

## Leveraging Data-Driven AI to Optimize Mining Operations

**Ogunleye-Johnson Folasade Oluwayemisi**

Federal University of Technology Akure.

folaloyeakin90@gmail.com

**ABSTRACT:** The urgent need to address challenges regarding safety, efficiency, and sustainability in the mining industry has consistently driven the integration of advanced technologies into operational decision making. The advent of Artificial Intelligence (AI) and Machine Learning (ML) is rapidly gaining its prominence in the Mining Industry. Today, mining operators are gradually optimizing their operational approach, leveraging AI enhancement in their decision-making process through the integration of sensor data, geospatial data, satellite imagery data, and more. Sensor-generated data helps identify performance trends and equipment health, while geospatial data provides insights into topographical constraints and mineral-rich zones. The applications of AI and ML models allow the extraction of valuable geospatial intelligence, essential for optimizing mining strategies and resource allocation. Leading global mining companies are beginning to adopt such practices, including predictive maintenance, equipment automation, smart mine planning, and Health, Safety, and Environment (HSE) initiatives.

**KEYWORDS:** Artificial Intelligence, Mining, Machine Learning, Data

### I. INTRODUCTION

Mining is an industry of great importance, significantly contributing to global economic development. However, it struggles with efficiency, safety, and sustainability challenges, which directly impact its financial viability and environmental footprint. Traditional mining relied on manual processes and physical surveys that were costly, time-consuming, and prone to errors. These challenges include geological uncertainties, hazardous work environments, and high operational costs. Even as the demand for minerals and metals increases, these limitations have made it clear that innovative solutions are needed to propel the industry forward. In pursuit of solutions, AI systems and machine learning (ML) are emerging as transformative forces in the mining sector. An AI system is an engineered or machine-based system that can, for a given set of objectives, generate outputs such as predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy (Mutsaers et al., 2024). They hold the potential to revolutionize mining efficiency and safety and foster sustainable mining practices. This integration unlocks smarter, faster, and more accurate decision-making across every phase of mining. According to research on intelligent resource management, advanced optimization systems can reduce operational latency by 37–72% while cutting costs by 43–78% compared to conventional methods, resulting in tremendous gains in breaking complex optimization problems into manageable components and applying fine-grained predictive models to each aspect of resource management (Omdena, 2025). By integrating AI and ML with earth observation imagery analysis, valuable geospatial intelligence enabling predictive maintenance and data-driven decision-making in mining can be generated.

Recent advances in optimization and simulation methods highlight artificial intelligence (AI) capabilities and AI-enabled applications as promising tools for identifying development venues leading to desired outcomes (Barmer et al., 2021). Improvements in computational abilities and data availability empower AI algorithms and lead to a new era of AI-based research. The fast growing body of research shows that machine-learning (ML) and data-driven AI-driven approaches may enhance mining economics. AI algorithms used for projections and simulations help choose the best behavior and management patterns, boosting productivity, optimizing operations, and increasing profitability (Omdena, 2025). The future of AI and ML integration in mining operations mostly relies on accurate data from sources. This paper explores the state of the art of mining operations—highlighting the challenges faced, the benefits of AI integration, applications, existing AI tools supporting cost-effective mining, and what the future holds for data driven mining in an increasingly digital world.

## II. RELATED WORKS

Chube et al. (2025) researched the optimization of mineral processing at Barrick Mines by deploying a machine learning model (Random Forest). This study demonstrates how Optimaviz can be used effectively to optimize mineral processing circuits, providing process engineers and metallurgists with a robust tool to derive actionable insights and enhance plant performance without coding knowledge. A large mining company faced challenges with equipment downtime and maintenance costs. Implementing a predictive maintenance solution significantly improved their operations by leveraging 4Sight Holdings data management and AI expertise. This was achieved by cleansing and standardizing their historical maintenance data, ensuring it was ready for AI analysis. Next, an AI model was developed to analyze this data and real-time sensor data to predict equipment failures. The model provided early warnings of potential issues, allowing the company to perform maintenance before breakdowns occurred. The results were impressive, with equipment downtime reduced by 30%, maintenance costs cut by 25%, and overall operational efficiency improved (Sheqmanagement, 2024). AICA deploys machine learning algorithms to automate the enrichment of MRO product data with speed and precision. These algorithms analyze existing data, learn from trends, and continuously improve the quality of data enrichment. This automation leads to significant time savings, cost reduction, and enhanced data accuracy (Aicadata, 2023).

### A. Mining Industry Challenges

Mining companies are constantly faced with meeting stakeholders' expectations of optimizing profitability and productivity, ensuring sustainability, and managing risk, safety, and health. Furthermore, mining operations face critical challenges that need addressing. Mining operations generate vast amounts of real-time data, and processing and analyzing this information require secure and robust data-handling procedures (Microsoft Corporation, 2024). The mining industry is pulled between two opposing forces: urgent demand and dwindling supply. An enormous quantity of minerals and metals must be supplied in a very brief time, with current estimates totaling three billion tons of minerals and metals needed by 2050 (Picterra, 2025). By comparison, the world mined 2.47 billion tons of non-fuel minerals and metals in 2018 (MinersAI, 2025). A new World Bank Group report, *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition*, estimates that to meet the growing demand for clean energy technologies, production of minerals such as graphite, lithium, and cobalt could increase by nearly 500% by

2050 (Picterra, 2025). Unfortunately, recent exploration results have been disappointing. Data show that during the last mining boom (2010–2015), the cost of exploration exceeded the value of ore discovered (Cooper, 2024). While this example of value destruction in mining may have passed, the exploration value proposition remains unfavorable. Since 2016, exploration results have been largely break-even (Cooper, 2024). Some believe it is getting progressively more difficult and costly to find quality deposits, and to overcome these challenges



