



Mining Industry News

An exclusive collection featuring
top-tier articles, visionary experts,
and essential industry insights

Sponsored by

VERDER

February 2026 - Edition 1



TABLE OF CONTENTS

4

ARTICLE

**Precision Beneath the Surface:
Advanced Sample Preparation
Solutions for Geology and Mining
Applications**

13

ARTICLE

**What Were the Biggest Mining
Highlights and Challenges of 2025?**

17

ARTICLE

**The UK Project Unlocking Mine Water
Heat's Potential**

23

ARTICLE

**ELTRA Solutions for Reliable
Elemental Analysis at Every Stage**

30

NEWS

**Graphite Goldmine: How Australia
Could Power the EV Boom**

33

ARTICLE

**Nickel Mining Market: Key Trends,
Challenges and Outlook**

41

ARTICLE

**Mining, Geology, & Construction
Materials With Microtrac**

48

ARTICLE

**AI in Mining Market: Overview, Trends
and Outlook**

53

ARTICLE

**Saving Lives in Mining: The Safety
Innovations Powering the Zero Harm
Goal**

57

ARTICLE

**Driving Precision and Sustainability in
Mining**



Foreword

Welcome to the latest edition of our Industry Focus eBook, where we explore the dynamic and evolving world of mining. As global demand for critical minerals accelerates, the sector is balancing productivity, sustainability, safety, and technological innovation in equal measure. From elemental analysis to artificial intelligence, mining today is defined by precision, reliability, and responsible progress. We are proud to present this collection in partnership with Verder, whose expertise in high performance analytical and sample preparation technologies supports laboratories and operations around the globe.

In **Precision Beneath the Surface: Advanced Sample Preparation Solutions for Geology and Mining Applications**, we examine how cutting edge preparation techniques are enabling more accurate geological insights and stronger decision making. **What Were the Biggest Mining Highlights and Challenges of 2025?** reflects on a pivotal year for the industry, assessing milestones, market shifts, and the operational hurdles shaping the road ahead.

Sustainability takes center stage in **The UK Project Unlocking Mine Water Heat's Potential**, which highlights how legacy mine infrastructure can be reimagined as a renewable energy resource. Analytical excellence is the focus of **ELTRA Solutions for Reliable Elemental Analysis at Every Stage**, showcasing how dependable data supports operations from exploration through processing.

Critical minerals remain at the forefront of the energy transition. **Graphite Goldmine: How Australia Could Power the EV Boom** explores Australia's strategic role in battery supply chains, while **Nickel Mining Market: Key Trends, Challenges and Outlook**

evaluates the forces influencing another essential EV material.

Technology and safety advancements continue to transform the sector. **Mining, Geology, & Construction Materials With Microtrac** demonstrates the importance of particle characterization, and **AI in Mining Market: Overview, Trends and Outlook** considers how digital tools are reshaping efficiency and forecasting. In **Saving Lives in Mining: The Safety Innovations Powering the Zero Harm Goal**, we spotlight the innovations driving safer working environments. Finally, **Driving Precision and Sustainability in Mining** captures the industry's broader commitment to responsible growth.

Together, these articles present a comprehensive view of a sector that is innovating with purpose. We hope this collection informs and inspires as mining continues to power modern society and the technologies of tomorrow.

Precision Beneath the Surface: Advanced Sample Preparation Solutions for Geology and Mining Applications

Accurate geological and mineralogical analysis begins long before the microscope or analytical instrument is switched on. In mining, exploration, and geoscience laboratories, sample preparation is the foundation of reliable results.



Image Credit: Shutterstock.com/Phawat

From heterogeneous ores and hard rock formations to fragile, porous minerals, each material presents its own preparation challenges.

Cutting, mounting, grinding, polishing, and thin sectioning must protect fragile structures and deliver reproducible surfaces. QATM combines equipment, consumables, and application know-how into an end-to-end preparation workflow built to maintain sample integrity.



End-to-end geology preparation workflow: Cutting, mounting/impregnation, grinding & polishing, and thin section preparation. Image Credit: QATM

Learn more about our expertise in Geology and Mining on our website

Why Preparation Quality is a Mining-Critical Variable

Geological samples are inherently complex. They vary widely in hardness, grain size, porosity, mineral composition, and structural integrity. Any damage introduced during preparation, such as microcracks, pull-outs, smearing, or thermal alteration, can compromise subsequent microscopic or analytical evaluation.

Reliable preparation ensures:

- Representative cross-sections of rocks, ores, minerals, and fossils
- Preservation of microstructures
- Flat, scratch-free surfaces suitable for optical microscopy, SEM, and image analysis

QATM's preparation workflows are designed to maintain material integrity while delivering reproducible, high-quality surfaces, even for the most challenging geological specimens.

At-A-Glance Workflow: From “As Received” to “Analysis-Ready”

A robust geology workflow typically follows four connected steps:

1. Cutting a representative piece from the starting material
2. Mounting/impregnation (especially for porous, brittle, or powdered samples)

3. Grinding and polishing to reach the required surface quality
4. Thin sections when transmitted-light petrography is required

The key point: each step is a quality gate for the next one. The highest-polishing process cannot “fix” damage created during cutting.

Cutting: Fast, Clean Sectioning Without Mechanical Damage

Cutting is where sample quality is either protected or quietly compromised.

To meet geology’s wide range of hardness and sensitivity, QATM offers multiple wheel options, including diamond, CBN, corundum, and silicon carbide. To safeguard the specimen from the very first step, QATM combines cutting performance with efficient coolant delivery that cools and lubricates the cutting interface directly.

This helps minimize thermal influence and keeps dust generation under control. Available in manual, semi-automatic, and fully automatic configurations, QATM cut-off machines enable fast, clean sectioning without damaging or deforming geological samples.

