Is smart mining an industry of the future?



Can technology solve miners´ trilemma: improving safety, sustainability and productivity?

- At a time when demand for metals is quickly rising yet few new discoveries are being made, AI and digitalization are helping to increase production.
- A smart revolution is underway – from exploration up to processing and refining. Operations are being optimized and automated.
- Miners can economically benefit from this new wave of technology adoption.

It seems the future is electric. That means demand is rising for metals of all kinds, including the cobalt, copper, lithium and nickel that will be needed for wires, batteries and motors. Yet times are challenging for miners as they seek ample deposits of these metals in stable, friendly countries, as well as the capital to develop new mines. In order to face this complex challenge, miners are ramping up their efforts and technological advancements offer a possible solution.

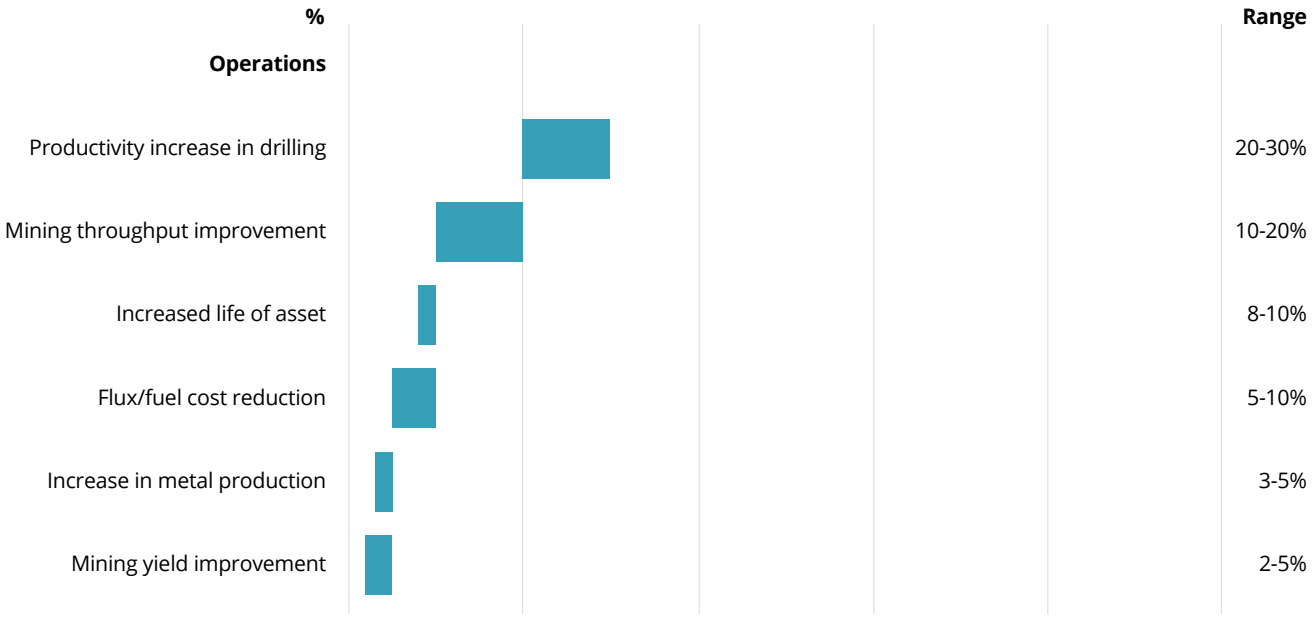
Technology adoption in one of the oldest sectors in the world has reached a pivotal point. Digital technology including artificial intelligence (AI) is helping to improve the discovery of new reserves of minerals as well as enhancing the productivity of existing mines (see Figure 1: digitizing the mine improves performance). It is aiding detection of ore bodies that were invisible to other techniques, as well as improving the rate of recovery of minerals. Beyond that, new technologies are making mines more sustainable by reducing the likelihood of accidents and boosting energy efficiency (see Figure 2: the five main benefits of AI and digitalization for mining companies).

