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Perspectives on Innovation: The Mining Industry Harnesses the (Sustainable) Opportunity of AI Technology

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- The global appetite for minerals—fueled largely by AI demand—has driven increased interest in mining companies, but long-term investors should not be dismissive of risks associated with the mining sector and specific companies within it.
- AI has the potential to be one of the most powerful secular growth themes the world has seen, with cascading effects across all sectors of the economy, including mining.
- Our approach to the mining industry reflects our team's risk-conscious approach, and our portfolios include companies that are innovating with AI to improve the environmental impact, health, and safety of the mining industry.

Access to critical minerals is increasingly becoming a global economic and geopolitical imperative. Companies and governments have long recognized the benefits of having a steady supply of critical minerals, but over recent weeks, the value of critical minerals has burst into the headlines through the contentious discussions between the United States and Ukraine.

In our 2022 paper, "Mining Industry Opportunities Emerge as Demand Grows for Essential Minerals for Decarbonization," the Calamos Sustainable Equities team explored the critical paradox facing the mining industry as the world accelerates toward a low-carbon economy, a global secular trend that we believe will remain intact even as the commitments of individual countries vary and fluctuate. While minerals are essential for clean energy technologies—with over three billion tons required by 2050, according to World Bank estimates—the mining sector presents significant environmental, social, and governance challenges. The industry's ecological footprint, labor practices, and operational risks have led many sustainable investors, including the Calamos Sustainable Equities team, to approach direct mining investments with caution.

Since the publication of our 2022 paper, demand for critical minerals (defined by the U.S. Geological Survey as those minerals that are essential to the economy), has increased significantly, due in large measure to the emergence of AI.

Our job as growth investors is to identify the opportunities and risks created by AI technologies, considering both financial and non-financial criteria. Regarding the critical minerals sector, two issues are at the forefront:

1. The exponential growth in AI applications is driving unprecedented demand for minerals like lithium, cobalt, and rare earth elements needed in advanced computing and energy storage systems.
2. AI is revolutionizing mining operations themselves.[1] According to the World Economic Forum, the global market for autonomous mining equipment, for example, is projected to grow from $3.1 billion in 2020 to $6.2 billion by 2026.[2]

Efficiency, Safety, and Environmental and Social Impacts: The Mining Industry Embraces Benefits of AI Technology

The adoption of AI in mining represents a fundamental shift toward safer, more efficient, productive, and sustainable operations. Thus, mining extraction companies using AI can be well-aligned with our sustainable investment criteria. We are encouraged to see mining companies using AI to improve the efficiency and safety of the mining industry while reducing the industry's environmental and social impacts. The chart below explores 10 ways that sustainable AI technologies improve profitability and competitiveness for mining companies.

10 Ways Mining Companies Harness AI to Manage Risks and Improve Growth Potential

1. Advanced Mineral Exploration	2. Autonomous Mining Equipment	3. Predictive Maintenance and Asset Management	4. Enhanced Ore Processing	5. Real-Time Monitoring for Environmental Compliance
Machine learning models now integrate geospatial data, satellite imagery, and historical exploration records to pinpoint untapped mineral deposits.	Autonomous vehicles and equipment are becoming more sophisticated, with AI enabling real-time decision-making and adaptability.	AI-driven systems predict equipment failures with remarkable accuracy by analyzing sensor data and performance records. This minimizes downtime, reduces maintenance costs, and extends the lifespan of critical machinery.	AI systems increase efficiency by optimize the separation and refining of minerals. AI algorithms analyze ore grades in real time and adjust processing parameters to maximize recovery rates and minimize waste.	By analyzing data from IoT sensors, drones, and satellite imagery, AI systems identify potential water contamination, detect dam instability, and other environmental risks.

6. Carbon Footprint Reduction	7. Workforce Augmentation and Training	8. Digital Twin Technology	9. Community Engagement	10. Enhanced Supply Chain Management
AI helps mining companies meet sustainability goals, with solutions that include optimizing energy usage and reducing greenhouse gas emissions.	VR and AR systems are integrated with AI for training workers. This ensures workers are prepared for the latest technologies and trained in safety protocols.	Digital twins are virtual replicas of physical assets. Powered by AI, they provide real-time simulations of mining operations, allowing mining companies to test scenarios and optimize processes without disrupting actual operations.	Mining companies are using AI to improve community relations and address stakeholder concerns.	AI is transforming supply chain operations by optimizing logistics and inventory management. Predictive analytics tools enable companies to anticipate demand and streamline the supply chain, reducing costs and improving reliability.

Investing in Innovation: Where We See Opportunity

In our 2022 paper, we noted that our assessment of risk and opportunity led our team to focus on companies helping to make mining operations more sustainable through automation, improved extraction methods, and reduced environmental impact, rather than on mining extraction companies themselves. With the growth of AI over the past several years, these investment opportunities have continued to grow; the chart below highlights some companies that have met our stringent financial and nonfinancial criteria.

Company	Investment Thesis	AI Applications
Epiroc	**Epiroc (EPOKY)** leverages AI to enhance mining operations through predictive maintenance, geospatial data analysis, and autonomous equipment. It uses AI for real-time environmental monitoring and digital twin technology to optimize processes and improve decision-making. This integration of AI promotes efficiency, cost reduction, and sustainability in the mining industry.	Digital twin technology Advanced mineral exploration Autonomous mining equipment
Atlas Copco	**Atlas Copco (ATCO-A**) advances AI in mining through its SMART LINK system for air compressor management and the Service Master project for monitoring production processes. Its 6thSense initiative integrates smart connected products to enhance automation and digitalization in mining operations.	Autonomous drilling AI driven optimization Predictive maintenance Enhanced decision-making
Bentley	**Bentley Systems (BSY)** enhances mining efficiency with AI-driven solutions like digital twins and advanced data analytics, providing real-time simulations for better decision-making and process optimization. Its AI tools also analyze geospatial and geological data to improve mineral discovery, production, safety, and sustainability.	Digital twin technology Generative AI Predictive analysis
SIEMENS	**Siemens (SIEGY)** is a major provider of industrial automation and digitalization solutions for mining operations. They offer comprehensive systems for mine electrification, automation, and digital twin technology that helps optimize mining processes and improve safety.	Digital twin technology Predictive maintenance Data Analytics
Rockwell Automation	**Rockwell Automation (ROK)** specializes in mining automation and process control systems. Its solutions include safety systems, conveyor automation, hoisting systems, and intelligent motor control centers specifically designed for mining operations.	Predictive maintenance Remote Asset Monitoring AI driven optimization
NVIDIA	**NVIDIA (NVDA)** supplies the computing platforms and AI technologies that power many modern mining solutions, from autonomous equipment to predictive maintenance systems.	Accelerated Computing Digital twin technology Real time monitoring

[1]Discovery Alert, "How AI is Revolutionizing Critical Mineral Mining for the Global Energy Transition," January 22, 2025, accessed from: https://discoveryalert.com.au/how-ai-is-revolutionizing-critical-mineral-mining-for-global-energy-transition

[2]World Economic Forum, "Unearthing opportunity: Why the time is now to invest in mining technologies for sustainable growth," September 19, 2024, accessed from: https://www.weforum.org/stories/2024/09/sustainable-mining-technology-investment-opportunity

Environmental, social and governance (ESG) is based on the premise of investing in companies that have good environmental records, are ethically run and have a positive social impact.

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