Figure 1: Mining operational modules (Microsoft, 2024)

## B. Challenges of Applying AI to Mining/Metals Operations

- i. **Data quality and accessibility:** Mining operations generate vast amounts of data from various sources, including sensors, equipment, geological surveys, and historical records. Ensuring quality, consistency, and accessibility of this data is a significant challenge for AI applications. Data may be incomplete, inaccurate, or stored in disparate formats, requiring preprocessing and integration efforts. Using models from other areas can introduce issues.
- ii. **Safety and reliability:** Safety is a top priority in mining, and AI solutions must be reliable and robust to ensure worker and equipment safety. Malfunctions or errors in AI algorithms could have serious consequences, leading to accidents, equipment damage, or production delays. Therefore, it is essential to thoroughly test, validate, and monitor AI systems to mitigate risks.
- iii. **Complexity of mining processes:** Mining operations are highly complex, variable, and dynamic, involving numerous interconnected processes such as exploration, drilling, blasting, hauling, and processing. Developing AI solutions that effectively model and optimize these processes requires a deep understanding of domain-specific challenges and constraints. Suboptimization is a major risk.
- iv. **Regulatory and compliance requirements:** Mining is subject to various regulations regarding safety, environmental protection, and community engagement. AI solutions must comply with these regulations, which may vary by jurisdiction and operation type. Ensuring regulatory compliance while deploying AI requires careful consideration of technical, legal, and ethical implications.
- v. **Cost and return on investment (ROI):** While AI offers significant productivity, efficiency, and safety benefits, initial investment and implementation costs can be substantial.

Mining companies must evaluate the expected ROI and prioritize projects based on their operational and profitability impact. Also, having a dedicated AI team may not always be beneficial; vendors offer high-value AI solutions, but embedding them into operations carries risk.

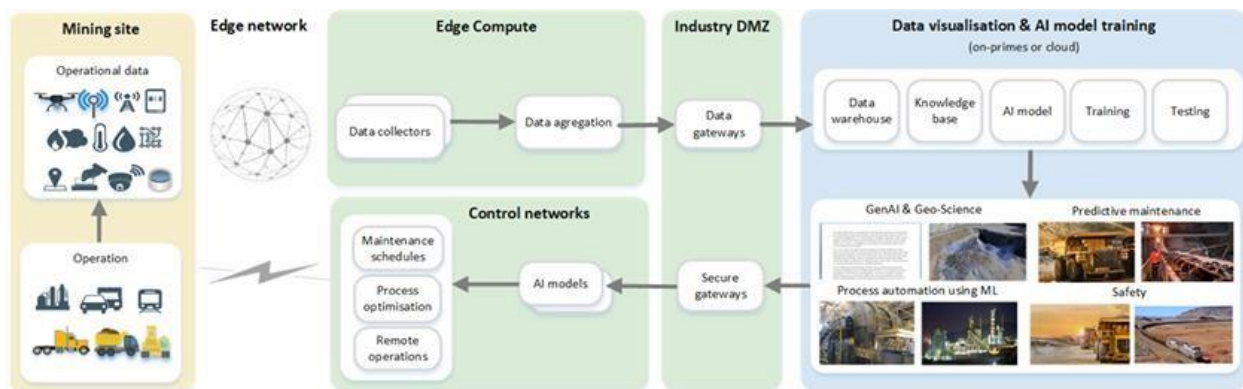
vi. **Integration with existing systems:** Many mining operations rely on legacy systems and infrastructure, which may be incompatible with modern AI technologies. Integrating AI solutions with systems such as fleet management, geological modeling, and enterprise resource planning requires careful planning and coordination.

vii. **Skill and knowledge gap:** Implementing AI in mining requires expertise in data science, machine learning, computer vision, and other AI fields. Advanced autonomy also involves robotics and mechanical systems. A shortage of talent with these skills highlights the need for training and capacity-building initiatives. Original equipment manufacturers are increasingly filling this role.

### C. Digital Architecture and AI Applications in Modern Mining Operations

Figure 3 presents a comprehensive digital architecture for modern mining operations, leveraging edge computing and data-driven artificial intelligence (AI) to optimize efficiency, safety, and decision-making. Various sensing devices deployed across mining sites collect operational data such as equipment performance, environmental conditions, and production metrics. This data is transmitted through an edge network to edge computing systems, where data collectors perform real-time aggregation. Aggregated data flows into two main systems: control networks and the Industry Demilitarized Zone (DMZ).

Control networks utilize pre-trained AI models to support maintenance scheduling, process optimization, and remote operations, enabling real-time decision-making close to the data source. Concurrently, the Industry DMZ transmits data to centralized platforms, either on-premise or cloud-based, for advanced data visualization and AI model training.



**Figure 2:** Conceptual Architecture in Modern Mining Industry

In this centralized environment, data is stored in data warehouses and enriched with knowledge bases. AI models are trained, tested, and deployed to support various applications, including generative AI in geoscience, predictive maintenance, process automation using machine learning (ML), and safety monitoring. The entire system forms a closed loop, where insights from AI continuously refine operations, creating a smart, adaptive mining environment that enhances productivity, reduces downtime, and ensures safer working conditions.