BHP Group, the world's largest mining company by stock market capitalization, estimates the world needs to double the amount of copper produced over the next 30 years to keep pace with the drive for net zero through electric vehicles, offshore wind and solar farms.[1] "We expect the next big wave in mining to come from the advanced use of digital technologies. As grades decline at existing copper mines and fewer new economic discoveries are made, next-generation technologies like artificial intelligence, machine learning and data analytics will need to be used to unlock more production and value from our existing mines", says Laura Tyler, Chief Technology Officer at BHP, in a company statement.[2]

The Axora Innovation Forecast 2023/2024, an authoritative survey of 160 industry experts, confirms that mines are increasingly harnessing technology, whether to enhance operations, boost throughput or help with

[1] BHP taps Microsoft, AI, to improve recovery at top copper mine. Reuters. May 30, 2023.
[2] Source: BHP Website

Figure 1: Digitizing the mine improves performance
Typical client improvement across selected key performance indicators



Source: Boston Consulting Group

decarbonization. The survey reveals the top three technologies deployed by mining companies as: AI (88%), cloud-based platforms (84%) and Internet of Things (IoT) (83.8%)[3]. What's more, the technologies with the biggest year-on-year jump in deployment were AI (+23%), followed by robotics (+14%) and digital twins (+14%).

AI finds previously invisible mineral deposits

Exploration projects have a high failure rate, meaning that there is plenty of scope for AI to improve things. With many of the more accessible mines already exploited, new AI technologies that can discover bodies of ore currently invisible to existing techniques have an invaluable role.

Several mining companies are collecting geological, geochemical and geophysical data to feed into AI software models. They hope that these will spot patterns and make recommendations about where to dig new mines.

Take KoBold Metals, a company founded in 2018 and backed by Breakthrough Energy Ventures, a Bill Gates-supported venture capital firm, as well as mining giants Equinor and BHP. As the company states on its

Figure 2: The five main benefits of AI and digitalization for mining companies

1. **Transforming exploration:** At a time when many of the more accessible mines have already been exploited, AI can help to discover new bodies of ore.
2. **Optimizing output:** AI is proving to boost the output of existing mines, optimizing production from old mines where the ore is low quality.
3. **Reducing costs:** Automating machinery and processes is proving to reduce costs by a material amount.
4. **Improving safety:** The use of robotics and automated trucks reduces the need for human intervention, leading to fewer accidents.
5. **Saving fuel costs and cutting emissions:** Automation and AI are proving to reduce fuel consumption and carbon emissions.

[3] Source: Axora, Innovation Forecast 2023/2024. A survey based on interviews with 160 senior decision makers at metals and mining companies around the world.

website: "We're trying to transform mineral exploration from a manual, judgment-guided, trial-and-error process into a data-driven and scalable science. It's the mother of all needle-in-a-haystack problems: find the significant minable deposits of cobalt, copper, lithium, and nickel resting anywhere from 100 to 2,000 meters deep in the Earth's surface."[4]

CEO Kurt House explains that the whole point of the company is to be "serially successful in exploration — and to improve exploration success overall and to decrease the capital intensity of discovery". KoBold stresses the importance of three factors, see Figure 3. Illustrating the effectiveness of its AI-enabled techniques, in February 2024 KoBold announced the discovery of a vast copper deposit in Zambia. It estimated that the Mingomba site in the northern Copperbelt province would become one of the world's top three high-grade copper mines.

Extracting more ore from existing mines

Importantly, the potential of AI and digital technology also stretches to optimizing the extraction of minerals from ore. This helps to take out more ore from older mines that have been exploited for decades and where the ore is low quality. That can mean increasing production from existing mines rather than opening new ones. American mining company Freeport-McMoRan started deploying AI in 2018 at its Bagdad copper mine in Arizona that had been operating for more than 50 years. Freeport's engineers, site operators and metallurgists developed and fine-tuned an AI model whose task was to give recommendations to improve the mill processing rate. The model was fed three years of data and programmed to look for tweaks that would boost output.[5] The result? In the quarter after implementation, the mine increased throughput by 10% and its copper recovery rate rose by 1%.[6] Freeport then decided to industrialize the AI model, extending the initiative to other mines. Scaling this AI model meant that Freeport no longer needed to replace its concentrator circuits, which extract, float and collect the copper mineral from crushed and milled ore.

