leadership roles across leading mining houses. His experience spans multiple mining methods, including ultra-deep level, bord-and-pillar, and open-pit mining, equipping him with deep technical and operational expertise in complex mining environments.

Prior to his current role, he served as Executive Operating Officer for South Africa at Harmony from July 2023 to December 2024, where he was responsible for the performance and optimisation of the company's South African operations.

Before rejoining Harmony, Mr Masemula was Senior Vice President and Head of Mining for Sibanye-Stillwater's PGM division. Earlier in his career, he held several senior leadership roles at Harmony, including Regional General Manager of key operations such as Kusasalethu, Doornkop, and Kalgold. He also spent a significant portion of his career at AngloGold Ashanti, where he held various positions, including General Manager and Mine Manager, gaining extensive operational and leadership experience across multiple assets.

Mr Masemula is a qualified mining engineer and holds a Bachelor of Engineering (Mining Engineering) from the University of Pretoria. He has further strengthened his business and leadership acumen through a Master of Business Administration (MBA) from Wits Business School and a Postgraduate Diploma in Management Practice from the University of Cape Town Graduate School Of Business. He also holds a Mine Manager's Certificate of Competency and other management qualifications.

He has contributed to the broader mining industry through his service as a Council Member of the Association of Mine Managers of South Africa (AMMSA) for two terms, reflecting his commitment to industry development and professional leadership.

Mr Masemula is recognised for his participative and enabling leadership style, with a strong emphasis on safety, operational excellence, and sustainable value creation. He has extensive experience leading large, complex workforces and advancing performance in high-risk, labour-intensive mining environments.

Riaan Carstens

Lead Geotechnical Engineer
Anglo American

Riaan Carstens studied Mining Engineering at the University of Pretoria and obtained his Mining Engineering Degree in 1993. He started his career in production and worked his way up to Mine Overseer before moving across to the rock engineering department working for the late Dr. Martin Pretorius in the Free State Gold Mines. In 1998 he moved to Goldfields and was appointed as Rock Engineering Manager at Leeudoorn Gold Mine. In 2003 he joined AngloGold Ashanti where we worked on various shafts at Western Deep Levels before being appointed as Manager Rock Engineering. In 2012 he moved to Anglo Platinum where he was appointed Manager Rock Engineering until 2017 when he moved to Anglo American as Principal Rock Engineer responsible for various projects and governance of Anglo Platinum Mines. In 2022 he was appointed as Lead Geotechnical Engineer in Anglo American. He is married to Lizette for 29 years and have a daughter Lia and son Heinrich.

Robert Armstrong

Principal Geologist (Geotechnical), Partner and Director
SRK Consulting South Africa

Robert specialises in open-pit geotechnical slope design for greenfield developments and mine expansion studies, as well as operational reviews and advisory services. His work includes geotechnical team upskilling, geotechnical model development, and the planning and execution of data collection programmes for geotechnical investigations.

He has worked across a wide range of commodities, mineralisation styles, and geological settings, including both hard and soft rock environments. His experience spans projects throughout Africa and in South America, the Middle East, and Eastern Europe, including several open pits exceeding 600 m in depth.

Robert served on the South African National Institute of Rock Engineering (SANIRE) National Council for nine years and was President of the Gauteng Regional Branch. He has authored and co-authored several publications in rock engineering, chaired the organising committee for the SAIMM International Symposium on Slope Stability in 2015, and served as Guest Contributing Editor for the SAIMM Slope Stability Special Edition published in August 2025.

The role of InSAR in monitoring structural deformation and subsidence within restricted caving environments

J. Pretorius, I. Gkikas, E. Moldes
SkyGeo, South Africa

For mines, monitoring surface deformation in active caving environments is often limited by the inability to maintain traditional prism or GNSS networks in high-risk exclusion zones. This paper presents an ongoing investigation at an underground mine where material is extracted 700 m beneath a steeply dipping orebody, inducing an extensional regime that threatens a critical access ramp and escapeway. Interferometric Synthetic Aperture Radar (InSAR) was adopted as a quantitative method to overcome monitoring gaps, providing a continuous spatial dataset where traditional point-based surveying was physically restricted. This paper explores how InSAR can provide insight into both horizontal and vertical components of movement. Early results indicate that by analysing opposing line-of-sight behaviour, it is possible to identify a significant lateral translation component toward the cave. This deformation is interpreted as analogous to normal-fault-dominated behaviour, in which deformation gradients enable inference of major and secondary parallel extensional structures. Such spatial detail aims to allow us to characterise the hierarchy of deformation structures where physical access is precluded. This preliminary work demonstrates how contextualised InSAR deformation analysis can support the refinement of geomechanical models by differentiating between subsidence- and translation-dominated zones. Initial correlation of surface observations with movement along a known graphite shear noted 300 m underground provides early validation of the underlying mechanism. Ultimately, this paper intends to show how the integration of satellite-based InSAR observations reveals a deformation footprint larger and more clearly defined than previously expected, offering a high-value data stream for managing infrastructure risk in 'denied access' areas.

Jason Pretorius
Director: Mining
SkyGeo

Jason has worked in the mining industry for over 15 years, focusing on the practical application of technology to solve operational challenges. With an MSc in Remote Sensing and a background rooted in geology, he specializes in bridging the gap between complex geospatial data and on-site requirements.

His current work centers on InSAR (Interferometric Synthetic Aperture Radar), leveraging satellite data to address critical mining issues such as ground stability and displacement monitoring.

A geotechnical assessment of proposed mining in shallow-depth weathered rock near the Hex River

K. Namise[1], B.P. Watson[2], T.J. Maphosa[2]
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[2]University of the Witwatersrand, South Africa

The paper describes the research done to determine the geotechnical requirements of mining in weathered rock near the Hex River at Bathopele mine. The geotechnical problem was further complicated by the water-bearing Dednam Fault, which was predicted to intersect both the river and the workings. A bord and pillar operation was planned for the area between 45 m and 60 m below the surface. The focus of the research was on excavation stability, pillar performance, and support requirements. The few boreholes drilled in the area did not contain rock samples long enough for uniaxial compressive tests. However, point-load tests were done to provide strength approximations. Pillar strength estimates were made by testing a range of width-to-height (w/h) ratios, prepared from weathered UG2 boulders found at the bottom of an old nearby open pit. The samples were tested between specially prepared metal platens and compared to similar tests on unweathered material. Rock mass characterisation was done using the available boreholes and excavations that had previously been mined within a horizontal distance of 50 m from the river. Stability graph analysis showed that under all anticipated conditions, the bords remain stable at a span of 6.0 m. However, bord intersections are likely to fall within the unstable or transition zones if mined without reinforcement. Full-column resin-grouted bolts with a length of 1.8 m were recommended at a spacing of 1.0 m for bords with fair and poor ground conditions. Statistical block analysis suggested that these bolt spacings needed to be accompanied by areal support. Secondary support was recommended for the hangingwall at intersections. It comprised 6.0 m long, 38 t cable anchors installed on a 1.4 m grid spacing at permitted intersections. The stringent support configurations may be relaxed once mining begins if telltale extensometers are included in the centre of the intersections. A comparison between the w/h ratio tests conducted on the weathered and normal reef suggested a significant drop in material strength in the area of consideration. The research shows that the drop in strength was accommodated by reducing the 'k'-value in the pillar strength formula. It was established that the pillars would likely be stable at a width and length of 4 m and 5 m, respectively. Since the stoping height was planned at about 2.2 m, the pillars would have a w/h ratio of about two and a safety factor of greater than 1.6.

Bryan Philip Watson

Associate Professor
The University of the Witwatersrand

~40 years in the mining industry: Platinum, gold and coal.
A strong focus on hard rock pillar design and behaviour.
Rock engineering design of shallow and deep-level stopes.
Underground instrumentation and laboratory testing.

An integrated multi-sensor monitoring approach for assessing preconditioning in deep-level narrow-reef mining

H. Greeff, L. Scheepers, M. Wiggins, J. Hanekom
CSIR, South Africa

Preconditioning is widely applied in deep-level South African gold mining to modify the rock mass ahead of mining, with the objective of reducing rockburst risk and improving excavation stability. However, reliable assessment of preconditioning effectiveness remains challenging, with most evaluations relying on single-technology measurements that provide only partial insight into the rock mass response.

This paper presents the development and implementation of an integrated multi-sensor monitoring approach for assessing preconditioning in a narrow-reef, deep-level mining environment. The study was conducted in a highly stressed up-dip production panel, where a controlled preconditioning trial was executed and monitored using multiple complementary sensing technologies.

The monitoring approach was designed around a suite of complementary sensing technologies to capture the rock mass response across multiple measurement domains. These included bi-static borehole radar, surface-based ground penetrating radar, photogrammetry, LiDAR, and borehole imaging; enabling the integration of subsurface, surface, and direct observational datasets within a single experimental framework.

A key contribution of this paper is the methodology developed to integrate these technologies within a coordinated experimental design. This includes the spatial arrangement of boreholes, alignment of measurement geometries, and acquisition of baseline and post-blast datasets for comparative analysis under operational mining conditions.

The results demonstrate that interpretations derived from individual technologies are inherently limited when used in isolation. Variations in sensitivity, resolution, and measurement domain can lead to incomplete or ambiguous conclusions regarding rock mass response. In contrast, the integrated dataset provides a more robust basis for interpretation through cross-validation of observations.

The paper highlights that multi-sensor validation is essential for reliable assessment of preconditioning performance and emphasises the importance of experimental design in enabling meaningful interpretation. The approach presented provides a practical basis for implementing integrated monitoring in underground mining operations and supports improved understanding of rock mass behaviour.

Heinrich Greeff

Principal Rock Engineer
Council for Scientific and Industrial Research

Heinrich launched his mining career in 2010 post university studies in physics, mathematics, and applied mathematics. Certified in rock engineering in South Africa, he specialised in ultra-deep-level gold mines before designing ground control systems in Canada, enhancing safety. Back in South Africa, Heinrich simplified ground-penetrating radar workflows for wider adoption. As CSIR's Principal Rock Engineer, he now leads the Geotechnical Sciences department, promoting innovative mining practices and technologies.

