WHITE PAPER

Modern Mining Trends and Challenges

Mining is a global industry steeped in history. With origins dating back to the foundations of civilization, mining has impacted major economies throughout history. The mining industry has faced several challenging scenarios over its lifetime for survival and growth. Increasing productivity to overcome natural factors, such as decreasing ore grades, harder rock mass, hazardous and remote deposits, as well as rising environmental and social awareness, has continually prompted the industry to enhance its processes along the entire value chain.

While the mining industry has been resilient, it is now faced with many significant challenges, several of which have never been seen before. Growing global populations and high-tech economies have generated an increasing demand for minerals, and that trend will only continue upward. Yet, mineral extraction and processing are becoming increasingly complex, and the depletion of Earth's resources and the impact on fragile environments are of growing concern. Like many industries with significant challenges to future growth, change is being driven in mining by technology innovations, better processes, safety concerns, environmental concerns, and even new opportunities.

Key Benefits

- Digital Transformation in the Mining Industry
- Automation, Robotics, and Remote Operations
- Factors of Change: Safety and Environmental
- Increasing Demand for Rare Earth Elements
- Trends and Industry Factors Influencing Lithium Mining

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Digital Transformation in the Mining Industry

Since the beginning of industrialization in the late 18th century, the industrial production paradigm has undergone numerous changes led primarily by equipment and materials innovations and the application of new technologies. These massive changes in how industries operate have been grouped into several industrial revolutions:

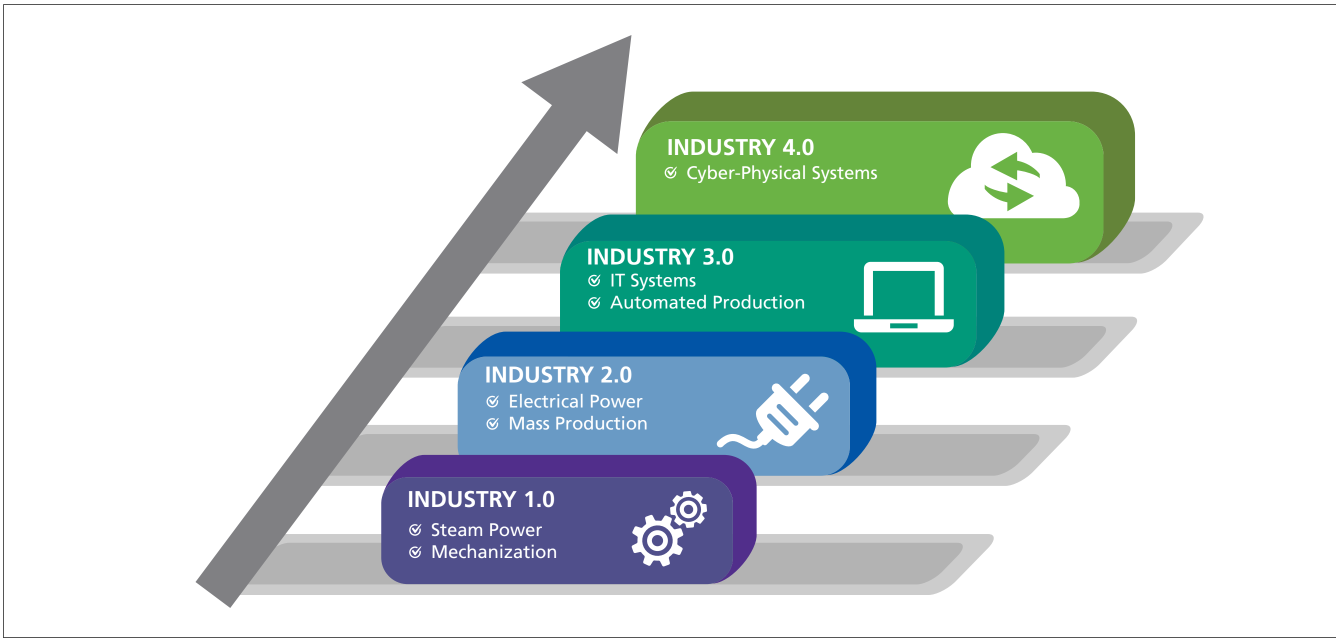

Figure 1. Industrial revolutions.

The current transformation that industries are going through is referred to as "Industry 4.0" in which production lines are automated even further and data exchange systems provide real-time data capture and monitoring. As more systems become digitally connected and integrated, operators can utilize the massive datasets generated to make better informed decisions and optimize production efficiencies. It also enables a set of new technology developments, e.g., the internet of things, advanced analytics, and others.[1]