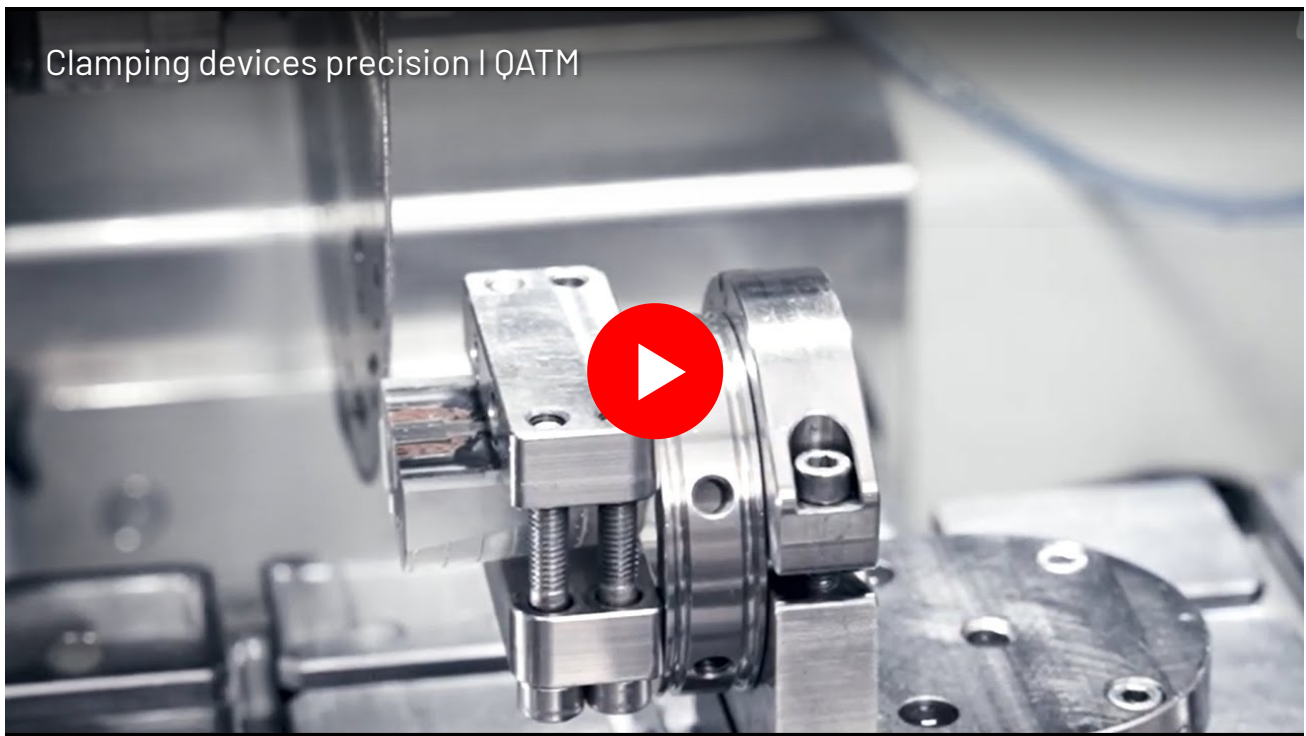


Precision cutting concept: wheel selection (diamond/CBN/corundum/SiC) and coolant supply to reduce thermal damage and dust formation. Image Credit: QATM

QATM Solution Highlight: Qcut 200 A (Precision Cutting)

QATM’s **Qcut 200 A** offers multiple operating modes (including grinding mode with diamond cup wheels) and process-support features such as cross feed, a “zone cutting” function, a honing device for diamond discs, and an integrated database for cutting processes.

Watch our video to see precision clamping devices in action.



Video Credit: QATM

What Role Does Mounting Play in Reliable Geological Analysis?

Mounting stabilises the specimen, protects edges, and provides the mechanical support required for consistent grinding and polishing. In geology and mineralogy, mounting is especially important for porous, cracked, fissured, fine-grained, or fragile materials, where insufficient support can lead to edge break-out and loss of structural detail.

To match different sample requirements, we use three main mounting approaches:

- Hot mounting: performed under pressure and temperature, delivering excellent planarity and edge retention.
- Cold mounting: ideal for heat- or pressure-sensitive samples, with resin systems selected according to curing behaviour, hardness, and removal rate.
- UV mounting: the fastest option, using light-curing acrylic resins for transparent mountings without mixing.

For mineralogical samples, cold mounting with epoxy resins is the most common method. For thin sections, including thin sections prepared from powdered samples, we recommend low-viscosity epoxy systems to ensure pores and cracks are filled effectively, and powder particles are securely enclosed. For reliable light-microscopy evaluation, the refractive index of the

mounting material should be close to that of glass to avoid optical distortion during transmitted-light analysis.

Vacuum Impregnation (When Porosity and Cracks Are the Real Challenge)

Vacuum impregnation is essential whenever pores, microcracks, or fissures would otherwise trap air and weaken edge stability during preparation.

Evacuate the vacuum container to draw air out of these cavities; under vacuum, a low-viscosity resin can then penetrate and stabilise the specimen. After filling the mould, place the sample under 2 bar overpressure for two hours to reduce bubble formation.

Keep in mind that light-curing mounting materials typically have higher viscosity, so complete impregnation of fine pores and cracks may not be achievable.

For laboratories that want to standardise these steps and handle other preparation challenges with confidence, QATM provides a dedicated Preparation Guide that brings together proven procedures, practical parameters, and expert know-how across the full geology and mineralogy workflow.



Vacuum impregnation principle for porous or cracked specimens: evacuation removes air, so low-viscosity resin penetrates cavities under vacuum. Image Credit: QATM

Access our free Preparation guide to learn more about best practices



Image Credit: QATM

Grinding and Polishing: Achieving Flatness, Contrast, and Repeatability

Grinding and polishing transform the mounted specimen into an analytical-ready surface. Geological samples often combine minerals with very different hardness levels, making controlled material removal essential.

QATM's grinding and polishing systems range from manual and semi-automatic units to fully automated platforms, supported by an extensive portfolio of consumables. Diamond grinding discs, silicon carbide papers, polishing cloths, and diamond suspensions are carefully matched to the sample material and analysis objective.

Intelligent control of pressure, speed, and processing time ensures:

- High planarity across heterogeneous structures
- Minimal relief between mineral phases
- Excellent reproducibility for routine and research applications

In our experience, preparation choices are strictly linked to specimen type, for example:

- Rocks requiring smooth, flat, reflective surfaces
- Ores requiring fine, uniform, high-contrast surfaces
- Minerals requiring clear, clean, detailed surfaces

This approach allows laboratories to efficiently prepare samples for reflected and transmitted light microscopy, SEM analysis, and quantitative mineralogical evaluation.

While these principles form the technical basis of high-quality preparation, selecting the right parameters and workflows often requires deeper application experience – especially when dealing with complex or heterogeneous geological materials.

Our comprehensive Expert Guide provides beginners and experienced users with a structured guide to materialographic sample preparation. Numerous photographically documented examples, practical tips, and a new chapter on geology and mineralogy make this book your competent reference work – ideal for everyday and unusual preparation tasks.