A journey to ZERO - The Anglo American story

R. Carstens
Anglo American, South Africa

In 2019, Anglo American embarked on a breakthrough journey to eliminate rock fall fatalities for a calendar year. This feat was never achieved in the 100-year history of the company. At the end of 2021 this objective was achieved for the first time and since then, Anglo American has not had a fall of ground-related fatal accident at any of their operations. The keynote will share some of the key initiatives that Anglo American introduced leading up to 2021 in the areas of people development, processes, systems and technology. It will also share current initiatives that Anglo American is busy with and provide a position on what will be required in future to ensure sustainability.

Decision support for rock tunnel construction: Prioritising excavation methods through fuzzy TOPSIS multicriteria analysis

N.O. Ogunsola
University of Johannesburg, South Africa

Selecting an appropriate tunnel excavation method is one of the most critical and complex decisions in underground construction, as it directly influences project cost, safety, schedule, and long-term structural performance. This paper applies a Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (Fuzzy TOPSIS) multicriteria decision-making (MCDM) framework to systematically prioritise seven rock tunnel excavation methods: the Cut-and-Cover Method (CCM), Tunnel Boring Machine (TBM), Drill-and-Blast Method (DBM), New Austrian Tunnelling Method/Sequential Excavation Method (NATM/SEM), Roadheader Excavation Method (RHEM), Pipe Jacking Method (PJM), and Box Jacking Method (BJM). Eight evaluation criteria are considered, encompassing capital investment, excavation profile, excavation operations, tunnel advance rate, rock mass disturbance, potential for accidents, ventilation requirements, and ground support requirements. By incorporating fuzzy set theory, the framework effectively captures the inherent ambiguity and subjectivity in expert engineering judgment, representing linguistic assessments as triangular fuzzy numbers rather than precise crisp values. Fuzzy TOPSIS is then applied to rank the seven excavation alternatives by measuring their geometric proximity to the fuzzy positive ideal solution and distance from the fuzzy negative ideal solution. This approach provides a transparent, structured, and reproducible decision-support mechanism that simultaneously accommodates both qualitative and quantitative evaluation factors under conditions of uncertainty. The findings of this study offer practical guidance to geotechnical and tunnelling engineers, project owners, and construction managers in selecting the most technically suitable and economically viable excavation method for rock tunnel projects, particularly during the feasibility and preliminary design stages, where informed early-stage decisions can significantly reduce project risk and cost overruns.

Keywords: Rock tunnel excavation method selection, Fuzzy TOPSIS, Multicriteria decision-making (MCDM), Fuzzy set theory, Decision support system

Nafiu Olanrewaju Ogunsola

Postdoctoral Researcher
University of Johannesburg

Dr. Nafiu Olanrewaju Ogunsola is a postdoctoral research fellow at the Sibanye-Stillwater Centre for Sustainable Mining within the Department of Mining Engineering and Mine Surveying, University of Johannesburg, South Africa. Before joining the University of Johannesburg, Nafiu was awarded the Global Korea Scholarship (GKS) by the Korean Government in 2019. He earned his PhD in Mineral Resources and Energy Engineering with a concentration in Rock Mechanics in August 2023 from Jeonbuk National University, Jeonju, South Korea. He also holds a Master of Engineering (M.Eng.) in Mining Engineering (Rock Mechanics) and a Bachelor of Engineering (B.Eng.) in Mining Engineering, completed in 2017 and 2012, respectively, from the Federal University of Technology, Akure (FUTA), Nigeria. Dr. Ogunsola is an accomplished mining and rock engineer with a strong passion for studying rock and other geomaterials in situ and in practical applications, as demonstrated by his extensive industrial and academic experience. He has worked with notable mining and geotechnical companies, including Dangote Mines, China Civil Engineering Construction Corporation (CCECC), and Uniglobe Construction Engineering Limited, all in Nigeria. His recent research primarily focuses on experimental and computational intelligence methods to better understand and predict the multiscale deformation and fracture behaviors of rocks and other geomaterials, addressing challenges in mineral extraction, infrastructure development, sustainability, geohazard mitigation, and energy.

Dr. Ogunsola's current research focuses on advancing sustainable mining practices and geomechanics; implementing smart mining and monitoring operations using artificial intelligence and machine learning; promoting rapid, sustainable access to orebodies in both surface and underground mines; and applying multi-criteria decision-making (MCDM) methods to address challenges in mining and geomechanics. Contributing to academia and advancing knowledge in his field, Dr. Ogunsola has published several articles in reputable journals and served as a reviewer for other journals.

Design and implementation in friable pyroxenite: A case study on risk anticipation

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Open pit slope failure is one of the major priority unwanted events (PUE). The fall of ground PUE is managed through five critical controls: slope design, drill and blast design, slope monitoring and exclusion zones. In Central Pit Sector E5, a layer of non-mineralised low grade pyroxenite is left on the highwall as part of the permanent highwall. This low grade pyroxenite is friable and gets progressively worse with weathering. This permanent highwall also comprises multiple major structures of which two are sub-parallel to the slope and two truncating structures forming a wedge. The area is classified as a high-risk zone due to major structures, poor intact rock, visible water seepage, consistent failure of critical controls (poor catchment retention) and previous bench scale failures.

On 31 July 2024 a multi-bench failure occurred in this sector. The preventative critical controls such as engineered slope design and drill and blast to slope designs were not effective but mitigative controls such as slope monitoring and exclusion zone were effective in managing the risk. Back analysis was conducted using Rocscience RS3 software to establish failure mechanism and verification of design inputs. The baseline model of undisturbed model without geological structures was found to be stable, indicating that the failure is structurally driven rather than rock mass driven or failure by rock mass shear. The second model simulated the two truncating structures as it was initially believed that they intersected to form a wedge. This model was stable. It was noted that these structures did not intersect. With further mapping and discovery of the face parallel structures, a third model that simulated all four major structures did not converge, with deformation that aligns with the observed failure. Subsequent models were analysed with different structure configurations to determine which structure orientations were the most detrimental to the highwall stability. The modelling showed that the face parallel geological structures resulted in instability. This is important as a forward analysis was later carried out because the behaviour of the highwall must be anticipated as mining progresses below the current failure. This is essential for planning, in which geotechnical engineering controls will be required to ensure safe mining.

The stack failure prompted revision of the preventative controls. The engineered slope design was revised to consider the structural data per geotechnical sector. The design was changed from finite element-based to discrete fracture network- based. The drill and blast designs were changed to account for fracture intensity and rock mass integrity in each sector. Additionally, the blast block sizes were reduced from production optimised hybrid block to trim blast block to minimise backbreak. A high risk area report was introduced in the mine planning session to ensure critical actions required to create a safe working environment are expedited. These changes resulted in an improved critical control compliance month on month.

Thlologelo Daddy Mametja

Chief Rock Engineer
Valterra Platinum- Mogalakwena

Thlologelo Daddy Mametja is Chief Rock Engineer at Valterra Platinum Mogalakwena Mine, operating Limpopo, South Africa. He holds a bachelor's degree in mining engineering, a postgraduate diploma in business administration as well as a Chamber of Mines rock mechanics certification. He is deeply committed to safety in the workplace and strongly believes in achieving Zero Harm and scratch-free production.

He temporarily joined the Mogalakwena Complex geotechnical team as vacation student in 2014 to conduct a slope monitoring enhancement project (published paper), which laid the foundation for slope optimization initiatives at the operation.

By 2016, he became a permanent member of Team Mogalakwena as a rock engineering graduate. Over the years, he advanced through various roles, including strata control officer, section rock mechanics engineer and pit rock engineer, accumulating nine years of experience at Mogalakwena Complex. Daddy has a decade of experience in the mining industry having started his career as a learner official at Rustenburg's underground mines.

Outside of his professional life, Thlologelo is a sports enthusiast with a passion for Formula 1, soccer, and cricket.

Empirical and numerical evaluation of pillar reclamation viability in a shallow platinum mine

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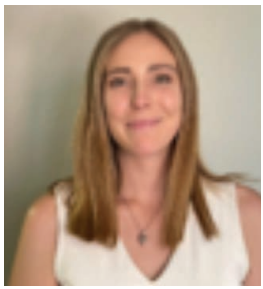
Pillar reclamation presents an opportunity to extend the life of depleted bord-and-pillar platinum mines by recovering ore locked in existing pillars. However, the geotechnical risks associated with pillar extraction, particularly in shallow mechanised operations, necessitate a structured and conservative evaluation of reclamation viability. This paper presents an assessment of pillar reclamation potential in a shallow platinum mine using a combination of exclusion zoning, empirical analysis, and numerical modelling. Areas unsuitable for reclamation were first delineated based on geological complexity, unfavourable pillar geometries, excessive mining spans, and clusters of pillars with low factors of safety. Viable reclamation zones were then evaluated using tributary area–based empirical methods to quantify changes in pillar stress, tensile zone development, and probability of failure for a range of extraction scenarios. Selected layouts were further assessed using two and three-dimensional numerical modelling to examine stress redistribution and pillar loading mechanisms. The study used laboratory-scale numerical models to replicate uniaxial compressive strength tests and assess the impact of discontinuities on rock strength, with results validated against stress-strain curves and elastic properties from actual laboratory data. These findings were then expanded to pillar-scale and mine-scale models to evaluate the effects of joints and shear bands under mining conditions, providing insight into appropriate design rock mass strength values for different geological conditions. A site-specific instrumentation and monitoring programme was developed. The paper demonstrates that although pillar reclamation can yield significant additional ore, its implementation must be selective and guided by risk-based assessments to preserve geotechnical stability and maintain operational safety.

Keywords: pillar reclamation, bord-and-pillar mining, laboratory-scale, pillar-scale, platinum mining, numerical modelling



Marizanne Esterhuizen

Geologist (Mining Geotechnical)
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Marizanne Esterhuizen is a dedicated Geologist specialising in Mining Geotechnical engineering, currently contributing her expertise as a Consulting Geologist at Middindi Consulting (Pty) Ltd. With over 4 years of professional experience, she has developed a comprehensive skill set in rock engineering and geotechnical design.

