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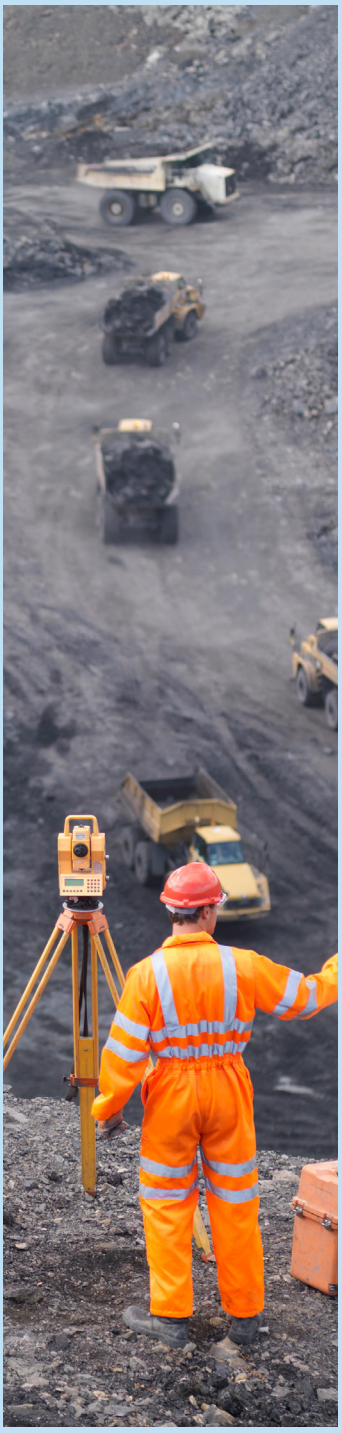

REINVENTING THE MINING BUSINESS MODEL WITH GENAI

Abstract

Artificial intelligence (AI), especially Generative AI (GenAI) is triggering seismic shifts across mining operations in the areas of ore processing, safety, and environmental compliance. This is driving mining companies to transform their business models. To understand this new frontier of AI/GenAI and take advantage of its potential, it is crucial to explore how innovative strategies can improve traditional processes and bring in new revenue streams and how to leverage strategic partnerships for sustainable growth.

This paper examines how GenAI can transform the mining industry as a powerful tool to drive new efficiencies. It also looks at how GenAI will be a core component of a new business model that can help mining companies increase their competitive advantage.

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Understanding the Paradigm Shift

The integration of artificial intelligence (AI) into mining processes promises to increase efficiency, safety, and sustainability. As a technology, generative AI (GenAI) is adaptable and can solve complex problems by analyzing vast amounts of data. This is crucial for the mining sector, which relies heavily on data and analytics.

Fig. 1: Applications of GenAI in various stages of mining

As seen in Figure 1, GenAI can transform the mining value chain across various stages. Further, based on the technology spending patterns of top mining companies across the globe, it is clear that these organizations recognize that GenAI can not merely optimize operations, but also help build a competitive advantage[1].

GenAI Adoption Insights

Global spending on GenAI solutions is expected to reach US $151.1 billion by 2027 with a compound annual growth rate (CAGR) of 86.1% over the 2024-2027 period[2]. A 2024 survey by a leading consulting firm reveals that GenAI is helping organizations recognize extraordinary opportunities for productivity gains, thereby quickly changing the way companies do business[2,3].

71% Executives plan to increase Tech investments in 2024 and beyond, With GenAI as top priority

10% Companies expecting to invest more than $50 Mn in AI/GenAI in 2024 and beyond

27% Companies expect more than 10% in cost savings in 2024 and beyond

Despite these promising figures, nearly half of the global mining industry is hesitant about integrating AI in their operations. Many companies choose to rely on manual tools and processes for supply chain management and operational planning. On the bright side, the other half of the mining industry that has embraced AI is witnessing substantial improvements in efficiency and decision making. Some of the tangible outcomes include 75% reduction in unplanned downtime, 50% faster data analysis (leading to more reliable decisions), and over 20% reduction in emissions[3,4].

Let us assess the importance of GenAI in mining by considering the competitive landscape, factors influencing GenAI adoption, and new market opportunities, as well as the value and sustainability of GenAI in the short and long term.