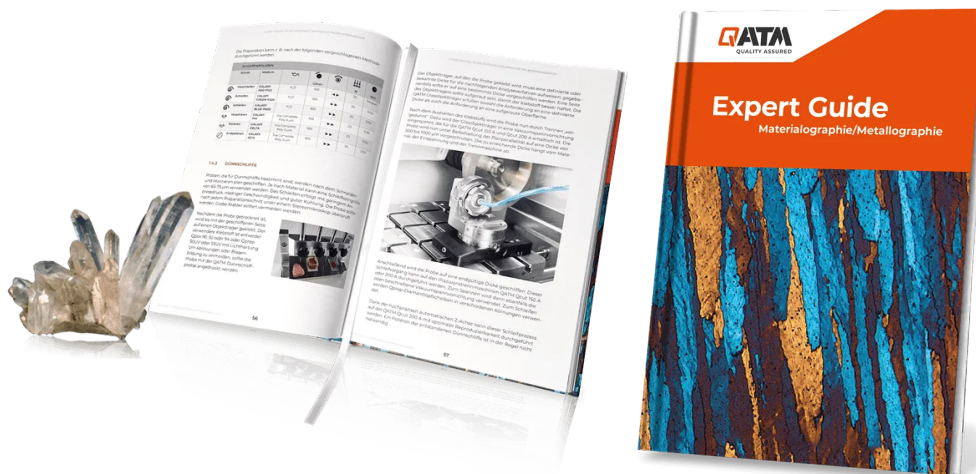


Image Credit: QATM

[Access our Comprehensive Expert Guide here](#)

QATM Solution Highlight: High Throughput Solutions

QATM suggests manual/semi-automatic systems like Qpol 300 A1/A2, and fully automatic systems such as Qpol 250 BOT / Qpol 300 BOT using central pressure.

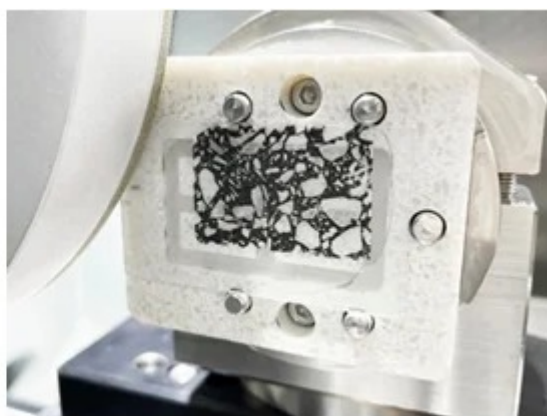
Thin Sections: Revealing Geological History Layer by Layer

Thin section preparation is a cornerstone of petrographic analysis. By reducing a sample to a thickness of approximately 20–30 μm , mineral textures, grain boundaries, and optical properties become visible under polarized light.

QATM provides dedicated solutions for thin section preparation, offering a reliable and complete route:

- Grinding the mounted sample flat (example abrasive grain size 65–75 μm , depending on material) with low contact pressure, low speed, and good cooling, checking under a stereomicroscope after each step to avoid coarse scratches
- Bonding the dried sample to a glass slide using Qpox adhesives or UV-curing materials, and using a thin section press to reduce detachment or bubble formation
- “Pre-thinning” by cutting to roughly 300–1000 μm while maintaining plane parallelism (using vacuum clamping devices available for Qcut 150 A and Qcut 200 A)
- Final grinding to a typical thickness of 20–30 μm , with guidance that pores/cracks opened during pre-thinning should be closed (example medium: Qpox 94), and using optical appearance as a practical check (e.g., quartz should remain white; yellowish indicates too thick).

At QATM, we also define the key requirements for thin-section glass slides: uniform thickness with low tolerances, a defined refractive index, and a roughened surface to ensure secure bonding.



Thin section thickness control: pre-thinning to 300–1000 μm with plane parallelism, followed by

grinding to 20–30 µm final thickness. Image Credit: QATM

What Makes QATM a Trusted Partner for the Mining Industry?

QATM's strength lies not only in individual machines but in its holistic understanding of the preparation process. By offering perfectly matched equipment, consumables, and application expertise, QATM enables laboratories to standardize workflows, improve efficiency, and achieve consistent results.

Key advantages include:

- Deep application know-how in geology and mineralogy
- Complete preparation solutions from cutting to thin sections
- Robust, reliable equipment designed for demanding laboratory environments
- Expert support to tailor preparation methods to specific materials and objectives

For mining and geoscience professionals, this translates into greater confidence in analytical results, faster turnaround times, and a solid foundation for exploration, quality control, and research decisions.

Secure what you do: With QATM, geological and mineralogical analysis is built on precision you can trust.

Get in contact with our experts



This information has been sourced, reviewed, and adapted from materials provided by QATM.

For more information on this source, please visit [QATM](#).

What Were the Biggest Mining Highlights and Challenges of 2025?

The mining industry's 2025 story was one of delivery, not hype. Speculation around battery metals gave way to operational reality as companies tackled the technical backbone of the energy transition - expanding lithium extraction, confronting copper bottlenecks, and negotiating the uncertain future of deep-sea mining.



Image Credit: Phawat/Shutterstock.com

Mining Research and Technological Developments of 2025

Precision mining and artificial intelligence

Research in 2025 focused on "precision mining", which involves using data and biotechnology to reduce the environmental footprint of extraction. A key development was the use of artificial intelligence (AI) in greenfield exploration to identify "blind" deposits - ore bodies with no surface expression.

Companies such as KoBold Metals used machine learning algorithms to map subsurface anomalies at the Mingomba project in Zambia.¹ By integrating satellite imagery, geochemical data, and seismic patterns, AI-supported exploration reduced the time from discovery to resource definition by approximately 30 %. This efficiency is an important metric as the industry addresses supply gaps in copper and nickel.

Direct lithium extraction enters commercial use

Direct lithium extraction (DLE) also moved from pilot phases to commercial use. During 2025, several projects in the "Lithium Triangle" of South America and the Smackover Formation in the United States implemented DLE technologies. Unlike traditional evaporation ponds, which require long lead times and high water consumption, these DLE processes utilize selective membranes and ion-exchange resins to extract lithium more quickly with a reduced surface footprint.¹ This development has supported the social license to operate in water-stressed regions.

Biomining trials

In the area of sustainability, research institutions in Australia and Canada continued trials on "biomining". This process uses engineered microbes to recover rare earth elements (REEs) from low-grade tailings through biological leaching. It aims to turn waste piles into viable resource streams, consistent with circular economy objectives.¹

Market Developments and the Deep-Sea Mining Debate

Copper supply

The global mining market in 2025 was influenced by a continued copper supply deficit. Although the growth rate of the electric vehicle (EV) market fluctuated in some regions, the demand for copper for grid modernization and renewable energy infrastructure remained steady. Declining ore grades in established Chilean and Peruvian mines contributed to elevated prices, prompting companies to explore new regions.

