



SAIMM
THE SOUTHERN AFRICAN INSTITUTE
OF MINING AND METALLURGY

CRITICAL MINERALS 2026

FROM POTENTIAL TO PROSPERITY –
BUILDING AFRICA'S CRITICAL MINERALS VALUE CHAINS
THROUGH COLLABORATION, INNOVATION AND GOVERNANCE

30–31 JULY 2026

VENUE: ROYAL MAJESTIC HOTEL, ROSEBANK, JOHANNESBURG

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Abstract Book



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METALLURGY JOHANNESBURG 2026

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FOREWORD

From Potential to Prosperity: Building Africa's Critical Minerals Value Chains Through Collaboration, Innovation and Governance

30–31 July 2026 | Royal Majestic Hotel, Rosebank, Johannesburg.

It is my great pleasure to welcome you to the Critical Minerals Conference 2026, convened under the auspices of the Southern African Institute of Mining and Metallurgy (SAIMM). This conference could not come at a more pivotal moment in our region's history. The global transition to a low-carbon economy has fundamentally reordered the strategic landscape of natural resources. Minerals once considered peripheral – lithium, cobalt, nickel, manganese, graphite, copper, and the rare earths – now sit at the very heart of the energy systems that will define the twenty-first century. Southern Africa is not a bystander to this transformation. Our region holds some of the most significant reserves of these materials on earth. The question before us is not whether Africa has what the world needs. It plainly does. The question is whether we will capture the full value of what lies beneath our soils – or whether, as has so often been the case, that value will be extracted and realised elsewhere.

That is the challenge our conference theme – From Potential to Prosperity – places squarely before us. It is a challenge that does not yield to any single actor or any single discipline. It demands a whole-of-value-chain response: coherent policy and governance frameworks; infrastructure and logistics corridors that open markets rather than close them; innovation and beneficiation that move processing and manufacturing closer to the point of extraction; and development models grounded in environmental stewardship, social equity, and genuine community partnership. Over the two days of this conference, we have assembled a remarkable range of voices to address precisely these imperatives. Our programme spans four thematic streams – Governance, Policy and Regional Collaboration; Infrastructure and Strategic Corridors; Innovation, Beneficiation and Value Addition; and ESG, Energy Transition and Inclusive Development – each reflecting a dimension of the problem that cannot be resolved in isolation from the others. Alongside the technical and scientific presentations, our side events, including the Ministerial Roundtable, the CEO Dialogue, and the Innovation Showcase, are designed to close the distance between policy intention, private capital, and practical implementation. We have brought together governments and regional bodies, mining houses and technology suppliers, development finance institutions, research organisations, civil society, and legal and regulatory advisors. That breadth is intentional. The structural barriers that prevent Africa from capturing greater value from its critical minerals endowment – policy fragmentation, infrastructure gaps, underinvestment in downstream capacity, governance deficits – require solutions that no single sector can design or deliver alone. Collaboration is not a nice-to-have. It is the precondition for any of the rest.

I also wish to acknowledge the quality and range of research and analysis that our presenters bring to this forum. From REE extraction science and digital traceability to railway corridor reform, copper supply constraints, just transition vulnerability indices, and the investability of the critical minerals pipeline, the intellectual content of this programme reflects the depth of expertise that exists across our region and beyond. It is a privilege to provide a platform for that work.

The timing of this conference is in itself significant. The energy transition is accelerating, geopolitical competition for critical mineral supply chains is intensifying, and the window of opportunity for Africa to position itself as a value-adding hub – rather than merely a primary exporter – is not permanently open. We meet here in Johannesburg, a city and a country that knows both the extraordinary potential and the hard lessons of mineral resource wealth. That experience, honestly reckoned with, is itself an asset we bring to these conversations. My sincere thanks go to the SAIMM team, whose dedication and professionalism have made this conference possible, and to our sponsors, partners, and supporting institutions for their commitment to this mission. I am deeply grateful to each of our speakers, panellists, moderators, and session chairs for the rigour and generosity they bring to the programme. To our delegates, whether joining us in person at the Royal Majestic Hotel or participating through our live stream from across the continent and beyond: you are why this conference exists. The conversations you will have in these sessions, over lunch, at the networking functions, and in the corridors, are as important as anything that appears on the formal programme. I encourage you to engage fully, to challenge and be challenged, and to leave with relationships and commitments that extend well beyond these two days.

Africa's critical minerals moment is now. Let us make the most of it.

Nomsa Mbere

Partner, Webber Wentzel

Conference Chairperson, SAIMM Critical Minerals Conference 2026

Johannesburg, July 2026

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Conference Chairperson



Nomsa Mbere

Partner
Webber Wentzel

Nomsa is a corporate and commercial lawyer with significant experience advising clients in the mining and resources sector. Her practice focuses on corporate structuring, M&A transactions, and the sale and acquisition of mining assets such as prospecting and mining rights.

She advises on a wide range of mining-related commercial matters, including offtake agreements, contract mining arrangements, sale of concentrates, and logistics contracts, such as freight rail, port handling, and truck logistic and infrastructure-related agreements.

With a deep understanding of the full mining value chain from volume validation, exploration and extraction through beneficiation to market evacuation, Nomsa regularly advises on strategic infrastructure planning, including road, rail, and port integration.

She also supports clients with the implementation of socio-economic development initiatives that incorporate ESG considerations, including economic succession planning in the context of mine closures and the transition to sustainable practices. This includes advising on renewable energy projects, particularly captive power solutions, and contributing to the strategic focus on critical minerals and the green economy.

Her integrated, commercially focused legal advice helps clients navigate complex regulatory and operational landscapes while aligning with long-term sustainability and economic development goals.

Nomsa has authored several articles on the “governance” aspect of ESG and has moderated, chaired, and spoken at a range of mining and ESG-related conferences

Keynote Presenters



Urishanie Govender

Chief Sustainability Officer
Harmony Gold

Dr Urishanie Govender is the Chief Sustainability Officer at Harmony Gold and a recognised sustainability, governance and board leader with more than 30 years of experience across the mining, metals, diamonds, gold, copper, engineering, infrastructure, environmental and public sectors. A professionally registered scientist (Pr.Sci.Nat.) and fellow member of the Institute of Directors South Africa (IoDSA), she has served as an Executive Director, Board Member, Committee Chairperson and Trustee across numerous public, private and non-profit governance structures. She currently provides fiduciary oversight across multiple environmental, rehabilitation and community trusts and previously served on the Board of SANParks, where she chaired the Conservation and Social Economic Transformation Committee. Dr Govender is internationally recognised for integrating sustainability into business strategy, strengthening governance and risk management and leading large-scale transformation programmes that create long-term stakeholder and shareholder value. An accomplished keynote speaker and published author in Tier 1 academic journals, she is passionate about advancing responsible mining, critical minerals development, climate resilience, community upliftment and sustainable economic growth.

Key Highlights

- Over 30 years of executive and governance leadership experience
- Chief Sustainability Officer, Harmony Gold; Director EHS ESG, Vedanta; S&SD Group Manager, De Beers
- Member, Institute of Directors South Africa (IoDSA)
- Professionally Registered Scientist (Pr.Sci.Nat.)
- More than 10 years of board and trustee experience
- Former SANParks Board Member and Chairperson of the Conservation and Social Economic Transformation Committee
- Trustee on multiple environmental, rehabilitation and community trusts
- Executive Director experience within a global mining organisation
- Specialist in sustainability, ESG, governance, risk, health, safety and environmental management
- Recognised thought leader, keynote speaker and published author in Tier 1 academic journals
- Passionate advocate for responsible mining, critical minerals, community development and sustainable value creation



Julie Courtnage

Executive Director
Mandela Mining Precinct

A sustainability scientist for 35 years, I have worked in many roles primarily in mining, and also in tertiary education, NGOs, international liaison and other industry sectors.

My purpose is to facilitate the deliberate creation of fundamentally different futures. My greatest talent is being able to see and articulate long-term, big, and complex stuff, and translate it into digestible pragmatism, with a plan.

A systems thinker by nature, and a quintessential generalist, my work starts by connecting with the humanity in everyone. What follows is strategy & scenario processes, leadership development, communication, ethics & governance, & programme management, with communities, individuals, teams and C-Suite.

I am happiest in the wild. I do pro bono work for select causes, enjoy photography and climbing, I cycle, write, and my most rewarding experience has been as a Therapy Dog handler, and an Equine Therapy volunteer. My sense of humour keeps me grounded, and occasionally apologising.

Keynote Address: From gold to gold-copper: Reframing the energy transition as a mining transition: The Harmony Story

U. Govender

Harmony Gold, South Africa

The global energy transition is commonly viewed through the lens of renewable energy, electrification and decarbonisation. Yet every solar facility, wind turbine, battery storage system, transmission network and electric vehicle depends on a reliable supply of minerals and metals. As demand for critical minerals accelerates, the conversation is increasingly shifting from an energy transition to a broader mining transition, one that requires the mining industry to deliver the materials essential for a lower-carbon future while meeting rising expectations for environmental stewardship, social responsibility and operational resilience. Copper has emerged as one of the defining minerals of this transition. However, the industry faces a growing challenge: while demand continues to increase, declining ore grades are driving higher energy requirements, greater water consumption, increased waste volumes and rising capital intensity. In this environment, long-term competitiveness will depend not only on access to mineral resources, but on the ability to operate efficiently, responsibly and sustainably.

Harmony's evolution from a gold producer to a gold-copper company provides a practical example of this transition in action. Built on a proven ability to acquire, optimise and extend the life of mature and complex gold assets, Harmony has developed a business model founded on disciplined capital allocation, operational excellence and responsible stewardship. Harmony has a sustainability framework that is the blueprint for integrating sustainability into the business. This framework and the unique deep underground capabilities now underpin the company's growing copper portfolio, including the CSA operation, the Eva Copper Project and the Wafi-Golpu copper-gold project, positioning Harmony to participate in the supply of minerals critical to global electrification and economic development.

Central to this journey is the belief that sustainability is not a parallel business function, but a driver of long-term value creation. The integration of renewable energy, water stewardship, circularity through tailings retreatment, digital innovation and data-driven decision-making demonstrates how environmental, social and governance considerations can strengthen operational performance, improve resilience and support sustainable growth.

We now explore how responsible mining, technological innovation and embedded sustainability are becoming defining characteristics of successful mining companies in an increasingly resource-constrained world. We will also consider the significant opportunity for Africa to participate more broadly in the critical minerals economy through investment, value-chain development, infrastructure, beneficiation and regional collaboration.

Ultimately, the transition to a low-carbon economy will depend as much on the future of mining as it does on the future of energy. The challenge for the industry is not simply to supply more minerals, but to do so in a manner that creates enduring value for shareholders, communities and society.

Harmony's journey from gold to gold-copper reflects one approach to meeting that challenge while contributing to the next era of responsible mining.

Leveraging Africa's ASM sector for equitable critical mineral value chains

M.G. Ncube

Independent Consultant, South Africa

Africa's critical mineral endowment positions the continent at the centre of the global energy transition, creating opportunities for economic development, industrialisation and participation in emerging mineral value chains. While responsible sourcing and sustainable mineral development discourse has largely focused on large-scale mining, artisanal and small-scale mining remains an important contributor to mineral production, employment and livelihoods across Africa. This paper examines the role of artisanal and small-scale mining in critical mineral value chains and evaluates governance pathways for its integration into responsible sourcing systems. Using a qualitative analytical approach, the paper reviews policy frameworks, governance mechanisms and selected case studies involving cobalt production in the Democratic Republic of Congo, lithium extraction in Zimbabwe, and the tin, tantalum and tungsten sector in Rwanda. The analysis explores the economic, social, environmental and institutional dynamics shaping participation in critical mineral value chains and identifies governance, finance, technology and market-access constraints. Findings show that artisanal and small-scale mining already contributes to strategically important critical mineral value systems but faces challenges including complex licensing requirements, limited access to finance and technology, weak traceability mechanisms, and growing environmental, social and governance compliance demands. The paper argues that exclusionary governance approaches may heighten supply chain risks. Instead, progressive formalisation, inclusive responsible sourcing models, digital traceability systems, improved access to finance and local value addition can strengthen sustainability, resilience, livelihoods, supply chain transparency and equitable energy transition outcomes.

Keywords: Artisanal and small-scale mining, Critical mineral value chains, Responsible sourcing, Critical mineral governance, Energy transition, Sustainable mineral development



Musawenkosi Ncube

Project Manager
Independent

Musa is a Project Management Professional (PMP) with a background in Mining Engineering and over seven years of experience leading and supporting projects across mining operations, sustainability and research environments. With a strong foundation in both technical execution and strategic oversight, he has developed expertise in stakeholder engagement, risk management, operational optimization and diverse team leadership. His blend of field experience and academic insight enables a systems-level approach to solving emerging problems within the evolving global sustainability landscape.

Deeply committed to sustainability and social impact, Musa focuses on integrating environmental stewardship, ethical sourcing and responsible governance into project approaches. Particular areas of interest include sustainable mining, the energy transition, critical minerals, artisanal and small-scale mining and the role of emerging technologies in improving operations. At the Critical Minerals Conference 2026, he challenges delegates to reframe ASM integration in the critical minerals discourse from governance imperative to a greater cause with a development opportunity. He illustrates how this mindset shift catalyses industry transformation and promotes inclusive development.

A mining transition vulnerability index for Africa's critical minerals

M. Cole, E. Canpolat, M. Lokanc

University of the Witwatersrand, South Africa

The global energy transition is driving unprecedented demand for critical minerals and metals, creating both opportunity and risk for resource-rich regions in Africa. This surge in demand raises the question: Will Africa's mineral wealth catalyse inclusive economic transformation, or perpetuate historical patterns of resource extraction that marginalised communities and failed to create sustained, local economic benefits? We adapt the vulnerability framework used by the IPCC to quantify the vulnerability of regions that host critical minerals, assessing exposure (where will future mines be?), sensitivity (who will be affected by mining?), and adaptive capacity (how will people cope?). We analyse six countries in Eastern and Southern Africa – the Democratic Republic of Congo, South Africa, Zambia, Malawi, Tanzania and Burundi – which host 75% of global cobalt, 78% of platinum group metals, 68% of manganese and significant reserves in nickel and REE. We develop a novel Mining Transition Vulnerability Index (MTVI) and present spatial vulnerability patterns for 45 provinces and regions that highlight hotspots where mining may bring more risk than opportunity. DRC's Sud-Kivu, Nord-Kivu, Ituri, Maniema, Lualaba and Haut-Katanga provinces show very high vulnerability while Burundi's Butanyerera, Buhumuza, Burunga and Gitega provinces, Malawi's Central region, South Africa's Limpopo province and Tanzania's Shinyanga region show high vulnerability. Although mining for critical minerals could create 100,000 direct jobs and over USD 14 billion in annual government revenues for Zambia, Malawi, Burundi and Tanzania until 2050, realising these opportunities requires a justice-centred approach that includes strengthening governance, improving benefit-sharing mechanisms, ensuring meaningful community participation, addressing historical impacts, protecting vulnerable people, and building adaptive capacity.

Keywords: Critical minerals, Energy transition minerals, Social inclusion, Vulnerability assessment, Composite index, Africa



Megan Cole

University of Johannesburg

Dr Megan Cole is a research specialist with over 20 years of experience in mining, climate change and sustainable development, and a DPhil from the University of Oxford. She started her career in the mining industry as a mine geologist, geotechnical engineer and later research manager for Anglo Platinum in South Africa. She led a team of graduates developing the 'mine of the future' and played a key role in developing corporate water and climate change strategies. She was featured in the Mail and Guardian's 'Book of South African Women' in 2009. In 2010 she moved to the UK and worked at the Smith School of Enterprise and the

Environment, University of Oxford, on climate change policy and strategy in developing countries. This included leading a team that developed the Government of Rwanda's National Strategy on Climate Change and Low Carbon Development, launched at COP17. She then undertook a DPhil on measuring sustainable development at global, national, provincial and local levels. Returning to South Africa in 2017, she joined the University of Cape Town to undertake research on operationalising the SDGs in the mining industry. She has since broadened her research to include mining communities, mine closure, ESG risks in mining, water and energy, the just energy transition, economic potential of mining towns, and critical minerals. She led the development of the South African Mine Closure Risk and Opportunities Atlas, an online, interactive tool supporting mine closure management and planning. She has published numerous academic papers and reports, and has undertaken research for the World Bank, the Water Research Commission, the Minerals Council of South Africa, the Public Affairs Research Institute (PARI), the Centre for Development and Enterprise (CDE), and the UK's Climate and Development Knowledge Network (CDKN). She is an honorary senior research fellow at the University of the Witwatersrand's Wits Mining Institute and a member of the SAIMM ESGS Committee.

From extraction to adoption: critical minerals, transition pathways, and technology acceptance in Southern Africa

B. Swamba

University of Johannesburg, South Africa

The accelerating global transition towards low-carbon energy systems has significantly increased demand for critical minerals required for electric vehicles, battery storage technologies, and other clean energy applications, positioning South Africa and the Democratic Republic of the Congo (DRC) as strategically important actors within global mineral value chains. Despite this growing importance, existing scholarship has concentrated primarily on upstream extraction, supply security, and geopolitical competition while paying comparatively limited attention to downstream technology adoption and the socio-technical dynamics that shape energy transitions within mineral-producing regions. This paper argues that sustainable critical mineral governance requires moving beyond extractive paradigms by integrating technology acceptance, industrial diversification, and inclusive transition pathways into regional development strategies. Drawing on Socio-Technical Transitions Theory, the Multi-Level Perspective, and the Technology Acceptance Model, the study develops an interdisciplinary framework for examining the relationship between critical mineral value chains and low-carbon mobility adoption in Southern Africa. A qualitative comparative case study design is employed, focusing on South Africa's PGMs-based automotive ecosystem and the DRC's cobalt mining sector through documentary analysis of peer-reviewed literature, policy frameworks, and international energy and critical mineral reports. The analysis conceptualises hybrid vehicles and electric vehicle conversion technologies as intermediary transition pathways that facilitate incremental electrification while responding to affordability constraints and infrastructural limitations. The findings are expected to demonstrate that mineral-producing countries risk remaining confined to upstream extraction unless governance frameworks simultaneously promote downstream technology adoption, local industrial upgrading, and inclusive innovation ecosystems. By linking critical mineral governance with technology acceptance and socio-technical transitions, the paper contributes an interdisciplinary perspective to debates on sustainable mineral development and offers policy-relevant insights for strengthening beneficiation, supporting regional value creation, and advancing equitable energy transition pathways in Southern Africa.