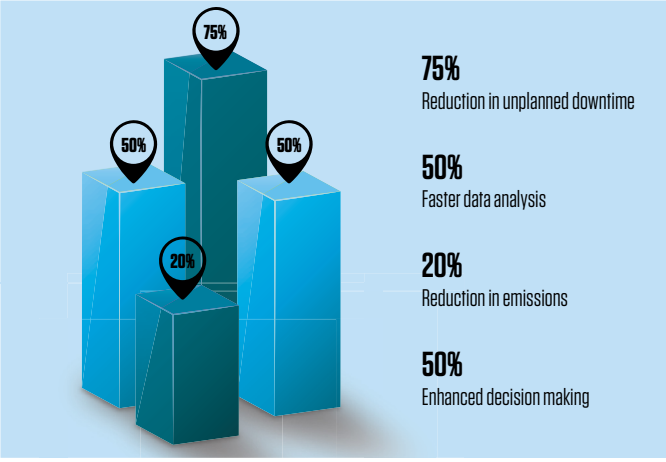

Fig 2: Key Benefits for Mining companies that are embracing AI

Market Dynamics and the Competitive Landscape

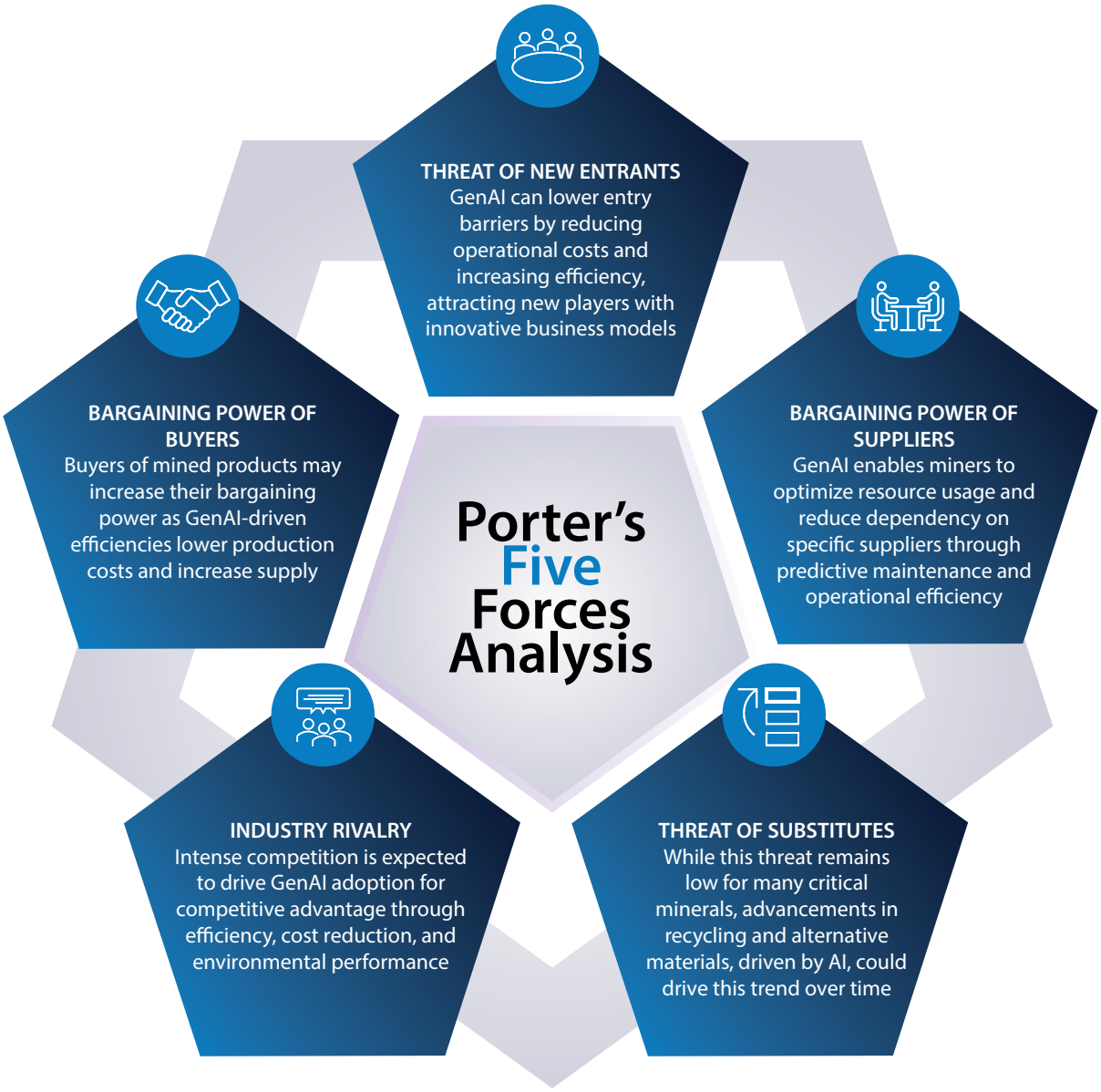

Fig. 3: Porter's five forces analysis of GenAI in mining

Before embarking on AI/GenAI transformation, it is important to understand how the implementation of these technologies may alter the competitive landscape and market dynamics. Here are some key factors for mining enterprises to consider:

- **Threat of new entrants:** The introduction of AI in the mining industry may lower the barriers to entry for new startups, especially those with expertise in AI and machine learning. This could heighten competitiveness in an already crowded marketplace.
- **Bargaining power of suppliers:** AI technology suppliers may acquire significant bargaining power when they offer unique or specialized AI solutions for the mining industry. This could potentially impact the industry's profitability and cost structure.
- **Bargaining power of buyers:** Mining companies that adopt AI solutions may find themselves in a better bargaining position when they demonstrate improved efficiency, cost savings, and productivity gains. This could potentially lead to greater price pressure on AI technology providers.
- **Threat of substitutes:** GenAI can accelerate the development of alternative materials, posing a threat to traditional mining products.
- **Competitive rivalry:** The competitive rivalry in the mining sector is likely to intensify as more companies invest in AI technologies. This could lead to pricing pressures, technological innovation, and an increased focus on differentiation and value-added services.

Based on this analysis, mining companies adopting GenAI can gain a sharper competitive advantage compared to companies lagging in their AI adoption[3].

Factors Influencing the Adoption of GenAI

The adoption of AI in mining may soon become an industry norm. Figure 4 outlines the key driving forces of AI transformation as well as the restraining factors that could hinder AI adoption in the mining sector.