Marizanne built her academic foundation at the University of the Free State, where she earned her BSc in Geology in 2020 and her Honours degree in 2021. Her professional career commenced at Anglo American Platinum's Mototolo Complex, where she was appointed as a Rock Engineering Graduate in 2022. During her graduate program she earned the award of Top Rock Engineering Graduate of 2022 and won the 2023 Graduate Business Improvement Symposium for her project on pillar optimisation.

At Middindi Consulting, Marizanne has played a pivotal role in a wide range of high-stake mining projects, across various commodities. Her technical proficiency is anchored in numerical modelling, utilising an extensive software suite that includes Map3D, Rocscience and UDEC.

Enhancing grout packs performance under high stress conditions using yielding packs support design at Dishaba Mine

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This project presents the evaluation and implementation of 80 cm × 80 cm yielding grout packs at Dishaba Lower, undertaken to address the premature failure observed in the current 102 cm × 102 cm grout packs particularly under high stress and closure conditions. The study integrated laboratory testing, underground trials, and cost analysis to assess the operational efficiency and structural performance of grout packs. Dishaba Mine is currently extracting the UG2 reef at depths ranging from approximately 550 m to 1240 m below surface.

Laboratory test results indicated that the 102 cm × 102 cm grout packs exhibit higher stiffness and achieved a 90% confidence peak load of 6500 kN at 25 mm deformation, whereas the 80 cm × 80 cm yielding packs recorded a peak load of 4600 kN at 35 mm deformation. Post-peak behaviour indicates that the 102 cm × 102 cm packs continued to deform drastically immediately after the peak, exhibiting a residual strength of approximately 3800 kN at 100 mm deformation. In comparison, the 80 cm × 80 cm yielding packs maintained peak load with a higher residual strength of approximately 4200 kN at 100 mm deformation, thus exhibiting enhanced yielding behaviour.

Underground trials were conducted under virgin, destressed, and elevated stress environments and confirmed the laboratory findings, with yielding packs outperforming the current packs by accommodating stress and closure at Dishaba Mine without premature failure. Furthermore, installation efficiency improved, with a reduction of approximately one hour per support line, enabling completion within a shift.

Cost analysis revealed a reduction of approximately 30% in grout volume, resulting in 10% cost saving per grout pack. These benefits are attributed to the reduced pack size and required pumped grout. The paper concludes that the yielding grout packs provide more yielding capacity and cost-efficiency for the geotechnical conditions at Dishaba Mine. It is recommended that these packs be adopted and review the current support design criteria of 50 mm deformation to 100 mm and evaluate potential ground optimisation opportunities, particularly in relation to the regional superimposed pillars.

Keywords: yielding grout packs, closure, high stress, pre-mature failure

Fumani Evlon Vukeya

Strata Control Officer
Valterra Platinum, Dishaba Mine

Fumani Evlon Vukeya is a dedicated Strata Control Officer with a strong academic foundation and practical experience in rock engineering within the mining industry. He currently serves at Valterra Platinum, Dishaba Mine, where he plays a key role in monitoring underground conditions, ensuring compliance with rock engineering standards, and supporting risk assessments to maintain safe and stable mining operations.

He began his career as a Rock Engineering Graduate Intern at Dishaba Mine in June 2024, where he gained hands-on experience in underground inspections, hazard identification, support quality control, and incident investigations. Through this role, he developed a solid understanding in rock engineering field and built a strong technical foundation that supports his current responsibilities.

Fumani has demonstrated excellence in his field, notably being recognized as one of the top achievers in the 2024 Strata Control Metalliferous October examinations, where he achieved impressive results on his first attempt. This accomplishment highlights both his technical capability and his dedication to professional excellence.

Academically, Fumani holds a Bachelor of Science in Geology, BSc Honours degree in Geohydrology obtained from the University of the Free State, and a Strata Control Metalliferous Certificate offered from the Mineral's Council. Driven by a clear vision for growth, Fumani aspires to further his studies in rock mechanics and ultimately become a competent Rock Engineer to continue make a meaningful difference in the field.

Explainable machine learning for rock tensile strength prediction under high-strain-rate conditions using SHAP and closed-form equations

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Abstract: The tensile strength of rocks under high-strain-rate loading is a critical parameter in engineering applications such as blasting, tunneling, and impact-resistant structural design. Accurate prediction of this parameter remains challenging due to the complex, nonlinear interactions among influencing variables. This paper presents a comparative machine learning framework for predicting the high-strain-rate loading-dependent tensile strength of rocks using an experimental database of 100 datasets compiled from the published literature. Four machine learning models were developed and evaluated: Random Forest (RF), Gradient Boosting (GB), Support Vector Regression (SVR), and an Artificial Neural Network (ANN). The input parameters comprised specimen diameter, Young's modulus, static tensile strength, and loading rate, while the high-strain-rate loading-dependent tensile strength served as the model output. Two dataset partitioning strategies (70:30 and 80:20 train-test splits) were employed to assess model robustness and generalisability. Model performance was rigorously evaluated using four metrics: Mean Squared Error (MSE), coefficient of determination (R^2), the a-20 index, and Variance Accounted For (VAF). The Gradient Boosting model outperformed all other models under the 70:30 split, achieving R^2 of 0.993, MSE of 0.003, VAF of 99.352%, and an a-20 index of 83.333%, while the ANN model demonstrated superior performance under the 80:20 split, recording R^2 of 0.995, MSE of 0.002, VAF of 99.516%, and the highest a-20 index of 95.000% across all models and configurations. To enhance practical applicability, the trained ANN-LM (4-3-1) model was translated into explicit closed-form mathematical equations, enabling direct use by practitioners without specialised software. Furthermore, SHapley Additive exPlanations (SHAP) analysis was applied to quantify and interpret the contribution of each input parameter to model predictions, revealing that loading rate and static tensile strength were the most influential variables. The findings of this study offer a reliable, interpretable, and deployable predictive tool for dynamic tensile strength estimation, with direct implications for rock engineering design, mining operations, and geotechnical hazard assessment.

Keywords: Machine Learning, Rock Mechanics, High-strain-rate tensile strength prediction, SHapley Additive exPlanations (SHAP), Artificial Neural Network (ANN)

Nafiu Olanrewaju Ogunsola

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Dr. Nafiu Olanrewaju Ogunsola is a postdoctoral research fellow at the Sibanye-Stillwater Centre for Sustainable Mining within the Department of Mining Engineering and Mine Surveying, University of Johannesburg, South Africa. Before joining the University of Johannesburg, Nafiu was awarded the Global Korea Scholarship (GKS) by the Korean Government in 2019. He earned his PhD in Mineral Resources and Energy Engineering with a concentration in Rock Mechanics in August 2023 from Jeonbuk National University, Jeonju, South Korea. He also holds a Master of Engineering (M.Eng.) in Mining Engineering (Rock Mechanics) and a Bachelor of Engineering (B.Eng.) in Mining Engineering, completed in 2017 and 2012, respectively, from the Federal University of Technology, Akure (FUTA), Nigeria. Dr. Ogunsola is an accomplished mining and rock engineer with a strong passion for studying rock and other geomaterials in situ and in practical applications, as demonstrated by his extensive industrial and academic experience. He has worked with notable mining and geotechnical companies, including Dangote Mines, China Civil Engineering Construction Corporation (CCECC), and Uniglobe Construction Engineering Limited, all in Nigeria. His recent research primarily focuses on experimental and computational intelligence methods to better understand and predict the multiscale deformation and fracture behaviors of rocks and other geomaterials, addressing challenges in mineral extraction, infrastructure development, sustainability, geohazard mitigation, and energy.

Dr. Ogunsola's current research focuses on advancing sustainable mining practices and geomechanics; implementing smart mining and monitoring operations using artificial intelligence and machine learning; promoting rapid, sustainable access to orebodies in both surface and underground mines; and applying multi-criteria decision-making (MCDM) methods to address challenges in mining and geomechanics. Contributing to academia and advancing knowledge in his field, Dr. Ogunsola has published several articles in reputable journals and served as a reviewer for other journals.

From pixels to pits: The evolution of satellite radar interferometry and its future in mine stability management

A. Mkandla
TRE Altamira, South Africa

Over the past three decades, Satellite Radar Interferometry (InSAR) has evolved from an emerging remote sensing novelty into a mature technology supporting geotechnical risk management across the global mining industry. This paper reviews the multi-decadal technological trajectory of InSAR technology, tracing its journey from early differential frameworks (DInSAR) to advanced Multi-Temporal techniques like Persistent Scatterer Interferometry (PSI) and Small Baseline Subset (SBAS).

Historically, the mining industry relied almost exclusively on localised, point-based ground instrumentation for slope stability monitoring. This retrospective overview demonstrates how the maturation of satellite constellations, improved spatial-temporal resolutions, and cloud-computed processing algorithms bridged the gap between raw data ('pixel') and actionable geotechnical insights. Looking to the future, the paper further explores the next stage in the evolution of InSAR and its implications for mine stability management. Emerging satellite missions, increasing observation frequencies, advances in artificial intelligence, and the integration of satellite observations with conventional geotechnical monitoring systems are expanding the role of InSAR in mining. Alongside these opportunities, the discussion also considers the challenges associated with increasing automation, growing data volumes, and the need to ensure that technological advances continue to complement engineering judgement and established monitoring practices.

Ultimately, the paper draws from various case studies over time to demonstrate how three decades of innovation have transformed and continue to transform radar pixels into engineering insights, positioning satellite interferometry as an important component of mine stability management and future geotechnical practice.

Andile Mkandla
TRE ALTAMIRA

Andile is a geoscientist and business development specialist focused on the application of satellite-based InSAR for large-scale geotechnical monitoring in mining environments across Sub-Saharan Africa. Holding an MSc in Earth Sciences from Stellenbosch University, his work centres on translating advanced SAR analytics into practical solutions for slope stability, tailings monitoring, and mine-wide risk assessment. He works at the intersection of geospatial technology and mining operations, supporting the integration of InSAR into data-driven geotechnical workflows.