Keywords: Critical minerals, energy transition, technology acceptance, socio-technical transitions, electric mobility, beneficiation, sustainable industrial development, Southern Africa



Bazolakio Swamba

Student

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Bazolakio Swamba is an interdisciplinary researcher whose work explores the intersection of critical minerals, energy transitions, governance, technology adoption, and sustainable development in Southern Africa. His research examines how mineral-rich countries can move beyond extractive economies towards inclusive industrialisation by strengthening mineral beneficiation, regional value addition, technological innovation, and socially responsive governance.

He is currently a PhD candidate at the University of Johannesburg, South Africa, where his research focuses on Artificial Intelligence-Assisted Governance Analytics of Stakeholders' Social Perceptions on Energy Minerals Mining, Beneficiation, and Value Addition in South Africa.

His doctoral research integrates engineering, governance, development studies, and sociology to investigate how artificial intelligence can support evidence-based decision-making, stakeholder engagement, and sustainable mineral governance within the energy transition.

Swamba holds a Master of Arts in Social Sciences (Forced Migration Studies) from the University of the Witwatersrand, where he specialised in displacement, vulnerability, and the social consequences of structural transformation. He also holds an Honours degree in Psychology from the Université Pédagogique Nationale in the Democratic Republic of the Congo (DRC), providing a strong foundation in behavioural science, community analysis, and the psychosocial dimensions of development. His multidisciplinary academic background enables him to bridge technical, institutional, and social perspectives in addressing complex challenges associated with critical mineral development.

His conference paper, "From Extraction to Adoption: Critical Minerals, Transition Pathways, and Technology Acceptance in Southern Africa," examines an important but underexplored dimension of the global energy transition. While existing research has focused predominantly on mineral extraction, supply security, and geopolitical competition, his study argues that sustainable critical mineral development also depends on downstream technology adoption, industrial diversification, and inclusive transition pathways. Using South Africa's platinum group metals (PGMs) sector and the DRC's cobalt industry as comparative case studies, the paper investigates how governance, innovation, and technology acceptance influence the transition from mineral extraction to clean-energy deployment.

Methodologically, Swamba adopts an interdisciplinary qualitative approach that combines comparative case study analysis, documentary review, policy analysis, and socio-technical systems thinking. Drawing on the Multi-Level Perspective (MLP), Socio-Technical Transitions Theory, and the Technology Acceptance Model (TAM), his work connects critical mineral governance with industrial policy, innovation systems, and clean mobility transitions, while identifying governance pathways that can strengthen regional value chains and sustainable industrial development.

His broader research interests include critical minerals governance, energy transition pathways, mineral beneficiation, technology acceptance, industrial policy, regional value chains, engineering governance, environmental, social and governance (ESG) frameworks, and sustainable development. He is particularly interested in understanding how African mineral-producing countries can capture greater value from their mineral resources while promoting technological capability, regional manufacturing, and inclusive socio-economic transformation.

Through his research, Swamba contributes to emerging debates on sustainable critical mineral development by demonstrating that Africa's future competitiveness will depend not only on its geological resource endowment but also on effective governance, technological capability, industrial upgrading, and the successful adoption of clean-energy technologies. His work provides practical policy insights for strengthening regional value chains and advancing a just, resilient, and sustainable energy transition across Southern Africa.

Social performance and the critical minerals imperative in Africa's just transition

D. Wessels

Immersion3 Consulting, South Africa

The global race toward net zero is intensifying demand for critical minerals – the essential inputs for clean energy technologies and digital infrastructure. Recent publications, including *The Role of Critical Minerals in Clean Energy Transitions* and *Harnessing Africa's Critical Mineral Opportunity*, converge on a single insight: achieving climate goals will require a rapid expansion of exploration and mining. Yet the same literature exposes persistent barriers – slow project development, high capital intensity, fragmented regulation, and weak infrastructure – that constrain supply growth, particularly across Africa.

Africa's geological potential is vast, but its ability to scale sustainable upstream production remains limited. The Democratic Republic of Congo exemplifies this paradox: rich in cobalt and copper, yet dependent on fragile logistics corridors such as Lobito, and burdened by social risks – evictions, child labour, and human rights violations – that shadow the continent's critical minerals boom. This tension also raises a fundamental question of social justice: how will the benefits of critical mineral growth be distributed, and will the transition alleviate or reinforce existing patterns of exclusion?

The presentation ('infographic journey') argues that the answer lies in early and integrated social performance management. Embedding social performance at the exploration stage – through contextual mapping, stakeholder engagement, and proactive risk identification – can de-risk assets, stabilise community relations, and promote inclusive development. Within the mining project ecosystem, a robust Social Performance Management System becomes not merely a compliance tool but a strategic enabler of balanced growth – helping reduce extractive pressures and align mineral development with the principles of a just transition. Ultimately, the path to net zero will be paved with minerals – but its legitimacy will depend on how responsibly, inclusively, and transparently those minerals are brought to market.



Deon Wessels

Director Social Performance and Strategic Integration
Immersion3 Consulting

Deon is a Social Performance specialist with over 25 years of experience, including extensive work on capital projects and corporate advisory. He brings a sharp ability to analyse, map, and creatively communicate social risks, impacts, and shared value opportunities. Deon's background includes senior roles at ERM and Anglo American, where he served as Social Performance Lead for the US\$10 billion Future of Mogalakwena Project Portfolio. He is also experienced in social assurance audits, stakeholder engagement, mine closure, and social due diligence. Deon holds an MBA from Stellenbosch Business School and is a WBCSD Leadership Program alumni. He is also a member of SAIMM and the Junior Mining Council.

The missing ESG pillar: Building municipal capability to support mining-led development

V. Naicker

Anglo American, South Africa

The long-term sustainability of mining-led development depends not only on corporate environmental, social and governance (ESG) commitments, but also on the capability of local municipalities to plan, coordinate and deliver services effectively. In South Africa, many municipalities face significant governance, financial and service delivery challenges that undermine their ability to support economic development. These challenges include weak planning and implementation capacity, deteriorating infrastructure, shortages of technical skills, poor financial sustainability, political instability, ineffective coordination across spheres of government and inadequate accountability for non-performance. In mining regions, these structural weaknesses are compounded by rapid population growth driven by labour migration, expanding informal settlements, increasing pressure on infrastructure and services, and limited collaboration between municipalities and mining companies.

These municipal constraints have direct implications for mining investment and the effectiveness of corporate social investments. Mining companies invest substantial resources in infrastructure and socio-economic development through Social and Labour Plans and other community initiatives. However, weak municipal planning systems often make it difficult to align mining investments with local development priorities. As a result, municipalities and mining companies frequently implement parallel projects, leading to duplication, fragmented development outcomes and reduced stakeholder trust. Inadequate municipal service delivery, particularly in areas such as water, sanitation and roads, can also disrupt mining operations and increase operational risks. Furthermore, many assets developed through mining investments deteriorate over time because municipalities often lack the resources and technical capacity required for ongoing operation and maintenance. Misalignment between municipal planning frameworks, such as Integrated Development Plans and mining regulatory requirements further exacerbates coordination challenges.

Recognising that municipal capability is a critical but often overlooked component of ESG performance and sustainable development, Anglo American launched the Municipal Capability and Partnership Programme (MCP) in 2019. The programme responds to the national call for greater private-sector participation in building a capable state. Established as a public-private partnership involving Anglo American, participating municipalities, the Department of Cooperative Governance and the Council for Scientific and Industrial Research, the MCP seeks to strengthen municipal planning, service delivery and institutional capability while improving collaboration between municipalities and the mining sector. The programme also aims to support economic diversification and strengthen local resilience in preparation for a post-mining future. Originally implemented across ten municipalities, the programme currently focuses on Gamagara and Tsantsabane in the Northern Cape, and Musina and Bloubaai in Limpopo.

The MCP has already demonstrated promising results. Participating municipalities have developed or updated critical planning instruments, including Spatial Development Frameworks, Local Economic Development strategies, Water Safety Plans and Operations and Maintenance Plans, many of which were previously absent or outdated. These improvements have strengthened municipal planning capacity and enhanced the alignment of public and private investment. Significant gains have also been recorded in water service performance, with notable improvements in Blue Drop and Green Drop compliance scores. Enhanced municipal capability has further enabled municipalities to secure additional government funding for infrastructure and development priorities.

The MCP experience demonstrates that investing in municipal capability can generate measurable benefits for communities, local government and the mining sector. By strengthening planning, service delivery and institutional capacity, municipalities become more effective development partners, improving the sustainability, impact and coordination of mining investments. This suggests that municipal capability should be recognised as a critical, yet often missing, pillar within ESG and mining-led development strategies.



Vanessa Naicker

Vice President Social Impact
Anglo American

Vanessa Naicker is seasoned mining leader with a career that spans petrochemical, heavy engineering and mining sectors, where she has driven transformation across the entire mining value chain. With extensive global experience across diverse commodities, geographies and cultures, she has built a reputation as a catalyst for sustainable development in resource-rich regions, combining operational insight with a deep commitment to long-term socio-economic progress.

A registered Professional Engineer and Certified Director, Vanessa brings together technical excellence, strategic vision and a strong outcomes-oriented approach. Throughout her career, she has led complex initiatives that balance business performance and broader societal impact, enabling inclusive growth and sustainable value creation. A passionate advocate for collaborative regional development, Vanessa champions a systems-based approach that recognises the interconnected nature of development ecosystems.

As Vice President Social Impact at Anglo American, she leads programmes and partnerships that extend well beyond compliance requirements. Her work focuses on advancing socio-economic development, supporting national and global mining development agendas, and unlocking opportunities associated with critical minerals that are essential to both the global energy transition and national growth priorities. Passionate about education and skills development, youth and women inclusion, she actively supports education reform that prepares future ready talent for an evolving world of work. She is committed to ensuring that mining remains a powerful enabler of development, creating lasting benefits for communities, industries and economies in South Africa, Africa and the world.

A comparative analysis of environmental, social and governance performance in South Africa's manganese subsector

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Improved environmental, social, and governance (ESG) practices are becoming an imperative for the mining sector to attract investment and enhance its competitiveness in the global critical minerals landscape. This paper evaluates the ESG performance of manganese companies and mines in South Africa by benchmarking their performance against competing manganese companies and mines operating in other countries.

A mixed methods approach was adopted to analyse company-level, country-level, and mine-level ESG data. ESG criteria assessed include water consumption, energy metrics, population density, proximity to protected areas, social responsibility, and regulatory risk in South Africa. Secondary data from company reports and market intelligence was used for quantitative analysis.

The findings indicate that most South African manganese companies lack formal ESG scores or ratings, apart from one which holds a 'severe' ESG risk rating and another with a 'moderate' rating. Environmental analysis reveals that total water and energy consumption of South African companies increased between 2022 and 2023 relative to production, compared to Australian companies. Scope 3 emissions dominate across all mining companies, far exceeding Scope 1 and 2 emissions. Most South African companies report particularly high Scope 3 emissions. The findings suggest slow adoption of renewable energy by South African manganese companies. In comparison to others, an Indian company was the only company to show a substantial increase in renewable energy adoption.

Geospatial indicators provide a distinct competitive advantage for South African manganese operations regarding environmental risk. All three South African mines operate at least 10 km away from protected areas, representing a very low-risk zone. In contrast, the Australian mine operates within a critical risk zone, potentially facing stricter environmental regulations. South African mines operate in low-density population thresholds, resulting in a lower social responsibility burden than Indian operations, which operate in 'very high density' areas.

From a social perspective, all manganese mining companies maintain stakeholder forums, reflecting transparency and community engagement. However, overall female representation remains low, despite slight upward trends at one South African mine. In terms of skills and workforce stability, an Australian company recorded the highest employee turnover, indicating potential retention challenges, whereas Gabonese companies demonstrated better workforce stability.

South Africa has a legal risk score of 36, based on Mining Journal Intelligence (2024) statistics, and is currently categorised as 'difficult to justify investment' due to regulatory complexity and stringent compliance requirements. A score of 48 on the Social Investment Risk Index highlights vulnerabilities to service delivery protests, labour disputes, and xenophobic tensions that can disrupt operations. In contrast, jurisdictions such as Australia and Canada maintain 'negligible risk' profiles through stable governance and effective community engagement frameworks.

The findings suggest opportunities for the South African manganese subsector to enhance its competitiveness through ESG improvements. ESG-driven investment can unlock new capital. Sustainable mining practices, including large-scale renewable energy integration, can improve industry reputation. Enhanced governance frameworks and proactive management of social risks may attract more foreign direct investment. Transparency, together with the collection and analysis of mine-level ESG data, is critical to overcoming the limitations associated with aggregated company-level reporting.



Sumaya Khan

Senior Researcher
Council for Scientific and Industrial Research (CSIR)

Sumaya Khan is a researcher and project leader in sustainable mining and critical minerals, currently working at the CSIR Mining Cluster. Her work focuses on strengthening the global competitiveness of South Africa's emerging critical minerals sector through integrated approaches that combine policy analysis, value chain optimisation, and sustainability.

She leads and contributes to multidisciplinary research programmes covering critical mineral value chains, circular economy in mining, and people-centred mining modernisation. Her work places particular emphasis on unlocking midstream opportunities and embedding ESG and circularity principles to drive long-term industrial development.

Sumaya has been actively involved in high-level stakeholder engagements across government, industry, and research institutions, contributing to strategic initiatives on mineral policy, localisation, and emerging battery value chains. She brings a strong analytical foundation, with experience in comparative global benchmarking and competitiveness assessments across critical minerals including manganese, platinum group metals, iron ore, chromium and copper.

Social and cultural paradoxes in the mining, processing and beneficiation of critical minerals in South Africa

A. Bazolakio, A.F. Mulaba-Bafubiandi

University of Johannesburg, South Africa

The global transition toward low-carbon energy systems has intensified demand for critical minerals such as platinum group metals, manganese, vanadium, and rare earth elements, positioning South Africa as a strategic node in global mineral value chains (International Energy Agency, 2021; Hund et al., 2020). However, this transition reveals a set of deeply embedded social and cultural paradoxes within the mining, processing, and beneficiation of these resources. While critical minerals are framed as drivers of sustainable development, industrialisation, and green transformation, their extraction and value-chain integration often reproduce historical inequalities, socio-economic marginalisation, and contested cultural dynamics in mining communities (Bebbington et al., 2018; Hilson & Maconachie, 2020).

In the South African context, these dynamics are further shaped by the legacy of apartheid spatial planning, labour systems, and uneven development, which continue to influence patterns of resource governance and community vulnerability (Swilling et al., 2016; Cole & Broadhurst, 2022).

South Africa's mineral wealth is widely recognised as a foundation for economic growth, employment creation, and technological advancement. The country's Critical Minerals and Metals Strategy (2025) explicitly promotes beneficiation and local value addition as pathways to inclusive development and global competitiveness (International Energy Agency, 2025). Yet, despite policy commitments, a significant proportion of minerals continues to be exported in raw or semi-processed forms, limiting domestic industrialisation and reinforcing dependency within global production systems (Pule, 2022). This structural contradiction constitutes a central economic paradox: resource abundance coexists with persistent inequality, unemployment, and underdevelopment in mining regions.

At the community level, mining generates both opportunity and disruption. The sector contributes significantly to livelihoods, supporting millions of people and accounting for a substantial share of national GDP (Sciolo, 2024). However, empirical evidence indicates that mining host communities—comprising over 10% of South Africa's population—often experience uneven development outcomes, including inadequate service delivery, environmental degradation, and socio-economic exclusion (Mapping study, 2020). Perceptions of unmet expectations, weak accountability, and limited benefit-sharing further exacerbate tensions between communities, mining corporations, and the state (Pule, 2022). These dynamics reflect a broader social paradox, where extractive activities promise development but frequently fail to deliver equitable and sustainable benefits.

Culturally, mining reshapes local identities, social relations, and traditional livelihoods. The influx of labour, capital, and infrastructure disrupts existing social systems while introducing new forms of dependency and aspiration. This produces a cultural paradox: mining simultaneously modernises and destabilises communities, creating hybrid socio-cultural environments characterised by both opportunity and precarity.

Furthermore, the global framing of critical minerals as “green” resources obscures the localised socio-environmental costs borne by mining communities, raising questions about the ethical foundations of the energy transition.

The paradox intensifies across the mineral value chain. While beneficiation is promoted as a solution to the resource curse, its implementation remains constrained by policy fragmentation, limited investment in research and development, and infrastructural challenges (Mining Indaba report, 2026). Consequently, South Africa risks remaining locked in upstream extraction, while higher-value processing and manufacturing accrue benefits elsewhere. This disconnect highlights a governance paradox, where ambitious policy frameworks coexist with institutional inefficiencies and implementation gaps.

This study adopts an interdisciplinary lens, integrating political economy, development studies, and socio-cultural analysis to examine how these paradoxes manifest across the mining–beneficiation continuum. It argues that

resolving these tensions requires moving beyond techno-economic approaches toward a more holistic framework that centres community agency, cultural contexts, and inclusive governance. Strengthening institutional capacity, enhancing community participation, and aligning beneficiation strategies with local development priorities are critical to ensuring that the energy transition does not reproduce extractive injustices under a green guise.

Ultimately, the paper contributes to emerging debates on critical minerals and just transitions by foregrounding the lived realities of mining communities. It demonstrates that without addressing the intertwined social, cultural, and governance paradoxes of extraction and beneficiation, South Africa's critical minerals sector risks perpetuating the very inequalities it is expected to resolve.

