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Future of mining with AI:
Building the first steps towards
an insight-driven organization

Introduction

With a majority of mines still using legacy technology and facing the growing need to drive operations deeper underground, easily attainable cost and productivity savings are getting harder to obtain. Moreover, productivity in mining operations world-wide continues to decline—despite continuous improvements to operations and even after adjusting for declining ore grades. On top of that, the industry continues to face:

- **Volatile commodity prices**—which continues to squeeze cash flow and put pressure on profitability;

- **Changing the nature of work**—where changing demographics, the nature of jobs and perceptions of mining as a career choice are heightening the need to re-envision talent management;

- **Maturity of existing mines**—leading to lower ore grades and longer haul distances;

- **Innovation barriers**—where mining companies tend to be risk averse and have an inclination to distrust collaboration due to IP and competition concerns.

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In planning for the future of operations, mining leaders seeking to turn challenges into opportunities are increasingly looking to the suite of advanced technologies related to artificial intelligence (AI), such as machine learning and natural language processing that help drive deeper insights, and deep learning neural networks that can significantly enhance image and speech recognition. While there are no single technology solutions to industry challenges, when effectively integrated into workflows traditionally requiring human intelligence, AI-related technologies are now enhancing the organization's capacity to accomplish tasks, make decisions, create engaging interactions, and generate stronger business outcomes.

This third report in the Deloitte-NORCAT series on key trends in the mining industry examines where AI and related applications are bringing tangible benefits and already making pathfinding differences to mining operations. Drawing on a series of interviews Deloitte and NORCAT conducted recently with technology companies building AI solutions for mining companies, it explains how and why these mining companies have used AI-based applications, while also identifying key benefits and considerations for optimizing investment in these technologies going forward.

It verifies that success in the mining industry increasingly depends on changing the way it does business—starting with adapting to changing skills for frontline workers, and better understanding how technology can ensure resources are used optimally, and that operations become safer and more productive. It underscores that getting there begins by addressing fundamental questions:

- **Why should mining companies adopt AI applications?**
- **Which key challenges arise when deploying AI within the mining industry?**
- **How can mining companies prepare to adopt AI and take the first steps?**

Navigating the complexities of any technology implementation can be challenging, however, and key partnerships are increasingly critical to ensuring technology enhances the company's core values and capacities, while remaining flexible and cost-effective.

Let's see how mining companies are already using AI-related technologies to make a difference.

Untangling what we mean by AI

ACTIONABLE INSIGHTS
Result of extensive data analytics where information gives enough insights to drive decision making

ANALYTICS
The use of data and algorithms to improve decision making by generating insights

COGNITIVE
Component of AI containing a human-like layer of interaction between people, underlying data and technologies that form AI
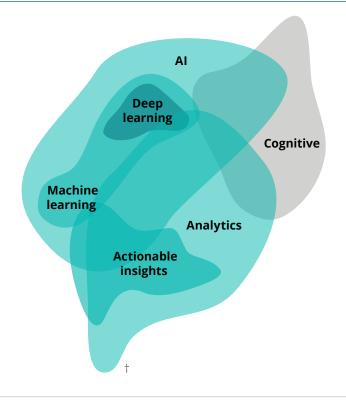
MACHINE LEARNING
Algorithms that improve over time through exposure to more data

DEEP LEARNING
Subset of Machine Learning that uses neural networks[1] with massive amounts of data to learn

1. Neural network: collection of simple processors connected together in layers. Each processor can only perform a very straightforward mathematical task, but a large network of them has much greater capabilities and can do many things which one on its own can't.
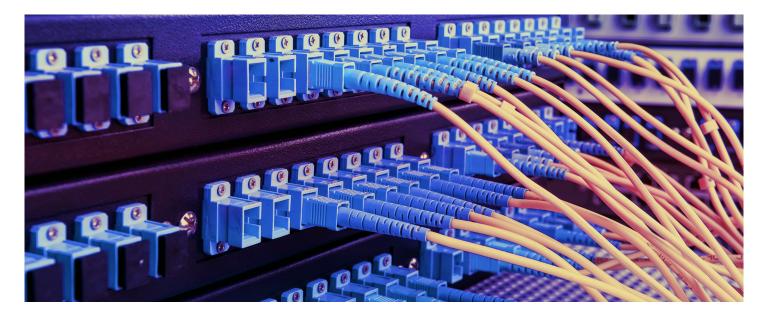
† To learn more about the AI concepts in the image, refer to the article: *Seizing the real AI opportunity*, Deloitte, 2018. Available on www.deloitte.ca

Making the case— why AI and why now

While artificial intelligence is still an emerging suite of advanced and practical technologies, AI is enabling mining companies to become insight-driven enterprises that utilize data to derive key benefits.