Geotechnical analysis of reduced middling in multi-reef mining conditions at Siyanda Bakgatla Platinum Mine, located within the Bushveld Igneous Complex

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[2]MLB Consulting, South Africa

This study investigates the geotechnical challenges at Siyanda Bakgatla Platinum Mine's Spud and Richard Shafts, where the UG2 Reef is being extracted beneath previously mined Merensky Reef horizons. With a vertical middling as narrow as 18 m, abutment stresses from Merensky remnant pillars have induced excessive stope closure, threatening the extractability of UG2 reserves. Through a combination of underground observational inspections and three-dimensional inelastic numerical modelling, this paper defines the critical limits for safe undermining. Results indicate that stable extraction is depth-dependent, allowing for UG2 pillar sizes ranging from 6 m at 500 mbs to 24 m at 1500 mbs.

Kulani Makhubele

Shaft Rock Engineer
Siyanda Bakgatla Platinum Mine

Kulani Makhubele is a passionate mining engineer, change management champion, and an advocate for safe and profitable mining. He is a Wits-educated mining engineer who has taken great interest in transforming complex geotechnical and operational workflows into streamlined, and highly efficient systems. Driven by the core philosophy that zero harm and optimal economic productivity are mutually reinforcing goals, his progressive career across the gold and platinum sectors highlights a proven track record of bridging the gap between sophisticated engineering theories and practical underground execution. Throughout his technical and supervisory tenures, he has successfully spearheaded cross-functional training campaigns, incident-prevention strategies, and continuous business improvement initiatives. In his role as a Shaft Rock Engineer, Kulani acts as a pivotal change agent by deconstructing dense numerical modelling and observational data into clear, actionable mining sequences that safeguard personnel while maximizing resource extraction in an intricate, multi-reef mining environment.

Beyond his technical capabilities, Kulani is a well-rounded leader who balances engineering precision with a high level of empathy and compassion. He is a naturally people-oriented professional who strongly believes in building collaborative environments and achieving operational objectives by empowering others. Known for his approachable leadership style, he frequently leverages humour to maintain team morale and accept unchangeable life challenges. Furthermore, Kulani is deeply committed to human capital development and proactive mentorship, consistently finding meaningful ways to guide and assist young, upcoming rock engineers as they enter the profession.

How machine learning should be applied responsibly and effectively in rock engineering

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[1]University of KwaZulu-Natal, South Africa
[2]Tshwane University of Technology, South Africa
[3]Sefako Makgatho Health Sciences University, South Africa

The rapid integration of machine learning into rock engineering presents both significant opportunities and critical responsibilities. In a VUCA environment marked by geological uncertainty, operational complexity, and growing sustainability demands, data-driven methods should complement not replace engineering judgment. This paper proposes a framework for the responsible application of machine learning in rock engineering, founded on transparency, adaptability, and rigorous validation. The framework positions machine learning within the traditional observational method, emphasising that predictive models must remain interpretable and continuously calibrated using field data. It promotes hybrid approaches that integrate physics-based and data-driven models to ensure consistency with established geo-mechanical principles. Particular emphasis is placed on data quality, representativeness, and governance, recognising that sparse or biased datasets may increase uncertainty rather than reduce it. To support agile decision-making, the framework advocates iterative deployment strategies in which models evolve alongside project stages through real-time monitoring and feedback loops. This enables dynamic risk assessment in applications such as pillar stability, ground support optimisation, and seismic hazard prediction. Uncertainty quantification is also essential, with outputs communicated probabilistically rather than as deterministic conclusions. Ethical and sustainability considerations are embedded throughout the framework. Responsible machine learning should minimise environmental impact by optimising designs, reducing over-excavation and material use, and improving operational safety. Governance structures including model auditability, documentation standards, and clear human oversight are proposed to ensure accountability. Ultimately, machine learning is positioned as a decision-support tool that strengthens resilience, adaptability, efficiency, and safety in modern rock engineering.

Keywords: framework, machine learning, algorithm, innovation, governance, decision making

Dr Richard Masethe

Senior Lecturer (Rock Mechanics and Engineering)
University of KwaZulu-Natal

Dr. Richard Masethe is a seasoned professional in the field of Rock Engineering and Mine Seismology, with a career spanning nearly two decades. He has been actively involved in overseeing seismic systems and executing a variety of rock engineering projects across complex underground environments. His academic journey, from undergraduate to doctoral studies, all completed at the University of the Witwatersrand, has provided him with a comprehensive and interdisciplinary foundation that continues to inform his research and teaching practice.

Improving underground safety: A rapid method to generate a barring assistance tool utilising machine learning

K. Mphahlele, H. Greeff, J. Hanekom
CSIR, South Africa

Barring remains a widely used and effective method for identifying and mitigating rock related hazards in underground mining. To enhance the safety and effectiveness of this practice, the CSIR developed an acoustic algorithm capable of monitoring barring activities and enabling trend analysis during sounding. Early investigations into acoustic rock mass assessment underscored the importance of both the recording device and accurate rock type classification for reliable waveform interpretation.

In response, the CSIR launched an eight-month rapid development programme to design a new algorithm tailored to the acoustic properties of gold reef lithologies, using mobile devices for in-field data collection. Surface trials were conducted to refine the system setup and proactively address any issues before commencing underground testing. This phase was critical for identifying internal and external factors that could affect data quality and operational performance. The involvement of a subject matter expert at this stage ensured that insights from the trials directly informed system refinement and algorithm development.

Selecting the optimal data acquisition method required comparative testing of multiple apps. Sensor Logger allowed strike force recording but had limited acoustic configuration options. Voice Recorder offered broader control over audio settings, but its automatic gain control could not be disabled. After several iterations of recording and analysis, AudioShare was selected as the most appropriate application due to its flexibility and recording quality.

To lead the algorithm development, the CSIR appointed a subject matter expert with prior experience in spatial acoustic analysis, an essential component of rapid research and development, where domain knowledge is critical to maximising the value of limited data. A custom-built segmentation tool was developed to extract, analyse, and classify key acoustic features from the labelled underground recordings. The tool's design allows for the integration of new datasets and enables dynamic adjustment of filter parameters. This ensures that as additional data becomes available, the algorithm can be continuously refined without requiring manual reprocessing of earlier recordings. This flexibility is vital in rapid development environments, where testing and refining multiple hypotheses efficiently is a core requirement.

A total of 2176 sounding strike clips were used to develop and refine the first iteration of the acoustic algorithm. The algorithm achieved an average classification accuracy of 94.3%, validating the reliability of the structured, rapid development approach. This paper illustrates that high-quality outcomes can be achieved within compressed timeframes when using a systematic methodology that emphasises iterative testing, efficient data collection, expert involvement, and robust data processing. The resulting algorithm provides a valuable foundation for further development and field validation, with the potential to support safer and more informed ground control decisions in underground mining operations.

Kholofelo Mphahlele

Candidate Rock Engineer
CSIR

Kholofelo Mphahlele is a candidate rock engineer specialising in geotechnical research, with a strong foundation in geotechnical science and four years of industry experience. He holds a BSc Honours degree in Geology from the University of Limpopo; He has a keen interest in rock mechanics and geotechnical research.

Kholofelo is particularly passionate about promoting underground safety, with a focus on protecting both workers and equipment through sound geotechnical practices. His work is driven by a commitment to improving safety standards and contributing to sustainable mining operations.

As a dedicated and emerging professional in the field, Kholofelo brings both technical insight and a collaborative approach to every project he undertakes.

Alternative data collection and data considerations for rock mass models

R. Armstrong
SRK Consulting, South Africa

Geotechnical models form the foundation of mining geotechnical design and influence decisions related to mine planning, excavation stability, excavation support, productivity, safety, and project economics. The confidence placed in these models is directly dependent on the quality, representativeness, and interpretation of the data used to develop them.

A geotechnical model comprises the geological, structural, groundwater, and rock mass models, which collectively define the geotechnical conditions governing the behaviour of surface and subsurface (underground) excavations. These models are informed by a range of data sources, most commonly drilling and mapping.

Because drilling provides largely linear data and mapping provides planar data, these datasets are often supplemented by a range of direct and indirect measurement techniques that provide additional spatial insight. Advances in technology have significantly improved the availability, quality, and cost-effectiveness of these data sources. However, the increasing accessibility of data collection and modelling tools has also created opportunities for data and models to be generated by individuals or organisations with limited experience, oversight, or quality control.

Errors, biases, and inconsistencies within geotechnical datasets can reduce confidence in the resulting geotechnical model and in the engineering parameters derived from it. This directly affects confidence in design outcomes and can introduce risks related to safety, stability, excavation performance, achievement of life-of-mine objectives, and unnecessary costs associated with overly conservative or inappropriate designs. In many cases, failures attributed to geotechnical/rock mass models are not modelling failures at all, but rather failures in the underlying data, interpretation, validation, and assumptions used to construct those models.

This presentation will discuss a practical guideline for developing geotechnical models, beginning with identifying the engineering decisions that the model is required to support and the key questions that must be answered to make those decisions with an appropriate level of confidence. It will examine the types of data required to address those questions, methods for assessing data quality and representativeness, and approaches for validating, documenting and managing residual uncertainty and risk within the completed model.

The data sources discussed will include geotechnical interval logging, drill core structural measurements, televiewer surveys, downhole geophysics, engineering geophysics, photogrammetry, and rock mass block models. Through practical examples, the presentation will highlight common pitfalls in data collection, interpretation, validation, and model development, and demonstrate how errors and unchecked assumptions can propagate through the modelling process and ultimately influence engineering outcomes.

The presentation will also explore the concept of the cost of confidence. While additional investigations and advanced technologies can improve confidence in a geotechnical model, they also increase project costs and effort. A key challenge is determining what information is required, what level of confidence is necessary to support engineering decisions, and when additional data collection materially reduces uncertainty rather than simply adding cost. The true cost of poor data is rarely the cost of collecting it; it is the cost of the engineering decisions that follow.

Integrated dynamic reporting in operational mines

S. Burke, M. Langley, L. Farrington, J. Latilla
Thiess (Pty) Ltd, Australia

Operational geotechnical management in open cut mining environments relies on up to date, accurate and relevant data to inform decision-making processes. Increasing volumes of spatial, observational, and monitoring data have become the norm in mine sites across the world. This has enabled GIS systems to become centralised hubs of information that can be leveraged by mining and geotechnical engineers in understanding trends and changing conditions.