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Bazolakio Swamba

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Bazolakio Swamba is an interdisciplinary researcher whose work explores the intersection of critical minerals, energy transitions, governance, technology adoption, and sustainable development in Southern Africa. His research examines how mineral-rich countries can move beyond extractive economies towards inclusive industrialisation by strengthening mineral beneficiation, regional value addition, technological innovation, and socially responsive governance.

He is currently a PhD candidate at the University of Johannesburg, South Africa, where his research focuses on Artificial Intelligence-Assisted Governance Analytics of Stakeholders' Social Perceptions on Energy Minerals Mining, Beneficiation, and Value Addition in South Africa.

His doctoral research integrates engineering, governance, development studies, and sociology to investigate how artificial intelligence can support evidence-based decision-making, stakeholder engagement, and sustainable mineral governance within the energy transition.

Swamba holds a Master of Arts in Social Sciences (Forced Migration Studies) from the University of the Witwatersrand, where he specialised in displacement, vulnerability, and the social consequences of structural transformation. He also holds an Honours degree in Psychology from the Université Pédagogique Nationale in the Democratic Republic of the Congo (DRC), providing a strong foundation in behavioural science, community analysis, and the psychosocial dimensions of development. His multidisciplinary academic background enables him to bridge technical, institutional, and social perspectives in addressing complex challenges associated with critical mineral development.

His conference paper, “From Extraction to Adoption: Critical Minerals, Transition Pathways, and Technology Acceptance in Southern Africa,” examines an important but underexplored dimension of the global energy transition. While existing research has focused predominantly on mineral extraction, supply security, and geopolitical competition, his study argues that sustainable critical mineral development also depends on downstream technology adoption, industrial diversification, and inclusive transition pathways. Using South Africa’s platinum group metals (PGMs) sector and the DRC’s cobalt industry as comparative case studies, the paper investigates how governance, innovation, and technology acceptance influence the transition from mineral extraction to clean-energy deployment.

Methodologically, Swamba adopts an interdisciplinary qualitative approach that combines comparative case study analysis, documentary review, policy analysis, and socio-technical systems thinking. Drawing on the Multi-Level Perspective (MLP), Socio-Technical Transitions Theory, and the Technology Acceptance Model (TAM), his work connects critical mineral governance with industrial policy, innovation systems, and clean mobility transitions, while identifying governance pathways that can strengthen regional value chains and sustainable industrial development.

His broader research interests include critical minerals governance, energy transition pathways, mineral beneficiation, technology acceptance, industrial policy, regional value chains, engineering governance, environmental, social and governance (ESG) frameworks, and sustainable development. He is particularly interested in understanding how African mineral-producing countries can capture greater value from their mineral resources while promoting technological capability, regional manufacturing, and inclusive socio-economic transformation.

Through his research, Swamba contributes to emerging debates on sustainable critical mineral development by demonstrating that Africa’s future competitiveness will depend not only on its geological resource endowment but also on effective governance, technological capability, industrial upgrading, and the successful adoption of clean-energy technologies. His work provides practical policy insights for strengthening regional value chains and advancing a just, resilient, and sustainable energy transition across Southern Africa.

Striking a balance between critical minerals and the right to education in Africa's role in green energy transition

H. Mutlokwa

University of Cape Town, South Africa

Africa is currently lagging in developing a clearer collective voice to balance the benefits of critical minerals revenues and developing its young population to be skilled in science and innovation that taps into critical minerals extraction. This paper aims to analyse the current continental mineral resources legal framework and any other relevant instruments woven through existing literature on beneficiation and social labour plans in extractive activities. Africa needs to take advantage of the fact that its population will double to approximately 2.5 billion people in 2050. This calls for harnessing skills development from learners with potential in Science, Technology, Engineering, and Mathematics subjects and modules in both elementary, secondary, and levels tertiary education (STEM). This could place Africa on an equal footing with China, India and other Asian 'tigers' in battery manufacturing for renewable energy. There is very little evidence of foreign companies extracting critical minerals, contributing meaningful development of skills for staff and learners from communities where critical minerals are found using enforceable social labour plans. Most schools within a 50 to 100 km radius of such extractive activities do not even have science laboratories with a bare minimum to foster a culture of learners appreciating the importance of science subjects for participating in the green energy transition. Aside from the reality of doubling the population of Africa by 2050, it is important that present critical minerals, such as cobalt and lithium, are also at risk of price volatility.

Keywords: right to education, STEM, social labour plans, critical minerals race, youth future

Hoitsimolimo Mutlokwa

University of Cape Town

Dr Hoitsimolimo Mutlokwa is a postdoctoral fellow at the UCT, Mineral & Energy Resources Law in Africa, University of Cape Town, specialising in social justice and inclusion within labour law, mining law, and disability rights. He has published on the role of local government in advancing social justice, critical minerals in Zimbabwe. Furthermore, Dr Mutlokwa is currently developing research on critical minerals, particularly lithium, through the lenses of labour law, corporate social responsibility, and international legal theory, including third World Approaches to International Law (TWAIL). His work also interrogates how neoliberal frameworks may undermine social justice in the extraction of critical minerals. Dr Mutlokwa aims to publish this research in accredited journals and to translate key insights into accessible opinion pieces for broader public engagement.

Junior and small-scale mining support initiative

J. Morris

Carbon Trust Africa, South Africa

Global demand for critical minerals is expected to increase four- to six-fold by 2040 under 1.5°C-aligned scenarios. Southern Africa is uniquely positioned to respond to this demand, holding nearly 30% of the world's known critical mineral reserves. Leveraging demand growth presents a major opportunity for the region to catalyse sustainable economic development and a just energy transition through increased sustainable mining activities.

However, this opportunity is not guaranteed. Without deliberate intervention, expanded mineral supply risks reinforcing business-as-usual extractive models that generate limited local value and exacerbate existing social, environmental, and governance challenges. A just energy transition requires not only more minerals, but minerals produced in ways that are climate-aligned, socially inclusive, and development-oriented.

Junior and small-scale miners are central to achieving this outcome. These actors form the backbone of the mining project and supply pipeline, driving a large share of exploration activity, holding most licences, and supporting livelihoods for many rural and economically marginalised communities. Yet despite their strategic importance, junior and small-scale miners remain under-supported. Limited access to patient capital, technical capacity, ESG expertise, and market linkages constrains their ability to advance projects, attract investment, and adopt sustainable practices. As a result, a critical 'missing middle' persists in the region's mining ecosystem.

The proposed Junior and Small-Scale Mining Support (JSMS) initiative responds directly to this gap. The overarching aim of the JSMS is to enable and accelerate the sustainable development of critical mineral projects by junior and small-scale miners in Southern Africa. At the global level, it contributes to unlocking reliable mineral supply for the clean energy transition. Regionally, it supports climate-aligned economic development, value addition, and investment mobilisation. At national and local levels, it advances a just transition by improving socio-economic outcomes for mining-affected communities, strengthening environmental performance, and embedding responsible practices from project inception.

A defining feature of the JSMS is its role as a coordinating and enabling mechanism. The initiative combines financing facilitation, technical assistance, ESG and climate alignment support, and convening power to improve project bankability, reduce risk, and crowd in capital and expertise. It is explicitly designed to complement and amplify existing support facilities, to avoid duplication while filling critical gaps. By linking miners to appropriate finance instruments, downstream buyers, technical experts, and public-sector partners, the JSMS strengthens the overall ecosystem for sustainable mining development.

The Carbon Trust will present our concept for establishing a JSMS initiative during the Critical Minerals Conference. We will also be hosting a roundtable discussion on the JSMS initiative during the SAIMM ESGS Conference in August 2026.



Jarredine Morris

Co-Head of Africa
Carbon Trust

Jarredine is the Associate Director at the Carbon Trust Africa office, with over a decade's experience in energy and climate change policy. For more than ten years, Jarredine worked for and on behalf of organised business in South Africa, engaging with government, organised labour, and civil society as well as other stakeholders.

She brings an in-depth understanding of policy development to create an enabling policy framework for the just transition to a low carbon economy, and expertise of global energy and climate policy dynamics and how these may impact and influence policy at a national level.

She also has unique insight of the policy requirements and challenges across both the public and private sectors.

Designing for Inclusion from first contact: Social performance frameworks in early critical minerals exploration

M.M. Phambane

Rio Tinto, South Africa

Africa's critical minerals ambitions rest on the phase of the value chain that receives the least social performance attention: early exploration. Before any mine exists, exploration programmes make first contact with host communities, and the engagement patterns established at this stage shape community relationships, social risk profiles, and investment outcomes for decades. Yet social performance frameworks in early exploration remain designed primarily around securing corporate access to land rather than enabling genuine community agency over decisions affecting it.

This paper argues that this constitutes a design problem with measurable economic consequences. Non-technical risk arising from community relationships constitutes approximately half of major extractive company risk exposure (Franks et al., 2014), and stakeholder engagement practice explains roughly two thirds of junior mining market capitalisation (Henisz et al., 2014). If engagement design determines this much investment value, the design gap at the exploration phase where the overwhelming majority of programmes will never become mines, yet all engage communities is a primary investment efficiency question for Africa's critical minerals pipeline.

Drawing on social performance practice across African exploration jurisdictions and doctoral research at the School of Mining Engineering, University of the Witwatersrand, the paper distinguishes consultation from consent: engagement that documents community input versus engagement structurally capable of changing project decisions. It examines how current frameworks produce documented acceptance without genuine agency; why community caution is more accurately understood as informed historical caution than as resistance; why honest expectation management at exploration exit is both an ethical and a commercial imperative given low conversion rates; and what a community-centred social performance framework for early exploration would require across four dimensions epistemic inclusion, honest expectation management, historically informed engagement design, and practitioner enablement.

The paper concludes that inclusive critical minerals development cannot be retrofitted at the mining stage: it is designed in, or designed out, at first contact. For a continent seeking to convert potential to prosperity, exploration-phase social performance design merits treatment as what the evidence indicates it is a primary determinant of both community outcomes and investment efficiency across the critical minerals value chain.



Maureen Mmapula Phambane

Rio Tinto Exploration

Maureen Phambane is the Communities and Social Performance (CSP) Manager for Africa and Eurasia Exploration at Rio Tinto, where she is responsible for social performance across an exploration portfolio spanning fourteen jurisdictions, covering both managed operations and joint venture partnerships. Her remit covers the earliest phases of the mining lifecycle the point of first contact between exploration programmes and host communities including engagement design, social risk assessment, new country entry due diligence, and the integration of community considerations into exploration investment decisions.

A mining engineer by training, Maureen began her career in underground operations, progressing from miner to shift supervisor before moving through technology development, global permitting, and group-level social performance roles at Anglo American — including strategic social performance support to major capital projects and, most recently, responsible tailings management across Africa and Australia, where she co-developed the GISTM Social Performance Playbook and supported enterprise-wide conformance with the Global Industry Standard on Tailings Management. Her experience spans the full project lifecycle from greenfield exploration to operations, with particular depth in embedding international standards such as the IFC Performance Standards, UNGPs, and FPIC into project planning and investment decision-making across multiple commodities and jurisdictions.

Critical minerals exploitation and the contribution of artisanal mining to DR Congo's economy

A.Y. Medard

Critical Minerals Extractivist, Democratic Republic of Congo

The African exponential demographic growth has brought about its own challenges in many African countries, and the situation seems to be similar in the majority of our national communities. The youth unemployment, violent crime, consumption of harmful substances and non-prescription drugs, lack of proper education due to parents' poverty, fraud and swindling activities, early pregnancy and parenthood, to name but a few. Our governments need to find alternative ways to create employment for the youth so as to avoid these social scourges.

The DR Congo is not immune from these challenges. I will therefore provide a succinct overview of the artisanal mining in this central and southern African country where I am a witness to the treatment and challenges of artisanal miners.

Types of Artisanal Mining

1. The recognised artisanal mining and
2. The illegal artisanal mining

The recognised artisanal mining

Mindful of the levels of unemployment, the authorities resolved to formalise the artisanal mining industry by setting up a state structure denominated 'Le Service d'Assistance et d'Encadrement des Mines Artisanales et de Petite Echelle,(SAEMAPE) meaning Assistance and Support Service for Artisanal and Small-scale Mining. The Ministry of Mineral Resources grants mining sites called ZEA (Zone d'Exploitation Artisanale) to these artisanal or small-scale miners. These private mining entities are operated either by cooperatives or small-scale mining companies that employ artisanal miners to dig for minerals contained in those particular ZEAs and build up stockpiles of raw minerals for sale to mainstream national and multinational mining corporations.

Illegal artisanal mining

As is known globally, the DR Congo is a geological scandal because the country is endowed with a wide variety of critical and ordinary mineral resources; mineral ores are found everywhere and anywhere in the country (in rivers, mountains, forests and savannahs). This abundance of minerals in our soil makes it difficult for the relevant authorities to monitor all informal mining activities in the country, therefore some explorations are not identified and monitored by the state institutions. In fact, some citizens engage in artisanal mining activities that are not known to the local and national authorities who have the state mandate to monitor and regulate the extractive industry. They either smuggle their raw minerals to neighbouring countries or sell them illegally to local smelter owners.

The path to the African green minerals strategy as the continental framework in building regional mineral value chains and equitable resource-based industrialisation

M.N. Ncube

African Union, South Africa

The presentation will outline the journey towards Africa's strategic roadmap for leveraging its mineral wealth to achieve a just energy transition and decarbonised future. Tracing the historical evolution from the 2009 Africa Mining Vision (AMV) to the 2025 launch of the African Green Minerals Strategy (AGMS). In-between, the AMDC has developed critical AMV implementation tools in tandem with continental developments, including the African Minerals Governance Framework (AMGF), the African Minerals and Energy Resource classification framework (AMREC) incorporating the Pan African Resources Reporting Code (PARC), and now the AGMS, which positions Africa as a key player in the global green economy. The AGMS emphasises the necessity of regionalism and cooperation to overcome national market size constraints and enable viable downstream and upstream linkages in manufacturing and beneficiation for instance. Amongst key interventions included is systemically aligning geological mineral information with linkage obligations, enforcing local content, STEM skill targets, and implementing tariffs to encourage regional value addition. With significant deposits of green minerals like cobalt, lithium, and manganese, Africa aims to move beyond raw material exports. The AGMS is built on the AMV pillars that push for minerals value chains to integrate industrialisation, regional integration, and sustainable development, ensuring that the continent's mineral resources drive long-term prosperity and a just transition for its people.



Mkhululi Nkosilamandla Ncube

African Minerals Development Centre

Programmes Officer at the African Minerals Development Centre (AMDC), which is a specialized agency of the African Union. Mkhululi provides strategic operational support and coordination for the implementation of the Africa Mining Vision and its Action Plan, as well as the minerals segment of the African Union Commodity Strategy. Mkhululi currently leads the Li-Ion Afro-Hackathon Initiative that is a demonstrable implementation of the African Green Minerals Strategy and also oversees the Artisanal and Small-Scale Mining (ASM) portfolio at AMDC, where he is currently leading the African Gemstone, Jewellery

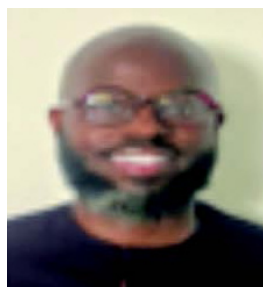
Exhibition and Conference (AGJEC) series - spurring multiple gemstone and jewellery events across the continent and finalising the African Gemstone and Jewellery Curriculum. With 20 years of minerals development experience, Mkhululi has held roles in development, knowledge management, and policy research at the United Nations Economic Commission for Africa (UNECA), the United Nations Development Programme (UNDP), and the Development Policy Management Forum (DPMF). His work has covered natural resources management, regional integration, trade, youth, and women empowerment. Additionally, Mkhululi has a separate background as a farmer, a small-scale mining beneficial owner, and an entrepreneur, having been recognized as a Start-upper of the Year and a multiple international finalist in community-based social enterprise competitions.

Legal and contractual frameworks governing critical minerals in Africa: Challenges and opportunities

M. Stevens

African Legal Support Facility, South Africa

As the demand for critical minerals required for energy transition, defence, aerospace and green industrialisation continues to grow, several developed countries have entered a new phase of industrial policy, defined not by market dynamics but by strategic intervention. This places Africa – a continent holding approximately 30% of the world’s minerals reserves – at the forefront of developed countries’ economic and industrial policies aimed at securing access to critical minerals. This demand has created a golden opportunity for African countries to leverage their resource endowment to redefine terms of engagement for mineral rights, thereby moving away from the traditional pit to port model. However, Africa’s ability to seize this moment to negotiate agreements capturing greater revenue, value addition, technology transfer and sustainable development significantly depend on coherence of the legal and contractual architecture governing rights to critical minerals extraction. This paper examines challenges and opportunities with legal and contractual frameworks governing critical minerals in Africa. The paper examines the geopolitical context that differentiates critical minerals contract negotiations from other mineral agreements. The paper analyses the need for careful negotiation of key legal and contractual provisions including stabilisation clauses, state participation, local content, beneficiation, fiscal provisions and investor dispute settlement mechanism to ensure that African countries retain greater value from their critical minerals beyond pure economic rents. The paper concludes by proposing legal and policy pathways linked to current continental and regional frameworks that promote African agency, economic sovereignty, and broad-based mineral-led sustainable development.



Mohamed Stevens

Legal Counsel

African Legal Support Facility

Mohamed Stevens is a seasoned lawyer with over a decade’s experience in the mining and energy sectors. He currently serves as Legal Counsel at the African Legal Support Facility (ALSF), a member of the African Development Bank Group, where he advises and coordinates mining and energy projects across multiple jurisdictions in Africa.

Mohamed contributes to several high-level initiatives. He serves on the Steering Committee of Investing in Mining Indaba and is a member of the African Union’s Technical Committee developing the Model Law on Mineral Resources. He also participates in drafting the African Artisanal and Small-Scale Mining Continental Strategy and works with a multi-stakeholder group to advance the African Minerals Governance Framework. Additionally, he chairs the Board of the Journal of International Investment and Extractive Industry Law. His professional experience spans Africa, Asia, and Europe.