Freeport estimated that completely replacing a concentrator would have been a $2 billion capital project, taking up to 10 years.[7]

While Freeport is a frontrunner in adopting AI, it is by no means alone. In May 2023, for instance, BHP teamed up with Microsoft to lift declining recovery rates at Escondida in Chile, the world's largest copper mine. Using real-time data from plants that process ore, in combination with AI-based recommendations from Microsoft's Azure platform, plant operators have the ability to adjust the variables that affect ore processing and grade recovery. The project is believed to have increased production by 5%.[8]



Figure 3: The 3 main elements of KoBold´s approach

1 Geo-Science	2 Comprehensive Data Aggregation	3 Artificial Intelligence
		
Our geoscience leads have been a part of the most significant discoveries of the last generation	KoBold invests substantially in aggregating all available information about the physics and chemistry of the Earth's crust	Our proprietary AI tools build a concept we call Efficacy of Information (EOI), enabling KoBold to determine which data to collect at each exploration step to maximize uncertainty reduction

[4] Source: KoBold website This AI Hunts For Hidden Hoards Of Battery Metals – (koboldmetals.com)
[5] Source: McKinsey, Inside a mining company's AI transformation
[6] Source: McKinsey, Freeport Mc-Moran turns data into value
[7] Source: McKinsey, Freeport Mc-Moran turns data into value
[8] Source: Bloomberg, 5/09/23

Automating mines to improve performance

The final way that miners are using technology to improve productivity is through automating mines. They are automating mining trucks, loading machines, drilling and bolting equipment.

For instance, Freeport's Bagdad mine will be the first US mine with a fully autonomous haulage system, using 33 Caterpillar trucks. "The three-year conversion project is expected to improve safety, optimize our fleet, reduce GHG emissions through reduced idle time and position us to capitalize on future technological advancements in electrification," said Freeport-McMoRan President, Kathleen Quirk.[9]

Bagdad is far from alone, as mines move swiftly towards greater automation. "The adoption of automation obviously varies between mines and across the world," explains Jyrki Salmi, research director and mining automation expert at Finland's University of Oulu Faculty of Technology, in the Mining Technology newsletter.[10] "But in general, it is probably safe to say that the modern mining industry is already moving towards a smarter and more automated way of working." As he says, vehicle fleets such as mine trucks, loading machines and drilling and bolting equipment can already operate completely autonomously through most work phases without human control, improving safety and increasing operational efficiency.

According to a 2023 report from Global Data, cited in the same article, the total population of tele-remote control and autonomous underground mining trucks and long-haul dump vehicles is estimated at 1,032. Australia and Canada lead the way, accounting for 41% and 17% respectively of that fleet[11]. They are followed by the US with 7%.

Connecting through the Internet of Things

Behind the automation of many of mining's routine tasks lie networks of cameras and sensors linked by the Internet of Things (IoT) that are helping to revolutionize mining. There is hardly a mine today that does not deploy an IoT approach, making data interaction more effective.[12]

Automous Haulage at Bagdad

- Bagdad expected to become the first U.S. mine
- Converting existing manned fleet to 100% autonomous
  - 30 trucks
  - CAPEX -$55 mm
  - Target Completion 2025
- Reduces human exposure to active mining areas
- Potential for efficiency gains / productivity improvements
- Further upside value with improved analytics
- Emissions reduction expected from reduced idle time and improved efficiency
- Initiative helps alleviate hiring needs and housing challenges
- Project will position us to capitalize on future technological advancements in electrification



Source: Freeport Q4 2023 Report

[9] Freeport-McMoRan to convert fleet of Cat 793 trucks at its Bagdad mine in Arizona to autonomous haulage using Cat MineStar Command for hauling. PR Newswire. October 31, 2023.
[10] Mine fleet management in the age of automation. Mining Technology. March 04, 2024.
[11] Source: Global Data, Development of Tele-remote and Autonomous Equipment in the Global Underground Mining Sector, 2023
[12] Source: Forbes, How 5G is empowering mining operations.