#### D. AI Applications in Modern Mining Operations

The mining industry is undergoing a significant transformation driven by technological advancements and the imperative for greater efficiency, sustainability, and operational intelligence. For mining and metals owners and operations leaders, maximizing net metal production at optimal operating costs is crucial (Omdena, 2025). Maintaining this momentum requires continuous optimization of the entire metal production value chain—both at individual process levels and as an integrated system. The following AI-driven applications in mining operations (see Figure 3) highlight key areas of impact:

- (a). **Tailings Modelling:** Data from tailings sensors enable the creation of detailed models of tailings piles. Technical engineers analyze this data to prevent leakage, contamination, or issues in water treatment processes.
- (b). **Geotechnical Monitoring Systems:** Inputs from geotechnical sensors, seismic alerts, dashboards, response plans, and historical seismic reports are analyzed to provide decision support and mitigate risks in activities such as stress management, drilling, blasting, and cave propagation.
- (c). **Preventive Maintenance:** Data-driven AI reduces equipment unscheduled downtime while improving safety and productivity.
- (d). **Process Optimization:** AI harnesses existing data, analyzing variances and trends to predict future outcomes and support decision-making. This can be applied across the mining value chain, from single processes to total mine optimization.
- (e). **Corrective Mine Planning Systems:** Data on mine planning deviations is analyzed to identify affected areas and develop integrated, optimized plans.
- (f). **Ore Reconciliation and Optimization Systems:** AI-enabled systems streamline comparisons and analysis of variances between estimated and actual data to forecast and optimize resource value.
- (g). **Portfolio Optimization Systems:** Historical operational data, similar operations data, external market information, and planning data are input into models that infer relationships to predict measurable financial and operational functions.
- (h). **Portfolio optimization systems:** Historical data from the operation, similar operations, and external markets and operational planning data are input into a model. The resulting algorithm makes inferences between these factors in order to predict the measurable

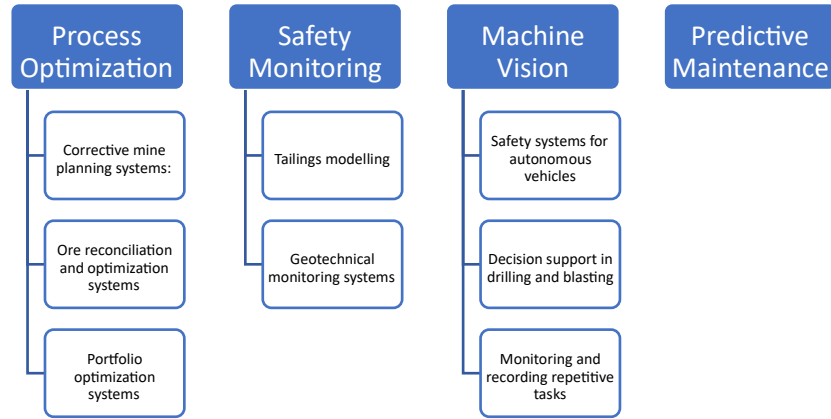


Figure 3: AI Application in Mining Operations

### III. AI TOOLS DEVELOPED FOR MINING OPERATIONS

#### (a). Satellite Imagery

In modern mining operations, satellite data has been pivotal offering large-scale visibility across challenging terrains, and with high-resolution imagery, mining companies can map vast mineral-rich regions, monitor land-use changes, and identify risks early. However, analyzing this data requires advanced tools like AI to extract actionable insights by transforming raw satellite data into detailed predictions, allowing them to locate mineral deposits, assess operational health, and track environmental changes effectively.

#### (b). AI algorithms: Mineral Deposits Locator.

AI improves the speed and cost-effectiveness of mineral exploration by predicting potential ore deposit locations from vast geological, geophysical, and historical datasets. Processing remote sensing and survey data extends exploration into remote areas, while AI-enabled subsurface digital twins provide insights into subsurface structures and deposits (Barmer et al., 2021). Machine learning models analyze historical exploration data alongside current imagery to predict resource concentrations in unexplored regions, optimizing exploration efforts and resources. Additionally, AI analyzes multispectral and hyperspectral satellite data to detect anomalies and patterns that pinpoint mineral-rich areas, reducing exploration time and costs significantly.

Beyond exploration, AI offers environmental monitoring capabilities by detecting vegetation loss, soil erosion, and acid mine drainage, which are often invisible to the naked eye. Early detection allows mining companies to proactively mitigate environmental damage and comply with regulations, underscoring AI’s role in sustainable mining (Picterra, 2025).

#### (c). Combining AI, Drones, and Satellite Imagery

While satellite imagery provides a macro-level view, drone technology complements it by capturing localized, high-resolution visuals. AI processes data from both sources to deliver comprehensive insights. Key applications include:

- i. **Site Safety Monitoring:** Satellites detect large-scale risks such as land instability, with drones providing detailed close-up imagery for rapid assessment.
- ii. **Resource Management:** Satellites map broad regions, and drones verify findings with high-precision data. AI integrates both datasets for optimized resource planning and extraction.

- iii. **Infrastructure Assessment:** Drones monitor critical infrastructure such as roads, processing plants, and waste facilities for structural issues, while satellites offer broader context. AI fuses these data streams to enhance infrastructure management.

#### **(d). Data Cube Generator**

This collects, processes, and normalizes all types of inputs into a neat, uniform, and flexible stack of data. This “3D” representation of a dataset remaps each file to a common resolution and format, ensuring seamless alignment between layers. Each layer retains critical geospatial and geologic metadata, enabling further analysis and application. Additional features, such as various buffering operations, allow primitive geometry layers to take real-world shape upon which further analysis can be done.

### **IV. PROCESS OPTIMIZATION**

Process optimization is a key application of artificial intelligence (AI) that leverages existing data to analyze variances and trends, predict future outcomes, and provide decision support. These techniques can be applied across the mining value chain, ranging from whole-mine optimization to single-process improvements, focusing on both long- and short-term objectives. Examples of AI applications in mining include:

#### **(a). Ore Reconciliation and Optimization**

AI-enabled ore reconciliation and optimization systems streamline the comparison and analysis of variances between estimated and actual data, enabling better understanding, forecasting, and value optimization. Portfolio optimization systems incorporate historical operational data, data from similar operations, external market factors, and operational planning inputs. The resulting models generate inferences that predict key financial and operational metrics (Global Mining Group, 2019).