An accomplished author, Mohamed has published extensively on topics such as transition minerals, green hydrogen, investment arbitration, oil and gas, back-channel negotiations, and sustainable development.

He holds two Master of Laws (LL.M) degrees in International Dispute Resolution and Management and Oil and Gas Law and Policy from the University of Dundee’s Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP). He also earned a Postgraduate Diploma in Law from Sierra Leone Law School and a Postgraduate Diploma in Legal Practice from BPP Law School, England and Wales.

Leveraging critical minerals for the attainment of sustainable development goals in SADC – a policy review and analysis

G. Dzinomwa¹, A.G.O Mutambara²

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The Southern African Development Community (SADC) region is richly endowed with critical minerals, notably copper, cobalt, lithium, graphite, nickel, manganese and rare earths. These are the main enablers of the green energy transition and digital transformation, all within the context of driving towards the Sustainable Development Goals that world leaders committed their countries to achieving by 2030. The SDGs emphasise, among other goals, elimination of poverty and hunger, provision of clean water and sanitation powered by clean yet affordable energy, buttressed under an industrialised and sustainable environment. These noble goals, alongside the SADC Protocol on Mining, are expected to foster inclusive growth, creation of skilled jobs and socio-economic transformation of the region. Individual national strategies have been crafted with the objective of harmonising exploration, mineral beneficiation and further value addition standards and procedures, collaborative research and development, and regional integration. This review and analysis, however, reveals inconsistencies in policy formulation; national strategies that overlook regional collaboration and integration. The resulting gaps cause significant shortfalls in industrialisation, value addition and revenue generation. Success stories are recorded in cases such as platinum group minerals where regional integration between South Africa and Zimbabwe is evident, albeit under some strain. Recommendations are made on ways to address the formulation of policies conducive to going forward, as well as reviewing and applying value chains with effective regional integration in line with the SDG goals.



Godfrey Dzinomwa

Professor of Extractive Metallurgy

Namibia University of Science and Technology

Godfrey Dzinomwa is a Professor of Extractive Metallurgy and the Head of the Department of Civil, Mining and Process Engineering at Namibia University of Science and Technology (NUST). He holds a BSc (Hon) in Metallurgical Engineering from the University of Zimbabwe and a PhD in Minerals Process from the University of Queensland in Australia. He has over thirty years of operational, academic and research experience mainly in the minerals sector, and he has held senior leadership positions in Zimbabwe, Botswana and Namibia. Godfrey has supervised a number of honours and postgraduate student research projects and published several papers in peer reviewed journals, and his current research interests are in the beneficiation of critical minerals. He is a member of the SAIMM and the international Society of Mining Professors (SOMP).

Critical minerals in South Africa: Catalyst for sustainable development or resource curse?

T. Madzivhandila

University of Johannesburg, South Africa

The growing global demand for critical minerals, driven by the transition to low-carbon energy systems and advanced technologies, has positioned resource-rich countries at the centre of economic and geopolitical transformation. South Africa, endowed with substantial reserves of platinum group metals, manganese, chromium, and other strategic minerals, is uniquely placed to benefit from this shift. This paper critically examines whether South Africa's critical mineral wealth constitutes a catalyst for inclusive development or reinforces characteristics of the resource curse. Drawing on secondary data, policy analysis, and comparative literature, the paper evaluates the economic, environmental, and socio-political dimensions of the mining sector.

The findings indicate that while the mining sector contributes significantly to GDP, export earnings, and employment, its developmental impact is constrained by limited beneficiation, environmental degradation, persistent inequality, and exposure to volatile global commodity markets. At the same time, South Africa's relatively diversified economy, institutional capacity, and strategic positioning in emerging green technologies – particularly hydrogen energy – highlights strong potential for a resource-based industrial transformation.

The paper argues that critical minerals in South Africa are neither inherently a boon nor a curse, but rather a conditional opportunity shaped by governance, policy coherence, and the extent of value addition. It concludes that without targeted interventions such as strengthening beneficiation, enhancing environmental regulation, and promoting economic diversification the country risks perpetuating elements of the resource curse. Conversely, effective management of mineral resources could enable South Africa to achieve sustainable and inclusive growth in the context of the global energy transition.

Keywords: Critical minerals, resource curse, resource blessing, beneficiation, mining sector, economic development, energy transition, industrialisation



Takalani Madzivhandila

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I am a Senior Lecturer in the Department of Metallurgy within the Faculty of Engineering and the Built Environment at the University of Johannesburg (UJ). I hold a Doctoral degree in Engineering Management, a Master's degree in Metallurgical Engineering, and a Diploma in Advanced Business Management. I am also a registered Professional Engineer (Pr. Eng.) with the Engineering Council of South Africa (ECSA), a designation I have held since 2014.

For almost 20 years, I have been actively involved in the higher education sector, first as a student and later as an academic. Over the past 15 years, I have progressed through various academic positions, including Tutor, Senior Tutor, Senior Technician, Assistant Lecturer, Lecturer, and Senior Lecturer. During this time, I have taught a wide range of undergraduate modules, including Management Skills, Metallurgy I, Quality Techniques, Physical Metallurgy, Practical Metallurgy, Foundry Technology, Material Testing, and Mechanical Metallurgy. My educational journey has shaped my teaching philosophy, reinforcing my belief that academic excellence extends beyond technical knowledge to include critical thinking, personal growth, and lifelong learning.

In addition to my teaching responsibilities, I have served in several academic leadership and governance roles, including membership of the School Research Committee and Faculty Board, as well as serving as an ECSA Assessor. I also contribute as an Advisory Board Member of the Process Energy and Environment Technology Station and the Metal Casting Technology Station at UJ, and as a member of the Centre for Nanoengineering and Advanced Materials (CeNAM).

Beyond academia, I have held several strategic leadership positions, including Board Member of Mintek, Board Chairperson of the SEDA Platinum Incubator, Board Chairperson of the Technology Station in Electronics (TUT), Board Member of the Institute of Advanced Tooling, Chairperson of the African Fashion Indaba, and Board Member of the Gauteng Fashion Council. These diverse roles have strengthened my leadership, governance, and strategic management capabilities while expanding my professional network.

My strong industry engagement significantly enriches my teaching by enabling me to integrate practical experience with theoretical concepts. Through my involvement with ECSA and industry partners, I ensure that my teaching aligns with professional accreditation standards while preparing students for engineering practice. I also mentor academic colleagues on ECSA accreditation processes and leadership development, contributing to continuous improvement within the institution.

My multidisciplinary experience has created valuable opportunities for both students and colleagues. Through industry collaborations, we have secured PhD funding for colleagues, as well as learnerships and internships for students at organizations such as Mintek. To further bridge the gap between theory and practice, I organize regular industry visits that expose students to real-world engineering environments and enhance their understanding of professional practice.

Throughout my academic career, I have built strong relationships with students by understanding their diverse backgrounds and learning needs. I believe that effective teaching requires more than subject expertise; it demands empathy, mentorship, practical experience, and a genuine commitment to student success. My goal is to inspire, support, and develop future engineering professionals who are academically competent, ethically grounded, and prepared to make meaningful contributions to society.

De-risking critical minerals exploration in Africa: Attracting private investment into the early-stage pipeline

O.C. Mashabila

Exploration Investment Company, Botswana

The global transition to a low-carbon economy has intensified demand for critical minerals, placing Africa's vast mineral endowment at the centre of future supply chains. Yet despite significant geological potential, many African jurisdictions continue to attract limited early-stage exploration investment. The principal challenge is not resource availability, but the ability to reduce exploration risk sufficiently enough to attract private capital.

Drawing on Botswana's experience and the mandate of the Exploration Investment Company Botswana, this paper examines practical approaches to de-risking critical minerals exploration and creating investable project pipelines. It argues that successful resource development begins long before a discovery is made, through deliberate investments in geoscience data, transparent regulatory systems, institutional capacity, and investor confidence.

The paper highlights Botswana's ongoing reforms, including enhanced geological mapping and geophysical surveys, digital mining cadastre systems, strengthened security of tenure, and policies aimed at promoting mineral diversification beyond diamonds. These initiatives demonstrate how governments can play a catalytic role in reducing uncertainty and improving the attractiveness of exploration opportunities.

The discussion further explores mechanisms for mobilising private-sector investment, including blended finance instruments, public-private partnerships, co-investment structures, and strategic collaboration between governments, development finance institutions, and industry. Particular emphasis is placed on addressing information gaps, improving data accessibility, and establishing transparent governance frameworks that support long-term investment decisions.

The paper concludes that Africa's ability to benefit from the growing demand for critical minerals will depend on its capacity to transform geological potential into investment-ready opportunities. By systematically reducing exploration risk and strengthening enabling frameworks, African countries can attract the capital required to unlock new discoveries, develop sustainable mineral value chains, and drive long-term economic growth.

African critical minerals investability: Botswana, the conversion problem, and the path from discovery to capital

J.A.H. Campbell

Botswana Minerals plc, Botswana

Africa's critical minerals opportunity will not be realised by geological endowment alone. It depends much more on whether mineral potential can be converted into projects that are technically credible, institutionally acceptable, and commercially financeable. This paper examines the conversion problem through the analytical lens of investability, defined as the alignment of technical confidence, administrative efficiency, fiscal predictability, infrastructure realism, and staged capital injection. The paper adopts an analytical policy review approach, drawing on current international policy and market sources, public institutional materials, and Botswana as a case study, with the AK6/Karowe trajectory used as an illustrative development example. The analysis finds that resource significance does not by itself produce investor-ready project pipelines. Rather, competitiveness increasingly depends on the quality of project preparation, the credibility of public geoscience and mineral-rights systems, and the availability of institutional mechanisms that reduce the interval between discovery and finance. Botswana is examined as a useful, though incomplete, example because it combines recognised mining credibility, improving investor perception, public geoscience capability, and an operating copper proof point in the Kalahari Copper Belt. The paper concludes that an African critical-minerals strategy will yield more durable outcomes if it focuses less on declaratory ambition and more on institutional arrangements that shorten time-to-understanding, time-to-permit, and time-to-capital.

Keywords: critical minerals, investability, Botswana, junior mining, project finance, beneficiation



James Campbell

Managing Director
Botswana Minerals plc

James Campbell is a mining and exploration leader with over 40 years of experience in diamonds and other minerals, encompassing both major and junior companies. He is currently Managing Director of Botswana Minerals plc and Technical Advisor to Shefa (Israel). His previous executive roles include positions at Rockwell Diamonds, Lucara Diamond, African Diamonds, West African Diamonds, and De Beers, where he served as General Manager, Exploration, and Executive Chairman Nicky Oppenheimer's Personal Assistant. He is also the co-founder and chair of

Common Purpose South Africa, a leadership development Non-Profit Organisation.

James holds a degree in Mining and Exploration Geology from the Royal School of Mines (Imperial College London) and an MBA with distinction from Durham University. A Fellow of several professional institutes (Institute of Mining, Metals & Materials (UK), South African Institute of Mining & Metallurgy, Geological Society of South Africa, and Institute of Directors of South Africa), he is also a Chartered Engineer, Chartered Scientist, and Registered Natural Scientist. He is currently pursuing a doctorate at the Da Vinci Institute on "A Business Incubator Framework for Junior Mineral Exploration and Development: A Southern African Perspective".

Digital risk governance for critical minerals: Using IoT to strengthen safety, ESG, and regulatory compliance across processing value chains

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Africa plays a critical role in supplying the minerals that underpin the global energy transition, including copper and cobalt, alongside gold. Across the continent, cyanide based processes remain central to gold extraction and, under certain metallurgical conditions, are also used in copper and cobalt processing. While cyanide is an effective and widely understood reagent, its toxicity poses serious risks to worker safety, the environment, and public trust when management systems are weak or poorly monitored. These risks are heightened by expanding production, ageing infrastructure, long transport corridors, and uneven regulatory capacity across many African jurisdictions.

This paper explores how an Internet of Things (IoT)-enabled; risk based management model can strengthen cyanide management, safety, and regulatory compliance in African mineral processing operations. Using a detailed gold processing case study, the paper demonstrates how real time monitoring of key parameters such as cyanide concentration, pH, flow rates, containment integrity, and hydrogen cyanide gas can be integrated into dynamic risk assessments and automated alert systems. This approach allows deviations to be detected early, enables proactive intervention, and generates reliable data to support operational control, oversight, and assurance. Most importantly, the framework is not limited to gold and is directly transferable to cyanide bearing copper and cobalt processing circuits, where similar chemical hazards and exposure risks exist.

Recent media reported incidents across Africa illustrate the consequences of inadequate monitoring and reactive regulation. In Liberia, reports of hazardous process chemicals entering river systems from the country's largest gold mine raised concerns about water quality, community health, and regulatory effectiveness (ABC News, Jan 2026). In Zimbabwe, a spill from a slime dam in Bindura led to confirmed cyanide contamination of boreholes, streams, and rivers, fish deaths, and an immediate mine shutdown following intervention by the Environmental Management Agency (Bulawayo24 News, 2025). Residents reported exposure concerns after initial assurances from the mine that water was safe, highlighting the limitations of internal testing and delayed detection.

In Zambia, the collapse of a waste dam at a copper mine resulted in cyanide and arsenic bearing effluent entering waterways connected to the Kafue River, a critical water source relied upon by millions (Newshour Press, 2025). Subsequent allegations that the scale of contamination was significantly underreported raised serious questions around transparency, monitoring accuracy, and regulatory oversight.

Taken together, these cases reveal a recurring pattern of delayed detection, post incident testing, and reactive enforcement.

Keywords: Cyanide management, Internet of Things (IoT), Risk based management, Critical Minerals processing, Regulatory compliance, Environmental protection, Real time monitoring



Mutshidzi Singo

University of Johannesburg

Mutshidzi Singo is a Product Stewardship and Technical Consultant at Draslovka, with over seven years of experience across metallurgical testwork, plant operations, process optimisation, and cyanide management in African gold and critical mineral operations. She is currently pursuing a Master of Engineering in Extractive Metallurgy, with research focused on IoT enabled, risk based approaches to strengthening cyanide management, safety, and regulatory compliance.

Mutshidzi's career spans roles as a Project Metallurgist and Junior Metallurgist at Maelgwyn Mineral Services Africa, where she conducted extensive onsite testwork, plant circuit profiling, cyanidation optimisation, and cyanide detoxification studies across multiple operations. Her technical expertise includes Oxygen Uptake Rate (OUR) testing, cyanide destruction methods, process control, and Aachen™ technology evaluation, Cyanide management and safety compliance.

In her current role, she supports clients on cyanide handling, safety compliance, emergency response planning, and plant trials, working closely with operations and engineering teams to optimise reagent usage and improve recovery while meeting International Cyanide Management standards.

Mutshidzi has presented her work at leading industry forums, including the SAIMM Young Professionals Conference and World Gold Conference, and is passionate about advancing safe, responsible, and inclusive mining practices.

Digital traceability solutions in the South African mining industry: Readiness, barriers, and a roadmap for implementation

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South Africa's mining sector faces intensifying global pressure from regulatory due-diligence frameworks and emerging requirements for Digital Product Passports (DPPs), which are dynamic, machine-readable datasets that provide a verifiable record of a mineral's journey from extraction to end-of-life. This paper investigates the strategic and technical readiness of the South African Mining Industry (SAMI) to adopt digital traceability systems, which link physical mineral flows to credible environmental, social, and governance (ESG) disclosures. A rigorous mixed-methods approach was employed, integrating benchmarking of global traceability standards with four multi-sectoral case studies: The Walmart-IBM Food Trust, Carrefour-IBM Food Trust, The WWF Pacific Tuna blockchain pilot, and The Minespider OreSource platform; complemented by a sector-wide survey and qualitative consultations at the 2026 Mining Indaba. Gold, platinum group metals (PGMs), copper, chromium, iron ore, and manganese emerged as high-priority commodities for traceability intervention. However, the organisations producing these minerals remain at a low level of readiness to adopt digital traceability systems. The survey responses suggest that most can be classified as 'Not Ready' (83%) or only in the 'Early Thinking' (17%) stage. Primary barriers include limited digital infrastructure, prohibitive capital costs, fragmented supply-chain data silos, and the absence of unified national data standards needed to support end-to-end traceability.

The paper proposes a national architecture built on hybrid governance, Global Standards 1 (GS1)-aligned standardisation, phased implementation, and inclusive enablement which includes a Traceability-as-a-Service (TaaS) model for junior miners and artisanal and small-scale mining (ASM) operators. Mineral traceability is positioned as a national competitiveness imperative; by formalising the digital provenance of its minerals, South Africa can safeguard export market share and verify its status as a responsible, transparent leader in the global mineral value chain.

Keywords: Digital traceability, South African Mining Industry ESG compliance, Blockchain, Digital Product Passport, Supply chain governance, Critical minerals, Junior miners, Artisanal and Small-Scale Mining, Hybrid governance

Ndamulelo Stephen Mpanamana

Senior Mining Engineer

Council for Scientific and Industrial Research (CSIR)

Ndamulelo Stephen Mpanamana is a highly technical Senior Mining Engineer at the Council for Scientific and Industrial Research (CSIR) within the Mining Cluster, where he leads strategic projects focused on the modernization and digital transformation of the South African mining sector. With a career spanning over 15 years, Mr. Mpanamana has developed extensive expertise in mining technical services, business improvement, mining operations, and risk management. His professional focus is centred on the integration of advanced technical engineering with sustainable business structures to drive operational excellence.

Currently, at the CSIR, Mr. Mpanamana is the lead researcher and author of the “Digital Traceability Solutions in the South African Mining Industry” project. This work provides a unified blueprint for implementing interoperable traceability frameworks aligned with global ESG standards and emerging regulatory requirements, such as the EU’s Digital Product Passport. His research is instrumental in positioning traceability as a national competitiveness project that secures market access for South African minerals while ensuring the inclusion of junior miners and small-scale operators through innovative “Traceability-as-a-Service” models.