It also places pressure on traditional reporting systems, which are often linear, static, and unable to adapt to the variability in field conditions

Conventional inspection and hazard reporting typically require users to complete fixed question sets regardless of relevance, resulting in inefficiencies, inconsistent data responses, and redundant reported outcomes. This limitation becomes evident in complex geological environments where conditions vary across the operation and in different application contexts. Condition changes may include floor/ structure dip, floor condition, dump construction material, and slope height to name a few.

To address these challenges, a GIS-integrated dynamic reporting system was developed and implemented. A key objective of this system is to provide a framework to assign risk to highwalls, lowwall and dumps by embedding non-linear logic within field data capture workflows. Additional objectives were to improve the quality, efficiency, and usability of geotechnical reporting, while maintaining a strong spatial linkage through GIS. This approach enables reporting processes to adapt in real time to field observations, ensuring that only relevant information is captured. Outputs are also aligned to site and conditional specific Trigger Action Response Plans.

Jonathan (John) Latilla

Group Manager Geology and Geotech
Thiess Pty Ltd, Brisbane, Australia

Supplying in-house geotechnical services to Thiess' operations in the Bowen Basin (Queensland, Australia), Hunter Valley (NSW), Indonesia, Mongolia and Stobie in Canada. In the past I was also involved with our projects at BHP Nickel West (Rocky's Reward, Western Australia), Majwe JV (Jwaneng, Botswana) where our contracts have since ended.

Includes: High level appraisals of geotechnical reports for possible tenders, operational site assistance, Geotechnical safety and systems audits, numerical analysis of slope stability (2D and 3Dlimit equilibrium and finite element), rock fall analyses (2D and 3D), ground control management plans reviews and audits, geotechnical inspections, troubleshooting, incident investigations, slope stability monitoring (SSR and prisms - basic user skills), structural mapping and interpretation, slope design.

Operational site support at Burton Coal Mine and Rocky's Reward

Interpretation of numerical modelling results for optimising massive mine design

D, van Rooyen[1], Dr J. Carvalho[2], M. Smithyman[3], A. Boodoo[1]
[1]Specialist Geotechnical Engineer, South Africa
[2]Mining & Rock Engineering, Canada
[3]Rock Engineering Consultant, Canada

Map3D numerical modelling was used to assess the optimal mining sequence for the Mogalakwena mine underground operation. Two different in situ stress scenarios were considered at the time based on assumptions and limited data availability. The modelling process evaluated five extraction sequencing strategies i.e., top-down, bottom-up (including primary-secondary and primary-secondary-tertiary variations), and the central chevron approach. These sequences were assessed using (□1-□3)/UCS (uniaxial compressive strength) ratio thresholds calibrated for the hangingwall and ore/footwall domains. Results indicated that Lifts 1 and 2 are not strongly stress-driven, with limited sensitivity to extraction sequence. In contrast, Lifts 3 and 4 enter a higher stress regime, where elevated stress concentrations develop in secondary pillars, diminishing rib pillars, and locally constrained geometries. The horizontally dominated stress scenario consistently produced the most critical response, with indications of pre-mining damage in deeper lifts.

The analysis demonstrates that extraction sequencing has limited influence at shallower depths on peak stress magnitudes, while layout and geometric controls play a more significant role in managing stability. The findings highlight the importance of avoiding highly stressed remnant pillars and refining sequencing strategies to reduce risk. These results provided a basis for optimising mine design and guiding future geotechnical assessments as additional site data becomes available.

Dewaldt van Rooyen

Specialist Geotechnical Engineer
Valterra Platinum

Dewaldt is a Specialist Geotechnical Engineer at Valterra Platinum, bringing 24 years of mining experience to his role within the Corporate Group Mining: Geotechnical Team, with a focus on Projects and Technology improvement initiatives. His career began as a learner official in 2000, and he progressed rapidly to eventually managing multiple employees as a Rock Engineering Manager. In addition to earning the COM Rock Mechanics Certificate, he holds six university postgraduate competency certificates in the field of Geotechnical Engineering.

Demonstrating strong leadership and technical expertise, his key achievements include revising mine pillar designs for increase extractions and support optimisation for cost savings, developing the Trigger Action Response Plan (TARP), integrating routine monitoring systems into operational cycles, and introducing Strata Control Technicians into pre-blast audit processes for safety. In the resent years his innovative approach has also driven research and development of a machine-learning algorithm to forecast fall-of-ground risk areas, as well as the application of underground radar technology. He is currently involved in Project Studies and central functional duties.

Dewaldt is an active member of the South African National Institute of Rock Engineering (SANIRE), serves as an examiner within the Rock Engineering discipline, and has contributed to the Rock Engineering Technical Council (RETC) in collaboration with the Minerals Council South Africa to combat falls of ground in the mining industry.

On a personal note, Dewaldt has been happily married to his lovely wife, Frieda, for 20 years. They have two children: a 17-year-old daughter and a 13-year-old son. Dewaldt's dedication to excellence and continuous improvement has made him a respected leader in geotechnical engineering field and a Dewaldt is a sought-after peer for advice. His impeccable sense of humour also makes him all round great guy to work with. So, you can trust this Bold guy.

A data-driven approach to geotechnical characterisation and support optimisation at Styldrift Platinum Mine

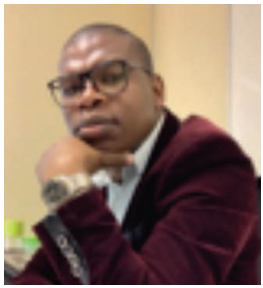
M. Nkosi[1], K.B. Lebron[2], M.C. van Eeden[2]
[1]Impala Platinum Styldrift Mine , South Africa
[2]MLB Consulting, South Africa

As part of a turnaround strategy at Styldrift Mine (No.1 Shaft), a technology-driven geotechnical approach was implemented to optimise excavation support design within a bord-and-pillar mining environment. The methodology replaces conventional empirical design practices with an integrated, data-driven framework incorporating advanced data acquisition, processing, and numerical modelling. Geotechnical data are acquired through systematic mapping and high-resolution 3D LiDAR scanning of excavation surfaces, enabling detailed characterisation of rock mass conditions and structural discontinuities. The data are processed to derive joint orientation, persistence, and spacing, and are used to develop representative stereonets and discrete fracture networks (DFNs) for input into numerical models.

Three-dimensional advanced inelastic numerical modelling is employed to assess excavation stability within a structurally controlled rock mass. The modelling framework explicitly simulates wedge and keyblock behaviour and evaluates the performance of various support configurations under changing stress conditions. Results indicate that conventional 1.8 m resin bolts are inadequate under certain conditions, whereas 3.0 m coupled resin bolts significantly improve roof stability and reduce fall-of-ground risk.

The integration of geotechnical data with advanced modelling enables optimisation of support design parameters, including bolt length, spacing, and configuration. This approach forms a key component of the turnaround strategy, supporting improved ground control, enhanced safety, and more consistent excavation stability in a complex underground mining environment.

Keywords: numerical modelling, 3DEC®, support optimisation, 3D LiDAR



Mncedi Nkosi

Shaft Rock Engineer
Impala Platinum Mine

Mr. Mncedi Nkosi is an accomplished Rock Engineer with an extensive career spanning 18 years in the South African hard rock mining industry. He holds a Bachelor of Science degree in Physics and a Master of Science in Physical Sciences from the University of KwaZulu-Natal (UKZN), providing him with a strong scientific foundation that has shaped his approach to rock engineering and geotechnical problem-solving.

Mr. Nkosi began his professional journey as a Graduate Management Trainee (Rock Engineering) in the conventional deep-level gold mines of the Vaal Reefs (Orkney) and West Wits mining region in Carletonville. His background in physics naturally led him to develop a keen interest in mine seismicity, particularly within the challenging deep-level mining environments extracting the Carbon Leader Reef at depths exceeding 3,000 metres below surface. This early exposure laid the groundwork for his expertise in rock mass behaviour under extreme mining conditions.

His career was further enriched through practical experience as a Junior Rock Engineer in the Bushveld Complex (Northam town), where he expanded his knowledge of conventional platinum mining. He also gained valuable exposure to massive mining methods during his time in the Cullinan Diamond Mine. However, his passion for hard rock tabular mining ultimately saw him return to the sector when he became involved in the sinking phase of the Styldrift Mine in 2013.

Today, Mr. Nkosi serves as a Rock Engineer at Impala Platinum's Styldrift operation, which is one of the industry's modern trackless bord-and-pillar mining environment. His current focus is on developing innovative support methodologies that align with the demands of safer, faster, and more productive trackless mining operation.

By integrating geotechnical data with emerging rock engineering technologies, Mr. Nkosi is dedicated to designing support systems that are safe, cost-effective, and operationally efficient. He is a strong advocate for the application of advanced technology in geotechnical engineering and firmly believes that the integration of digital tools, monitoring systems, and geological data is transforming rock engineering from a largely empirical discipline into a predictive, data-driven science capable of delivering improved safety and performance in modern mining operations.

Mr. Nkosi's diverse experience across deep gold, platinum, diamond, and shaft-sinking projects, combined with his passion for innovation and practical rock engineering solutions, positions him as one of the valuable contributors to the advancement of rock engineering in the mining industry.

Merensky reef crush pillar stability assessment, with a focus on pillar bursting

U. Maquina[1], K.B. Lebron[2], H. Jordaan[3], M.R. Vermeulen[4]
[1]Sibanye Stillwater, South Africa
[2]MLB Consulting, South Africa

This paper investigates the stability and failure characteristics of crush pillars at Mine A (part of the Western Limb of the Bushveld Igenous Complex) through integrated geotechnical analysis and numerical modelling. Elastic stress redistribution was evaluated using boundary element modelling, while inelastic pillar behaviour and failure mechanisms were simulated using explicit three-dimensional finite difference modelling.

The analysis incorporates detailed assessment of pillar geometry, stress distribution, and axial strain response under varying mining conditions. Results indicate that pillars with excessive width-to-height ratios subjected to elevated stress conditions exhibit an increased propensity for unstable behaviour, including the potential for strain localisation and dynamic failure. In particular, oversized pillars may transition from stable yielding to brittle response under high confinement and stress concentrations.

The paper demonstrates that appropriate pillar dimensioning is critical in maintaining controlled yielding behaviour and mitigating bursting risk. The findings emphasise the necessity of compliance with design criteria, implementation of monitoring systems, and application of targeted remedial measures where required.