#### **(b). Predictive Maintenance**

Machine health data collected from sensors, along with historical component failure records, feed into predictive maintenance models. These models forecast potential failures and recommend maintenance timing to avoid unplanned downtime, thereby enhancing safety and productivity (Barmer et al., 2021).

#### **(c). Safety Monitoring**

Predictive maintenance principles extend to safety and environmental applications. For instance, tailings modelling utilizes sensor data to create dynamic models of tailings storage facilities, allowing engineers to prevent leakage, contamination, or water treatment issues (Omdena, 2025).

#### **(d). Geotechnical Monitoring Systems**

Data from geotechnical sensors, seismic alerts, dashboards, response plans, and historical seismic reports are analyzed to support decision-making and mitigate risks associated with stress management, drilling, blasting, and cave propagation (Corrigan & Ikonnikova, 2024). The Global Mining Group is developing a case study library to illustrate AI’s benefits across these processes.

#### **(e). Foundations of AI: A Framework for AI in Mining**

Machine vision technologies use image-based capture to monitor mining activities. Algorithms process the data to deliver actionable insights, such as autonomous vehicle safety systems that

detect obstacles and hazardous conditions to trigger appropriate responses (Global Mining Group, 2019).

**(f). Decision Support in Drilling and Blasting**

Machine vision systems mounted on equipment such as buckets or shovels analyze fragmentation and other parameters, enabling optimization of drilling and blasting operations (Picterra, 2025).

**(g). Corrective Mine Planning Systems**

Mine planning data, including deviations, are input into AI models that identify trends and affected areas. The outputs inform the development of integrated, optimized mine plans (Mutsaers et al., 2024).

**(h). Monitoring and Recording Repetitive Tasks**

Machine vision systems can automatically monitor repetitive tasks—such as load-haul-dump cycles—collecting data to optimize these processes (Intellisensio, 2025).

## V. BENEFITS OF AI INTEGRATION IN MINING

AI integration delivers transformative benefits across the mining sector, addressing the needs of various stakeholders. These include enhanced value propositions and competitive advantages (Mutsaers et al., 2024; Global Mining Group, 2019; Barmer et al., 2021), optimized operational plans and schedules, and improved engineering and design processes that reduce operating costs and risks.

- (a). AI improves exploration accuracy, reduces operational costs, and supports more informed decision-making, facilitating smarter resource allocation and accelerated project timelines. For governments, AI-driven environmental monitoring ensures regulatory compliance and supports data-driven policymaking, balancing economic growth with environmental stewardship. Local communities benefit from reduced environmental impacts and increased transparency, fostering trust and minimizing disruptions to ecosystems and livelihoods. Collectively, these advantages contribute to a more efficient, responsible, and forward-looking mining industry that prioritizes innovation, sustainability, and collaboration (International Energy Agency, 2022).
- (b). AI algorithms assist engineers and designers by generating multiple design alternatives tailored to specific criteria, optimizing for cost, time, sustainability, and other priorities. These tools analyze vast datasets to inform decisions regarding mine and mill performance, material selection, equipment utilization, worker behavior, safety, energy consumption, and more (Jackson, 2023).

## VI. FUTURE OF DATA-DRIVEN MINING STRATEGY

The convergence of AI, machine learning, and geospatial intelligence is transforming mining towards more sustainable and responsible practices. Advanced AI algorithms can identify complex patterns and correlations in geospatial data that may be imperceptible to humans, potentially leading to the discovery of new mineral deposits and more efficient, cost-effective exploration methods. AI can also predict the social and economic impacts of mining operations on local communities, enabling improved planning, proactive community engagement, and mitigation of adverse effects. Combined with AI-driven environmental impact assessments, these technologies

help ensure mining operations align with sustainability goals and regulatory requirements (Saini, 2023; Omdena, 2025).