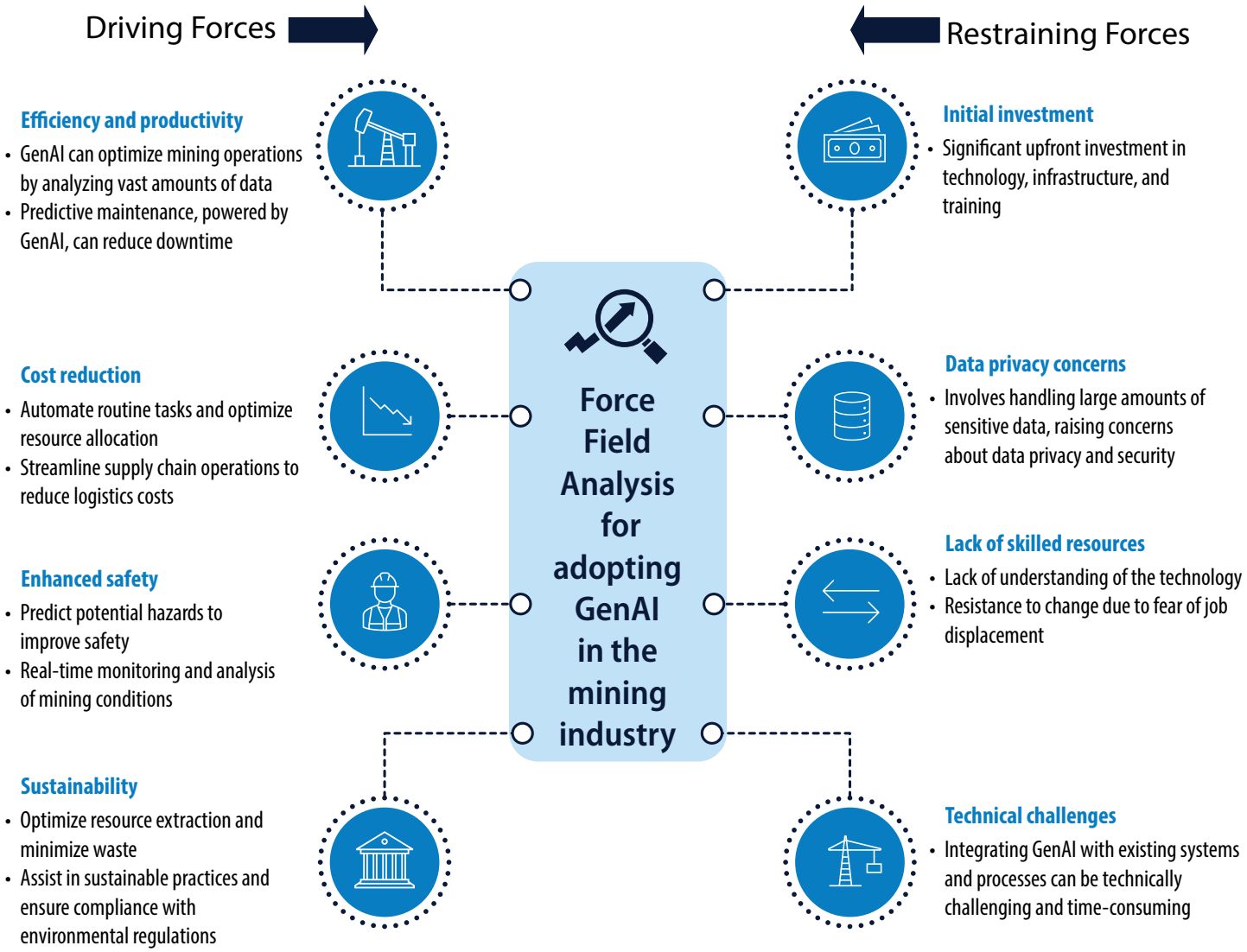

Fig. 4: Force field analysis of AI adoption in the mining industry[5]

Overcome restraining forces

Here is how mining companies can address the key challenges to AI adoption:

- **High initial investment** – Form alliances with AI startups or tech giants to reduce the financial burden and gain access to cutting-edge technologies.
- **Lack of skilled resources** – Create comprehensive training programs, change management strategies, and feedback loops for employees to voice concerns.
- **Data privacy concerns** – Invest in robust cybersecurity measures and ensure compliance with data protection regulations. Educate employees on cybersecurity best practices.
- **Low technical affinity** – Establish an ethics committee to oversee AI initiatives. Participate in industry forums to ensure compliance and address ethical concerns.

Leverage driving forces

Here is how mining companies can maximize return on investment or ROI from GenAI adoption:

- **Efficiency and productivity** – Implement GenAI solutions in areas with the highest potential for efficiency gains such as predictive maintenance and resource allocation.
- **Cost reduction** – Automate repetitive and labor-intensive tasks to cut operational costs. Focus on low-hanging fruits for the short term.
- **Enhanced safety** – Deploy AI in safety monitoring systems to predict accidents. AI can analyze sensor data to detect hazardous conditions and alert workers in real time.
- **Sustainability** – GenAI can monitor and analyze safety data in real time, providing insights that help prevent accidents and ensure compliance with safety regulations.

Strategic Frameworks to Implement GenAI

1. The blue ocean strategy

The blue ocean strategy is a business approach that focuses on creating new and uncontested market spaces while simultaneously pursuing differentiation and cost effectiveness. The Eliminate-Reduce-Raise-Create (ERRC) matrix is a key tool in the blue ocean strategy that helps companies identify areas where they can innovate and differentiate.