The integration of numerical modelling provides a robust framework for predicting pillar performance and optimising design in high-stress environments, contributing to improved safety and operational efficiency.

Keywords: crush pillar stability, numerical modelling, pillar bursting, strain criterion

Unathi Maqina

Senior Rock Engineer
Sibanye Stillwater

Unathi Maqina is a Senior Rock Engineer at Sibanye Stillwater's Marikana Operations with over 13 years of progressive experience in mining, geology, geotechnical engineering, and rock engineering across platinum, zinc, diamond, gold, and copper mining operations. He holds a BSc in Geology and a BSc Honours in Geology from the University of Pretoria, a Post Graduate Diploma in Business Administration from Wits Business School, Rock Mechanics (RCM 627) and Strata Control (SCC 801) certifications from the Chamber of Mines, and is currently completing an Executive MBA at Henley Business School Africa.

His career began in 2011 as a Junior Geologist at Rio Tinto's Palabora Mining Company, where he developed a strong foundation in underground geological mapping, structural interpretation, and mine development support. In 2012, he joined AngloGold Ashanti as a Strata Control Officer, gaining valuable experience in underground deep level Gold rock engineering, instrumentation, development and stope audits, and serving as the Lead Strata Control Officer for the Attic Project.

In 2014, Unathi joined De Beers Group as a Junior Geotechnical Engineer for the Venetia Underground Project which sunk 2 shafts and developed a decline. At Venetia, Unathi was exposed to geotechnical mapping, kinematic analyses, ground control district management, risk assessments, and geotechnical reporting. His experience expanded further in 2017 when he joined New Concept Mining as Product Implementation Lead. During this period, he successfully bridged technical engineering with operational execution by leading underground and surface product trials, managing product implementation programmes, and delivering technical training to production personnel, sales teams, and mining customers.

In 2021, he joined Vedanta Zinc International as Senior Rock Engineer, where he focused on numerical modelling, slope optimisation, geotechnical modelling, waste rock dump stability, and standards development. His expertise in mine design optimisation and rock engineering governance led to his appointment at Sibanye Stillwater in 2022 as Superintendent Rock Engineer at K4 Shaft. In this strategic leadership role, he provided technical assurance and governance, development of systems and processes and mentored rock engineering professionals.

In December 2024, Unathi was appointed Senior Rock Engineer at Sibanye Stillwater, where he leads rock engineering strategy, support design optimisation, geotechnical risk management, mine planning input, numerical modelling, budgeting, and governance initiatives. He is passionate about integrating sound engineering principles with practical operational excellence to improve safety, productivity, and sustainable mining practices.

Throughout his career, Unathi has demonstrated a commitment to technical excellence, innovation, mentorship, and servant leadership. His contributions have been recognised through several prestigious awards, including Sibanye Stillwater Rock Engineer of the Quarter for both Quarter 2 and Quarter 3 of 2024.

In recognition of his outstanding contribution to the advancement of the rock engineering profession, leadership within the industry, and dedication to improving mining safety, Unathi was honoured with the South African National Institute of Rock Engineers (SANIRE) Rock Engineering Practitioner of the Year Award for 2025.

Mototolo Der Brochen: Adopting various mining strategies to successfully develop new declines through a preferential weathered zone

N. Ndlela
Valterra Platinum – Mototolo Mine, South Africa

Mototolo Der Brochen Mine, located on the eastern limb of the Bushveld Igneous Complex is developing four declines for mining of UG2 reef using the mechanised bord-and-pillar method. The general reef dip is 9° at Mototolo, but at Der Brochen where the UG2 outcrops surface, the reef dips steeper at 18°. The declines are therefore developed at an apparent dip of 9°, with planned dimensions of 4.5 m height and 6.0 m in width to accommodate fully mechanised equipment. The UG2 reef outcrop position is located within the groundwater table that completely weathered the 3.5 m (average) thick pyroxenite unit, situated immediately in the hangingwall of the UG2 reef. The zone of weathering is locally termed preferential weathered zone (PWZ). The properties of the PWZ make the rock mass conditions very poor and reduces excavation stability which constitutes the greatest challenge to mining. This paper aims to highlight the strategies adopted to successfully mine through the PWZ.

During the feasibility study, geotechnical data were collected from exploration boreholes, geological and geotechnical mapping, laboratory rock testing, and data from neighbouring mines. Hydrogeology studies were also conducted to understand the possible impact of groundwater in the mining project to inform mitigating strategies. The excavation and support design for mining these declines through the PWZ were conducted through analytical, kinematic, and numerical methods.

As the declines started to develop, the feasibility results were confirmed as mining through the PWZ was characterised by very poor rock-mass quality, clay-filled joints, and significant groundwater inflows (600–900 m^3/day), resulting in compromised excavation stability and frequent side-wall slabbing and face unravelling during early decline development. These conditions lead to repeated unplanned stoppages, elevated support demand, and a slower mining cycle. It soon became apparent that the excavation and support design and equipment were not entirely adequate to deal with these ground conditions, and new strategies had to be adopted.

The support requirements for the declines were upgraded for the very poor PWZ rock mass to include pre-consolidation, 1.8 m resin bolts, 4.0 m flexi-bolts, consolidation holes, galvanised mesh, and 50 mm fibre-reinforced shotcrete. This support requirement was then adapted to the improved ground conditions as the PWZ lessened in thickness, further away from the influence of the groundwater table. The excavation mining cut was also adapted to provide the most stable hangingwall conditions whilst developing the declines in the ultra-poor rock mass and excessively thick preferential weathered UG2 hangingwall.

This paper will show how the mining cut and location relative to the poor hangingwall was adapted and the positive impact it had to ensure a more optimised mining and support cycle to improve affiance, and to create a safer mining environment. Effective dewatering strategies were also implemented to channel groundwater away from excavation and prevent interaction with installed support units. The adopted ground support and groundwater management strategies have proven to be successful, with no rock-related incidents or accidents recorded since the start of mining the four declines.

Ntuthuko Ndlela

Shaft Rock Engineer
Valterra Platinum - Mototolo

Ntuthuko's mining career started after completion of his BSc Honours Geology at University of KwaZulu Natal in 2010. Having been a bursary beneficiary of Anglo American Platinum, he joined the ADC graduate program and was placed at Amendelbult section. He was trained in both Rock Engineering and Geology Departments as a graduate until permanently placed as a Section Geologist in 2013.

In 2019, Ntuthuko joined Samancor Western Chrome Mines as a Senior Geologist responsible for Buffels East Mine. He later transitioned back to Rock Engineering until the beginning of 2024 at Samancor WCM. He was part of the team that was involved in the change of Samancor's business model of transitioning from underground operations to surface mining. During this phase, Ntuthuko was involved in the feasibility studies of 8 opencast operations until their full-scale operations. While some of those opencast mines are still in operation, others mined until the end of their lives and Ntuthuko was also involved in the rehabilitation and restoration process.

After leaving at Samancor, Ntuthuko rejoined Anglo American Platinum (now Valterra) at Mototolo in 2024. He was part of the start of new Der Brochen project team on the Geotechnical side. Currently, Ntuthuko is appointed 14.1(8) for Der Brochen Mine and Lebowa Mine. At Lebowa, Ntuthuko is taking all the learnings/ best practices from the Der Brochen Project to Lebowa St George Project that will mine through a major fault zone and reopen ground to extend the life of Lebowa Mine by more than 25years.

Ntuthuko mining career spans for 15 years and still counting.

Numerical modelling to evaluate the strength of different pillar shapes

J.A. Maritz, D.F. Malan
University of Pretoria, South Africa

Recent analytical studies on the strength of regular pillars of different shapes indicate a strong agreement with that of square pillars for the same effective width. In this paper, numerical modelling was used to evaluate the strength of different pillar shapes, both regular and irregular, with a constant effective width, to investigate the effect of shape on pillar strength. Because effective width is a function of the pillar's area and perimeter, maintaining a constant effective width requires a change in area. This has implications for extraction ratios and possible pillar optimisation. For the class of regular shapes, a square, triangular, and hexagonal pillar shape was investigated, while the irregular pillar shapes included a five-sided polygon, a random odd shape, and a series of rectangular pillars. These pillars were modelled using the TEXAN limit equilibrium failure model. The results indicate that the modelled strength of regular-shaped pillars with a similar effective width is comparable, whereas irregular pillars yield lower strength levels. The findings of this study illustrate the limitations of the perimeter rule. Care should be taken when using the effective width as an input parameter in traditional empirical pillar strength formulae, such as those of Salamon and Munro, Hedley and Grant. Additionally, it was concluded that the actual strength of rectangular pillars exhibits greater deviation from the effective width approximation as the pillar elongation increases.

Keywords: pillar shape, numerical modelling, pillar strength, perimeter rule

Jannie Maritz

Senior Lecturer
University of Pretoria

After graduating from the University of Pretoria in 2000, Mr Maritz started his professional career in the gold mining industry. By 2006, he had obtained all his industry certificates in mining, as well as rock engineering. He subsequently joined a consulting firm where he acted as a mining engineering consultant on various projects around the globe. He started his own rock engineering consulting firm and, in 2011, also joined the University of Pretoria as full-time senior lecturer in rock engineering and mine design. He has a particularly interest in numerical modelling, pillar optimisation and design, the use of virtual and augmented reality applications in mining, as well as interactive teaching and learning, and the use of multimedia in the classroom. He is a past president and fellow of the South African National Institute of Rock Engineering (SANIRE), where he is still actively involved in the development of new rock engineering qualifications. As a registered professional engineer with the Engineering Council of South Africa (ECSA), he holds memberships to various other industry societies within the mining and engineering disciplines. Mr Maritz has published several papers in academic journals and has delivered presentations at conferences around the world. He has co-published a book chapter in the field of education, which looked at how engineering students develop skills for working in groups. He is involved in various teaching and learning project teams at the University of Pretoria, which are looking at ways to improve the learning experience for in-class and online teaching. Mr Maritz has supervised more than 15 postgraduate research projects.