## VII. CONCLUSION

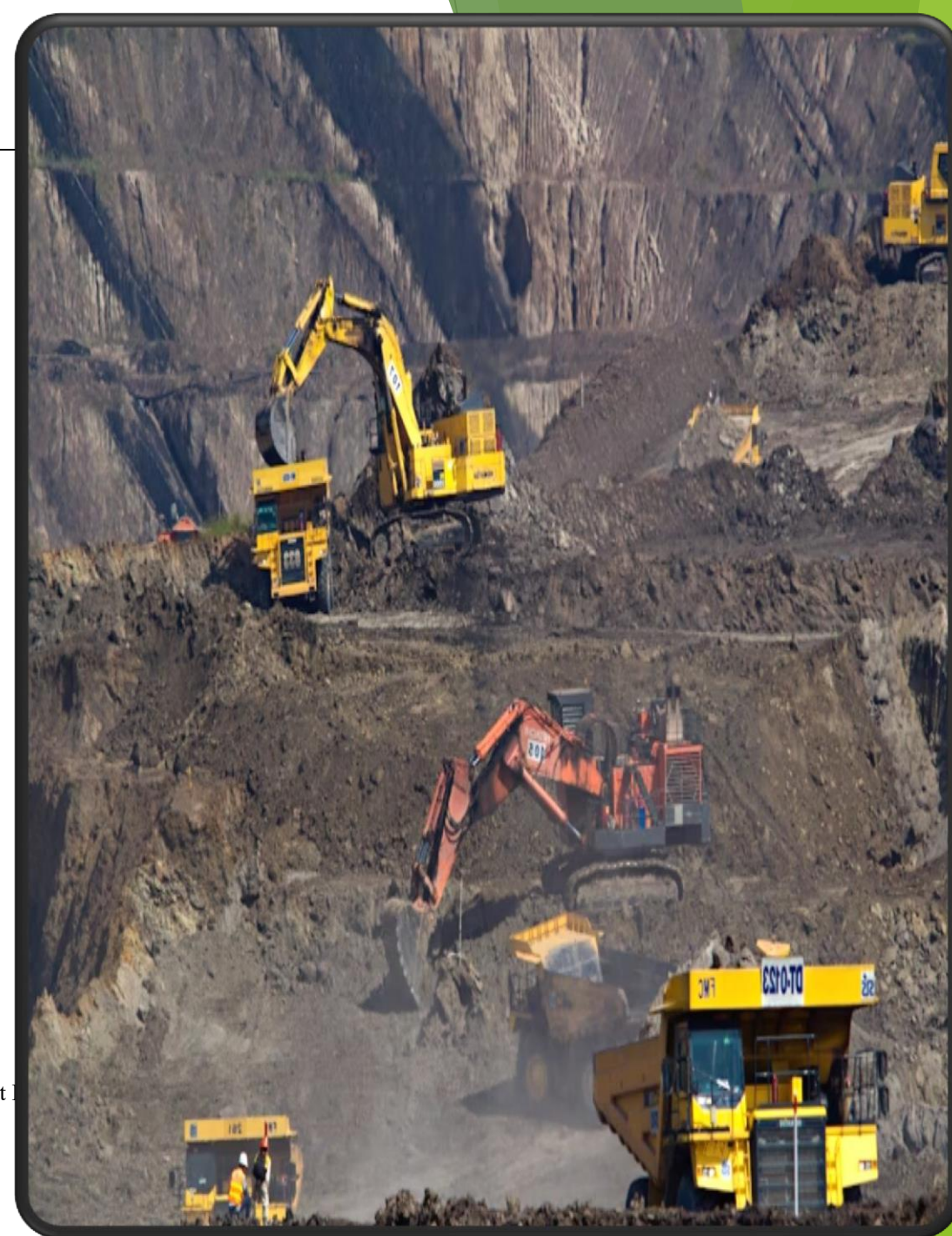
The mining industry is inherently complex and faces significant challenges amid rising global demand for energy and minerals. To remain competitive and sustainable, mining companies must rapidly evolve by identifying potential risks and opportunities and developing strategies to mitigate or capitalize on them. Incorporating scenario planning into strategic processes and enhancing supply chain resilience and agility are essential steps. Ultimately, becoming more insight-driven and collaborative through the adoption of data-driven AI technologies will be critical to achieving superior business outcomes and successfully navigating future disruptions (Cooper, 2024; Sheqmanagement, 2024).

## REFERENCES

- [1] Picterra. (2025). *How AI & machine learning are revolutionizing mining efficiency*. <https://picterra.ch/blog/how-ai-machine-learning-are-revolutionizing-mining-efficiency/>
- [2] MinersAI. (2025). *AI-powered mineral exploration*.
- [3] Cooper, K. (2024). Data, analytics, AI 'vital for competitive advantage' in mining – Rio Tinto. *Mining Digital*. Verdict Media Limited. <https://miningdigital.com/automation-and-ai/riotinto-innovation-key-transformation>
- [4] Klingler, N. (2024). 7 cutting-edge applications of AI in mining for 2025. *Viso.ai*. <https://viso.ai/applications/ai-in-mining/>
- [5] Terra Drone Arabia. (n.d.). AI in mining: Is it transforming how we extract resources?
- [6] Saini, N. (2023). Research paper on artificial intelligence & its applications. *International Journal for Research Trends and Innovation*, 8(4). <https://doi.org/>
- [7] Microsoft Corporation. (2024). *AI transformation in mining: The next wave of digital innovation* [White paper].
- [8] Corrigan, C., & Ikonnikova, S. (2024). A review of the use of AI in the mining industry: Insights and ethical considerations for multi-objective optimization. *The Extractive Industries and Society*, 17. <https://doi.org/> [if available]
- [9] Mutsaers, B., Zwick, R., Sun, J., Harris, M., & Borrego, I. (2024). Benefits and challenges of AI in mining and metals. *International Society for Automation*.
- [10] Global Mining Group. (2019). *Foundations of AI: A framework for AI in mining*. Canada: Clò Communications Inc.
- [11] Barmer, H., Dzombak, R., Gaston, M., Palat, V., Redner, F., Smith, T., & Wohlbier, J. (2021). *Scalable AI* [White paper]. National AI Engineering Initiative. <https://insights.sei.cmu.edu/library/scalable-ai/>
- [12] International Energy Agency. (2022). Why is ESG so important to critical mineral supplies, and what can we do about it? <https://www.iea.org/commentaries/why-is-esg-so-important-to-critical-mineral-supplies-and-what-can-we-do-about-it>

- [13] Jackson, A. (2023). Top 10: Uses of artificial intelligence in mining. *Mining Digital*. <https://miningdigital.com/automation-and-ai/top-10-uses-artificial-intelligence-mining>
- [14] Omdena. (2025, April). AI in mining: Transforming operations for safety and efficiency. <https://www.omdena.com/blog/ai-in-mining-guide>
- [15] Ncube, T., Olawoore, P., Maphosa, P., Mogashoa, S., AlJohani, F., & Swanepoel, M. (2025). Data-driven strategies to optimise Ma'aden Barrick Copper Company (MBCC) flotation circuit – the power of visualisation and machine learning in data mining. *Mineral Engineering*, 221. <https://doi.org/> [if available]
- [16] Sheqmanagement. (2024). Leveraging AI to revolutionise mining. <https://sheqmanagement.com/leveraging-ai-to-revolutionise-mining/>
- [17] Intellisenseio. (2025). 4 key mining industry trends where AI is making an impact. <https://www.intellisense.io/2025/02/4-key-mining-industry-trends-where-ai-is-making-animpact/>
- [18] Aicadata. (2023). Leveraging AI for enhanced MRO data management in the mining industry. <https://aicadata.com/leveraging-ai-for-enhanced-mro-data-management-in-the-miningindustry/>