FACTORS	ELIMINATE	REDUCE	RAISE	CREATE
Operational inefficiencies	Redundant processes that cause delays	Equipment downtime	Real-time data analysis	AI-driven prescriptive maintenance
Environmental impact	Practices that lead to excess waste and pollution	Carbon footprint and energy consumption	Sustainable practices	Green mining technologies
Cost structure	Costs from inefficient resource utilization	Capital expenditure on non-essential equipment	Investment in AI for long-term savings	New revenue streams from AI
Market offerings	Traditional exploration methods	Over-reliance on manual labor	Customization and personalization of services	Innovative value-added services leveraging GenAI

Table 1: ERRC matrix for GenAI in mining

Based on the ERRC matrix, here is how companies can leverage the blue ocean strategy to innovate and differentiate:

- **Create uncontested market spaces** – Traditional mining operations often compete in a 'red ocean' of intense rivalry where companies vie for the greater share of finite demand. By adopting GenAI, mining companies can shift to a 'blue ocean' strategy where they create new demand and operate in an uncontested market space. This involves rethinking the entire mining process, from exploration to extraction and processing, to uncover new efficiencies and opportunities.
- **Differentiate through innovation** – GenAI can drive significant innovation in the mining industry. For instance, AI-powered predictive maintenance can reduce equipment downtime, while advanced data analytics can optimize resource extraction and processing. These innovations not only enhance operational efficiency but also differentiate organizations from their competitors, thereby creating a unique value proposition for customers and stakeholders.
- **Pursue cost reduction and efficiency** – A key aspect of the blue ocean strategy is achieving differentiation while simultaneously reducing costs. GenAI can help mining companies achieve this by automating routine tasks, improving decision making processes, and enhancing supply chain management. These improvements help lower cost and increase productivity, allowing companies to offer competitive pricing while maintaining high quality standards.
- **Expand the value chain** – By adopting a blue ocean strategy, mining companies can expand their value chain to include new services and products. For example, they can offer AI-driven consulting services to other industries by leveraging their expertise in GenAI applications. This not only opens up new revenue streams but also positions the company as a leader in technological innovation[6].

2. The VRIO Framework

The VRIO (Value, Rarity, Imitability, and Organization) framework can help analyze the impact of AI in the mining industry. It can provide insights into sustainable competitive advantage as well as the potential for long-term success of AI implementations.

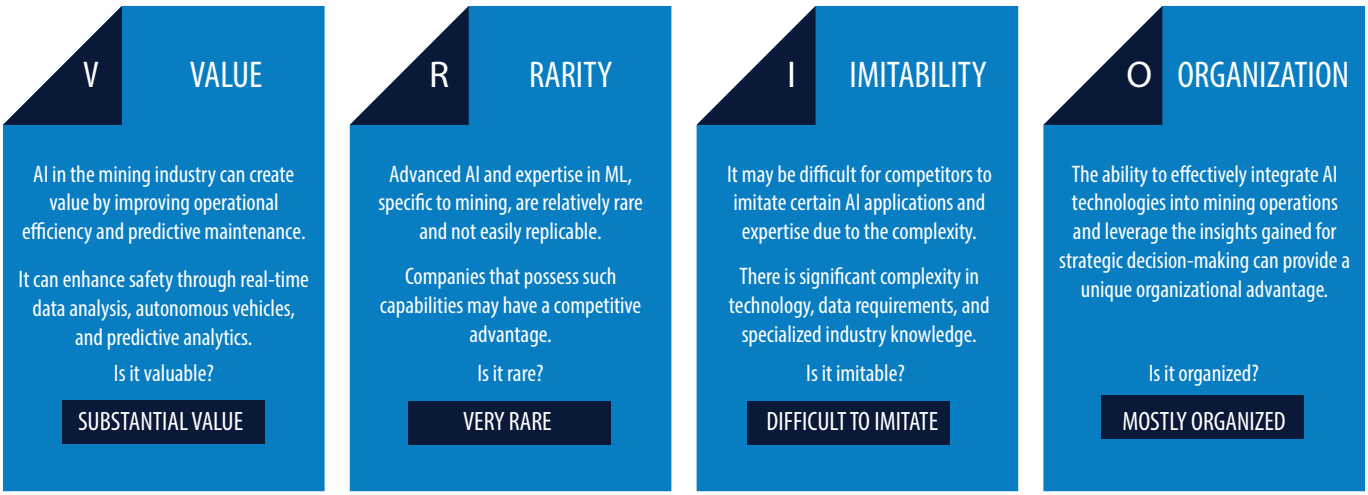

Fig. 5: Using the VRIO framework for GenAI adoption

AI and GenAI adoption in the mining industry score highly for all the attributes of VRIO framework, as seen in Figure 5. This means that the integration of GenAI in mining can deliver a significant competitive advantage.

3. GenAI adoption roadmap

The speed and scale of Gen adoption is crucial to gain a competitive advantage and, hence, companies must act swiftly. Figure 6 provides a reference roadmap based on the technology adoption framework used by a leading consultancy firm.