Deep-sea mining continues to concern

The debate over deep-sea mining (DSM) remained a prominent market topic. The International Seabed Authority (ISA) continued negotiations on the "Mining Code", but sessions throughout the year did not finalize regulations for the extraction of polymetallic nodules in the Clarion-Clipperton Zone. Although some nations sought to begin commercial operations to secure mineral supplies, a group of over 30 to 40 nations called for a precautionary pause or a moratorium.²

The market remains divided on this issue. Proponents argue that deep-sea extraction has a lower carbon footprint than terrestrial mining because it requires less infrastructure. Conversely, environmental scientists have noted potential risks to benthic ecosystems and fisheries. The lack of regulatory consensus has resulted in continued uncertainty for commercial entities awaiting exploitation contracts.²

Export restrictions on raw ores

"Resource Nationalism" also persisted in 2025. Several nations in Africa and Southeast Asia implemented export restrictions on raw ores to encourage investment in domestic

downstream processing. This led to a realignment of supply chains as Western companies evaluated the costs of domestic smelting versus maintaining market share in these regions.

Mining Company Developments in 2025

Corporate mining activity in 2025 focused on portfolio adjustments and acquisitions in the copper and lithium sectors.

[Rio Tinto](#) increased its position in the lithium market following the integration of Arcadium Lithium assets. The company focused on these assets to increase production capacity by 2030. Simultaneously, Rio Tinto reached a new stage at the Simandou iron ore project in Guinea, where the first shipments of high-grade ore commenced following the resolution of previous logistical challenges.³

[Anglo American](#) restructured its operations in 2025. Following a rejected takeover bid in 2024, the company moved to demerge its platinum group metals business and began the separation of its diamond business (De Beers). This strategy reflects an industry trend of selling assets outside of a core focus on transition metals.

[Glencore](#) retained its coal business after acquiring [Teck Resources'](#) steelmaking coal assets. The company maintained the combined operations to utilize coal earnings while continuing its focus on transition metal production.¹

*Deep-Sea Mining
Technologies: Can Innovation
Make Ocean Mining
Sustainable?*

What were the top 5 sustainable mining companies in 2025?

Looking Ahead to 2026 in the Mining Sector

Several trends are expected to influence the industry in 2026:

- **Battery technology:** The development of solid-state batteries may affect demand for traditional nickel-manganese-cobalt (NMC) chemistries and associated mining projects.⁴
- **Processing requirements:** More nations may implement requirements for domestic mineral processing, affecting how miners invest in local infrastructure.
- **Underground automation:** The deployment of fully autonomous underground drilling and

blasting systems is expected to increase, aiming to reduce safety risks for personnel in hazardous environments.

- **International investment:** Saudi Arabia's Maaden is expected to continue pursuing acquisitions in South American copper and nickel projects, increasing its role in the global mineral trade.⁴

In 2025, mining stopped talking about the energy transition and got on with building it. AI-driven exploration, commercial-scale direct lithium extraction, and early biomining trials showed real progress behind the scenes, while copper shortages and geopolitical pressure reshaped global supply chains.

Deep-sea mining remained stuck in regulatory limbo, resource nationalism gathered pace, and major miners reshuffled portfolios to double down on transition metals. It was a year defined less by speculation and more by substance – laying the technical and political groundwork for what comes next.

[Click here to download a free PDF copy of this page](#)

References and Further Reading

1. International Energy Agency (IEA). *Global Critical Minerals Outlook 2025*. IEA Publications. <https://www.iea.org/reports/global-critical-minerals-outlook-2025>
2. International Seabed Authority (ISA). *Documents from the 30th Session (2025)*. <https://isa.org.jm/sessions/30th-session-2025/>
3. Rio Tinto Group. *Annual Report 2024 and Operational Updates 2025*. <https://www.riotinto.com/en/invest/reports/annual-report>
4. S&P Global. *Mining and Metals Outlook 2025/2026: Strategic Supply and Geopolitical Risk*. S&P Global Commodity Insights. <https://www.spglobal.com/commodity-insights/en/market-insights/metals-mining>

Disclaimer: The views expressed here are those of the author expressed in their private capacity and do not necessarily represent the views of AZoM.com Limited T/A AZoNetwork the owner and operator of this website. This disclaimer forms part of the [Terms and conditions](#) of use of this website.

The UK Project Unlocking Mine Water Heat's Potential

The push for decarbonization, along with the development of sustainable heating and cooling systems, has shifted the attention of governments and experts worldwide toward historically flooded mines. The heat trapped in underground mine water can be used to heat homes and commercial buildings, and the United Kingdom is investing heavily in mine-water heat schemes to significantly reduce energy consumption.



Image Credit: Sobrevolando Patagonia/Shutterstock.com

What is the Mine Water Heat Scheme?

Mine water heating technology has been in operation since the 1980s, with various types of mine-water geothermal energy (MWGE) systems that use different technologies to extract heat from water in abandoned mines.

Mine water is heated by natural processes, and seasonal temperature fluctuations do not readily affect the amount of heat trapped within the abandoned mines. The mine water heating technology extracts the trapped heat in flooded, disused mines and, through specialized equipment, delivers it to communities and business units as low-carbon heat.

Mine-water with a carbon-neutral, sustainable heat supply, coupled with modern heat pump technology, is the perfect low-enthalpy space-heating source for modern, retrofitted

residential units. Mine-water temperatures remain stable throughout the year, making it a suitable and safe source of constant energy.¹

Key Features of Mine Water Heating Technology

The water in abandoned mines follows the typical geothermal gradient, with temperature increasing with depth. At a depth of around 1 km, the water temperature has been recorded to be around 40 °C.

A typical mine water heating system involves transferring heat from the inactive mining site to a secondary specialized heat transfer system, typically using a plate or shell-and-tube heat exchanger. The specialized secondary heat transfer units are integrated with heat pumps, boosting the extraction of heat, and stabilizing the geothermal energy to be delivered to the consumer at usable and stable temperatures, like 50 °C to 60 °C.

The heat pumps can be centralized at a single location or distributed at viable secondary energy centers. The use of a heat exchanger with the heat pump is critical to prevent corrosion from direct contact between the mine water and the heat pump components.²

Want to save for later? Click here.

Types of Mine-Water Geothermal Energy Extraction Systems

Experts analyze physical and chemical parameters to determine the optimal mode of heat extraction during the planning and installation of an MWGE system. The mine water heat extraction technology may be an open system or a closed system to ensure maximum heat delivery to the consumer.

Open System Heat Extraction

In open system MWGE, mine water is brought to the surface using specialized pumping systems or gravity drainage. It involves a groundwater-sourced heat pump system and a shell-and-tube or plate heat exchanger.