Benefits of AI

- Faster decisions with greater accuracy
- Improved health and safety
- Boosting efficiency through error elimination
- Smaller environmental footprint

Having worked with companies that are developing AI applications for the mining industry, NORCAT recently teamed up with Deloitte to conduct a series of interviews with these companies to better understand how and why they used AI-based technology, to identify the key benefits artificial intelligence technologies afford, and to make the case for greater adoption within the industry. The stories told by all companies interviewed depict active products, solutions and associated benefits, with the following companies highlighted to further illustrate their impact.

Implementing this technology allowed our team to process day-to-day data 18 times faster than what is typically done in the field.

– RockMass Technologies

FASTER DECISIONS WITH GREATER ACCURACY

With mine operations requiring ever larger amounts of data processing, the majority of which is still collected manually or by visual inspection, using machine learning to deliver value by instantly collecting data and deriving on-site insightful decision factors has the potential to vastly streamline the workflow while reducing error—in some cases by orders of magnitude. **RockMass Technologies**, for example, has deployed the latest generation of sensors to capture real-time data to identify potential failure planes on rock surfaces, using handheld hardware to analyze rock surfaces and providing the data to the user within minutes. This is done with software that analyzes data 18 times faster than current manual methods, the result is a consistent and radically efficient method for making accurate and quick assessment of potential risks.

For the first time in this industry, we see the promise of a closed loop, from training to operations and back again. This allows us to establish the standards of best practice required and then to monitor each individual operator to pre-empt performance decay and collectively drive towards workforce excellence.

–ThoroughTec

IMPROVED HEALTH AND SAFETY

AI supports better and faster decision making, which is critical to improving health and safety conditions for frontline mineworkers, reducing their exposure to dangerous situations, and accelerating the shift in mining to be more "process, rather than people oriented". Leveraging AI capabilities is at the core of **ThoroughTec**'s simulator based training platform, where wearable sensors continuously monitor

worker behavior, generating data that is then automatically analyzed to spot problematic behavioural trends and recommend highly-focused remedial training in a simulator-based environment. This enables mine managers to proactively respond to latent or emergent gaps in operator capabilities, optimising training interventions to best match individual worker needs and ultimately raising the standards of operator performance across the entire workforce.

BOOSTING EFFICIENCY THROUGH ERROR ELIMINATION

Quickly deriving patterns from large amounts of data can drive efficiency by increasing the consistency and quality of work that typically is subject to human error. **Ionic Engineering**'s use of machine learning to vastly enhance image recognition used in identifying the copper grades reduces to negligible the error rate compared to employees doing the work. By training

The ones who benefit with AI are the ones that make the investment with the vendors and have first access.

– Ionic Engineering

the machine in parallel with a person— specifically, by using neural networks to learn characteristics the operator is looking for—operation time and product quality is ultimately improved, thereby upping the potential to reduce costs.

SMALLER ENVIRONMENTAL FOOTPRINT

Embedding AI technology in pre-existing systems is helping the mining industry reduce energy demand and decrease its environmental footprint. Ventilation presents the largest energy cost in an underground mine. Drawing on more than six years of data, **Shyft Inc.** is using machine learning to forecast energy peaks. AI-enhanced automatic adjustment of ventilation systems using integrated process control assists with significant energy cost reductions.

Thanks to automated code generation via industrial plug-and-play technology, ventilation technicians can relocate devices, such as fans, to new locations almost as easily as plugging in a mouse or keyboard on a computer. Industrial devices are recognized and can be activated remotely or automatically.

– Shyft Inc.

Again, no technology ever has or will be a magic bullet for industry at large or in any specific operational context. At the same time, the mining industry is learning that AI-related technologies can help frontline workers make better decisions quicker, while reducing human error, environmental footprints and the need for human intervention in potentially dangerous situations.

Implementing and using AI-related technologies, however, brings significant challenges, and mining companies need first and foremost to understand the key constraints and barriers they're apt to face when deploying AI within their organizations.

Building the case— challenges in AI implementation

As is often the case with new technology, implementation can be difficult, time-consuming and ultimately more costly than anticipated—implicating not only technical challenges, but people and environmental factors as well. Insights garnered from the Deloitte-NORCAT interviews underscore a number of key challenges common to AI-based implementations, including:

- **Poor testing method to generate insight**
  Difficulty in gathering consistently high-quality data to train models and generate actionable insights

- **Industry culture resistant to adopt AI**
  Leaders lacking a systemized approach to innovation and/or the communication expertise or departments to help embed AI in the corporate DNA

- **Limited understanding of deployment of AI-related technology (operations and financial returns)**
  Mining professionals see that while some solutions yield favourable test results, their implementation is complex. Similarly, implementation of AI related products impacts daily production and typically does not yield a return for shareholders immediately

- **Lack of current capabilities to support AI**
  Needing to combine traditional mining skills with advanced technology skills, leaders must consider hiring more ambitious talent from the technology environment, thereby making creativity related processes more flexible and designing more inspiring work environments.