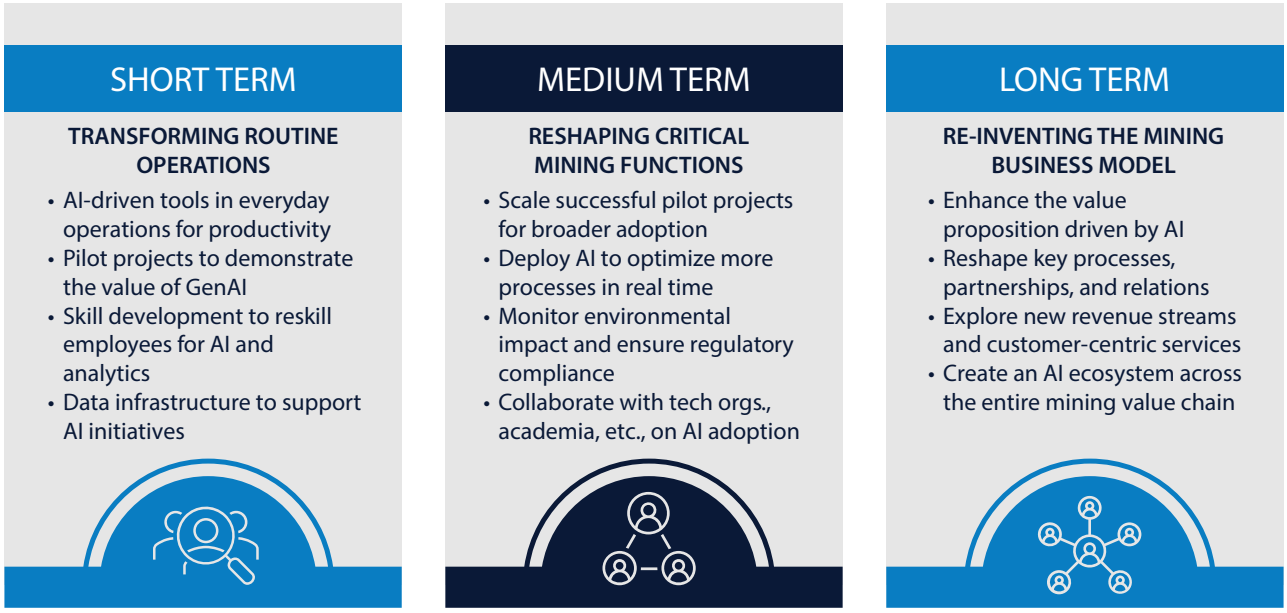

Fig. 6: Reference GenAI adoption framework from short to long term

Using this framework, mining companies can adopt AI in a systematic way, from short to long term projects.

Integrating GenAI in the Mining Value Chain

The next step is to identify key opportunity areas where integrating GenAI can deliver the most significant benefits and prioritize these based on the potential value creation.[7] Thus, before integrating GenAI into the mining value chain, it is important to identify key opportunity areas in mining activities and processes with a focus on efficiency, sustainability, and customer satisfaction. The value chain analysis framework seen in Figure 6 shows how a typical mining company can integrate GenAI across all stages of the value chain.