# Leveraging Data-Driven AI to Optimize Mining Operations



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- ▶ AI Application & Tools in Mining ▶ Benefits of Data-Driven AI in mining ▶ Future of AI in Mining
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# INTRODUCTION



Figure 1: Mining operations overview (Mining Life cycle)

[0.5281/zenodo.17918694](https://doi.org/10.5281/zenodo.17918694)

# BACKGROUND STUDY

- ▶ Mining is an industry of great importance, significantly contributing to global economic development. However, it struggles with efficiency, safety, and sustainability challenges, which directly impact its economic viability and environmental footprint.
- ▶ However, traditional mining relied on manual processes and physical surveys that were costly, time-consuming, and prone to errors. These include geological uncertainties, hazardous work environments, and high operational costs. Even as

the demand for minerals and metals increases, these limitations have made it clear that innovative solutions are needed to propel the industry forward

## **BACKGROUND STUDY**



- ▶ In the pursuit of solutions, AI system and machine learning (ML) are emerging as transformative forces in the mining sector.
- ▶ Recent advances in methods for optimization and simulations highlight artificial intelligence (AI) capabilities and AI-enabled applications as a promising tool for identifying a development venue

leading to the desired outcome (Barmer et al., 2021)

## RELATED WORK

- ▶ According to the International Energy Agency (IEA, 2022), by 2040 the world demand for nickel and cobalt may grow 20 times, for lithium close to 40 times, and for copper 2.6 times (IEA, 2022).
- ▶ The resource-use projections draw attention to locations of sizable geologic deposits and mining, prevalent in the countries of the Global South with a combination of economic, environmental, and political problems (Hoggard et al., 2020).

- ▶ According to estimates by the United Nations Environment group (UNEP, 2016, 2019), African countries alone are home to at least 30 % of the world's mineral reserves.

## RELATED WORK

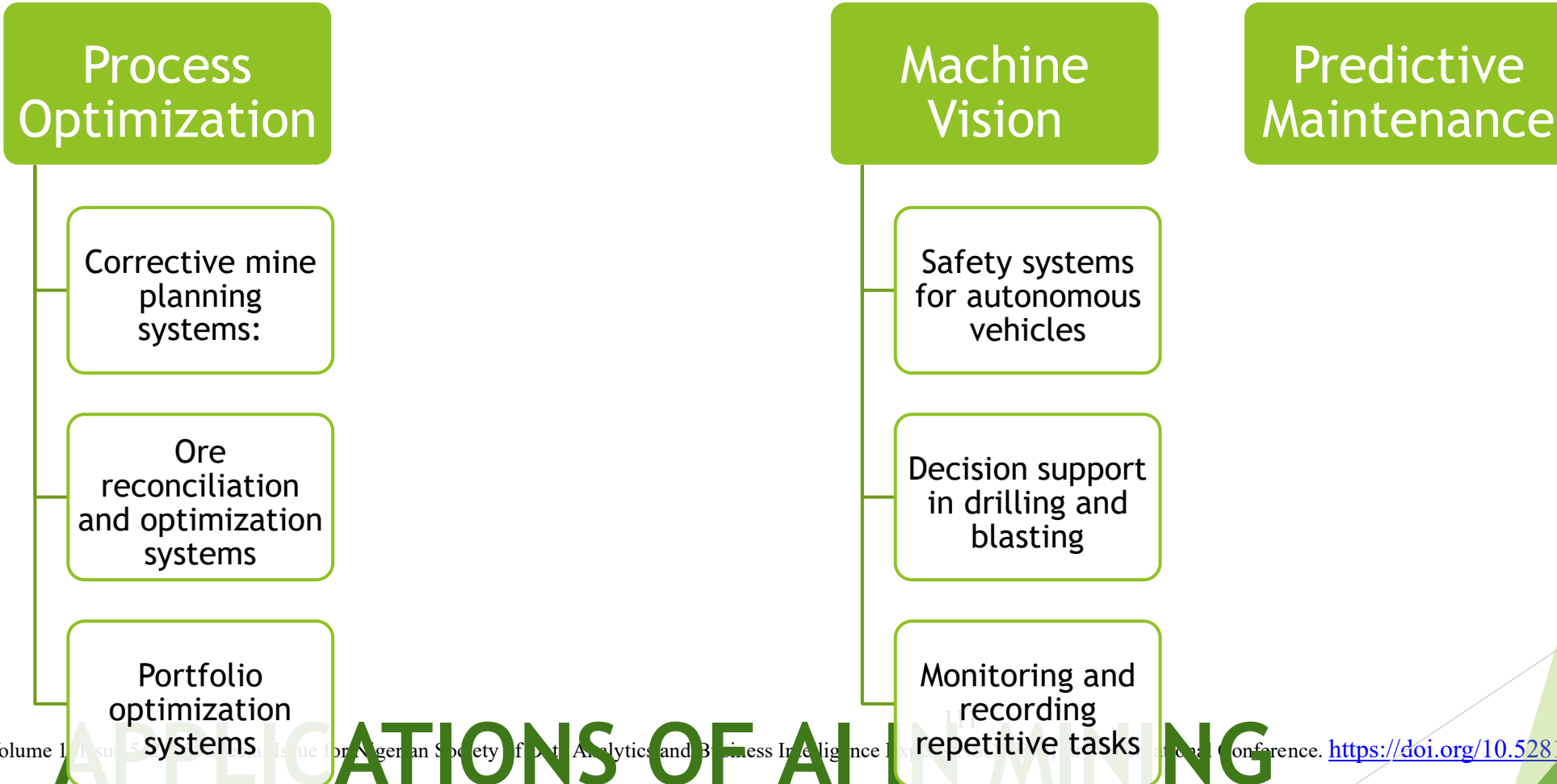
- ▶ T. Chube et al [2025], researched the optimization of mineral processing at the Barrick Mines deploying Machine Learning Model (Random Forest), This study demonstrates how Optimaviz can be used to effectively optimize mineral processing circuits, providing process engineers and metallurgists with a robust tool to derive actionable insights and enhance plant performance without the need for coding knowledge [15].
- ▶ A large mining company, faced challenges with equipment downtime and maintenance costs. Implementing a predictive maintenance solution significantly improved their operations by leveraging 4Sight Holdings data