The rock engineering assistant: Digital platform for rock engineers

J.W.L. Hanekom
CSIR, South Africa

Rock engineering practitioners routinely collect substantial volumes of geotechnical information during underground inspections and routine operational activities. These data typically include observations of rock mass conditions, support installation quality, hazardous conditions, and occurrences such as falls of ground. In most cases, such information is used immediately to inform remedial actions or operational decisions. However, once these initial decisions have been made, the data are seldom retained in a structured and accessible manner, as new observations continuously demand attention. Furthermore, data captured and stored in standalone spreadsheets are vulnerable to loss through file corruption, deletion, or poor version control, resulting in the loss of valuable historical records of rock mass behaviour.

Advances in digital technologies provide opportunities to significantly improve the capture, storage, and analysis of geotechnical data. Digital platforms enable the systematic preservation of historical data and facilitate the integration of datasets from multiple sources. This, in turn, allows historical information to be utilised to identify trends, forecast potential rock mass behaviour, and support more informed decision-making in underground environments.

A digital geotechnical platform has been developed with the objective of maximising the value derived from routinely collected rock engineering data. The ultimate aim of the platform is to integrate diverse datasets to provide indicators of geotechnical risk and to support data-driven decision-making. Several functional modules have been developed to demonstrate the potential of such a system.

The platform incorporates tablet-based data capture methods that replace conventional paper-based recording systems. Data collected underground during a shift can be synchronised with the central platform once wireless connectivity becomes available.

All captured data are spatially referenced and displayed on a mine plan interface, allowing the visual interpretation of the spatial distribution of geotechnical observations. Icon-based indicators at specific locations provide direct access to the original field records, enabling users to review detailed information associated with each observation.

The platform demonstrates the potential of integrated digital systems to enhance the management and analysis of geotechnical data, thereby supporting improved risk identification and decision-making on all operations, but specifically in underground mining operations.

Johan Wilhelm Ludwig Hanekom

Chief Rock Engineer
CSIR

I completed graduate and post-graduate studies at the current North-West University between 1984 and 1989. Then joined AngloGold in 1989 as a Strata Control Officer in the Rock Mechanics Department at the Vaal Reefs Operations. I attained the required South African mining Strata Control and Rock Engineering qualifications in 1989 and 1990 respectively, with an Anglogold Advanced Certificate in 1992. I became Rock Engineering Manager at Saaiplaas and later Bambanani Mines, both within AngloGold. During this time I completed the Graduate Diploma in Engineering (GDE) in 1996 and MSc (Engineering), specialising in Rock Engineering, at the University of the Witwatersrand in 2002. I obtained the industry Advanced Certificate in 2005, also from the University of the Witwatersrand.

During the years for Anglogold, I was accustomed to gold mining in the Vaal Reefs and Welkom areas and was exposed to the other Anglogold operations, still operating at that time.

In 2000 I joined Steffen, Robertson and Kirsten (SRK) Consulting in the Welkom (Free State, RSA) office as a Principal Engineer. I started a rock engineering consultancy, MIDD Consulting in 2002. I merged with IndiRoc Consulting to create Middindi Consulting, specialising in Rock Engineering, Geotechnical and Geological Services in 2004 up to February 2019.

I assisted with part-time lecturing and research at the University of Pretoria's Mining Engineering Department and held the Harmony Chair in Rock engineering and numerical modelling from 2015 to 2018.

Following Middindi Consulting, I acted as an independent consultant, specialising in rock engineering working for a company, FollowSS. In 2022 I was contracted as Chief Rock Engineer for the Mining Cluster in CSIR 2022.

The 22 years in consulting exposed me to mining in all commodities and in several countries, including Chile, Russia and several African Countries including DRC, Mali and Tanzania. During this period. I provided advice to mining methods that included surface and underground operations, conventional scattered to massive mining layouts, and rock engineering aspects that ranged from feasibility studies to detailed numerical modelling.

During the last 3 years, at the CSIR, I was tasked to build a rock engineering presence in the Mining Cluster and undertake research that will support the industry through appropriate and directed research into rock engineering aspects.

To date, I have 36 years of experience in the field of rock engineering.

The feasibility of ML for optimising non-yielding pillars in hard-rock bord-and-pillar designs in underground mines

O. Vetman[1], H.D Masethe[2], M.A. Masethe[3], R.T. Masethe[1]
[1]University of KwaZulu-Natal, South Africa
[2]Tshwane University of Technology, South Africa
[3]Sefako Makgatho Health Science University, South Africa

In a Volatile, Uncertain, Complex, and Ambiguous (VUCA) mining environment, optimising non-yielding pillar design in hard-rock bord-and-pillar mining remains a significant rock engineering challenge. Conventional pillar design approaches, which rely primarily on empirical formulations and engineering judgment, often lack the flexibility required to accommodate complex geological variability and changing operational conditions. This paper investigates the feasibility of integrating machine learning (ML) techniques with established South African pillar design methodologies to improve design accuracy, safety, and extraction efficiency. A hybrid modelling framework is proposed that combines traditional pillar strength equations with supervised ML algorithms, including XGBoost, Support Vector Machines (SVM), and Ridge Regression, to predict pillar strength and Factor of Safety (FoS) under varying geotechnical conditions. The paper evaluates the capability of these models to replicate and enhance engineering design decisions, optimise bord-and-pillar layouts, and generalise across different mining scenarios. Model performance is assessed using standard regression metrics, including Root Mean Square Error (RMSE), coefficient of determination (R^2), and comparative accuracy against conventional empirical methods. The results suggested that ML models outperformed traditional approaches, reducing RMSE by approximately 20–35% and achieving R^2 values greater than 0.85, compared to typical baseline values of 0.60–0.70. Furthermore, the hybrid framework improves prediction accuracy by 15–25% and optimises pillar layouts, increasing extraction ratios by 5–12% without compromising stability. The findings support the development of intelligent, data-driven rock engineering systems, providing a pathway toward safer, more efficient, and adaptive hard-rock bord-and-pillar mining operations.

Keywords: Non-yielding pillars, Bord-and-pillar mining, ML, Pillar design optimisation, Factor of Safety, Geotechnical modelling

Vetman Onke
Student
University of KwaZulu-Natal

Vetman Onke is a recent university graduate with a Bachelor's Degree in BSc Hons Geological Science, currently pursuing a Master of Science in Geology at the University of KwaZulu-Natal. While pursuing his Honors, he earned a certificate of excellence in Rock Engineering for his academic performance.

Onke is currently a teacher's assistant at the University of KwaZulu-Natal, assisting students in Rock Mechanics, focusing on the geotechnical properties of rock samples, lab testing, and analysis. He also assists with the Mineralogy and Microscopy module, focusing on identification and mineralogical classification using microscopes. In his free time, with his positive attitude and relentless kindness, he enjoys sharing practical tips and tutoring freshmen on how to deepen their understanding of geology, as he has throughout his high school years in Bizana, in the Eastern Cape, where he was born. Onke is fascinated and inspired by the ability of multiple disciplines to work together in carrying out underground mining operations. Outside academic matters, Onke enjoys sports from soccer to rugby.

The geomechanical risks of depositing reprocessed tailings into open pits intersecting legacy underground workings

S. Smith, B.S. Vaughan, T. Rangasamy
Middindi Consulting (Pty) Ltd, South Africa

The deposition of reprocessed tailings into open pits intersecting legacy underground workings presents a significant geomechanical hazard. Industry practice often assumes 'visual stability,' inferring that desiccated tailings possess adequate shear strength to self-seal unmapped voids. The paper demonstrate that these visual cues are unreliable and that the self-sealing hypothesis lacks geotechnical validity. Numerical investigation using two-dimensional and three-dimensional finite element modelling was conducted to evaluate the structural performance of tailings above underlying voids. To test the upper bound of self-support behaviour, the tailings were assigned optimistic 'dried base' shear strength parameters: cohesion of 1 kPa and a friction angle of 28°. Even under these favourable assumptions, finite element modelling results confirmed that the material cannot mobilise sufficient soil arching to form a stable natural plug. Under a 'Do Nothing' scenario, the system experienced a complete loss of static equilibrium. Numerical non-convergence indicated that the mobilised shear stress from the rising tailings storage facility load exceeded the available shear strength. This creates a vertical conduit, leading to hydraulic piping and large-scale downward migration. The predicted surface subsidence exceeding 25 m confirms that reliance on natural consolidation represents a severe risk. An engineered rockfill plug to provide mechanical buttressing was proposed and recommended. An inadequately drained plug leads to hydraulic overloading; the barrier must offer high-capacity drainage while transitioning into a mechanically self-sealing barrier.

Stefan Smith
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Stefan Smith is a Senior Strata Control Officer at Middindi Consulting (Pty) Ltd, with over 16 years of geotechnical engineering experience across gold, platinum, chrome, and coal mining, including seismically active deep-level environments. He specialises in rock mechanics design, highwall risk assessment, and geotechnical reporting for major mining clients. His career includes leadership roles at Harmony Gold and Anglo Platinum, where he served as Acting Rock Engineer and contributed to achieving 7 million fatality-free shifts in 2019. He holds a Chamber of Mines Certificate in Strata Control and a Blasting Ticket, and is currently completing his Certificate in Rock Mechanics.

The significance of mobile machine damage on the effectiveness of full-column grouted resin bolts

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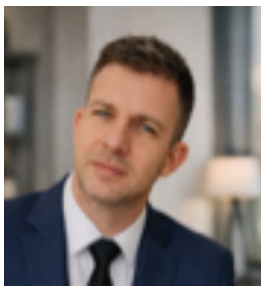
Full-column resin-grouted bolts frequently experience damage by self-propelled mobile machines in narrow, mechanised bord-and-pillar operations on the Bushveld Complex. Approximately 3% of installed bolts are replaced due to such damage. This paper evaluated the extent of damage and its influence on the load-bearing capacity of these bolts following machine impact. A combined laboratory and field investigation was conducted across five underground sites. Bolts were installed in specially prepared steel pipe assemblies and subjected to controlled impacts using Load-Haul-Dump vehicles. The assemblies were then sectioned into 100 mm segments for visual inspection and push testing. The results were compared to undamaged control samples. Where the resin annulus was 4.5 mm or less, damage was generally limited to the first 100 mm from the hole collar. Bond strength beyond this zone remained comparable to that of undamaged control samples. Installations with larger annuli showed more extensive resin degradation, poor mixing, and gloving, resulting in significantly reduced bond strength. The findings indicate that automatic replacement of all visibly damaged bolts is overly conservative where installation quality and annulus control are acceptable. Bolts installed with annuli of 4.5 mm or less using mechanised bolters may retain adequate functionality following machine impact, whereas installations with larger annuli should be treated more cautiously.