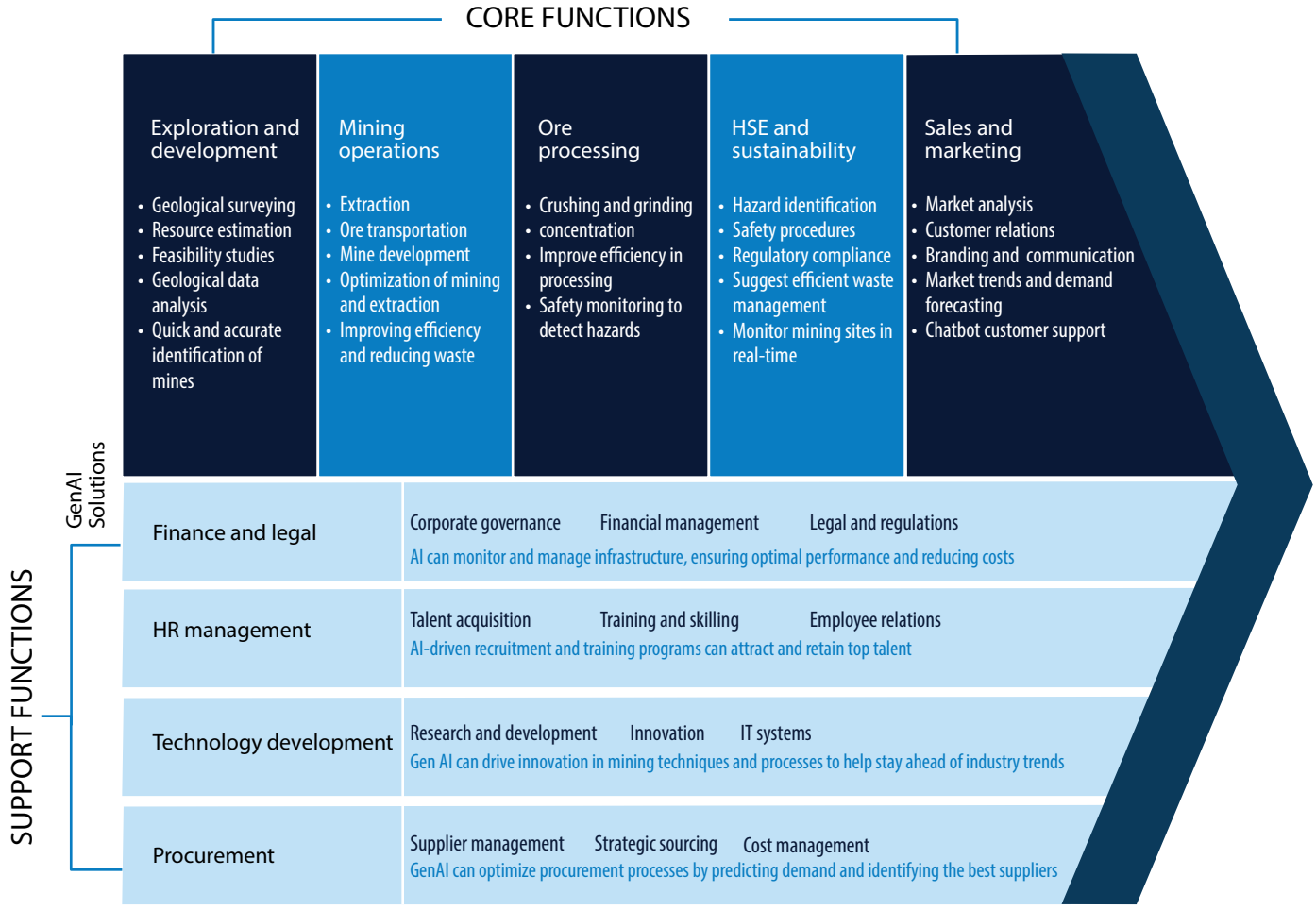

Fig. 7: Value chain analysis using GenAI

Incorporating GenAI into the mining value chain can greatly improve efficiency and decision making across the following stages:

- **Exploration** – GenAI can analyze geological data to identify potential sites more accurately.
- **Operations** – It can optimize extraction techniques and predict maintenance needs.
- **Processing** – GenAI can enhance crushing, grinding, and refining processes.
- **Logistics** – It can manage inventory and optimize transportation routes.
- **Sales and marketing** – GenAI can analyze market trends and personalize customer interactions.
- **Support activities** – GenAI can enable automation and predictive analytics across activities such as procurement and human resource management.

Furthermore, GenAI can also help monitor environmental impact and improve community engagement, ensuring sustainable and responsible mining practices[8].

Mapping Opportunities to Value Creation

The value-opportunity assessment matrix helps prioritize AI and GenAI integration based on the potential value and implementation feasibility in areas of immediate focus. Lower-value or lower-opportunity areas are assigned secondary importance and considered for later stages. This ensures efficient allocation of resources to maximize the benefits of GenAI.

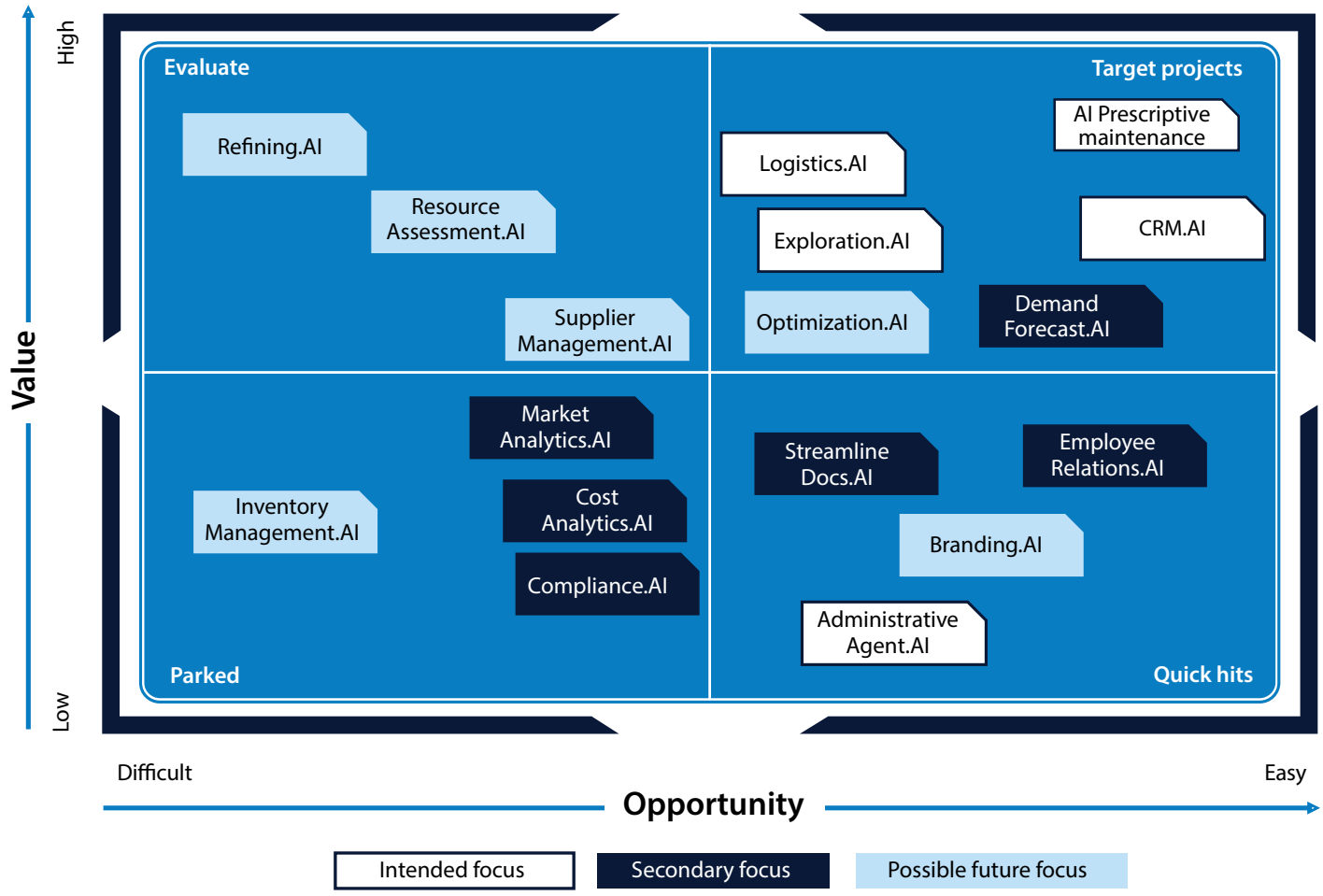

Fig. 8: Value-opportunity assessment matrix of GenAI use cases in mining[9]