Prior to his tenure at the CSIR, Mr. Mpanamana served as a Manager in Operations Transformation at Deloitte Consulting from 2022 to 2025. In this role, he managed complex consulting engagements and led issue-investigation working groups aimed at optimizing industrial processes.

His experience in consulting is complemented by significant operational roles, including his time at Exxaro as a Mining Engineer, where he spearheaded the implementation of digital systems for mining operations and managed contractor performance.

One of his most notable achievements was his work on the implementation of the Anglo-American Operating Model. Serving first as a specialist and later as a Project Manager, he was a key figure in this strategic design change, which fundamentally altered how operations were conducted across the organization.

His earlier career highlights include serving as a Technical Manager at Aveng Moolmans and holding leadership positions at Kumba Iron Ore, where he managed loading and hauling operations involving over 200 employees, as well as specialized drill and blast initiatives.

Mr. Mpanamana holds a B.Sc. in Engineering (Mining) from the University of the Witwatersrand (Wits). Committed to continuous professional development, he has acquired specialized certifications in Change Management, Facilitation Skills, and Business Improvement Tools and Principles. He is also proficient in SAFe Agile methodologies and risk management frameworks.

His professional philosophy is rooted in the belief that the development of people is the fundamental basis for any sustainable work environment. By combining this people-centric approach with rigorous technical analysis and business performance modelling, Mr. Mpanamana continues to contribute to the resilience and global standing of the South African mining value chain

Digital, Data, and Diversity: Leveraging technology to enable a diverse workforce in critical minerals

G. Mishra

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The rapid growth in demand for critical minerals driven by the energy transition and digital economy is reshaping mining value chains globally. While significant focus has been placed on supply, infrastructure, and beneficiation, far less attention has been given to workforce inclusion and diversity as a critical enabler of long-term value creation.

This paper explores how AI and digital technologies can enable a more diverse workforce across the critical minerals value chain from mining and processing to supply chains and downstream industries. It highlights key structural barriers that continue to limit participation, including access to skills, digital connectivity, and formal employment opportunities – particularly in emerging markets.

The paper will focus on three areas where technology is already reshaping inclusion:

- Redesigning work through digital and AI-enabled operations: Remote operations, automation, and smart mining technologies are reducing physical and geographic constraints, enabling broader participation across roles that were traditionally inaccessible.
- Using data and AI to drive accountability: Data platforms and AI analytics can help organisations measure, monitor, and improve workforce diversity outcomes, embedding inclusion into ESG and operational performance.
- Expanding access through digital ecosystems: Digital training platforms, workforce systems, and online marketplaces are creating new pathways for skills development, employment, and enterprise participation.

At the same time, the presentation will address key risks, including uneven access to digital infrastructure, capability gaps, and the potential for bias in AI systems. These challenges highlight the importance of responsible technology deployment and inclusive design.

Drawing on industry examples and practical insights, the session will outline actionable steps for mining companies, policymakers, and technology providers to leverage AI and digital innovation to build a more diverse and inclusive workforce.

By positioning technology not just as a productivity lever but as an enabler of inclusion, this paper contributes to the broader goal of building more resilient, sustainable, and equitable critical minerals ecosystems.



Gargi Mishra

Microsoft

Dr. Gargi Mishra is a Senior Industry Advisor for Energy & Resources at Microsoft for the MEA region, where she works with mining and energy leaders across the value chain to shape AI driven transformation strategies that deliver measurable business value. She believes that AI transformation is not simply about technology adoption, but about building organisational capability, leadership confidence, and responsible ways of working with technology.

With over 22 years of experience spanning mining, energy, technology, sustainability, and innovation, Dr. Mishra brings deep expertise in strategic foresight, emerging technologies, and responsible digital transformation. She helps organisations move beyond experimentation to unlock value from AI while addressing operational, workforce, and societal challenges.

Her work emphasises the ethical and human dimensions of AI, supporting organisations in adopting AI responsibly, inclusively, and at scale. Combining practical industry experience with systems thinking, she helps leaders navigate complexity and uncertainty in a rapidly changing global landscape.

Dr. Mishra believes the real opportunity with AI lies not in adopting tools, but in building organisational AI capabilities that strengthen operational excellence and enable meaningful transformation. Guided by this belief, she launched the first of its kind AI for Mining Leaders programme in 2025, in partnership with SAIMM – The Southern African Institute of Mining and Metallurgy. The programme brought mining leaders together to move from curiosity to capability – from “What is AI?” to “Here is my first AI agent.”

Designed for leaders rather than technologists, the programme combines strategy with hands on capability building and uses mining specific examples grounded in operational reality.

Dr. Mishra has also served as a sessional lecturer for Executive MBA programmes at a leading business schools, where she taught innovation, digital transformation strategy, and emerging technologies. She has served on international judging panels, including the World Festival and Africa Tech Week Awards, and is a contributing author to Foresight in Focus: Scenario Planning for the Next Industrial Revolution, now used in academic programmes.

Africa's copper supply: Growth, constraints, and value chain participation in the energy transition

L. Mpangala

Project Blue, South Africa

The global transition to a low-carbon economy is accelerating demand for copper, driven by its critical role in electrification, renewable energy systems, and grid infrastructure. Africa, led by the Democratic Republic of Congo and Zambia, is expected to play an increasingly significant role in meeting this demand, with substantial mine supply growth projected over the coming decade. However, despite this resource potential, structural constraints may limit the region's ability to fully capture value from this growth.

This paper provides a comprehensive overview of African copper supply: examining recent trends, key producing regions, and the project pipeline shaping future output. In addition to established producers, it highlights the growing role of emerging jurisdictions such as Botswana, Angola, Namibia and South Africa, which are attracting renewed exploration and investment interest and could contribute to a more diversified regional supply base.

The paper explores the structural constraints that continue to limit production growth and value realisation, including infrastructure bottlenecks, power reliability, regulatory uncertainty, and limited domestic processing capacity.

In parallel, the paper assesses trade flows and market dynamics, highlighting Africa's position within global copper supply chains and its continued reliance on concentrate exports. The implications of evolving geopolitical and commercial relationships, particularly with major refining hubs, are also examined.

Finally, the paper considers the outlook for both supply and demand, situating Africa's copper sector within the broader context of the energy transition. It evaluates the region's potential to move up the value chain, identifying key challenges and opportunities for increased beneficiation and downstream integration.

By linking resource potential with market realities, this paper contributes to the discussion on how Africa can translate copper endowment into sustainable economic value in an increasingly competitive global supply chain.



Loyce Mpangala

Senior Analyst
Project Blue

Loyce Mpangala is a Senior Analyst at Project Blue, specialising in copper, molybdenum, and rhenium markets. With a background in geology, Loyce brings a strong technical foundation to market analysis, combining an understanding of resource development with insights into global supply-demand dynamics.

Her work focuses on analysing mine supply, project pipelines, and trade flows, with particular attention to the evolving role of critical minerals in the energy transition. She has developed expertise in assessing supply trends across key producing regions, including emerging and established jurisdictions.

Loyce has a strong interest in Africa's copper sector and its growing importance within the global supply chain. She is particularly focused on the region's supply growth potential, structural constraints, and opportunities for greater value addition and downstream integration.

Unlocking Africa's critical minerals for industrial growth – governance, legal architecture, and the lessons of implementation

N. Mberé

Webber Wentzel, South Africa

Africa holds an estimated 30% of the world's mineral reserves, encompassing cobalt, lithium, manganese, platinum group metals, copper, and rare earth elements, the foundational inputs for the global energy transition and advanced manufacturing. Yet, despite this extraordinary resource endowment, the continent remains predominantly an exporter of raw and semi-processed minerals, with the bulk of value addition occurring elsewhere. Across Southern Africa, governments are increasingly deploying beneficiation not merely as an industrialisation strategy, but as an explicit instrument of citizen economic empowerment, using mineral wealth as a platform for structural transformation, job creation, and the broadening of economic participation. The policy ambition is legitimate and the political momentum is real. The central question, however, is whether the governance architecture, regulatory frameworks, and institutional capacity exist to translate that ambition into durable industrial outcomes, or whether beneficiation mandates, unenforced and unsupported, risk becoming the latest iteration of a familiar African paradox: abundant resources, persistent underdevelopment.

This paper examines the governance and legal architecture underpinning the critical minerals value chain agenda across the SADC region. It argues that the problem is not an absence of law, the enabling architecture, from the AfCFTA to national beneficiation legislation, is more comprehensive and more sophisticated than this conversation typically allows. What the region consistently struggles with is implementation. Drawing on practitioner engagements conducted through the Botswana Breakfast Series, a structured stakeholder dialogue, the paper grounds its analysis in the real-world constraints and opportunities facing one of the region's most strategically positioned mineral economies, and extracts lessons of broader applicability to the governance of Africa's critical minerals agenda.

The paper first identifies the genuinely sound elements of the existing architecture. At the continental level: the AfCFTA, with its tariff liberalisation, Investment Protocol, and designation of mineral beneficiation as a priority sector; and the SADC Protocol suite, including the Protocol on Trade, the Protocol on Mining, the Industrialisation Strategy and Roadmap 2015–2063, and the Regional Infrastructure Development Master Plan. At the national level: legislative frameworks incorporating beneficiation mandates and Special Economic Zone regimes designed to attract processing investment; enabling reforms to the regulatory environment for green bonds, fintech, and public-private partnerships; and the growing alignment of Development Finance Institutions, including the AfDB, IFC, IDC, and DBSA, with critical minerals value chain development. The Botswana experience illustrates what a well-sequenced national approach can look like: capital markets modernisation through the Botswana Stock Exchange, a structured SOE reform and PPP programme through PEEPA, a promising mineral beneficiation roadmap anchored in its copper and battery minerals endowment, and an ambition to position a landlocked state as a landlinked logistics and industrial hub. On paper, the architecture exists. The challenge is execution.

The paper then interrogates five structural failures that prevent this architecture from translating into industrial outcomes. First, beneficiation mandates remain aspirational across the region: the need to distinguish between Stage 1 beneficiation (concentration, smelting, and refining near the point of extraction) and Stage 2 beneficiation (fabrication and manufacturing of finished products), which carry very different economic, scale, skills, and locational requirements. Conflating the two in a single legislative mandate, as is common in the region, risks imposing obligations that are neither technically feasible nor commercially appropriate for the jurisdiction's current industrial base. Second, and relatedly, citizen empowerment through beneficiation cannot be mandated into existence without the enabling conditions that make it commercially viable: reliable and affordable energy, integrated logistics infrastructure, a skilled workforce, and access to capital. Across Southern Africa, these

conditions remain critically underdeveloped; mandate-driven beneficiation unsupported by enabling infrastructure generates neither sustainable industry nor the employment and economic participation that the empowerment agenda demands. Third, SADC member states frequently design critical minerals policies in isolation, with competing beneficiation mandates fragmenting what could be regionally integrated value chains. A multi-party approach to feedstock validation and metallurgical hub development, of the kind explored in the Botswana context, offers a more viable model than duplicating sub-scale national processing operations. Fourth, governance deficits, including SOE governance failures, judicial capacity constraints, arbitration enforcement risk, regulatory unpredictability, and underdeveloped ESG compliance frameworks, deter the long-term investment that capital-intensive processing infrastructure demands. Fifth, and most fundamentally, the absence of systems-level thinking produces individually sound interventions that do not cohere into a functioning value chain: a smelter requires energy; energy requires infrastructure; infrastructure requires financing; financing requires regulatory certainty; regulatory certainty requires legal reform; and legal reform requires political will. The system is interconnected. Intervening at one node without addressing the others produces limited and often counterproductive results.

The paper concludes with five governance priorities. First, strengthening implementation institutions: dedicated inter-ministerial task forces, comprising Finance, Minerals, Trade, and the Office of the Presidency, at both national and regional level, with clear mandates, accountability mechanisms, and regular progress oversight. Second, prioritising a credible regional energy solution: operationalising the SADC Power Pool is an urgent prerequisite to any beneficiation agenda, and clean energy simultaneously positions African-processed minerals as responsibly sourced, potentially commanding premium pricing in ESG-conscious markets. Third, harmonising the regulatory environment: a comprehensive gap analysis of investment laws, PPP frameworks, listings regimes, and beneficiation legislation, with recommendations for modernisation aligned with SADC and global standards, should be commissioned as a priority, recognising that legal harmonisation does not surrender sovereignty but reduces the compliance costs that erode the region's collective investment attractiveness. Fourth, mobilising blended finance at scale: a structured approach to engaging DFIs including the AfDB, IFC, BII, and FMO for co-funding and technical assistance is essential to converting the currently thin pipeline of bankable beneficiation projects into investment-ready propositions. Fifth, building a coalition of the committed: a focused Joint Government-Private Sector Steering Committee with a core group of decision-makers can develop concrete early deliverables and demonstrate the early wins that build momentum, without waiting for full regional consensus before acting.

The paper's overarching thesis, advanced from the perspective of a legal practitioner advising private sector participants, governments, and institutions across the SADC region, is that the law is not the problem. Rather, the legal framework can, and must, provide the certainty, predictability, and enforceability that investors require before committing capital to long-horizon infrastructure projects. Experience from on-the-ground engagement with mineral and capital market ecosystems across the region demonstrates that these outcomes are practically achievable where reforms are appropriately sequenced, supported by political sponsorship, and underpinned by institutional will.



Nomsa Mbere

Partner
Webber Wentzel

Nomsa is a corporate and commercial lawyer with significant experience advising clients in the mining and resources sector. Her practice focuses on corporate structuring, M&A transactions, and the sale and acquisition of mining assets such as prospecting and mining rights.

She advises on a wide range of mining-related commercial matters, including offtake agreements, contract mining arrangements, sale of concentrates, and logistics contracts, such as freight rail, port handling, and truck logistic and infrastructure-related agreements.

With a deep understanding of the full mining value chain from volume validation, exploration and extraction through beneficiation to market evacuation, Nomsa regularly advises on strategic infrastructure planning, including road, rail, and port integration.

She also supports clients with the implementation of socio-economic development initiatives that incorporate ESG considerations, including economic succession planning in the context of mine closures and the transition to sustainable practices. This includes advising on renewable energy projects, particularly captive power solutions, and contributing to the strategic focus on critical minerals and the green economy.

Her integrated, commercially focused legal advice helps clients navigate complex regulatory and operational landscapes while aligning with long-term sustainability and economic development goals.

Nomsa has authored several articles on the “governance” aspect of ESG and has moderated, chaired, and spoken at a range of mining and ESG-related conferences

Enabling a responsible and competitive critical minerals value chain: Innovation, technology, circularity, and skills development

H.D.O. Brodner, J.S. Ntsoelengoe

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The global deployment of battery electric vehicles, grid-scale energy storage, and renewable generation technologies is increasing demand for critical minerals, including lithium, cobalt, nickel, graphite, and rare earth elements. Under a net-zero emissions scenario, the International Energy Agency projects that lithium demand could rise approximately ninefold and cobalt demand approximately twofold between 2023 and 2040, with the combined market value of key energy-transition minerals doubling to tripling by 2030 (IEA, 2025). South Africa holds globally significant reserves of platinum group metals (PGMs), manganese, vanadium, and chromite, and has reported occurrences and exploration interest in battery-relevant minerals – yet captures limited value from downstream processing and beneficiation.

This paper considers how four connected enablers – innovation, digital and automation technologies, circular economy principles, and skills development – can strengthen the critical minerals value chain and support more responsible performance. It is grounded in South Africa's G20 Presidency Critical Minerals Framework (2025), with particular attention to Pillar 5 (Innovation, Circularity and Technology) and Pillar 6 (Skills, Capacity and Knowledge Exchange). The analysis brings together peer-reviewed literature, policy instruments, and four emerging South African strategic initiatives to identify practical integration opportunities from exploration through to post-mining transition.

Machine learning can improve exploration targeting where good geophysical and geochemical datasets are available. Digital twins and real-time sensor systems can also reduce reagent consumption and tailings generation, although the scale of improvement will differ by commodity, plant configuration, data quality, and implementation maturity. Blockchain-based traceability can support verifiable chain-of-custody data for responsible sourcing compliance; a requirement increasingly reflected in the EU Critical Raw Materials Act (2024) and comparable market expectations.

Circular economy interventions, including tailings reprocessing, acid mine drainage valorisation, and post-mining land rehabilitation, offer resource recovery and liability reduction opportunities. Recent literature shows growing applied research in hydrometallurgical recovery and secondary resource processing, but less emphasis on whole-system life cycle assessment at the mine-region scale, creating targeted research and technology-development opportunities for South African RTOs and universities. Two emerging institutional mechanisms – Mineral Development Zones (MDZs) and Centres of Excellence (CoEs) – are evaluated as platforms for embedding these enablers in regional mining ecosystems. MDZs are conceived as geographically designated full value-chain zones integrating beneficiation infrastructure, STI capacity, circular economy systems, and skills development within a harmonised regulatory environment. Separately, the CSIR was announced as the proposed Talent Development CoE lead within the Future Minerals Forum initiative in January 2025, alongside proposed CoE leads at KACST for technology and innovation and UM6P for sustainability. These mechanisms are evaluated as prospective institutional designs rather than implemented programmes with demonstrated outcomes.

The paper concludes that innovation-led exploration, digital operations, circular resource recovery, and structured skills pipelines can support a more competitive and responsible minerals sector, but only if they are deliberately connected. This requires clear institutional design, inter-departmental coordination, sustained R&D investment, and industry co-design. If properly constituted and funded, MDZs and CoEs offer practical mechanisms for bringing these elements together. The paper identifies implications for policymakers, industry, and research institutions in relation to legislative enablement, inter-departmental coordination, MDZ co-design, METS commercialisation, curriculum alignment, and CoE operationalisation.

Keywords: critical minerals, mineral development zones, innovation, digitalisation, circular economy, skills development, beneficiation, centres of excellence, value chains, South Africa



Sibongile Ntsoelengoe

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Sibongile “Bongi” Ntsoelengoe is a seasoned mining executive with more than 20 years of experience across the mining value chain, spanning operations, project commissioning, process engineering, feasibility studies, strategy, digital transformation, research and innovation, and business development.