Open system MWGE includes one with reinjection technology, ensuring conservation of water resources and regulation of reservoir pressure. An open-system MWGE with a discharge mechanism is also a popular choice, as the thermally spent mine water is expelled near the

ocean surface. However, this technology mines water after heat extraction and actively or passively treats it to ensure the quality of the mine water is compatible with local water bodies.³

Closed Loop Systems

In a closed-loop MWGE system, a secondary heat transfer fluid circulates through heat exchanger pipes submerged in mine water, absorbing available heat without extracting mine water to the surface. While closed-loop systems require considerably fewer environmental permits, the heat extraction and delivery are much more restricted than the open-loop MWGE systems.

Current Status and Projects in the United Kingdom

Gateshead Mine Water Heat Scheme: Revolutionizing the Mine Water Heat Technology

The open-access Living Laboratory in Gateshead was launched in early 2025 to monitor the interactions among three operational mine water heat schemes in the Northern part of England. The heat scheme is the source of extremely rare data, which is being published for researchers worldwide to access.

The Heat Network Investment Project (HNIP) and Gateshead Council collaborated to complete the Gateshead Mine Water Heat Project in around four years. The Gateshead network is the largest MWGE network in Great Britain, using a 6-Megawatt (MW) heat pump to extract and distribute heat via a 5-km pipe network. The project is powering around 350 council-owned homes, with an estimated annual CO₂ saving of around 1800 tons.

The initiative is led by the Mining Remediation Authority, which has made thousands of hours of data from the Gateshead mine water heat network available, providing energy to more than 350 homes and businesses.

The data is collected from the Gateshead system every 15 minutes and published for the public. The data is attracting attention from top research groups and academic institutions, including a research group from the Lawrence Berkley National Laboratory, which is working directly for the University of California, under the umbrella of the US Department of Energy's Office of Science.⁴

Lindsay Mine Water Heat Scheme: Wales's First Commercial Project

The government of Wales is working tirelessly to ensure the availability of low-carbon heating for homes. The Carmarthenshire County Council (CC) area was a mining hub in the 16th century, with abundant untapped heat from mine water.

In 2025, the Mining Remediation Authority, in collaboration with local business Thermal Earth Ltd., developed a treatment plant near Ammanford, processing 25 liters of mine water per second.

The project uses submerged heat exchangers in settlement ponds to extract heat from mine water without disturbing underground water levels. The use of mine water as a low-carbon heating source has led to an annual reduction in CO₂ emissions of 17 tons.⁵

Durham County Mine Water Heating System Project to Power Over 750 Homes till 2035

A new community near Seaham, Durham County, will be powered by a mine water heat system that extracts heat from disused mines. This project will yield ecological benefits and protect the groundwater aquifer, which is the key source of drinking water for household communities.

Durham County Council and the Mining Remediation Authority, in collaboration with Karbon Homes, have entered into a partnership with Vital Energi to design, build, and operate a mine water heat system to provide affordable heating to over 750 homes.⁶

Challenges and Necessary Actions

Several key challenges act as a barrier to the success of mine water geothermal projects. From diverse stakeholders' perspectives, expectations are misaligned with project deliverables in many cases, particularly due to regulatory challenges, extensive, time-consuming licensing requirements, and insufficient financial resources.

Experts have also identified a major gap in risk management strategies, along with regulatory and policy challenges, which critically limit the scope of mine water heat schemes. The high capital costs, along with the lack of competitive bidders, are hindering the implementation of MWGE systems in flooded coalfield areas.

A multifaceted approach focused on financial incentives and security, risk management, skilled workforce development, and community collaboration is needed to resolve the financial, regulatory, and socio-economic challenges.⁷

The energy expenditure for heating buildings in the UK is around 38 %, with MWGE playing a key role in ensuring compliance with the Sustainable Development Goals (SDGs).⁸ The Mining Remediation Authority is focusing on making systems and processes secure and resilient, incorporating data-driven decision making, and developing governance frameworks with stakeholder engagement, ensuring a boost in the delivery, benefits, efficiency, and profits of MWGE in the future.⁹

References and Further Reading

1. Walls, D. et al. (2021). A Review of the Performance of Minewater Heating and Cooling Systems. *Energies*. 14(19). 6215. Available at: <https://doi.org/10.3390/en14196215>
2. Burnside, N. et al. (2016). Hydrochemistry and stable isotopes as tools for understanding the sustainability of minewater geothermal energy production from a 'standing column' heat pump system: Markham Colliery, Bolsover, Derbyshire, UK. *International Journal of Coal Geology*, 165, 223-230. Available at: <https://doi.org/10.1016/j.coal.2016.08.021>
3. Bailey, M. et al. (2016). Heat recovery potential of mine water treatment systems in Great Britain. *International Journal of Coal Geology*, 164, 77-84. Available at: <https://doi.org/10.1016/j.coal.2016.03.007>
4. Lake, E. (2026). *Town pioneers research into mine water heat technology*. BBC. North East and Cumbria. [Online]. Available at: <https://www.bbc.com/news/articles/c98jxn13n4no> [Accessed on: February 08, 2026].
5. Mining Remediation Authority, Government of UK. (2025). *Landmark mine water heat scheme goes live in Wales*. Mine water management: Press Release. Available at: <https://www.gov.uk/government/news/landmark-mine-water-heat-scheme-goes-live-in-wales> [Accessed on: February 09, 2026]
6. Lake, E. (2025). *Work begins on mine water heating system*. BBC News. North East and Cumbria. [Online]. Available at: <https://www.bbc.com/news/articles/cn9vvy7rnyyp> [Accessed on: February 09, 2026].
7. Li, J. et al. (2025). Equity or profit? Understanding the social sustainability challenges of mine water heating network implementation. *Energy Research & Social Science*. 104062. 124. Available at: <https://doi.org/10.1016/j.erss.2025.104062>
8. Mining Remediation Authority (2026). *Mine Water Heat Opportunities Framework 2024 to 2027*. [Online]. Available at: <https://www.miningremediation.co.uk/mine-water-heat-opportunities-framework/> [Accessed on February 10, 2026].
9. Mining Remediation Authority, Gov. of UK. (2026). *Mine Water Heat: Fit for the Future*. [Online]. Available at: <https://plans.miningremediation.co.uk/business-plan/fftf-progress> [Accessed on: February 10, 2026].

Disclaimer: The views expressed here are those of the author expressed in their private capacity and do not necessarily represent the views of AZoM.com Limited T/A AZoNetwork the owner and operator of this website. This disclaimer forms part of the [Terms and conditions](#) of use of this website.

TSR3 11/125/1000 Rotating Tube Furnace



High Efficiency Continuous Thermal Processing for Mining Applications

The Carbolite TSR3 11/125/1000 rotating tube furnace is engineered to deliver superior processing performance for mining laboratories seeking faster, more consistent results. Unlike traditional batch furnaces, the TSR3 provides continuous thermal processing, enabling higher throughput and improved workflow efficiency, ideal for operations focused on productivity and repeatability.