The potential of robotics

Combining AI with robotics brings huge potential, helping mining companies to solve their trilemma: safety, sustainability and productivity. A whole range of startups has formed, including Offworld, an AI-focused company that is developing a range of autonomous mining robotics to extract resources on the Earth and the Moon. Offworld has already partnered with players like BHP, Anglo American and the Luxembourg Space Agency. The company promises to revolutionize mining through products like the Excavator which conducts rock face mapping before and during its precision excavation of ore, so limiting waste rock excavation, enabling selective sorting of excavated material, and increasing downstream efficiency.



Source: Offworld

Autonomous trucks, for example, depend on wireless 5G communications to function effectively because their software relies on sent and received data, as well as GPS (global positioning system data) to navigate surface and underground tunnels. Similarly, the network of countless sensors that populates most mines needs to convey data in an extremely fast and efficient way. When linked up by 5G connectivity, IoT can do this efficiently thanks to the expanded bandwidth.

The use of the IoT to convey data – enabling other technologies such as AI and virtual reality – fosters automation of production, drilling, blasting and milling. For that reason, the market intelligence firm Ariston estimates that the size of 5G in the mining market will surpass $2.15bn in 2023, reaching $12.75bn in 2029. This growth is the equivalent of a 34.5% compound annual growth rate.[13]

Valuations in the mining sector

In recent years, the mining sector has experienced expanding profit margins and improvements in other profitability metrics like return on equity (see Figure 4). This new wave of technology adoption could have the potential of improving them even further, as miners reap its evident advantages.

Beyond the potential of AI and technology, the mining sector has attractive valuations on a historical basis—despite the fact that they have recently moved higher relative to the MSCI World index (see Figure 5).

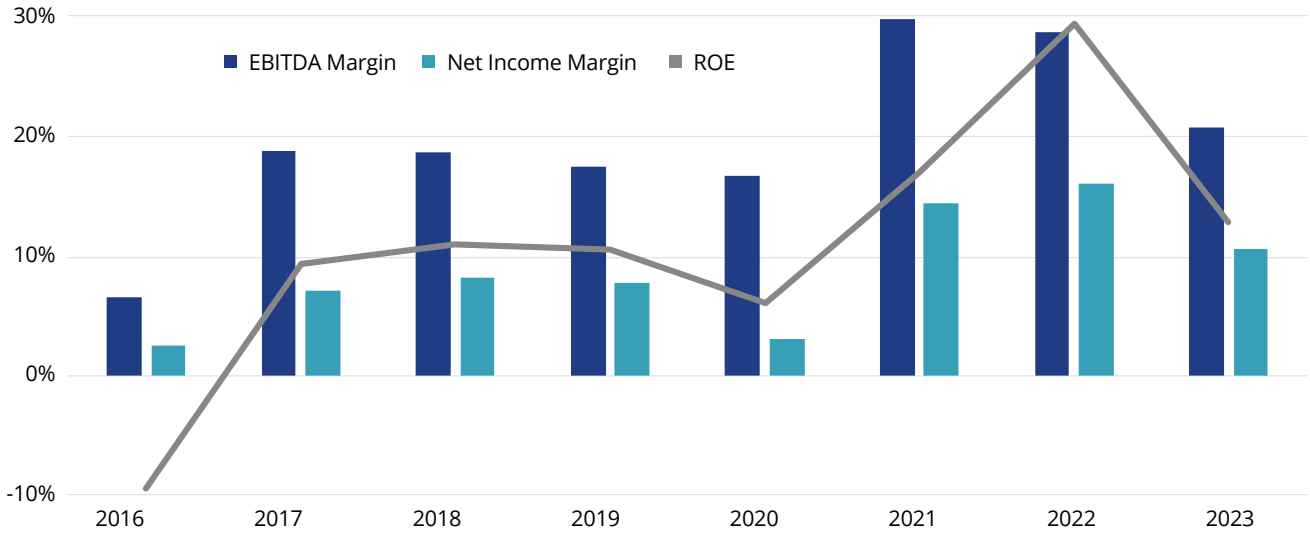
Case study: Sweden's largest copper mine saves costs and carbon