A metallurgical and process engineer by training, she has led enterprise-wide technology and innovation strategies that have improved safety, strengthened operational performance, accelerated technology adoption and supported more sustainable mining practices.

She is currently the Executive Cluster Manager for Future Production: Mining at the CSIR, where she leads critical minerals, mining innovation, technology development and commercial applications. Her work focuses on translating research questions into technically practical industry solutions, strengthening regional innovation ecosystems and supporting the development of competitive and sustainable mineral value chains.

Bongi has contributed to national and regional critical minerals initiatives, including the G20 Critical Minerals Framework and programmes aimed at strengthening South Africa’s research, development and innovation capability. Her work has also involved engagement with stakeholders across Southern Africa and internationally, including benchmarking South Africa’s competitiveness against leading mining jurisdictions.

Previously, as Manager of Technology at Kumba Iron Ore, an Anglo-American business, she developed and implemented an integrated technology and innovation roadmap that supported the organisation’s modernisation journey and the deployment of new operational, innovative solutions.

Bongi also brings board-level governance experience as an Independent Non-Executive Director at Fraser Alexander and is actively involved in the Southern African Institute of Mining and Metallurgy, where she contributes to strengthening the mining innovation ecosystem and advancing industry capability.

Skills readiness and capability gaps in implementing South Africa's critical minerals strategy

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The global transition to low-carbon energy has intensified demand for critical minerals, placing significant pressure on Africa's resources. In response, South Africa published its national Critical Minerals and Metals Strategy in 2025, which recognises South Africa's strategic role in the global energy transition, digitalisation, and advanced manufacturing. The strategy outlines a coordinated roadmap to leverage the country's vast mineral endowment to drive inclusive growth, industrialisation, job creating and transformation. A central pillar of the strategy is Building a Skilled Workforce, which recognises that the successful implementation of the strategy depends on the availability of sector-oriented and future-ready skills. The aim of the paper is to assesses the extent to which South Africa's current skills ecosystem is equipped to enable full participation in critical minerals value chains and emerging industries. This is done by mapping skills supply, identifying capability gaps, and evaluating readiness in leveraging opportunities in critical minerals. The study adopted a mixed methods research design, combining quantitative data from surveys with qualitative insights from stakeholder interviews and discussions. Survey findings indicate that several technical skills are critical for supporting critical minerals value chains, with the highest demand identified in processing and beneficiation, followed by manufacturing and downstream applications. Stakeholder interviews emphasised the need for renewed focus on practical, hands-on skills training, alongside growing recognition of digital technologies and artificial intelligence. Additionally, while critical minerals-specific skills are important, there is a stronger need for cross-sectoral competencies that enable long term economic participation beyond short term commodity cycles. Key non-technical skills include leadership and change management, as well as policy and regulatory compliance. Overall, based on the findings of the study, realising South Africa's critical minerals ambitions will require more than mineral endowment alone. It will depend on coordinated efforts to address barriers to skills development in the mining industry, which include strengthening industry and academia linkages, and aligning education and training systems when considering evolving value-chain and industrial needs.



Anna Gowera

University of the Witwatersrand

Anna Gowera is an environmental and occupational health and safety (OHS) professional with over ten years' experience across mining, power generation, electricity distribution, construction, manufacturing, systems auditing and root cause analysis, and tertiary education. She brings a combination of environmental management, operational OHS expertise, and research led systems thinking to advancing responsible and context-informed mining.

Anna is currently a PhD candidate in Environmental Sciences at the University of the Witwatersrand, affiliated with the Wits Mining Institute and the School of Animal, Plant and Environmental Sciences. Her research examines the socioecological impacts of informal mining on rural communities in South Africa's chrome mining regions, integrating satellite remote sensing, environmental analysis, and community based qualitative research to understand land use change, environmental risk, ecosystems perspectives, and livelihood dynamics in mining affected landscapes. She is also engaged in industry-

based research on South Africa's critical minerals skills needs, and on the evolving occupational health and safety landscape as pertains to mining modernisation. Her work sits at the intersection of environmental sustainability, occupational health and safety, and the evolving demands of the critical minerals transition.

Alongside her doctoral work, Anna has led and contributed to applied, industry-facing initiatives in critical minerals research, occupational health and safety, and the development and delivery of training curricula. She works with stakeholders across South Africa and international research networks, contributing to collaborative, solutions-oriented approaches to sector challenges. This work is contributing to an emerging body of research outputs on critical minerals and mining transitions, including a forthcoming publication. She was a panellist at the 2026 Mining Indaba, contributing to the discussion "Can you make mining more sustainable?". Anna has also been featured on a critical minerals podcast for the European Union funded HERawS (Highlights on European Raw Materials Sustainability) initiative. In her SAIMM Critical Minerals Conference presentation, Anna will discuss the skills gaps and capacity demands influencing South Africa's readiness for participation in global critical minerals value chains.

Committed to knowledge sharing and transdisciplinary collaboration, she actively participated in research fellowships addressing real-world sustainability challenges. This includes work on Vancouver Island, Canada, where she co-developed a community-focused action plan to address invasive alien plant species impacting local ecosystems and livelihoods. Additionally, she was part of a collaborative summer school project in Postojna, Slovenia, focused on conceptualising and scaling a green hydrogen based critical minerals initiative. Her interests include governance, behavioural and cultural dimensions of occupational safety, and inclusive pathways for sustainable mineral development. She also supervises mines and minerals sector-based research and supports the development of emerging mining occupational health and safety professionals.

Advancing REE extraction and separation readiness from primary and secondary resources at Mintek

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Mintek, South Africa

Rare earth elements (REEs) are essential to modern technologies, including permanent magnets, renewable energy systems, and advanced electronics. Despite its long mining history across a range of commodities and its hosting of one of the world's highest-grade monazite deposits, South Africa currently has no active REEs mine. However, renewed momentum is evident in ongoing efforts to revive the Steenkampskraal deposit, advance the development of Zandkopsdrift, and evaluate the recovery of REEs from Phalaborwa phosphogypsum, signalling growing potential for a domestic REEs value chain. In support of these developments, Mintek has established a strong hydrometallurgical capability for processing South African RE-bearing resources, demonstrated through work on both monazite and phosphogypsum. These case studies highlight locally-developed expertise in REEs extraction through acid and caustic-based leaching routes, followed by solution purification using precipitation and solvent extraction techniques to produce upgraded mixed REEs products suitable for downstream separation. Current work focuses on solvent-extraction-based separation of REEs using several extractant systems, encouraging progress toward separating heavy REEs from light and middle REEs fractions. These advances support ongoing efforts to establish an REEs separation capability at Mintek as part of a broader national initiative to enable downstream beneficiation of local REEs resources.

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Siyabonga Sipho Nkabinde

Senior Scientist
Mintek

Dr. Siyabonga is a Hydrometallurgist specializing in developing and optimizing extractive metallurgy flowsheets for critical and strategic metals. His work focuses on leaching, solution purification, and solvent extraction to recover critical metals from primary and secondary resources. He has led and contributed to research programs supporting South Africa's rare earth value chain, including the processing of monazite and phosphogypsum. He is experienced in experimental design, test work coordination, metallurgical performance evaluation, and actively supports project development, funding proposals, and postgraduate supervision in collaborative research environments.

Repurposing coal fly ash and phosphogypsum waste material for the recovery of critical minerals

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There is a growing demand for critical minerals, particularly rare earth elements (REEs) that is causing the need for alternative and sustainable sources of energy beyond conventional mining. It is important to note that coal fly ash (CFA), a by-product of coal-fired power generation and phosphogypsum production, is an extremely valuable but underutilised secondary resource that is rich in rare earth elements, as well as other critical elements.

This work focuses on the repurposing of CFA derived from South African coal, along with phosphogypsum, for the recovery of rare earth elements and other critical minerals essential to modern technology in order to improve their use. This work examines the chemical and mineralogical characteristics of both CFA and phosphogypsum in order to better understand the occurrence and distribution of target elements within these complex matrices.

An inductively coupled plasma mass spectrometry (ICP-MS) analysis is performed after the sample has been prepared and digested according to the appropriate procedure. Additionally, different extraction techniques, including acid leaching, are being investigated for the purpose of determining their applicability for removing critical minerals from waste streams in a selective manner.

This study aims to develop a framework of integrated analytical and processing techniques for valuing coal fly ash and phosphogypsum within the minerals industry, in order to support the use of coal fly ash and phosphogypsum as commodities. As a result of this work, we are making significant contributions to sustainable resource utilisation, reducing environmental liabilities, and establishing alternative supply chains for critical minerals.

Keywords: Coal fly ash (CFA); Phosphogypsum; Rare earth elements (REEs); Critical minerals; ICP-MS; Acid leaching; Waste valorisation; Secondary resources; Sustainable resource recovery



Tshilidzi Rampfumedzi

Scientist
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Tshilidzi Rampfumedzi is a Scientist in the Analytical Chemistry Division at Mintek, specializing in the analysis of Platinum Group Metals (PGMs) and Rare Earth Elements (REEs). He holds an MSc in Chemistry and is currently pursuing a PhD focused on the determination and recovery of REEs from coal fly ash. His expertise includes advanced analytical techniques such as ICP-OES, ICP-MS, XRF, AAS, Ion Chromatography, and Fire Assay, with strong experience in method validation and ISO/IEC 17025-accredited laboratory systems. Tshilidzi has contributed to research and development projects involving complex matrices and is actively involved in scientific writing, including journal publications, conference and technical reporting. His research interests focus on sustainable resource recovery and the application of analytical chemistry to environmental and industrial challenges.

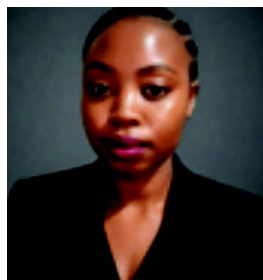
Thermally-induced phase transformation of phosphogypsum for rare earths recovery

X.V. Rikhotso, J. Sehata, A. Mkhohlakali, H.M. Mabowa, L. Chimuka, J. Tshilongo

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The increasing global demand for critical minerals, particularly rare earth elements (REEs), has increased the search for sustainable and alternative resource streams. While primary deposits remain the dominant sources, secondary materials such as phosphogypsum (PG), a by-product of phosphoric acid production, represent a significant underexploited reserve of REEs, which are significant for advanced technologies. This paper investigates the thermal activation as a pre-treatment to modify the PG matrix to enhance REEs accessibility and leaching efficiency. The approach aims to investigate and understand the impact of thermal treatment on the mineralogy and chemical composition of PG and to effect crystallographic changes, such as phase changes or increased porosity. Inductively coupled plasma-mass spectrometry is used for the analysis of REEs from the dissolved samples. Recovery of REEs from PG promotes sustainable minerals beneficiation while reducing industrial waste impacts and improving the circular economy by converting waste into critical minerals. REEs recovery from secondary sources reduces reliance on primary mining, while addressing waste management and diversifying supply chains, thereby contributing to environmental sustainability.

Keywords: Rare earth elements, secondary resource, phosphogypsum, thermal activation, ICP-MS, critical minerals



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TXikhongelo Rikhotso is a scientist in the Applied Chemical Analysis Division at Mintek, with over six years of experience in the analytical chemistry field. She holds a master's degree in chemistry from the University of the Witwatersrand and is currently pursuing a PhD in chemistry at the University of the Witwatersrand. Her research is focused on valorising secondary resources to recover rare earth elements (REEs), aligning her academic work with industry-relevant challenges.

Her expertise lies in the advanced spectroscopic instrumentation (ICP-MS and ICP-OES) applied to geological, environmental, and industrial samples. She has extensive experience in the analysis of critical minerals, supporting the growing demand for accurate characterisation of materials essential to modern technologies and sustainable energy solutions.

She has contributed to several research outputs. Her publications include work on PGOSBA-15 composites for environmental remediation, studies on the selective separation and quantification of U and Th, and she has co-authored in the rare earths element research conducted at Mintek. These contributions demonstrate her ability to integrate analytical chemistry with environmental research, particularly in the context of critical and strategic minerals.

Department of calcium, aluminium, silica, iron, and phosphorus during caustic cracking of monazite ores: Effect of impurity accumulation in recycled caustic liquor on cracking performance

S. Mokoena¹, Beberto Baloyi¹, G. Ndlovu¹, E. Muller¹, P. Petersen², T. Mokone²

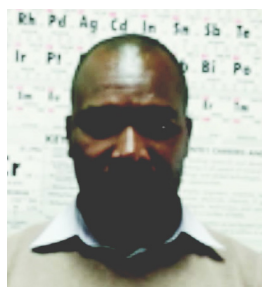
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The caustic cracking process route is considered as one of the most efficient options for pretreatment of monazite to recover rare earth elements. The process converts highly stable rare earth phosphate minerals into acid soluble rare earth hydroxide. During this process, the phosphate ions form trisodium phosphate which is used as a fertiliser, and this makes the process preferable to other processes.

During caustic crack process, sodium hydroxide reacts with the monazite mineral as well as impurity elements such as quartz, iron, calcium and aluminium to form various sodium compounds. The phosphorus that is associated with monazite and other species forms trisodium phosphate which could be recovered as a by-product of the process. Moreover, due to excessive sodium hydroxide addition, the unused sodium hydroxide reports to the solution stream. This paper proposes that the solution stream be recycled to increase the utilisation factor of sodium hydroxide. An investigation carried out on two different monazite-bearing ores indicated variable aluminium and silica dissolutions while iron and calcium yielded low dissolution on both samples. The dissolution of aluminium and silica seemed to be influenced by the mineral phases of these elements. Preliminary results show that silica associated with quartz is insoluble while other silicate minerals were soluble in caustic solution. The cracking performance which is measured by the leaching of phosphorus from the monazite ores fluctuated between 72 and 80% for the high-grade monazite ore and 72 and 88% for the low-grade monazite ore. The results indicate that recycling of the caustic solution had no significant impact on the overall cracking performance.

Keywords: monazite, caustic, cracking, pretreatment, rare earth elements



Sam Mokoena

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Sam Mokoena is currently a Principal Process Engineer at Mintek in the Hydrometallurgy Division. He holds a Bachelor of Science in Chemical Engineering degree obtained from the University of Witwatersrand in 2007 and Bachelor of Commerce in Business Management obtained from the University of South Africa in 2019. He has vast experience in extraction metallurgy, focusing on process and flowsheet development and process optimisation. He has worked on many commodities including copper, cobalt, zinc, manganese, nickel, pgms, rare earth elements, etc.

In addition to his experience in extractive metallurgy, he has been involved in water treatment projects and front-end engineering designs for several flagship projects.

Particle swarm optimisation of rare earth elements recovery from coal fly ash using wet magnetic separation

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Rare earth elements (REEs) are critical materials redefining modern technologies, including permanent magnets, MRI imaging systems, and renewable energy generators. South Africa produces approximately 25 million tons of coal fly ash annually, of which only 7 - 10% is recycled, representing a significant untapped secondary source of REEs, including neodymium, lanthanum, cerium, terbium, and yttrium. Current recovery approaches rely predominantly on direct acid leaching and flotation without preconcentration, resulting in insufficient REE recovery and grade. Additionally, existing magnetic separation studies focus primarily on the removal of magnetic minerals such as magnetite and hematite, with limited investigation into optimising parameters for REE preconcentration from the non-magnetic fraction. This paper aims to determine the optimal process parameters for maximising REE recovery and grade from South African coal fly ash using wet magnetic separation as an upgrading technique. Dry low-intensity magnetic separation will first remove the magnetic mineral fractions, followed by wet high-intensity magnetic separation to isolate paramagnetic REE-bearing minerals. Key process parameters, including feed rate, temperature, pulp density, magnetic field strength, and particle size, will be systematically investigated. Particle swarm optimisation, a metaheuristic algorithm, will be used to efficiently identify optimal parameter combinations while minimising experimental iterations. Characterisation of feed material and separation products will be conducted using X-ray diffraction, scanning electron microscopy, and induced plasma mass spectroscopy. The findings are expected to establish a sound preconcentration framework for REE recovery from coal fly ash, contributing to South Africa's competitiveness in the growing global REE market.

Keywords: Particle Swarm Optimisation, Magnetic separation, Coal fly ash



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Tapiwa is a BEng Tech graduate in Physical Metallurgy from the University of Johannesburg (UJ) pursuing a Beng Tech Honours in Metallurgical Engineering and currently gaining hands-on experience as an intern in UJ's Mechanical Metallurgy department. He has a strong foundation in materials science and a passion for sustainable material development and selection. He's dedicated to advancing engineering solutions that are both efficient and environmentally conscious. With enthusiasm for public speaking, he has represented the University of Johannesburg twice in the annual student debate having won it twice, complementing his technical abilities as well. He's an active student member of the SAIMM YPC, the current academic officer of the Metallurgical Engineering Students Association (UJ) and seeks to grow within the minerals and metallurgy industry.

Solvent extraction and separation of light rare earth elements from acid mine drainage

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The availability of raw materials is crucial to our society. In many applications, critical minerals like light rare earth elements (LREEs) are essential. Future exploitation of secondary sources is strongly considered because a variety of variables limit their virgin mining and production. One significant source of LREEs is acid mine drainage (AMD) from both current and historical mining operations. In this paper, a systematic evaluation is made of the recovery of REEs from gold mining AMD using solvent extraction. The results demonstrated that a diluted sulfuric acid solution produced the best dissolutions of light REEs (>95%). After leaching, different organophosphorus extractants, such as D2EHPA and Cyanex 572, were used in solvent extraction to selectively remove REEs from the leach solution. D2EHPA and Cyanex 572 achieved extractions that were nearly 100%. Increasing the contact time and pH of the leaching liquid had a positive effect on the extraction of LREEs, as demonstrated by the solvent extraction experiments. Three stages were required to extract LREEs, according to McCabe-Thiele diagrams for extraction using D2EHPA.