Its rotating tube design ensures excellent exposure of the material to the process atmosphere, promoting faster reaction kinetics and reducing overall processing time. This uniform mixing within the work tube helps achieve highly consistent outcomes in applications such as reduction, roasting, and calcination.

The furnace supports both air and inert atmospheres, offering flexibility for a range of mineral processing tasks. In addition, a specialised TSR variant is available for safe operation under hydrogen atmospheres, expanding its suitability for advanced reduction processes where a controlled, reactive environment is essential.

With precise temperature control up to 1,100°C, robust construction, and a user friendly interface, the TSR3 11/125/1000 delivers reliable, reproducible results while helping laboratories streamline operations and maximise resource recovery.

[Download the
Product Sheet](#)

[Get in touch with
our experts](#)

ELTRA Solutions for Reliable Elemental Analysis at Every Stage

Elemental analysis is central to mining operations and plays a role throughout the entire value chain, from early exploration and ore processing to process monitoring and quality control of the final product.

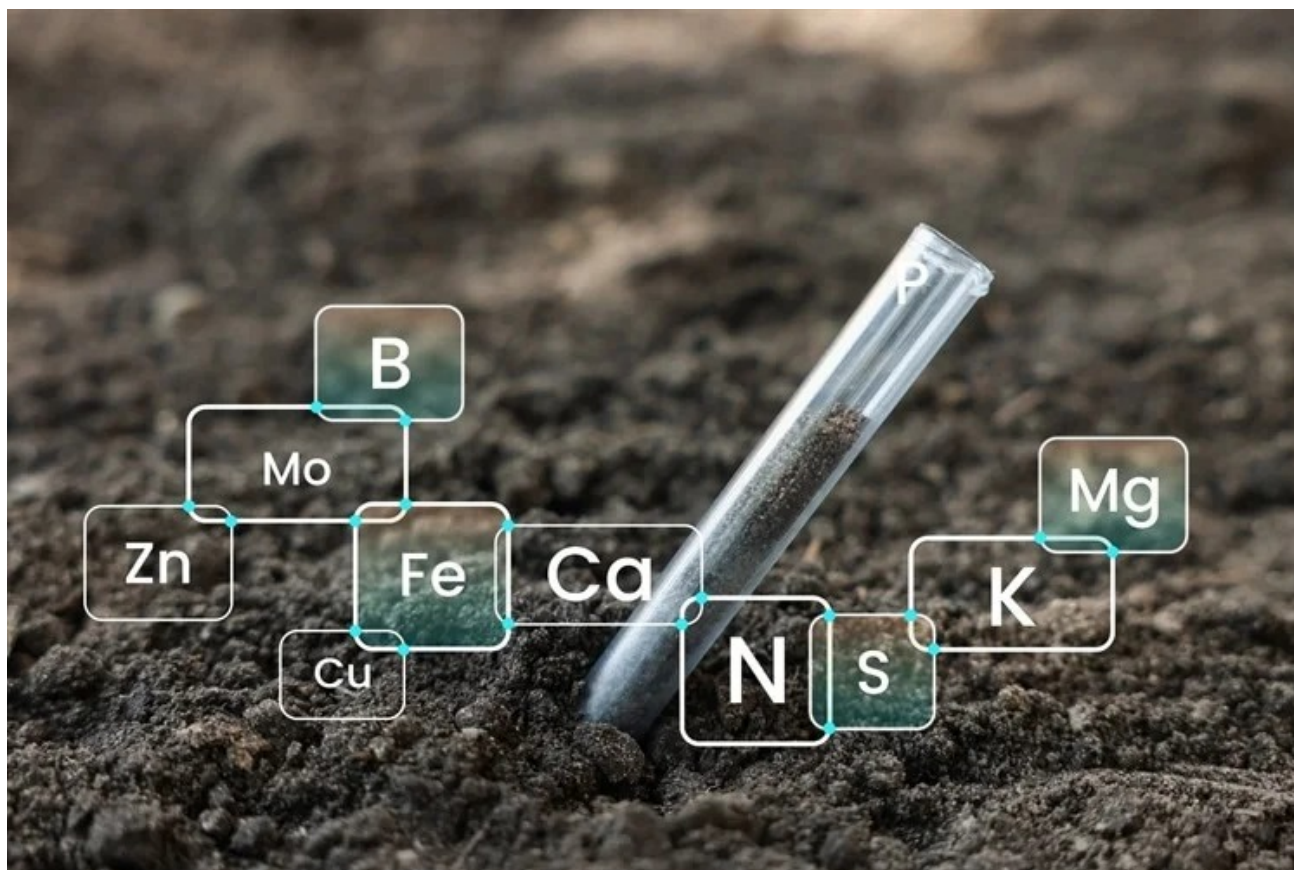


Image Credit: Shutterstock.com/New Africa

The assessment of material quality, key process decisions, and adherence to regulatory requirements all rely on reliable data on elemental composition.

There is often significant compositional variability in mined materials such as ores, concentrates, and fuels. As well as major elements, light elements such as oxygen, carbon, sulfur, and hydrogen also influence material behavior during thermal treatment, roasting, smelting, and combustion.

The presence of these elements impacts energy demand, reaction pathways, and process stability. Mining laboratories employ elemental analysis and loss-on-ignition (LOI) determination as standard analytical tasks for this reason.

LOI analysis delivers useful information on carbonates, moisture, hydrated phases, and other

volatile components; elemental analyzers provide quantitative data on sulfur, carbon, and other non-metallic elements.

The combination of these methods supports routine material characterization and process control across a number of mining and mineral processing stages.

ELTRA GmbH has a range of elemental analyzers and thermal analysis systems for laboratories in mining and related industries. This article examines a series of common analytical applications, citing examples from copper, gold, iron ore, and coal mining.

Elemental Analysis Applications in Key Mining Sectors

Copper Mining: Carbon and Sulfur Analysis in Copper Concentrates



Image Credit: ELTRA

Copper concentrates typically contain increased sulfur levels due to sulfide mineralization. Carbon determination is also an important consideration, especially in terms of metallurgical process control.

Both of these parameters are monitored routinely due to their effect on gas composition, smelting conditions, and energy consumption.

The **ELEMENTRAC CS-i** uses a typical sample mass of 200 mg, operating in the extended four-cell configuration to enable carbon determination up to 35 % and sulfur determination up to 32 %. The ELEMENTRAC CS-i also covers low ppm concentrations.

This measuring range allows the analysis of concentrates with varying compositions with no need to alter the analytical setup.