Keywords: full-column resin-grouted bolts, mobile machine damage, resin annulus, bond strength, support replacement criteria.



Andreas Esterhuizen

Senior Geotechnical Engineering Consultant
Open House Management Solutions

Andreas Esterhuizen has over 25 years of experience in the field of rock engineering, all of which have been with Open House Management Solutions (OHMS). He began his mining career as a Strata Control Officer at Harties Gold Mine before moving to Buffelsfontein Gold Mine, where he gained extensive experience in deep-level conventional gold mining.

In 2005, Andreas relocated to Lydenburg to establish OHMS's Eastern Bushveld office, supporting the rapidly expanding platinum and chrome mining industry. Throughout his career, he has held numerous rock engineering appointments and has served as Rock Engineering Manager and Chief Rock Engineer for a diverse range of underground and surface mining operations across multiple commodities.

His career has progressed from operational rock engineering to specialist geotechnical consulting, providing technical advice, independent reviews, and design input for mining projects throughout Africa, the Americas, and Canada. His professional interests include underground and surface rock engineering, mine design, ground support systems, pillar design, slope stability, and geotechnical risk management.

Andreas recently completed an MSc (Engineering) degree at the University of the Witwatersrand. His research investigated the effects of operational damage on the performance of fully encapsulated resin rockbolts. The paper presented today is based on this research and contributes to a better understanding of support system performance in underground mining environments.

Application of time-lapse passive seismic tomography in cave mining

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In block caving operations, knowing the shape and the evolution of the cave is critical since it influences local and regional ground stability, and operational strategy. Time-lapse passive seismic body-wave and attenuation tomography are effective tools for monitoring the initiation and progression of cave growth as well tracking the evolution of the stress field within the rock-mass. The tomographic fields of P- and S-wave velocities as well as quality factor Q (inverse attenuation) are valuable parameters for ground control engineering to better understand how the rock-mass is behaving during initiation and propagation of caving in addition to identify areas of high stress for risk mitigation. Time-lapse body-wave tomography maps changes in the primary P- and S-wave travel-times to changes in the spatial and temporal distribution of P- and S-wave velocities. Time-lapse attenuation tomography is an extension of body-wave tomographic analysis which maps changes in attenuation of the higher frequency components of the primary P- and S-waves. Greater attenuation can be interpreted as increased rock damage or the reduction of stress leading to fracture opening. In this paper, we provide examples of time-lapse tomography in three different producing block caving mines. Both velocity and attenuation tomography results are presented and compared to seismicity at specific intervals during ongoing development of the cave from undercut blasting to cave initiation and caving propagation. The results are compared with and without the seed 3D velocity model. This allows an assessment of the dependence of results on a priori assumptions and allows for comparison with open hole and height-of-draw estimates.

Doug Angus

VP of Mining
ESG Solutions

Doug Angus is VP of Mining at ESG Solutions, a company that provides world class acquisition and data services for real-time rock-mass characterization to improve mine safety and operational efficiency. He studied applied geophysics from Queen's University, gaining his MSc(Eng) in applied seismology focused on moment tensor inversion of mine seismic data and his PhD in theoretical seismology focused on wave propagation in anisotropic heterogenous. For more than 10 years he worked as an academic in the UK focused on integrating seismology with geomechanics, rock physics and multi-phase fluid flow; as a research associate at Bristol University (2006-2008) and subsequently Associate Professor of Seismic Geomechanics at the University of Leeds (2008-2016).

Valterra Platinum, Dishaba Mine haulage pillar optimisation

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This paper evaluates the stability and optimisation potential of haulage pillars at Valterra Platinum's Dishaba Mine through integrated numerical modelling. Regional stability was assessed using boundary element modelling (BEM) with Map3D® to evaluate the Rockwall Condition Factor (RCF) across six mining areas, while local pillar behaviour was investigated using explicit three-dimensional finite difference modelling (FDM) with FLAC3D® to simulate stress redistribution, convergence, and inelastic response.

The results indicate that the majority of pillars remain within acceptable stability limits, characterised by moderate stress concentrations and limited inelastic deformation. Localised overstressing and strain-driven fracturing are observed at pillar edges, while pillar cores retain significant load-bearing capacity due to confinement. RCF values generally reflect good to average ground conditions, with isolated zones of elevated stress requiring consideration.

The integrated modelling approach demonstrates that residual pillar capacity remains sufficient to support cautious, area-specific optimisation. The findings support the implementation of conservative pillar optimisation strategies under controlled operational conditions, with emphasis on monitoring and validation. Optimisation is estimated to yield an increase of approximately 1.7 Mt in recoverable reserves, extending the life of mine by approximately one year.

This paper highlights the importance of combined BEM–FDM methodologies for capturing both regional stress trends and localised inelastic behaviour in pillar systems.

Nhlakanipho Jiyane

Shaft Rock Engineer
Valterra Platinum Mine-Dishaba Mine

I am a qualified Rock Engineer with a sound background in mining, backed by the Mining Engineering degree from Wits. I have been engaged in value creating projects while working for a few major mining houses within the Platinum belt in South Africa. My experience has been mainly in the shallow platinum mining environment in both the Western and Eastern Igneous Bushveld Complex.

I am currently working as the Shaft Rock Engineer at Dishaba Mine, and engaged with the number of key optimization initiatives, underpinned by a strong belief in safety culture and accountable leadership.

Why in-situ testing matters for cementitious membrane support in underground mining

G.H. Louw
Fraser McGill Mining and Minerals Advisory, South Africa

Cementitious-based membrane support systems are widely used in underground mining as part of areal support strategies to stabilise excavations and contain rock mass deterioration between tendon support units. While laboratory testing provides baseline material properties such as tensile and shear strength, these controlled conditions do not adequately represent the complexities associated with underground application. As a result, in-situ testing is essential to accurately assess the true performance and reliability of these systems under actual mining conditions.

This paper emphasises the importance of in-situ testing as a critical component in the evaluation, design, and implementation of cementitious membrane support. Underground conditions introduce a range of variables that significantly influence support performance, including rock mass quality, surface roughness, environmental conditions, batching consistency, and application methodology. These factors directly affect the adhesion, thickness, curing behaviour, and overall strength development of the installed support, and cannot be reliably simulated in a laboratory environment.

A key aspect of membrane support performance is its ability to contain and stabilise rock blocks between tendon support elements. Analytical assessments show that support resistance is governed by the weight of potentially unstable rock blocks, which is a function of rock density, gravitational forces, and fallout thickness. In blocky rock masses with intersecting joint sets, the potential exists for localised fallout between support units, placing significant demand on the tensile capacity of the membrane. In such cases, minimum strength requirements are defined to ensure that the membrane can resist these loads, particularly during early curing stages when the excavation is most vulnerable.

In-situ testing, typically through pull testing methods, provides a direct measure of tensile and shear strength, as well as insight into failure mechanisms and bonding characteristics. Testing conducted over multiple curing intervals allows for the assessment of early-age strength development, which is critical for safe re-entry, as well as longer-term performance. The results consistently show that there can be substantial differences between laboratory-derived strengths and those achieved in-situ, particularly within the first 24 to 72 hours of curing. This highlights the risk of relying solely on laboratory data for design and specification purposes.

The findings further demonstrate that membrane thickness plays a significant role in support performance, with a clear correlation between thickness and load-bearing capacity. Variability in applied thickness, often resulting from inconsistent application or poor material behaviour, can therefore lead to reduced support effectiveness. In addition, the interaction between the membrane and the rock surface, including mechanical interlocking on irregular surfaces, contributes to overall system strength and must be considered in design and evaluation.
Beyond strength characteristics, in-situ testing also provides valuable insight into practical aspects such as batching efficiency, application quality, rebound, and curing consistency. These factors directly impact the reliability and repeatability of the support system in a production environment.
The paper concludes that in-situ testing is fundamental to understanding the real performance of cementitious membrane support. It enables validation of design assumptions, calibration of analytical and numerical models, and optimisation of support standards. Incorporating routine in-situ testing into geotechnical practice ultimately leads to more robust support design, improved safety, and increased confidence in the long-term stability of underground excavations.

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George Louw

Geotechnical Engineer
Fraser McGill Mining and Minerals Advisory

George Louw is a Geotechnical Engineer with around 20 years of experience across operations, projects, and consulting in the mining and minerals industry. His experience is largely built in hard rock mining environments, particularly within the Bushveld Igneous Complex in South Africa, as well as in deep, large-scale copper mining operations in Australia.

He has spent a significant part of his career working in the Bushveld, where he has dealt with a wide range of geotechnical challenges associated with deep-level mining. This includes ground support design, stability assessments, and managing geotechnical risk in high stress conditions. His approach is always practical, with a strong focus on solutions that can be implemented effectively on site.

George has also gained valuable international experience in Australia, working on massive mining operations in deep copper mines. This exposure has given him a broader perspective on different mining methods, large-scale geotechnical behaviour, and how to adapt designs to suit varying geological and operational conditions.

He has a strong interest in geology and believes it plays a critical role in geotechnical engineering. He makes a point of incorporating detailed geological understanding into his work, whether it's for studies or design. By doing this, he ensures that key geological features and structures are properly accounted for, which leads to more reliable and practical outcomes.

A key focus area for George is numerical modelling, which he sees as the future of geotechnical design. He regularly uses numerical modelling tools to understand stress distributions, assess stability, and test different mining scenarios. He combines this with empirical methods and engineering judgement to provide well-rounded and realistic recommendations.

Over the years, George has been involved in various stages of mining projects, from early studies through to implementation. He works well within multidisciplinary teams and contributes to both technical design and practical problem solving on site.

Overall, his approach is straightforward and grounded — combining solid technical work with practical experience. He continues to focus on improving geotechnical design practices, particularly through better integration of geology and increased use of numerical modelling.