Jeffrey Baloyi

Senior Chemical Engineer

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Dr. Baloyi is a Senior Chemical Engineer, Council for Scientific and Industrial Research (CSIR), South Africa. He is a Professional Registered with the Engineering Council of South Africa (ECSA). He holds a PhD from the University of Witwatersrand and MSc Project Management from University of Pretoria. Dr. Baloyi, is a highly accomplished professional with over 15 years of experience in mining and industrial research and development. Dr. Baloyi was featured by Mail & Guardian in 2020 as 200 Young South Africans - Category: Science and Technology.

Optimising spodumene concentration using sensor-based sorting and heavy liquid separation tests: A case study in Brazil

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Sensor-based sorting (SBS) offers innovative methods to optimise the concentration flowsheet of spodumene, a key lithium-bearing mineral. Using XRT, optical and near-infrared sensors, SBS identifies and separates spodumene from waste material based on physical properties. Applied as preconcentration stages, SBS enhances ore processing efficiency, increases valuable mineral yield, and reduces operational costs and environmental impacts. The heavy liquid separation (HLS) test is crucial for determining the feasibility of upgrading via gravity separation techniques like dense media separation (DMS). The paper proposes combining SBS and HLS tests to develop an efficient processing route for spodumene in a lithium pegmatites project in Brazil. Integrating DMS and SBS can produce cleaner spodumene concentrates, minimise environmental impact and operational costs, and improve resource management. This approach significantly enhances the economic viability of lithium extraction and advances the green energy sector.

Keywords: Sensor-based-sorting, Pre-concentration, Test work, Heavy Liquid Separation, Dense Media Separation, Spodumene, Critical Minerals

Jean Bosco Makola

Steinert GmbH



Jean Bosco Makola is the Regional Sales Manager – Africa for STEINERT GmbH, where he leads business development and strategic growth across the African mining sector, specializing in advanced sensor-based ore sorting and magnetic separation technologies. With more than 14 years of experience spanning metallurgy, mineral processing, technical sales, and business strategy, he has established himself as a trusted advisor to mining companies seeking innovative solutions to improve operational efficiency, resource recovery, and project economics.

Jean holds a Master of Business Administration (MBA) from Henley Business School, where his research focused on unlocking circular economy opportunities in Africa's mining industry through the reprocessing of secondary raw materials. He also holds an Honours Degree in Technology and Innovation Management from the University of Pretoria and graduated Cum Laude with a Bachelor of Technology in Chemical Engineering from the Vaal University of Technology.

Since joining STEINERT in 2024, Jean has been responsible for expanding the company's presence across Africa, developing strategic partnerships, managing complex customer projects, and supporting the successful implementation of sensor-based sorting technologies. His work has included leading test work programmes in Germany and South Africa, supporting feasibility studies, and developing solutions for copper, iron ore, lithium, gold, coal, and industrial mineral applications.

Prior to joining STEINERT, Jean spent almost a decade with Derrick Corporation, progressing from Sales Engineer to Sales Manager for Africa. During this period, he played a key role in expanding the company's footprint throughout West and North Africa while managing multicultural teams and supporting numerous mineral processing projects across the continent.

Earlier in his career, he worked as a metallurgist at Spectrum Technical and Anglo Platinum, where he gained practical experience in copper processing, plant optimisation, quality management, and metallurgical operations, building a strong technical foundation that continues to support his customer-focused approach today.

Jean is passionate about bridging the gap between innovative technology and practical mining applications. His professional interests include sensor-based ore sorting, fine vibrating screens, and mineral processing optimisation, critical minerals, and sustainable mining practices that support the transition towards a circular economy. Through his work, he actively collaborates with mining companies, engineering consultants, research institutions, and industry stakeholders to demonstrate how advanced pre-concentration technologies can improve recoveries, reduce energy and water consumption, lower greenhouse gas emissions, and unlock value from previously uneconomic mineral resources. He is a regular participant in international mining conferences and technical forums, where he shares practical experience on the application of emerging technologies to improve the future of mining in Africa.

Metallurgical performance of an industrial Concorde Cell in various streams of a PGM concentrator

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A PGM concentrator in South Africa acquired a single Blast Tube DN250 Concorde industrial scale unit in 2020. The Concorde unit was used for continuous testing on various streams and compared to the metallurgical performance of the plant. Blast Tube flowrate rated at 75 m³/h. Streams tested included rougher feed, scavenger feed and cleaner feed. Once the optimum stream was found, the unit was transferred to another PGM site of the same company for permanent installation. While the Concorde Cell could not outperform the first mechanical cells of the equivalent bank in terms of recovery, it produced much higher upgrade ratios, consistently achieving final concentrate grade across the streams tested for up to 30% stage recovery. This paper will present the metallurgical performance of the Concorde Cell depending on the stream and on the operating parameters



Rolivhuwa Munyenyiwo

Metso

Rolivhuwa is a metallurgical professional with Metso, specializing in flotation test work. Her work includes flotation test work, commissioning, and client focused reporting, with a growing focus on flotation technologies and their application in the mineral processing environment.

She has contributed to Concorde Cell™ test programs, combining practical test execution with process modelling and mass balance analysis. His role involves preparing technical plans, presenting results, and ensuring clients clearly understand the scope and outcomes of test work.

Rolivhuwa is passionate about advancing mineral processing through innovative flotation solutions and clear communication of technical findings. She has delivered structured presentations and reports that highlight actionable insights for both colleagues and clients.

At the Critical Minerals Conference, Rolivhuwa will present on the metallurgical performance of an industrial Concorde Cell™ in various streams of a PGM concentrator, sharing results from recent work and demonstrating the potential of advanced flotation technologies in improving concentrator performance.

Optimisation of copper-cobalt extraction using response surface methodology coupled with Bayesian neural networks

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²Mineral Processing and Technology Research Centre, South Africa

This paper presents a novel synergistic framework integrating Response Surface Methodology (RSM) with Bayesian Neural Networks (BNNs) to optimise copper-cobalt extraction. A Box-Behnken experimental design (BBD) was used to systematically investigate the effects of key extraction variables, including extraction temperature, solid-to-liquid/solvent-to-feed ratio, and reaction time. The experimental matrix generated a dataset relating process conditions to metal recovery efficiency, enabling the development of both statistical and probabilistic predictive models. An RSM quadratic model was first fitted to capture the main and interactive effects among the selected factors. In parallel, a BNN was trained as a data-driven surrogate model to learn nonlinear relationships between extraction parameters and copper-cobalt recovery. Bayesian learning was leveraged to provide predictive uncertainty alongside mean performance, improving model reliability for decision-making during optimisation. Model performance was evaluated using k-fold cross-validation, comparing predictive accuracy and generalisation capability between the RSM model and the BNN. To interpret model behaviour and identify influential process variables, model-agnostic sensitivity/importance analyses were performed, highlighting the dominant effects of the extraction conditions on copper-cobalt dissolution and recovery. The RSM-BNN coupling approach was then applied to guide optimisation toward conditions predicted to maximise recovery while maintaining practical process constraints. Under optimised conditions, the proposed framework yielded a validated improvement in copper-cobalt extraction compared with RSM-only optimisation, demonstrating the effectiveness of uncertainty-aware Bayesian modelling for complex leaching systems.

Keywords: Response Surface Methodology, Machine Learning, XGBoost, SHAP, Extraction Optimisation, Box-Behnken Design, Green Chemistry



Tapiwa S. Zireva

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Tapiwa is a BEng Tech graduate in Physical Metallurgy from the University of Johannesburg (UJ) pursuing a Beng Tech Honours in Metallurgical Engineering and currently gaining hands-on experience as an intern in UJ's Mechanical Metallurgy department. He has a strong foundation in materials science and a passion for sustainable material development and selection. He's dedicated to advancing engineering solutions that are both efficient and environmentally conscious. With enthusiasm for public speaking, he has represented the University of Johannesburg twice in the annual student debate having won it twice, complementing his technical abilities as well. He's an active student member of the SAIMM YPC, the current academic officer of the Metallurgical Engineering Students Association (UJ) and seeks to grow within the minerals and metallurgy industry.

Selective copper removal from anode slimes via acid leaching: Implications for critical mineral recovery

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Copper anode slimes from the Mufulira refinery at Mopani Copper Mines contain elevated copper levels (18%), which adversely affect the grade and recovery of valuable metals in downstream processing. Effective decopperisation is therefore required to enhance the recovery of precious and critical elements. This paper investigates the removal of copper from anode slimes to below 5% using hot acid leaching under controlled laboratory conditions. Key process variables including leaching time (1-3 h), temperature (60-80°C), pH (0.9-1.5), pulp density (25-35% solids), and oxidant addition were systematically evaluated in sulfuric acid media. Results show that leaching without an oxidant yielded moderate copper extraction (40-54%) after 3 h, with performance improving with increasing temperature and acidity but reaching a plateau. In contrast, oxidant-assisted leaching using hydrogen peroxide significantly enhanced copper dissolution, achieving extraction efficiencies exceeding 90% with rapid kinetics in the first 1-2 h. An optimum operating window was identified at 3 h, 60°C, pH approximately 1.0, and 25-30% solids with oxidant addition, reducing copper in the residue from 18% to 1.7%. The results demonstrate improved selectivity, preserving valuable metals in the residue for downstream recovery. The study highlights the potential of optimised hydrometallurgical processing of anode slimes to improve resource efficiency and support critical mineral recovery. Industrial implementation, reagent optimisation, environmental management, and pilot-scale validation are recommended to facilitate integration into the Mufulira refinery flowsheet.



Chinyanta Ndhlovu

Final Year Metallurgical Student and Researcher
Copperbelt University

Chinyanta Ndhlovu is a final-year Metallurgical Engineering student at the Copperbelt University, Zambia, with a strong academic and practical focus on hydrometallurgy and copper processing. His research centres on the decopperisation of copper anode slimes using hot leaching techniques, conducted in collaboration with Mopani Copper Mines. His work aims to improve process efficiency, enhance selective metal recovery, and support sustainable extraction within critical mineral value chains.

He has been actively involved in industrial exposure and plant familiarisation, gaining practical insight into electrowinning, smelting, and process optimisation. Chinyanta is passionate about advancing metallurgical solutions that contribute to resource efficiency and environmental sustainability in the mining sector.

He is an emerging professional dedicated to research, innovation, and continuous learning within the global minerals and metallurgical industry.

Beneficiation of critical minerals from mine tailings: Microstructural insights and processing opportunities

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The recovery of critical minerals from mine tailings represents a strategic opportunity to support resource security and sustainable mining. This abstract investigates the mineralogical, chemical, and microstructural characteristics of gold (M1) and base metal (M2) tailings to evaluate their potential for critical mineral beneficiation.

A multi-scale characterisation approach combining SEM, automated mineralogical mapping (TIMA), XRD, and micro-CT was employed to assess phase distribution, mineral liberation, and pore connectivity. These parameters are critical in determining the efficiency of downstream beneficiation techniques such as flotation, magnetic separation, and hydrometallurgical extraction.

Results indicate that M1 tailings are dominated by quartz with limited liberation of value-bearing phases, constraining recovery potential. In contrast, M2 tailings exhibit a more complex mineral assemblage with enhanced liberation characteristics, making them more amenable to beneficiation. Microstructural analysis highlights the role of particle association and pore structure in influencing reagent accessibility and recovery efficiency.

The findings demonstrate that tailored beneficiation strategies, informed by detailed microstructural and mineralogical analysis, can enhance the recovery of critical minerals from legacy tailings. This approach supports both economic value extraction and environmental rehabilitation, positioning mine tailings as secondary resources within the critical minerals supply chain.

Khuthadzo Mudzanani

R&D Engineer

Mintek

Khuthadzo Mudzanani is a mining and metallurgical engineering professional with a focus on mine tailings, critical minerals, and sustainable beneficiation. She has experience in gold processing operations, particularly in CIP (Carbon-in-Pulp) circuits, where she has worked with key plant parameters such as carbon measurement, and adsorption performance to support efficient gold recovery.

She is interested in practical, real-world solutions that improve process performance while reducing waste and unlocking value from existing resources. Her work is driven by a desire to contribute to more sustainable and responsible mining practices, especially through the recovery and use of secondary materials within the critical minerals value chain. Khuthadzo is committed to bridging the gap between plant operations and long-term environmental and economic sustainability.

Moving more than minerals: Railway corridors as enablers in SADC's critical minerals economy

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The Southern African Development Community (SADC) railway corridors have historically enabled bulk mineral exports; however, this model captures limited value, employment, and returns for the region. The SADC region has a compelling investment case for repositioning rail corridors as bankable industrial platforms that anchor beneficiation, regional value chains, and cross border industrial clustering. Such a shift can reduce risk, improve throughput, and enhance project bankability. For development finance institutions and governments, this approach creates scalable opportunities where infrastructure investment, industrial policy, and risk sharing mechanisms converge to unlock sustainable regional integration and inclusive growth.

Enhancing logistics corridor performance through informed decision-making

R.A. Dondofema

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The logistics sector is important for the growth and sustainability of any industrial sector that transports freight, including mining. An efficient and effective logistics network reduces the cost of doing business and improves the competitiveness of organisations that depend on that network. Challenges in the South African logistics network leads to high logistics costs compared to our main trade partners and competitors. Inefficiencies in freight logistics are hindering industrial investments and are, in some cases, leading to disinvestment.

The network's ineffectiveness has been identified as a significant challenge, posing a threat to sustainable economic growth. Evidence-based decision-making needs to be based on good information. The opportunity exists to develop South Africa's logistics information infrastructure in support of performance monitoring and informed decision-making. This enhances the capability to make effective choices when developing interventions that could enhance the system. Furthermore, transparent information systems that clearly show the performance of various network elements has the potential to enhance stakeholder trust.

Interventions to improve logistics performance should focus on systemic improvements rather than isolated projects. There are many information platforms developed in South Africa aimed at improving corridors operations; however it is yet to be seen how exactly these platforms impact corridors' performance and how stakeholders are using these platforms.

We propose to use the Logistics Observatory and Logistics Accountability Scorecard to demonstrate how these tools can be used by decision makers to influence corridor performance.



Richmore Aron Dondofema

Senior Engineer

Council for Scientific and Industrial Research

Richmore is currently a Senior Engineer at CSIR under the Smart Mobility Cluster and an expert in macro logistics and supply networks analysis. With a background in Industrial Engineering, he uses a systems approach to analyse complex problems and understand the operational dynamics of our national key corridors. He is using his expertise to inform, analyse, and facilitate solution generation within the national logistics system. Richmore is part of a technical team that spearheads and supports the formulation of frameworks and technical documents, edits strategies, and occasionally edits journal articles aligned with his expertise. Richmore holds a PhD in Industrial Engineering and a Master's in Industrial Engineering from the University of Stellenbosch.

Agile logistics practices to foster low-carbon economy in South Africa's minerals transportation

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The reduction of carbon emissions in South Africa's mining transportation sector is essential for achieving national sustainability objectives and complying with global climate commitments. Flexible logistics approaches, driven by adaptability, digitisation, and multimodal integration, present an innovative way to decrease carbon emissions while enhancing competitiveness. This paper looks at how transferring freight from road to rail, aided by multimodal hubs, may reduce transportation emissions of South Africa's mining transportation industry. It emphasises the importance of digital technologies like IoT sensors, AI-enabled routing, and blockchain monitoring in maximising fleet utilisation and assuring compliance with forthcoming carbon border adjustment methods. The goals of a circular economy are supported by initiatives in green procurement, which include the use of recyclable packaging and collaborations with low-carbon suppliers. The significance of local resource utilisation and shorter supply chains is reinforced by consistency and its connection to South Africa's Critical Minerals and Metals Strategy (2025). This research suggests that Agile logistics emerges as an effective approach for decarbonisation in mineral transportation, concurrently strengthening its role in the global low-carbon economy, even though it faces infrastructure limitations. Therefore, the paper argues that through incorporating rail development, digital tracking technologies, and sustainable procurement strategies, South Africa can not only reduce emissions but also enhance regional trade and secure a more prominent position in the international low-carbon market.



Mamly Hildah Serero

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A researcher, entrepreneur, and tutor with a civil engineering background and experience in motivational speaking. Holds various diplomas and currently pursuing a Master's in Quality Engineering. Consistently ranked among the top 4 in class, actively engages in teaching and cultural programs. Demonstrates a teachable spirit and a commitment to excellence. Focused on research to improve organizational operations and ensure quality standards in projects, aiming to help companies remain competitive in the global market. Provides strategic and operational support for project execution and monitoring across disciplines, with a positive attitude towards goal achievement and empowering others. Follows the motto: "never stop pursuing your dreams and keep on working on winning." Her hobbies reflect a dedication to both personal growth and community involvement, wherein she actively learns about recent engineering practices and serves as a mentor to undergraduate students. In addition to her educational pursuits, she is passionate about enhancing the product life cycle, managing risks associated with mining operations, and implementing Quality Management Systems within the foundry sectors. This combination of interests showcases her commitment to field advancement and the development of future engineers.

Global competitiveness assessment of South African manganese mining: A benchmarking study of production, reserves and infrastructure access

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Manganese has been listed as a critical mineral both domestically and globally due to its role in green energy technologies. This paper evaluates the competitiveness of South Africa's manganese extraction by benchmarking its performance against key competing countries – Australia, Gabon and India. A mixed methods approach was adopted to analyse country-level and mine-level data for production, reserve quality, and infrastructure accessibility using 2023 data.

Findings indicate that South Africa holds the largest manganese reserves in the world (600 Mt), concentrated in the Kalahari Manganese field. South Africa and Australia demonstrate high production and high export volumes compared to Gabon and India, while India shows higher internal consumption and beneficiation.

Considering individual manganese mines in South Africa, Tshipi Borwa had the highest saleable production (3.30 Mtpa) and the highest recovery rate (91.5%), potentially indicating favourable ore characteristics, efficient processing, and a strong alignment to market specifications. South African open-pit mining operations had stripping ratios of between 2 and 4, suggesting an extraction cost advantage.