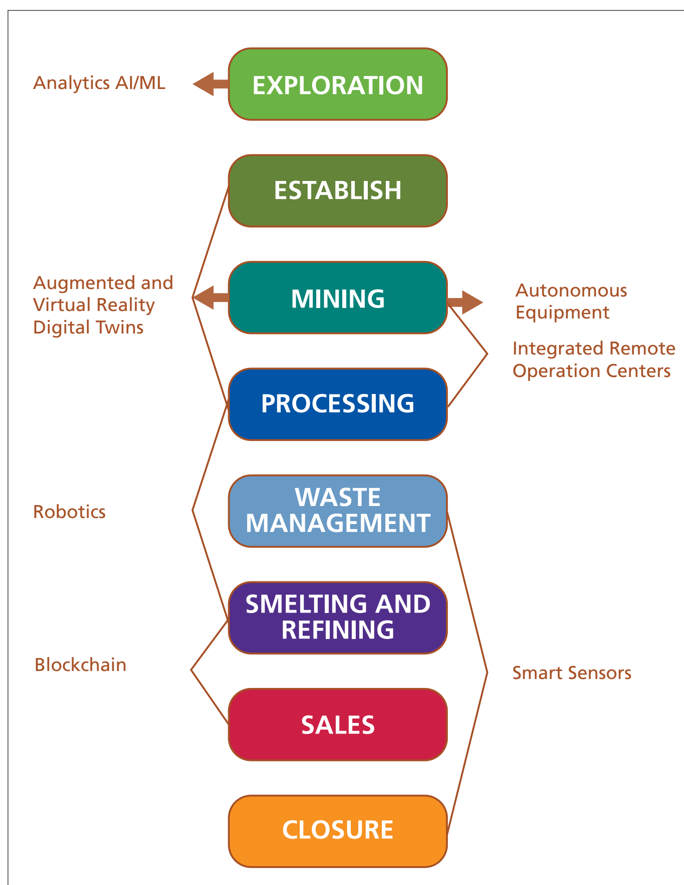

Figure 2. DT technologies in the differernt stages of the mining value chain.

Automation, Robotics, and Remote Operations

As the mining industry adapts to growing demands and new challenges, industry growth over the next decade is anticipated to be driven by increasing implementation of automation, robotics, and remote operation centers. The use of autonomous equipment, such as haul trucks, other vehicles, and drill rigs, is expanding rapidly. For instance, as of February 2020, large equipment manufacturers had already supplied 459 autonomous trucks for mining operations worldwide.[2,3]

Robotics are being used to enter and explore abandoned mines where they analyze deposits for the presence of minerals that are now important for new technologies. Robotics can also be used to track the locations of people, robots, and other equipment during mining operations.

The use of remote operations centers can provide companies with optimized personnel performance and increased time efficiency. Combined with autonomous equipment and robotics, a remote operation center can operate around the clock and reduce the number of personnel and amount of infrastructure needed to extract resources.

Safety and Environmental Concerns

A significant driver for the next decade will be addressing safety and environmental concerns in mining operations.

Safety Concerns

The last decade's focus has been on removing workers from high-risk activities by automation of processes and autonomous and semi-autonomous (remote-controlled) equipment. For instance, the use of autonomous robotics increases the safety of personnel by:

- Reducing the amount of time in which personnel are in potentially hazardous areas.
- Monitoring environmental conditions and alerting personnel to unsafe conditions.
- Allowing safer exploration of flooded mines and deep-sea deposits.

The COVID-19 pandemic has demonstrated that automation and digital operations can do more than reduce costs and drive efficiencies. Miners have found that automation technologies help them manage COVID-19 risks in several important ways:

- Improved and integrated remote workforce support systems
- Robotics and automation that reduce the need for personnel to be present in active mining areas
- Digital technology that enables them to remotely monitor operations from outside the mine

Environmental Challenges

The replacement of fossil fuel-powered vehicles and equipment in the mining industry is a must in a world moving away from such energy sources to more sustainable ones. The adoption of more stringent environmental regulations in much of the world reflects the growing need to continue moving toward more sustainable energy sources. Some heavy equipment manufacturers are already increasing their collaboration with mining companies to achieve this goal.[4]

Meeting more rigorous environmental regulations and attending to the concerns of local communities are the minimum requirements for maintaining the social license to operate. Innovation, therefore, has also been aimed at developing cleaner and more environmentally-friendly solutions throughout the mining business value chain.

Increasing Market Demand for Rare Earth Elements

During the past 20 years, there has been significant growth in the rare earth elements (REE) market that has expanded and diversified the mining industry. REE are elements such as cerium, yttrium, lanthanum, neodymium, and a handful of others. REE exhibit many optical, electrical, and magnetic properties that play an irreplaceable role in modern technologies and industrial applications, including:

- Chemical catalysts and magnets
- Rechargeable batteries
- Smartphones and other communication devices
- Fiber optics and luminescent materials
- Ceramics and glass polishing

In North America, Europe, and the Asia Pacific, the REE market is driven by the demand for these products to manufacture magnets and catalysts for the automotive industry and batteries for electric vehicles. In other countries, such as India, the widespread adoption of smartphones and initiatives to provide high-speed digital communication are expected to drive demand for optical fibers and luminescent materials during the next decade.[5]

While REE are considered vital elements for modern and future industries, there is also growing pressure for an analytical solution that can accurately characterize and quantify REE content as new customers and enterprises begin to utilize more REE in their workflows. Analytical technologies such as inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma optical emission spectroscopy (ICP-OES) are key solutions in this field. These technologies have capabilities that allow for rapid analysis of a wide variety of REE and sample types while effectively manage matrix interferences.