INSIGHT GENERATION
One result of the increasing number of connected devices generating data is the difficulty validating and collating the different sources into a structured database. Much of the difficulty lies around streamlining the quality of digital and visual information that can be leveraged by AI to come up with useful insights. In response, **ThoroughTec** adopted an agile approach when developing their product, running algorithms on test data in parallel with human observations. The results were used to improve the algorithms while the complexity of the test scenarios progressively increased and human involvement scaled back.

INDUSTRY CULTURE
Mining was traditionally perceived as a risky undertaking with uncertain grades, investment volatility and variable metal prices so every opportunity to reduce risk and stay with the proven methods of operation was encouraged. This risk aversion stifled innovation opportunities and many major operations avoided taking the lead in proving empirical performance of new technologies because the up-front costs and the potential failure or risks involved with bleeding edge innovations was considered unwise. **Wipware**'s approach was to focus on improving the daily experience of frontline workers—including shifting from entirely trial and error practices of the past, where employees attempting to predict the crusher gap often increased equipment downtime. Relying on neural networks, **Wipware** provides real time material sizing data throughout the mining process that enables automated process control, which improve workers' abilities to anticipate disruptions in their operations and cut costs through less downtime and extended equipment life.

LIMITED UNDERSTANDING
Successful AI implementations are often game-changing but the mining professional needs to understand they require a fulsome balance of financial returns, improved and iterative changes processes and engaged employees—starting with executives developing patience and not expecting returns after the next quarter. One company achieving this balance is Ontario-based **Praemo**, who collaborated with employees throughout their product's pilot phase, which allowed companies to see first hand how **Praemo**'s technology analyzes data in real time to identify abnormal equipment and process behaviours. By testing product with mining company's equipment, employees were not only integrated into the product development process but afforded the opportunity to get actionable insights from the product, thereby encouraging employee input to help improve the solution. It also enabled partner companies to see how the solutions improves their operations over time, rather than deploying the full end-to-end solution upfront.

LACK OF CAPACITY
Because mining companies tend to acquire AI capabilities from external sources rather than develop them, implementations can get quickly bogged down—especially in the face of technology that tends to evolve rapidly. It also reinforces the long-standing industry habit of not deploying anything that's not ready for market at a time when it's abundantly confirmed that more agile and phased approaches to implementations comprise clear competitive advantages.[2] As a lab-based startup partnering with industry in order to pilot their technology, **RockMass Technologies** quickly established trust among mining companies that welcomed them to be part of their testing processes. This demonstrated how nascent technology can help improve operations and situate strategic partners for longer-term growth—a potentially time-consuming process that nonetheless pays off at the end.

Regardless of whether a solution involves AI, the mining industry continues to face numerous hurdles when it comes to change and technology adoption. However, as with managing all challenges, the choices mining executives make today will decide whether obstacles become opportunities tomorrow. And with sustainability increasingly a matter of longer-term approaches, the need for technology-assisted solutions has never been greater.

At the same time, developing cost-effective solutions requires a great deal more than just diving in and figuring out as you go along. In order to increase the chances of success, mining corporations need to go through a series of well-defined steps in designing and implementing AI strategies and applications.

2. Mining innovation puts people first, Deloitte/NORCAT, 2017

Becoming an insight-driven enterprise

Mining companies already integrating disparate data sources and using technology to generate higher-level insights and capabilities understand well that technology alone is not enough.

To deliver on AI, the right balance of business and technical skills is required, starting with knowing the difference between simply acquiring technology and developing a set of proper analytic functions and capacities. Ultimately, it's about deploying sensible and right-sized AI applications that enables companies in deriving both spot and long-term solutions, while also controlling scale and risk.

Omnia AI[3]—Deloitte Canada's artificial intelligence practice—utilizes a framework to help mining executives understand how they can achieve a desired future state, and implement AI applications for their operations. Regardless of the application, the framework can be scaled, and by combining mining companies' expertise

with appropriately sized technology and the right data, it helps deliver machine learning, deep learning, advanced analytics, change management, governance best practices and project management that is cost effective and flexible.

Omnia AI's 5-step process for ensuring mining companies investing in AI technology optimize the effort and the results.

Having worked with multiple companies on deploying AI, Deloitte has come to understand that building an insight-driven enterprise depends centrally on technical vision that's embedded in the business vision upfront, as well as on starting with a proof of concept and being bold in trying new approaches.

At the same time, success metrics need also to be clearly defined, well aligned with core capacities and flexible enough to accommodate shifts and iterations across design and implementation processes.