Induction furnace combustion is used for carbon and sulfur determination, with infrared

detection used to analyze CO₂ and SO₂.

This method can be used when working with concentrates containing either multi-percent sulfur or low carbon concentrations derived from carbon-bearing gangue minerals and flotation reagents.

ELEMENTRAC CS-i can be equipped with an autoloader for up to 130 samples, making it ideal for laboratories processing large sample volumes. This autoloader enables consistent throughput and unattended operation in routine quality control environments.

Gold Mining: Sulfur Screening in Exploration



Video Credit: ELTRA

Elemental analysis is regularly applied in gold exploration, allowing gold concentrations to be determined with confidence.

Sulfur is a useful indicator element during early exploration and resource evaluation because many gold deposits are associated with sulfide mineralization.

Sulfur screening can be used to identify sulfide-rich zones within host rocks, enabling the interpretation of mineralization patterns.

Variations in mineralization intensity are often highlighted by changes in sulfur concentration along drill cores or across surface samples, potentially indicating and supporting the prioritization of additional investigation.

The ELEMENTRAC CS-i r uses induction combustion with infrared detection of SO₂ to facilitate this type of screening.

Sulfur can be determined from low ppm levels up to around 32 % with the extended four-cell configuration and a typical geological sample mass of 200 mg. This range is sufficient to accommodate both weakly mineralized material and samples that contain high sulfide content.

Short analysis times enable the processing of large sample series, support early-stage decision-making, and deliver consistent sulfur data for exploration programs.

Coal Mining: Carbon and Sulfur Determination with ELEMENTRAC CS-r



Image Credit: ELTRA

Carbon and sulfur analysis are key to effective coal characterization, as both parameters affect calorific value, emissions, and combustion behavior.

This data is an important factor in coal classification, environmental reporting, and pricing.

The ELEMENTRAC CS-r is designed for carbon-rich materials analysis, such as coal and graphite. Combustion is performed in a resistance-heated ceramic furnace, with infrared detection of CO₂ and SO₂. This approach ensures total oxidation, including refractory or high-carbon materials.

Carbon can be determined from low ppm levels up to 100 % in the four-cell configuration, using a nominal sample mass of 250 mg. It is also possible to measure sulfur up to approximately 44 %.

This enables trace analysis and high-content determination without requiring modifications to

the system configuration.

Infrared detector paths are manufactured from solid-gold components, reducing the effects of aggressive combustion gases and contributing to stable detector performance over long periods of routine use.



Image Credit: ELTRA

Applications include coke production, analysis of graphite materials, coal quality control, and environmental monitoring. The system has been specifically designed for the consistent analysis of conditions and routine laboratory operation.

Iron Ore Mining: Loss on Ignition Using Thermostep TGA



Image Credit: ELTRA

Loss on ignition is commonly used to assess moisture, hydrated minerals, carbonates, and other volatile components in iron ore analysis. These components have the potential to influence processing behavior.

LOI determination is generally performed by heating samples to 1000 °C and holding this temperature for approximately one hour. These conditions result in the release of volatile constituents while iron oxides remain stable.

ISO 11536 describes this procedure and is commonly used as a reference method.



Image Credit: ELTRA

The [Thermostep TGA](#) applies this principle in an automated thermogravimetric system. Samples are heated according to defined temperature programs, under controlled atmospheres, with continuous mass recording.

Automated cooling supports routine laboratory operation and reduces handling steps.

The system can simultaneously process up to 19 samples, plus a reference crucible. The furnace operates at temperatures up to 1000 °C and allows the use of oxygen, nitrogen, or air as process gases.

The ThermoStep TGA is also used in coal testing for automated proximate analysis in line with ASTM D7582.

ELTRA Instruments in Mining Laboratory Operation

Analytical instruments in mining laboratories are often integrated into routine workflows and operated continuously. ELTRA systems are widely used in this environment, seeing daily use in laboratories to support production control, exploration, and quality assurance.

Instrument design is focused on stable operation under a range of challenging conditions, including elevated sulfur contents, abrasive samples, and variable matrices.

It is also necessary to design furnace systems, gas paths, and detector components for sustained use with limited interruptions for maintenance.

Automation options help maintain consistent analysis conditions across different shifts and operators while supporting the handling of large sample numbers.

These capabilities see ELTRA instruments being widely used in laboratories working with extended or 24-hour operating schedules.

ELTRA supports standardized analytical procedures across various mining applications by offering elemental analysis and loss on ignition within a coordinated product range.

The company's portfolio of instruments is widely recognized in the industry and integrated into laboratory infrastructures at mining operations across the globe.

Ready to start your next project?

Get expert advice from the team

Acknowledgments

Produced from materials originally authored by ELTRA.



This information has been sourced, reviewed, and adapted from materials provided by ELTRA.

For more information on this source, please visit [ELTRA](#).

Graphite Goldmine: How Australia Could Power the EV Boom

From mining to batteries, Australia's overlooked mineral could become a global game-changer in clean energy.



Image Credit: Akifyeva S/Shutterstock.com

Graphite: The Unsung Hero of EV Batteries

Graphite might not get the same hype as lithium, but it's just as essential to electric vehicle (EV) batteries – especially as the main material used in anodes. Thanks to its high electrical conductivity and chemical stability, graphite is a core part of lithium-ion battery tech.

With EV adoption accelerating globally, demand for battery-grade graphite is spiking. Right now, Australia holds about 4 % of the world's graphite resources and ranks 8th for Economic Demonstrated Resources (EDR) – a respectable 26.9 million tons. The problem? Australia doesn't yet have large-scale facilities to process graphite for EV batteries.

Mining Smarter: AI, Renewables, and Greener Processing

Getting graphite ready for battery use isn't simple - it requires energy-intensive processes. But new tech is changing the game.

Researchers from CSIRO, Geoscience Australia, and Stanford University are looking at smarter ways to mine and process graphite. Think AI, machine learning, and better resource mapping to boost efficiency and cut environmental impact. Most of the development is focused in South Australia, Western Australia, and Queensland.

There's also growing interest in using solar and wind to power graphite processing, making the whole system cleaner and cheaper.

Untapped Resources Meet Global Demand

Using geological and economic data, the researchers identified key graphite deposits across Australia. With more advanced tools like predictive modeling, exploration efforts are getting faster and more accurate.

Their analysis showed that even though Australia has plenty of high-quality graphite, most of it hasn't been tapped. That could soon change, especially with growing global demand and a push to secure supply chains for critical minerals.

One key takeaway? There's huge value in processing graphite locally. Right now, raw graphite concentrate sells for around USD 700 per ton, but when it's processed into anode material, that number jumps to USD 7,000. That's a big incentive for building a domestic refining industry.