Swedish miner Boliden has used automation to achieve major productivity gains at Aitik, Sweden's largest open-pit copper mine. A WiFi network had originally been deployed to connect everything but it was not designed for the wide outdoor coverage needed. Ericsson, the telecoms company, provided a 4G/5G network to automate and remotely control equipment at the mine. Automation has cut the Aitik mine's annual costs by approximately 1%. There was also a 10% saving in fuel consumption, equating to 9,400 metric tons of CO2 emissions.[14]

[13] Source: Arizton, 5G in mining market – global outlook forecast 2023 – 2029.
[14] Source: Ericsson. Mining automation and the reduction of carbon emissions. https://www.ericsson.com/en/cases/2019/mining-automation-and-the-reduction-of-carbon-emissions

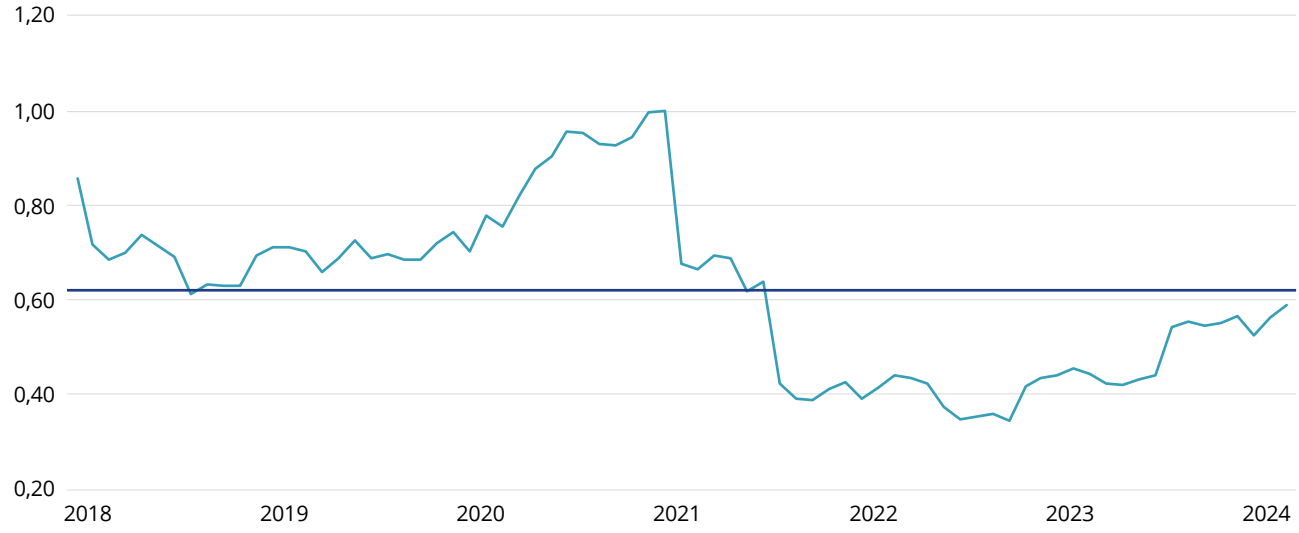


Figure 4: Profitability of the Mining Sector



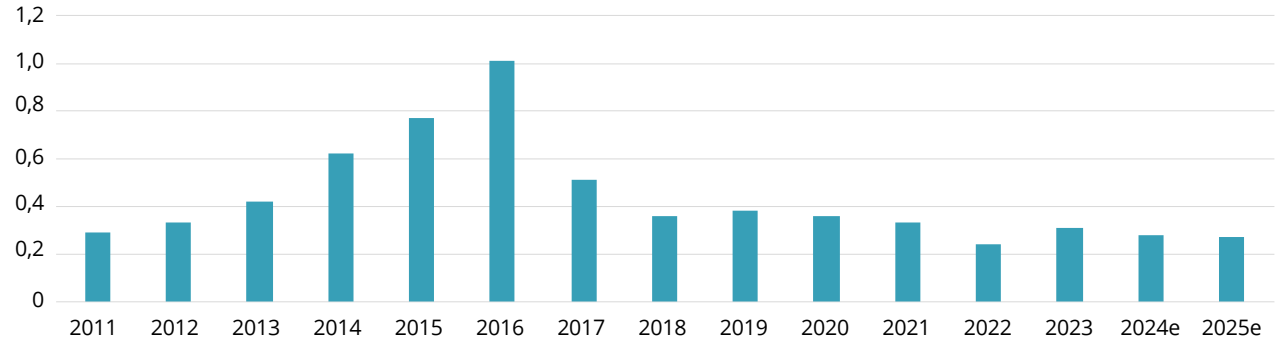
Source: Bloomberg. Data calculated for the MSCI World Metals and Mining Index.

Figure 5: MSCI World Metals & Mining P/E relative to MSCI World



Source: Bloomberg, VanEck. Data for the MSCI World Metals and Mining Index and MSCI World. 31/01/2018 – 30/03/2024

Figure 6: Net Debt / Equity

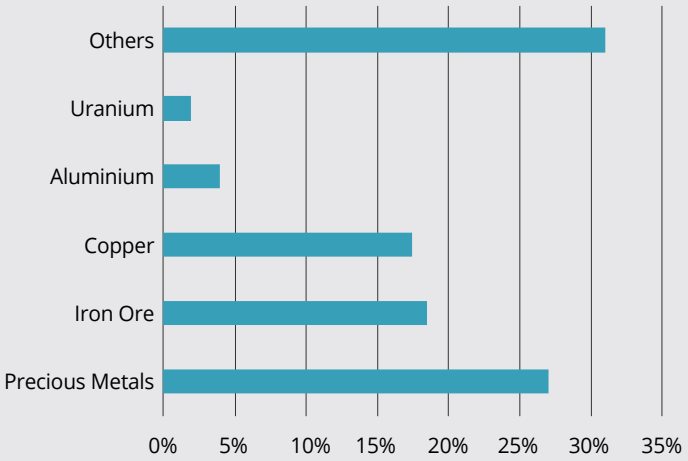


Source: Morgan Stanley Research, brokerage report "European Metals & Mining Tracker", 25/04/2024

VanEck Global Mining UCITS ETF (ISIN: IE00BDFBTQ78)

At VanEck we were the first to offer an easier and more liquid strategy to access the global mining sector, within a UCITS wrapper. The VanEck Global Mining UCITS ETF invests in the leading miners in the world, providing exposure to the key metals for the accelerating energy transition. Miners are known for regularly returning capital to investors, in the form of dividends and share buybacks, as well as representing an historical inflation hedge. The ETF's main risks are sector concentration risk, the risk of investing in smaller companies and emerging markets risk.

The ETF offers exposure to the following metals, based on revenues generation[15]:



When it comes to financial leverage, the mining sector looks in healthy shape. Mining companies have steadily been reducing their debts, as visible from the above graph that uses a select portfolio of global miners as a proxy for the sector.

Conclusion

While mining is often viewed of as a traditional industry of the past, AI and digitalization are beginning to change the sector. The technologies are making new ore deposits more accessible while optimizing the production from existing mines and cutting costs. This may prove revolutionary for mining companies, helping them to meet the demands of the green transition and an electric future, alongside safety, while trying to maximize profitability.

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[15] Source: Factset, as of 30/03/2024

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