Ultimately, success for mining companies is not about adopting the latest technologies. It's about developing an organizational culture that leverages digital thinking into the heart of the business, such that strategies and practices work together to transform the way corporate and operational decisions are made across the enterprise.[4]

3. More information on Omnia AI is included in the *About Deloitte/NORCAT partnership* section of this report
4. *The digital revolution*, Deloitte, February 2017

1. Discovery
Mining and resource industry leaders confirm that careful planning and discovery at the outset of a technology implementation can significantly reduce risk. Companies start by aligning the goals and aspirations of business leaders with how the future of mining looks to the organization. This is followed by asking the right questions to identify key users and use cases, understand industry trends and opportunities, identify resources, and determine where AI is best able to help.

2. Data preparation
Focusing on data with a high potential for impact, deploying a methodology that is well-structured, repeatable, reviewable and transferable is critical to success once boots are on the ground. With an emphasis on designing contingency plans to account for the unforeseen—as well as accounting for assumptions and identifying when to stop analysis to reassess and iterate—this phase involves transforming raw source data into a form that can be used to unlock insights and generate business decisions.

3. Analytical modelling
Representing the development phase of a technology engagement, the objective now is to use industry best practices to analyze the structured data to determine the data model needed to address the challenge, from machine learning to deep learning models based on the complexity of the business case. During this phase, managing operational complexity is enhanced, such as accounting for things like mine depth and other factors relevant to accurate analysis. Context-driven modelling also helps in addressing unforeseen risks, including lack of technical infrastructure available for implementation or low production during the initial implementation of the AI related technology.

4. Insight communication
Intuitive data visualization is generated that builds the user story and consistently translates numeric data into operational impact whereby all stakeholders understand how the technology contributes to revenue and organizational capacity building. The process also enables leaders to act on insights and further explore analytic models.

5. Operationalization
Setting structured guidelines around the repeatable and iterative nature of visualized solutions affords mining leaders the flexibility in the day-to-day management of their analytical capabilities to identify which units will benefit from the solution, and to further assess operational approaches such as knowledge transfer and staff augmentation, or development, training and transfer. Operational solutions are positioned to solve the challenge, documenting processes along the way to ensure initiatives can be taken from idea to deployment.

Future of mining is here

Adoption of any digital technology is fraught with challenges, from transition periods lacking tangible results, to myriad challenges relating to data quality, organizational culture and limited understanding of and capacities to fully deploy the technology.

Yet, the growing evidence of their benefits indicates AI-based technologies in the mining industry are here to stay, allowing companies to make more accurate decisions faster, improve health and safety, boost efficiency and ensure human errors are almost negligible, all while helping create smaller environmental footprints.

This article surfaced some of the use cases for AI in mining, and introduced a multi-faceted framework to help mining executives start tackling the key steps to deploy AI. To further discover the best approaches of AI deployment—or to discuss which steps you should undertake as part of your own AI journey—contact us today.

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About Deloitte/NORCAT partnership

Deloitte, one of Canada's leading professional services firms, provides audit, tax, consulting, and financial advisory services. Deloitte LLP, an Ontario limited liability partnership, is the Canadian member firm of Deloitte Touche Tohmatsu Limited.

NORCAT is the only non-profit regional innovation centre in the world that has an operating mine designed to enable start-ups, small/medium enterprises, and international companies to develop, test, and showcase new and innovative technologies in an operating mine environment. This unique facility anchors one of the world's leading advanced manufacturing and mining technology clusters and represents a "one-stop shop" to see future technologies and innovations that are poised to transform the global mining industry.

NORCAT's Underground Centre has been working with mining companies to understand the urgent need for training—for both new and existing workers—on the efficient, productive, and safe use of new technologies. To accomplish this, over the past 20 years NORCAT has worked with clients, government, academic institutions, and partners to develop an array of integrated training and development programs to serve multiple sectors both in Canada and around the world.

As part of their strategic partnership, Deloitte and NORCAT are taking steps to help the global mining industry better understand emerging mining technology and innovation trends. Their goal is to combine on-the-ground insight gained from companies that have installed emerging technologies at the NORCAT Underground Centre with the market knowledge of the Deloitte global mining team.

About Omnia AI
Omnia AI is the core of Deloitte's Artificial Intelligence practice. With over 350 dedicated professionals with deep expertise in AI, machine learning, data integration and analytics/visualization, we lead all others in helping Canadian businesses unlock the potential of AI.

Omnia AI helps clients identify, understand, develop, deploy, manage, and capture optimal value from AI. Omnia AI focuses on people, process, and context, as well, and ensuring the technology aligns perfectly with the strategic direction of the company and the sector in which it operates.

Publication Series
Other articles Deloitte has developed in collaboration with NORCAT, focus on how the mining industry is adopting a "Human Centred Design" approach to mining innovation and how the "Future of Work" in mining will affect both front-line employees and leadership, can be found on the webpage "Deloitte and NORCAT – Collaborating to explore the future of mining" at www.deloitte.ca

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