Based on GlobalData's Thematic Impact Assessment[9]

As seen in Figure 8, the value-opportunity assessment matrix plots 'opportunity' on the X-axis on a scale of 'difficult' to 'easy' in terms of implementation. The 'value' factor is plotted on the Y-axis ranging from 'low' to 'high' in terms of potential for value generation. Based on the plotting, the following key insights emerge:

- High-value and high-opportunity areas such as AI-driven automation in mining operations, predictive maintenance, AI-driven exploration, and AI-driven research and development can be prioritized for immediate focus due to their substantial potential in increasing efficiency, reducing costs, and driving innovation.
- Medium-value and high-opportunity activities like using AI for assessing resources and enhancing refining processes can be considered as they offer significant improvements in decision-making and process optimization.
- Low-value or low-opportunity areas such as basic administrative tasks and routine compliance areas should be considered for later stages as they offer minimal impact on core operations.
- This strategic prioritization ensures effective resource allocation to maximize the benefits of GenAI in enhancing productivity and competitiveness in the mining industry.
- Alongside the benefits of cost savings and improved efficiency, GenAI can also generate additional revenue[6].

Exploring New Revenue Streams with GenAI

Leveraging GenAI within the mining value chain not only enhances operational efficiency and reduces costs but also unlocks significant revenue potential. Two ways in mining companies can achieve this with GenAI are by:

- Increasing efficiency and profit margins
- Collaborating with other providers to uncover new revenue opportunities

1. Increasing efficiency and profit margins

Figure 8 depicts the potential benefits of integrating GenAI in the mining value chain.

Key Areas	Revenue Streams	Potential Business Impact
Resource management Use AI to optimize resource extraction and processing	**Increase profitability** by reducing waste and improving yield, which can directly reflect in the bottom line	**5 - 10%** ↑ Increase in resource recovery rates
AI-enhanced exploration Use AI to analyze geological data and identify new mining sites with higher accuracy	**Increase the success rate** of exploration projects, leading to more profitable mining operations	**10 - 20%** ↑ Increase in success rate of finding viable mining sites
Operational efficiency Apply AI to streamline operational processes such as logistics, supply chain management, and energy usage	**Lower operational costs** and improve margins through efficiency gains	**12 - 18%** ↓ Reduction in logistics, SCM, and energy usage costs, which directly improve profit margins
Safety and compliance Develop AI systems to enhance safety and ensure compliance with regulations	**Reduce costs** associated with accidents and regulatory fines. Offer these solutions to other companies	**5 - 12%** ↓ Reduction in costs associated with accidents and regulatory fines, as well as insurance premiums
Environmental monitoring Use AI to monitor environmental impact and improve sustainability practices	**Attract investment** and partnerships by demonstrating commitment to sustainability	**5 - 10%** ↑ Potential in funding from stakeholders interested in sustainable practices
Real-time data analytics Implement AI-driven analytics to provide real-time insights into mining operations	**Improve decision-making** processes, leading to better resource allocation and increased profitability	**5 - 10%** ↑ Faster decision making, leading to better resource allocation and profitability

Fig. 9: Avenues for maximizing profit margins and efficiency[10,11,12,13,15]

Having analyzed the business impact of GenAI in key mining processes, it is also critical to prioritize which use cases to target in the short, medium, and long term. This can be determined using the value-opportunity matrix described earlier.

2. Finding revenue streams through collaboration

By leveraging the strengths of GenAI and the expertise of IT services and technology providers, mining organizations can unlock new revenue streams, drive innovation, and sharpen their competitive edge in the market.

Technology integration strategy/ Partnerships/Joint ventures

Collaborative strategies

- Partner with academia and global capability centers (GCC) to develop mining technologies and generate new IP
- License these technologies or form joint ventures to generate additional revenue

AI-as-a-Service

- Offer AI solutions and expertise to other mining companies
- Offer AI solutions as a subscription service to other mining companies to create a steady revenue stream.

Data monetization

- Mining companies collect vast amounts of geological, operational, and environmental data
- Analyze and package mining data and sell valuable insights to other industries

Fig. 10: New revenue streams based on partnerships or joint ventures[10]

Such collaboration combines the technological capabilities of IT providers with the industry expertise of mining companies. It pools together resources such as capital, technology, and human expertise while sharing the risks associated with new technology implementations and market fluctuations. Joint ventures offer services like predictive maintenance with IoT sensors and data analytics, AI-driven operational optimization, environmental monitoring for compliance, and supply chain management through blockchain.