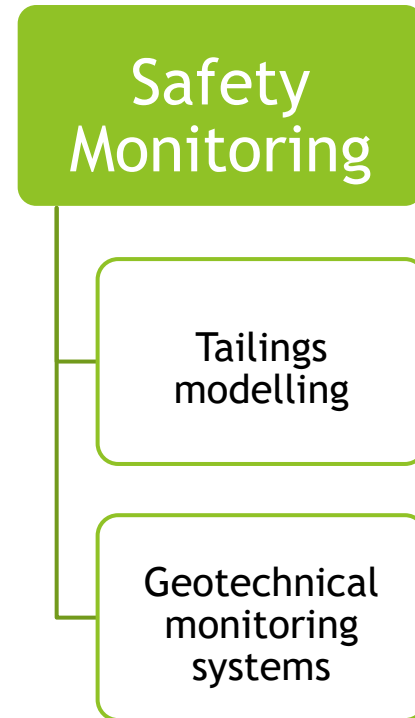
management and AI expertise [16]. This was achieved by cleansing and standardizing their historical maintenance data, ensuring it was ready for AI analysis. Next, an AI model was developed to analyze this data and real-time data from sensors to predict equipment failures. allowing the company to perform maintenance before breakdowns occurred. The results were impressive, with equipment downtime being reduced by 30%, maintenance costs cut by 25%, and the overall efficiency of their operations improved

## CHALLENGES

- ▶ Data quality and accessibility
- ▶ Safety and reliability
- ▶ Complexity of mining processes

- ▶ Regulatory and compliance requirements
- ▶ Cost and return on investment (ROI)
- ▶ systems
- ▶ Skill and knowledge gap
- ▶ Security and risk management:





# BENEFITS OF DATA-DRIVEN AI IN MINING



# BENEFITS OF DATA-DRIVEN AI IN MINING

## Safety:

- Many AI projects, such as those that use advanced autonomous systems, remove people from hazardous situations. Applications such as predictive maintenance, object detection, and fatigue and other monitoring systems can also be applied to prevent safety incidents before they occur.

## Productivity:

- Many AI projects improve productivity by eliminating time-consuming and routine tasks performed by humans. They can also improve planning and decision-making processes and leads to more productive operations.

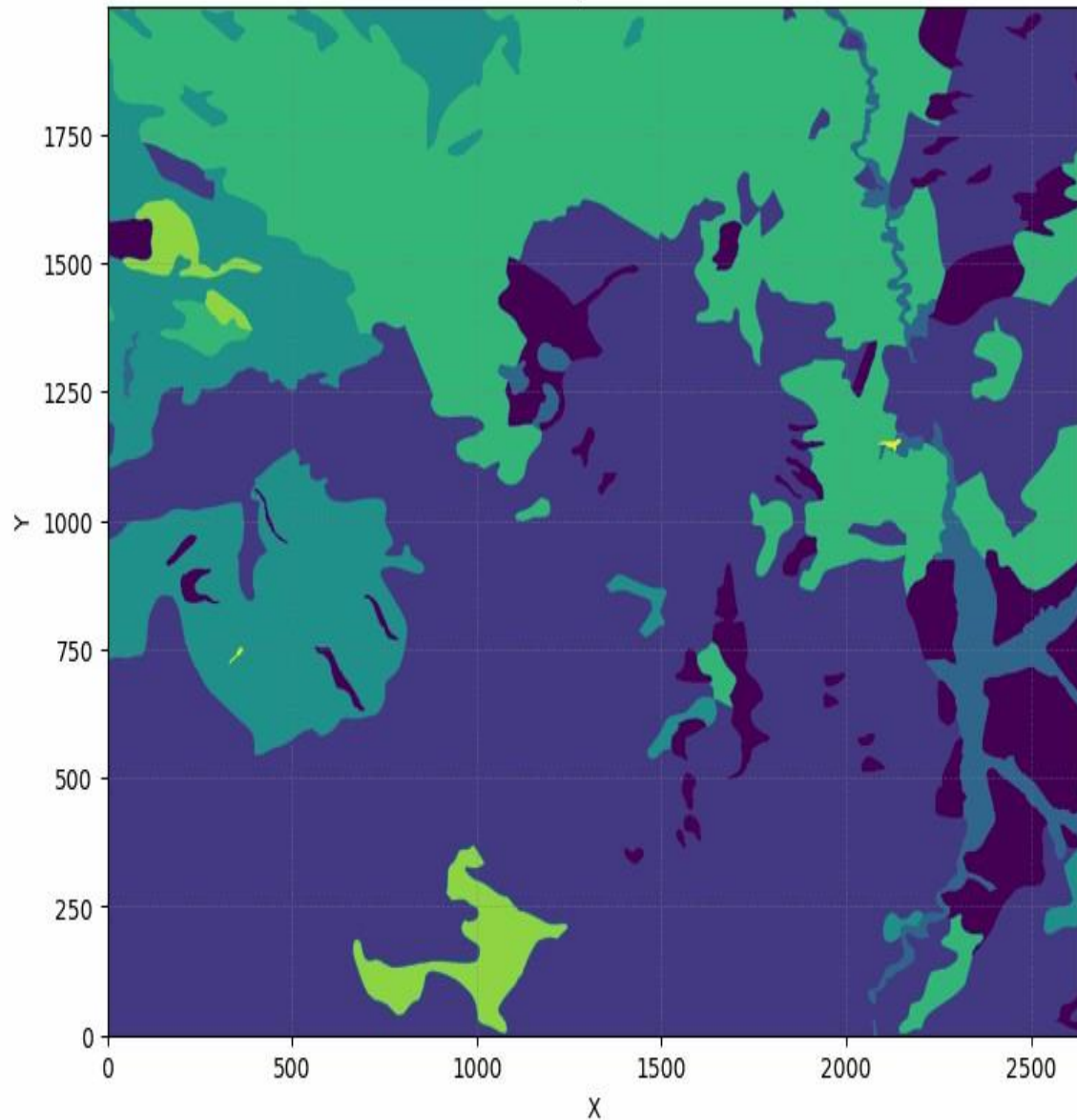
## Sustainability:

- The business and operational improvements that AI enables can help mining operations to be sustainable in the long term.

- By harnessing real-time plant(equipment) information and maintenance data, the reliability of assets can be increased

# AI TOOLS FOR MINING OPERATIONS

Layer 1



Data Cube Generator collects, processes, and normalizes all types of inputs into a neat, uniform, and flexible stack of data

Mineral Probability Maps: MinersAI, harness the power of artificial intelligence and machine learning to transform geospatial data into predictive insights for mineral exploration

# FUTURE OF AI IN MINING

- ▶ BHP and Microsoft, uses AI and machine learning (ML) to boost copper production. The companies are doing this by using real-time data from the copper concentrators and Azure Machine Learning to make hourly predictions. These are then consequently used to make recommendations to the operations team.
- ▶ AI can help with mining exploration by analysing huge amounts of data, identifying on-site targets and

providing insights on both. It provides greater efficiency on site with regards to both time and cost.

## **FUTURE OF AI IN MINING**

- ▶ Barrick Gold Cooperation, one of the world's largest gold mining companies, is an example of a company that has been implementing AI technologies for mine exploration for several years. The company uses AI algorithms to process geological and geophysical data and helps to identify potential mining locations and optimise drilling operations. AI-based sorting systems can identify valuable minerals from waste rock in realtime and ultimately improve recovery rates and reduce processing costs as a result.

- ▶ Leading global mining company Vale launched its first AI centre in 2020 in Espirito Santo. With a commitment to sustainability and safety, the company uses the technology to analyse ore samples and make decisions on the best sorting methods to maximise mineral recovery, which has led to the improvement of environmental, health and safety on site.

## CONCLUSION

- ▶ Modern mining often employs advanced machinery, automation, and monitoring technologies to enhance efficiency while minimizing ecological impact and ensuring worker safety throughout the operation.

- ▶ Optimization helps drive enhanced profitability, and safety. It enables mining operators to plan, schedule, execute, measure, and manage with greater accuracy and precision.
- ▶ Stability helps ensure predictability and reliability in mining operations. It improves productivity, planning accuracy, supply chain efficiency, safety outcomes, risk management, and more.

productivity,

# CONCLUSION

- ▶ AI can help teams improve exploration outcomes and cost efficiency, predict failures before they disrupt production, enhance blast designs for better fragmentation and over/under-break control, and more
- ▶ Addressing the challenges requires collaboration between mining companies, technology providers, institutions and regulatory bodies to develop tailored solutions that meet the industry's specific needs and constraints.

research

- ▶ By overcoming these challenges, AI has the potential to drive innovation, improve competitiveness and foster sustainable growth in the mining sector.

## REFERENCES

- [1] Picterra, “How AI & machine learning are revolutionizing mining efficiency”, <https://picterra.ch/blog/howai-machine-learning-are-revolutionizing-mining-efficiency/>, 2025
- [2] MinersAI, “AI-Powered Mineral Exploration” 2025
- [3] K. Cooper, “Data, analytics, AI ‘vital for competitive advantage’ in mining - Rio Tinto”, <https://miningdigital.com/automation-and-ai/rio-tinto-innovation-key-transformation>, Verdict Media Limited, 2024
- [4] N. Klingler, “7 Cutting-Edge Applications of AI in Mining for 2025”, <https://viso.ai/applications/ai-in-mining/>, viso.ai, 2024
- [5] “AI in Mining- Is It Transforming How We Extract Resources” - Terra Drone Arabia
- [6] N. Saini, “Research paper on artificial intelligence & its applications”, International Journal for Research Trends and Innovation, . vol.8, Issue 4, 2023 | ISSN: 2456-3315

- [7] Microsoft, “AI Transformation in Mining The Next Wave of Digital Innovation” Mining Industry White Paper Microsoft Corporation, Mar 2024
- [8] C. Corrigan, S. Ikonnikova, “A review of the use of AI in the mining industry: Insights and ethical considerations for multi-objective optimization”, The Extractive Industries and Society, vol 17, Mar. 2024
- [9] Bas Mutsaers, Rob Zwick, Joanne Sun, Mark Harris and Ismael Borrego, “Benefits and Challenges of AI in Mining and Metals”, International Society for Automation Dec. 2024
- [10] Global Mining Group, “Foundations of AI : A Framework for AI in Mining”, Canada: Clò Communications Inc, 2019