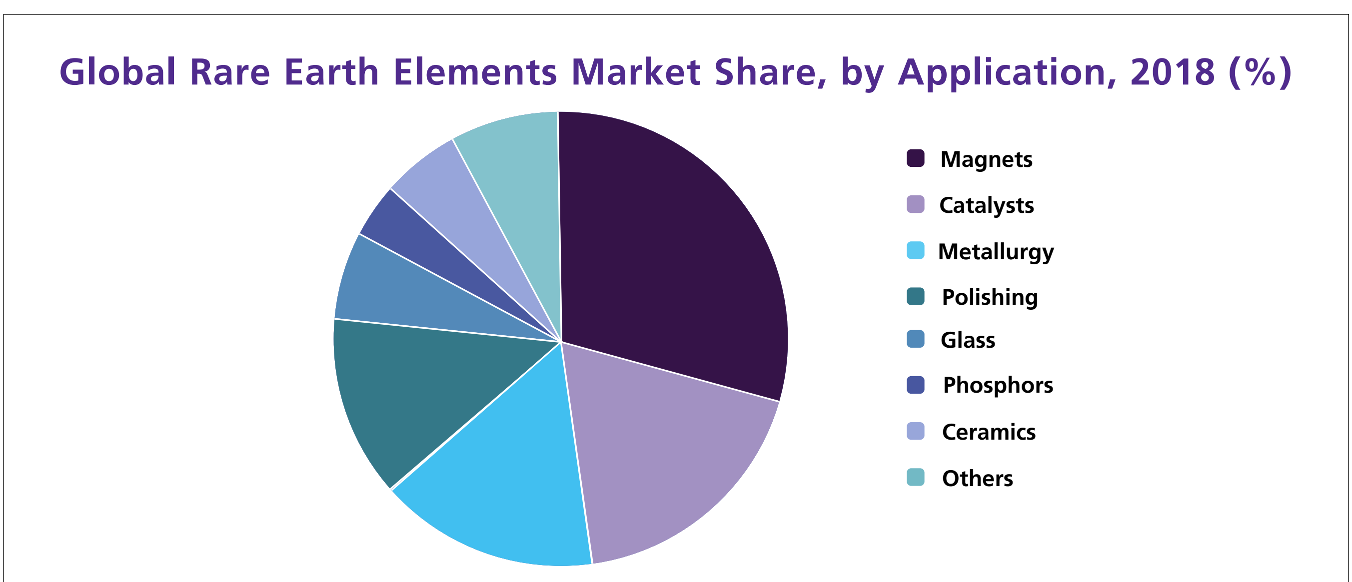

Figure 3. Applications for REE.

Electric Vehicles and Lithium Mining

Over the last decade, lithium-ion batteries have enabled a new revolution in the transportation and energy sectors. Governments, automakers, and chemical companies have ramped up investment plans to support cleaner transportation methods and renewable energy applications.

Advances in electric vehicle (EV) technology and energy storage, along with growing concerns about CO^2 emissions from cars, have led to restructuring in the automotive industry. Powertrain technology and manufacturing processes have been adapted to new EV manufacturing requirements. As the global push for EV adoption strengthens, it has been estimated that 80% of future car sales will need to meet CO^2 and fuel-efficiency regulations.[w] Thus, lithium-ion battery manufacturing and applications are expected to grow significantly over the next decade to meet the demand to shift away from fossil fuel-powered vehicles to EV.

Analytical Techniques for Mining

Analysis	Technique	Explore	Drill and Blast	Crush and Mill	Separate	Refine
Metal Analysis	AAS, ICP-OES, ICP-MS	●	●	●	●	●
Ionic Leach	ICP-OES, ICP-MS	●	●	●		
Selected Elements	FIMS, FIAS, AAS, ICP-OES, ICP-MS	●	●	●		
Halogens	LC-ICP-MS	●	●			
Loss on Ignition	TGA	●	●			
Clay Characterization	UV-Vis, ICP-MS	●	●			
Mineral Characterization	NIR	●	●			

PerkinElmer infographic on mining analyses.

Are you interested in learning more about ICP-MS and ICP-OES capabilities for REE testing?

Application Note

- Direct Determination of Trace Rare Earth Impurities in High-Purity Europium Oxide using the NexION 5000 ICP-MS
- Analysis of Rare Earth Elements by Laser Ablation-ICP-MS with the NexION 2000 ICP-MS
- Using MSF to Resolve Difficult Interferences in Metallurgical Samples with the Avio 550 Max ICP-OES

Webinar

- Solving the Rare Earth and Other Element Challenges Using a Multi-Quadrupole ICP-MS

Video Presentation

- Accurate Rare Earth Element (REE) Analysis by ICP-MS

Are you interested in learning more about analytical solutions for battery materials?

Application Note

- High-Precision Analysis of Battery Materials with the Avio 550 Max ICP-OES

Technical Note

- HP-ICP-OES: Using the Avio 550/560 Max to Achieve the Highest Possible Precisions

References

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