Geospatial analysis revealed that the South African mines are well-located considering their access to service towns and larger centres. They are in a more favourable position compared to the Australian and Gabonese mines. The South African mines all score highly when considering their road and rail access. They have rail lines near the mine as well as primary road access. This places South African mines in a favourable position compared to their competitors.

Although South Africa can benefit operationally from these advantages, these advantages are not fully realised due to inefficiencies leading to logistical bottlenecks and deteriorating rail performance. The lack of downstream beneficiation further threatens its competitive positioning in the global critical minerals landscape. These logistical challenges consequently increase export costs. In comparison, competitors such as Australia and Gabon have more efficient logistics and favourable investment environments.

Primary cost data for the South African manganese sector was limited, thereby highlighting the need for dedicated data collection programmes for the manganese sector.

There are opportunities for South Africa to enhance the competitiveness of its manganese sector by developing local high-purity manganese sulphate monohydrate (HPMSM) processing plants for value-addition, through exploring a regional approach to developing the manganese value chain, enhancing the efficiency of rail and port infrastructure to improve logistics, improving resource confidence through exploration, expanding reserves through technology adoption, and identifying new ports to support manganese exports.



Sumaya Khan

Senior Researcher
Council for Scientific and Industrial Research (CSIR)

Sumaya Khan is a researcher and project leader in sustainable mining and critical minerals, currently working at the CSIR Mining Cluster. Her work focuses on strengthening the global competitiveness of South Africa's emerging critical minerals sector through integrated approaches that combine policy analysis, value chain optimisation, and sustainability.

She leads and contributes to multidisciplinary research programmes covering critical mineral value chains, circular economy in mining, and people-centred mining modernisation. Her work places particular emphasis on unlocking midstream opportunities and embedding ESG and circularity principles to drive long-term industrial development.

Sumaya has been actively involved in high-level stakeholder engagements across government, industry, and research institutions, contributing to strategic initiatives on mineral policy, localisation, and emerging battery value chains. She brings a strong analytical foundation, with experience in comparative global benchmarking and competitiveness assessments across critical minerals including manganese, platinum group metals, iron ore, chromium and copper.

From endowment to prosperity: Unlocking Southern Africa's critical minerals opportunity

G. Lane

Vuuma, South Africa

Southern Africa stands at a pivotal moment in its development. The global energy transition, growing demand for critical minerals, supply chain diversification and increasing geopolitical competition for strategic resources have created a once-in-a-generation opportunity for the region. With globally significant deposits of platinum group metals, manganese, chrome, copper, cobalt, lithium, rare earth elements and other strategic minerals, Southern Africa has the potential to become a globally competitive critical minerals hub and a major contributor to future industrial value chains.

Yet history has repeatedly demonstrated that mineral endowment alone does not create prosperity. Resource-rich regions succeed not because of the minerals they possess, but because of their ability to convert natural endowment into investment, industrial development, employment creation and long-term societal value. The central question facing Southern Africa is therefore not whether it possesses the necessary resources, but whether it can organise itself to capture the opportunity.

This paper argues that Southern Africa's critical minerals opportunity is fundamentally not a resource challenge, but an endowment stewardship challenge. The region already possesses three strategic endowments required for success: a mineral endowment, an infrastructure endowment and a capability endowment.

The mineral endowment provides the foundation for opportunity. The infrastructure endowment, including strategic rail corridors, ports, energy systems, logistics networks and industrial assets, provides the means to connect resources to regional and global markets. The capability endowment, comprising universities, technical and vocational institutions, research organisations, professional bodies, industry development programmes and leadership pathways, provides the human capital required to develop, operate and continuously improve these systems over time.

Individually, these endowments are significant. Collectively, they represent one of Southern Africa's greatest competitive advantages. However, they are frequently planned, governed, funded and developed as separate systems. Infrastructure planning is often disconnected from capability development. Capability development is frequently disconnected from industrial strategy. Investment decisions are commonly made without consideration of the broader ecosystem required to sustain long-term value creation. The challenge is not the absence of individual components, but the absence of a coherent system that aligns them around a shared development agenda.

Drawing on practical experience from strategic mining corridors, export infrastructure development, capability development initiatives, professionalisation programmes and regional collaboration efforts, the paper explores how governments, industry, financiers, academia, professional institutions and civil society can work together to strengthen the connections between these endowments. It proposes a systems approach to ecosystem stewardship and examines the role of governance, collaboration and collective leadership in transforming fragmented initiatives into an integrated development system capable of supporting globally competitive critical minerals value chains.

The paper argues that future competitiveness will be determined not by the scale of mineral resources alone, but by the effectiveness with which regions integrate and steward their mineral, infrastructure and capability endowments. Southern Africa already possesses much of what it needs to succeed. The defining challenge for the next decade is whether governments, industry, academia, financiers and civil society can exercise the collective leadership required to steward these endowments as an integrated system.

While focused on Southern Africa, the lessons have broader relevance across the African continent. The paper concludes that the regions that succeed in the critical minerals era will not necessarily be those with the largest resource endowments, but those most capable of aligning infrastructure, capability and governance around a shared vision for long-term value creation. The opportunity is extraordinary. The challenge is whether Southern Africa can transform its endowments into prosperity.



Gary Lane

Vuuma

With a passion for transforming the mining industry, Gary Lane has established a global reputation as an industry leader and innovator over the past three decades.

Gary's distinguished career began with Anglo American, where he held various engineering and project management roles, successfully delivering multiple mega capital projects. After completing his MBA, he co-founded Cyst Corporation 23 years ago, a pioneering consultancy focused on mining optimisation that helped reshape industry approaches to operational excellence.

His entrepreneurial vision led to the launch of a technology startup dedicated to next-generation mining solutions, followed by the establishment of the Vuuma Group of companies eight years ago. The Vuuma Group specialises in accelerated adult learning and people-centric consulting with an emphasis on systems thinking—addressing the critical human element often overlooked in technical industries. The Vuuma Group specialises in accelerated adult learning and people-centric consulting with an emphasis on systems thinking—addressing the critical human element often overlooked in technical industries.

Gary is a Fellow of the SAIMM and served as the Chairperson of the SAIMM Technical Programmes for the past 7 years.

Choosing the future: Railway reform scenarios and the competitiveness of Southern Africa's critical minerals value chains

E. de Ruiter

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Southern Africa's critical minerals endowment — manganese, chrome, platinum group metals, copper, cobalt, and iron ore — represents genuine strategic potential in the global transition to a low-carbon economy. Yet between geological potential and economic prosperity sits a single, largely underappreciated constraint: the freight railway system.

South Africa's freight rail network, operated by Transnet Freight Rail, has suffered a sustained capacity and reliability collapse: volumes, once above 230 million tonnes per annum (MTPA), have fallen below 140 MTPA and are still declining. Manganese producers have diverted 6 MTPA to road, chrome 14 MTPA; annual export revenue losses run to tens of billions of rand. South Africa is becoming an unreliable supplier at the precise moment global demand is rising — and when supply chain traceability and security of supply have become conditions of market access under instruments such as the EU Critical Raw Materials Act.

This paper presents Auctoro Advisory's freight railway reform scenario framework — a four-scenario analysis built on two axes: market openness (monopoly to competitive) and commercial sustainability (fiscally dependent to self-funding). The four scenarios — Full Steam Ahead, Borrowed Time, Muddling Along, and The Rusty Giant — each carry a policy execution characterisation and quantified consequences for freight volumes, investment, employment, and critical minerals competitiveness.

In The Rusty Giant (good policy ignored), volumes fall below 150 MTPA, the system enters a debt-and-disinvestment spiral, and mineral producers face compounding export losses; new investment is precluded by logistics risk.

In Borrowed Time (good policy selectively executed) — South Africa's current position — state recapitalisation preserves the monopoly's solvency but defers rather than resolves structural failure. Volumes stabilise at 150–160 MTPA, but neither new private investment nor beneficiation-adjacent freight flows are stimulated. It is not a stable equilibrium.

In Muddling Along (good policy poorly executed), premature market opening without regulatory foundations causes fragmentation and value destruction. New operators withdraw when access frameworks prove commercially unviable; infrastructure rehabilitation stalls.

Only in Full Steam Ahead (good policy properly executed) — vertical separation, an independent regulator, and fair third-party access sequenced correctly — does the system build toward its validated 250–300 MTPA potential, at which beneficiation-adjacent freight becomes viable, regional corridor integration with Lobito, Beira, and Nacala becomes commercially rational, and Southern Africa becomes a credible, reliable supply chain partner.

Railway reform trajectory is a first-order investment variable in the critical minerals value chain, determining not only logistics cost and reliability but whether downstream processing investment is commercially rational at all. The framework offers policymakers, development finance institutions, and mining investors a structured basis for assessing South Africa's current trajectory and the institutional steps required to reach Full Steam Ahead.

This paper is offered as a companion to a related submission to this stream, which frames Southern Africa's opportunity around the integrated stewardship of mineral, infrastructure, and capability endowments. Whereas that paper sets the broader frame, this one supplies a detailed, quantified treatment of one endowment — freight rail — showing concretely what is at stake when it is left unresolved.



Evert de Ruiter

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Evert de Ruiter is the Managing Director of Auctoro Advisory and the founder and Managing Director of Synthesys Logistics Solutions, a systems engineering firm specialising in logistics system transformation.

For over two decades Evert has focused on the railway industry developing a particular interest in freight solutions by concentrating on the sector's key business requirement: cost-effective transportation systems.

He possesses extensive knowledge of business strategy railway transportation solutions supply chain management mining bulk and intermodal logistics enterprise systems and systems integration as well as management consulting.

Evert also has direct experience of working at Transnet for nearly three years where he served as the General Manager for Operations Transformation in the Office of the Group Chief Executive at Transnet Group from March 2020 to November 2021. He concluded his service at Transnet at the end of August 2022 as the Chief of Staff for Transnet Engineering where he was responsible for the division's strategy continuous improvement legal services and strategic business development.

He has worked for leading local and international firms including Wabtec Progress Rail Bombardier Transportation General Electric Transportation Ansaldo STS Bytes Systems Integration and KPMG Consulting.

His experience has seen him work on projects in South Africa Mozambique Botswana the Netherlands Namibia Nigeria Zambia Guinea the United Kingdom the USA and Australia.

This has enabled him to gain invaluable experience working on projects with clients including Transnet, Kumba Iron Ore, Anglo American Coal, Deutsche Bahn, PRASA, Grindrod, America Latina Logistica, Aurecon, , the South African National Defence Force, CBI Electric, Murray & Roberts, the South African Railway Safety Regulator, TransNamib, Vale, Accenture, BHP Billiton, Value Logistics, Botswana Railways and CFM.

Electronic and electrical waste as a novel source of critical minerals

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The global transition toward renewable energy, electric mobility, and advanced digital technologies created an unprecedented demand for critical raw materials (CRMs). Simultaneously, the hyper-consumption and rapid obsolescence of modern consumer electronics have generated a surge in waste electrical and electronic equipment (WEEE), widely known as e-waste. Historically managed as a hazardous waste requiring costly disposal and mitigation, e-waste is increasingly recognised as a highly profitable, anthropogenic 'secondary ore.' This paper reframes the global e-waste crisis by evaluating WEEE not as a refuse problem, but as an abundant reservoir of critical and precious metals. The primary objective of this review is to systematically characterise and quantify the critical metal inventory embedded within global e-waste streams by mapping the concentrations, volumes, and economic value of key strategic metals across various WEEE categories. The analysis specifically targets precious metals (gold, silver, palladium), battery metals (lithium, cobalt, nickel), and rare earth elements (REEs, such as neodymium, praseodymium, and dysprosium). The methodology strictly contrasts the elemental 'ore grades' found in complex electronic sub-components against those of primary terrestrial ores, while also evaluating the geopolitical risk of primary mining monopolies vs the localised, distributed availability of domestic e-waste reserves. The analysis of literature sources demonstrates that the concentration of critical metals in e-waste frequently exceeds that of naturally occurring terrestrial ores by orders of magnitude. Data indicate that PCBs contain gold at concentrations 40 to 50 times higher than commercially viable primary gold mines, alongside highly concentrated deposits of palladium, silver, and copper. Spent lithium-ion batteries represent a densely concentrated, readily available stock of cobalt and lithium—elements currently plagued by volatile pricing, severe geographical concentration, and ethical mining controversies. Whereas permanent magnets recovered from discarded hard disk drives, audio equipment, and electric motors constitute one of the richest, most viable secondary sources of critical REEs. The paper reveals that 'urban mining'—the extraction of these metals from anthropogenic waste—not only circumvents the massive land degradation, water consumption, and carbon emissions associated with traditional mining but fundamentally decentralises global resource monopolies. By treating e-waste as a strategic domestic asset, nations heavily dependent on importing CRMs can offset the effects of geopolitical shocks, trade disputes, and export restrictions. Categorising e-waste merely as an environmental hazard ignores its profound economic and strategic utility. WEEE constitutes one of the most critical resource repositories of the 21st century. Unlocking this secondary supply chain is an absolute imperative for sustaining the global green energy transition and future technological innovation. This requires implementing aggressive extended producer responsibility mandates, redesigning electronics for end-of-life modularity, and heavily incentivising the collection infrastructure necessary to secure these critical secondary ores.



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Dr Marcin Durski is a Research & Development Manager at EWaste Africa where he works on the introduction of novel and innovative solutions regarding the recycling and refurbishment of different types of e-waste. Dr Durski received his BSc. Eng. and MSc. Eng. in Chemical Technology from Warsaw University of Technology in Poland and moved in 2016 to South Africa to continue his pursuit of the doctoral degree in Chemical Engineering, which was granted in 2021 by the University of KwaZulu-Natal.

Determination of the cause of high dust load during converter processing

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This paper aims to determine the causes of high dust loads during copper converting on the Pierce Smith (PS) converters at Mopani Copper Mines in Mufulira, Copperbelt. The production of copper involves several steps, one of which is the converting process. During this process, impure copper is heated in a furnace and oxidised, removing impurities and producing blister copper. However, the converting process is often associated with high dust emissions, which can cause an environmental problem and pose a health risk to workers. The aim of this paper was to determine the cause of high dust loads during converting and identifying possible solutions to reduce dust emissions. A comprehensive study was conducted, including plant test works, in-plant observations, and laboratory analyses.

In order to carry out this project, an assessment of the particle size of process inputs like cold dope (copper chunks, reverts, scrap) and silica flux was done. A chemical analysis of silica flux was also carried out, as well as to determine the effect airflow rates and speed of ID fan on the quantity of dust emissions. For silica flux particle size distribution and chemical composition, samples were collected from strategic points within the smelter department. Collected samples were taken to the laboratory for screen and chemical analysis. Furthermore, particle sizes of cold dope were monitored and noted before being charged to a converter. Airflow rates and ID fan speeds were monitored and noted during operations and compared to amounts of dust emitted for several blows.

From the results obtained for the silica flux particle size, it was observed that finer particles (14.42% and 7.18%) were more than the recommended amounts which are (10%) and (2.5%) respectively. The chemical composition was 92.26%, which was lower than the recommended 95% and above. There were variations in the particle sizes of cold dopes which were being charged in a converter as fine dust particulates were collected by loaders and placed in boats. Higher air flow rates were found to lead to higher dust emissions and lower ID fan speeds led to higher amounts of dust being captured in the dust chamber and evaporative cooler.

Based on the findings of this paper, screen analysis for every batch of silica flux delivered is recommended. Purchasing silica flux that does not meet the ideal particle size distribution of 10% fines to 80% middling and 10% coarse particles and grades below 95% must at all costs be avoided. It is essential for loader operators to properly sort chunks, copper scrap and reverts in relation to their particle sizes as opposed to just picking up everything from the ground which leads to high accumulation of fines which are placed in boats before being fed to a converter. At higher air flow rates, we experienced more dust generation because feeding of fines was causing them to be blown away due to the high pressure in the converter – which is (0.86-1.5 bar) 100KPa. It is necessary that as much dust as possible be trapped in the dust chamber and evaporative cooler; lower ID fan speeds which show more dust being captured in the two vessels must be employed. At higher speeds, less dust was trapped and proceeded to the acid plant.

Flowsheet development for the recovery of tantalum from a pegmatite ore body

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This paper developed a flowsheet for the recovery of tantalum from a pegmatite orebody. The increasing demand for critical minerals, particularly tantalum, necessitates efficient beneficiation strategies for low grade and mineralogically complex pegmatite ores. This paper aimed to develop a flowsheet to produce a tantalum concentrate exceeding 25% Ta_2O_5 from a pegmatite ore sourced with a head grade of 592 ppm Ta_2O_5 and tantalum hosted mainly in tantalite Mn and microlite with low magnetic susceptibility. The ore was crushed and milled with HPGR to -1 mm, and tantalum deportment showed significant distribution in both coarse (+500 μm) and fine (-75 μm) fractions, motivating a multi-stage, size sensitive circuit. Spirals in rougher-cleaner-scavenger configuration achieved a cleaner concentrate of 4.1% Ta_2O_5 at 88% recovery but also revealed notable tantalum losses in ultrafine and coarse fractions, highlighting limitations of spirals alone for this ore. Falcon concentration on the -106 μm spiral scavenger tails effectively recovered fine tantalum, upgrading the concentrate to 968 ppm Ta_2O_5 at approximately 97% recovery from the Falcon feed. Crucially, the multi gravity separator (MGS) was shown to bridge the ultrafine processing gap: when applied to milled cleaner spiral concentrate (100% passing 150 μm), upgraded a 4.1% Ta_2O_5 feed to concentrates exceeding 25% Ta_2O_5 at up to 90% tantalum at recoveries of up to 90%, with upgrade ratios between about 2.5 and 7.8. The results demonstrate that a combined Spiral-Falcon-MGS flowsheet can overcome the challenges of fine liberation and low magnetic susceptibility, delivering a market acceptable tantalum concentrate from a low grade pegmatite ore.

Keywords: Tantalum, Pegmatite, Gravity concentration, Multi Gravity Separator, Critical Minerals



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