TECHNOLOGY INTEGRATION	RESOURCE SHARING	RISK MANAGEMENT
IT provider role: Bring advanced technological tools, software, and systems	**Capital:** Both parties contribute financially to fund joint projects, research, and development	**Shared technology risk:** Share risks in adopting and integrating new tech, ensuring that all parties are invested
Mining company role: Provide industry-specific knowledge, operational expertise, and insights	**Technology:** Share technological assets such as software, hardware, and infrastructure	**Market adaptability:** Develop strategies to handle economic and market changes
Synergistic innovation: Combine tech capabilities and industry expertise to create innovative solutions that improve efficiency, safety, and productivity	**Human resources:** Combine the skills and knowledge of employees from both companies to foster innovation and problem-solving	**Financial stability:** Share financial risks to reduce individual exposure and create a more stable operational environment

Fig. 11: Technology, resource, and risk-sharing matrix

Creating a New Business Model for AI-first Mining Operations

By restructuring the mining business model to embrace AI-driven insights and efficiencies, companies can achieve significant operational improvements, cost reductions, sustainability gains, and new revenue streams. Figure 12 depicts such a model using the business model canvas.

Key Partners

- Collaboration with AI technology providers and startups
- Strategic alliances with data analytics firms
- Partnerships with educational institutions for AI research and talent development

Key Activities

- AI-driven exploration using predictive models
- Automated and real-time data analysis for operationalefficiency

Key Resources

- GenAI platforms and software
- Data repositories for ML
- AI-specialized personnel and data scientists

Value Proposition

- Tailored solutions using GenAI to meet specific material requirements
- Enhanced precision in resource estimation and extraction
- Optimized processes through AI
- Improved environmental sustainability
- AI-powered monitoring systems to enhance worker safety

Customer Relations

- Personalized data services for clients
- AI-enabled customer support
- Blockchain and AI traceability

Channels

- Digital marketplaces for trading minerals

Customer Segments

- Companies seeking ethically sourced minerals
- Governments looking for data-driven resource management
- Companies interested in AI-enhanced mining operations

Cost Structures

- Investment in AI technology and infrastructure
- Costs associated with data acquisition and management
- Upskilling the workforce for AI competency

Revenue Streams

- Licensing of proprietary AI technologies
- Premium pricing for AI-enhanced minerals
- Consultancy services for data-driven mining using AI

Fig. 12: The business model canvas of an AI-first mining company[14]

By focusing on the areas mentioned in Figure 12, mining companies can enhance core operations with GenAI and drive efficiency, safety, and profitability without losing focus on the primary business. A business model canvas comparing the traditional business model and the AI-first business model can be seen in the Appendix.

Conclusion

The integration of Generative AI in the mining industry is set to revolutionize traditional business models. GenAI has the potential to create additional value, surpassing that of traditional AI and analytics. Its capabilities in prescriptive maintenance, resource optimization, and operational efficiency can significantly reduce costs, enhance productivity, and generate new revenue streams for mining organizations.

By conducting a strategic analysis of the value and opportunities of GenAI and mapping this to an adoption framework, mining organizations can discover new market opportunities and build a more sustainable and sharper competitive edge. Embracing GenAI represents a paradigm shift for the mining sector. Mining organizations that adopt this technology with a strategic roadmap will pave the way in driving sustainable growth and creating lasting value for stakeholders.

Appendix

Traditional Mining Business Model + Re-Invented Mining Business Model with Integration of AI

Value Proposition

- **Joint ventures with local mining companies**
- **Suppliers of mining equipment and technology**
- **Logistics and transportation companies**
- **Governments and regulatory bodies**
- Collaboration with AI Tech providers and startups
- Strategic alliances with data analytics firms
- Partnerships with institutions for AI research and talent

Key Activities

- **Mineral exploration and extraction**
- **Resource processing and refinement, and EHS initiatives**
- AI-driven exploration using predictive models
- Real-time data analysis operational efficiency

Key Resources

- Mineral reserves and R&D
- Machines, equipment, and skilled workforce
- GenAI platforms and software
- Data repositories for ML
- AI-specialized personnel and data scientists

Value Proposition

- **Reliable supply of high-quality minerals**
- **Sustainable and responsible mining practices**
- **Advanced technology for efficient resource extraction**
- **Strong safety culture**
- Tailored solutions using GenAI to meet specific material requirements
- Enhanced precision in resource estimation and extraction
- Cost reduction through AI-optimized processes
- Improved environmental sustainability and AI-powered monitoring systems to enhance worker safety

Customer Relations

- **Long-term contracts with industrial customers**
- **Customer support and technical assistance**
- Personalized data services for clients
- AI-enabled customer support
- Blockchain and AI traceability

Channels

- **Direct sales to manufacturers and processors**
- **Distribution through commodity markets**
- **Captive usage**
- Digital marketplaces for trading minerals

Customer Segments

- **Manufacturers in various industries (e.g., automotive, electronics)**
- **Governments and public sector (for infrastructure projects)**
- **Other mining companies (for joint ventures and partnerships)**
- Companies seeking ethically sourced minerals
- Governments looking for data-driven resource management
- Companies interested in AI-enhanced mining operations

Cost Structures

- **Capital expenditure for exploration and development**
- **Operating costs for mining and processing**
- **Research and development expenses**
- **Environmental compliance and rehabilitation costs**
- **Financial cost**
- Investment in AI technology and infrastructure
- Costs associated with data acquisition and management
- Upskilling the workforce for AI competency

Revenue Streams

- **Sale of extracted minerals and resources**
- **Long-term supply agreements**
- **Licensing of technology and patents**
- **Services provided to other mining companies**
- **Sale of old machinery**
- Licensing of proprietary AI technologies
- Premium pricing for AI-enhanced minerals
- Consultancy services for data-driven mining using AI

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