The China Factor and Why Local Processing Matters

China currently accounts for around 95 % of the world's graphite anode material production. That's a major bottleneck and a risk for EV supply chains worldwide.

Australia's natural graphite reserves could help break that dependency. But it needs infrastructure, investment, and policy support to scale up domestic production.

Expanding local capacity could make the country a top global supplier and reduce exposure to international supply chain disruptions, which is critical as EV battery demand continues to climb.

Graphite's Role Beyond EVs

While EVs are the headline, graphite's potential extends beyond them. It plays a big role in energy storage systems that support renewables such as solar and wind, making it essential for future energy grids.

Researchers also highlighted the value of developing more efficient recycling systems to recover graphite and other key materials from used batteries, reducing environmental damage and boosting sustainability.

And let's not forget graphite's industrial uses: from lubricants to steel production, where its thermal and electrical properties shine. Emerging technologies in spheronization and purification could help Australia produce higher-quality graphite and attract global investment.

What's Next: Building a Competitive Edge

The report's big message? Australia has what it takes to become a serious player in the global battery materials market if it acts now.

That means:

- Investing in advanced exploration and processing
- Building a sustainable, renewable-powered graphite supply chain
- Collaborating internationally - especially with the US - to strengthen tech and trade partnerships

Done right, this could boost Australia's economy, secure its role in the clean energy future, and help drive the shift to electric transport.

Disclaimer: The views expressed here are those of the author expressed in their private capacity and do not necessarily represent the views of AZoM.com Limited T/A AZoNetwork the owner and operator of this website. This disclaimer forms part of the [Terms and conditions](#) of use of this website.

Source:

[CSIRO](#)

Nickel Mining Market: Key Trends, Challenges and Outlook

Nickel has long been essential to stainless steel production, but its role in electric vehicle batteries is becoming increasingly important. Today, the nickel market faces a supply-demand imbalance. Indonesia now accounts for more than 60 % of global production, and output has exceeded consumption through 2025, pushing prices down to levels that threaten the viability of mines in Australia and other higher-cost regions. While stainless steel still accounts for the majority of nickel worldwide, battery manufacturing is growing faster. Analysts expect this momentum to lift total demand to 4.4 million tons by 2031.^{1, 2}



Image Credit: Nanang Sugi/Shutterstock.com

Application Areas of Nickel Mining

The nickel mining industry serves two distinct market segments with different technical requirements and growth trajectories.

Stainless steel

Stainless steel production remains the primary application, representing approximately 69 %

of global nickel consumption as of 2024.³ The metal's inherent corrosion resistance and structural integrity make it an essential component in construction, manufacturing, and industrial equipment.

Austenitic stainless steels, specifically the widely used grades 304 and 316, require a nickel content of 8-18 %. These materials are found in everything from household kitchen appliances and medical instruments to heavy-duty chemical processing equipment and architectural cladding.

Batteries

The battery sector represents the fastest-growing application segment and is the primary driver of new exploration and refining investments.

Nickel is a critical component in lithium-ion battery cathodes, particularly in nickel-manganese-cobalt (NMC) and nickel-cobalt-aluminum (NCA) chemistries. High-nickel cathode formulations, such as NMC 811, which contains 80 % nickel, enable significantly higher energy density. This increased density allows electric vehicles (EVs) to achieve extended driving ranges without the added weight of larger battery packs.⁴

This specific technical requirement has created robust demand for Class I nickel, defined as material with at least 99.8 % purity, the only grade that can be efficiently processed into the nickel sulfate required for battery manufacturing.

The growth rate of the battery sector continues to outpace traditional industrial applications. By late 2024, battery applications accounted for approximately 17 % of total global nickel demand, and this figure is projected to rise steadily as EV adoption accelerates across North America, Europe, and China.⁵

Market data indicates that NCM622 battery chemistry captured approximately 32 % of the battery market in 2024, while the more nickel-intensive NCM811 reached a 40 % market share during the same period.⁶

Macroeconomic Context and Regional Stability

The nickel mining market is highly sensitive to macroeconomic stability in emerging economies, which host a significant share of the world's mining and refining infrastructure. Global capital flows, including domestic financial health and external capital indicators, serve as a barometer for the industrial resilience of these regions.

Emerging market stability

The ability of mining-heavy regions to maintain the infrastructure, energy grids, and logistics necessary for mineral exports is often tied to their broader economic health. For instance, in December 2025, Pakistan reported receiving \$3.6 billion in remittances.¹

Although Pakistan is not a primary producer of nickel, such macroeconomic indicators reflect the financial stability and liquidity available within the broader Asian and emerging market corridors. For nations involved in the midstream processing or downstream manufacturing of nickel-dependent products, these inflows provide essential economic buffers.

Want to save this article for later? [Click here.](#)

Steady capital flows allow for the continued development of ports, power plants, and transportation networks that facilitate the movement of critical minerals. In regions like Southeast Asia, where nickel production is concentrated, overall macroeconomic stability is required to sustain the massive capital expenditures associated with new refinery projects and to navigate global commodity price shocks.¹

The growth anchor

Against this backdrop of regional economic indicators, the market relies on long-term demand anchors to justify continued investment. The most prominent anchor is the forecast from Mordor Intelligence, which expects nickel market volumes to reach 4.4 million tons by 2031.² This projection provides the strategic framework for the industry, suggesting that despite current oversupply, the fundamental trajectory is one of expansion. This long-term target encourages producers to maintain operational capacity even during periods of price suppression, anticipating the massive scale of electrification required for global net-zero targets.

Recent Developments in the Nickel Mining Market

The nickel market is currently emerging from what analysts describe as "The Great Surplus" of 2024–2025. In 2024, the market was defined by primary production outstripping consumption by approximately 179,000 tons, with total production reaching 3.53 million tons. This trend intensified in 2025, with final year-end data indicating a surplus of 198,000 tons. Global

production in 2025 reached approximately 3.74 million tons, while total demand stood at 3.54 million tons.⁷

As of January 2026, these surplus conditions have become the primary driver of industry restructuring. Indonesia's massive production expansion remains the central theme. In 2024, Indonesia's mine output represented 46 % of global primary nickel production, a figure that increased through 2025.⁷

Indonesia successfully forced a massive "downstreaming" shift by utilizing its 2020 ban on raw ore exports. Chinese metallurgical firms have invested heavily in Indonesian High-Pressure Acid Leaching (HPAL) plants that process limonite ores to produce Mixed Hydroxide Precipitate (MHP), an essential intermediate in the battery supply chain.

This surge in low-cost supply has fundamentally transformed the competitive landscape for Western miners. The most significant structural shift occurred in October 2024, when BHP officially suspended its Nickel West operations and the West Musgrave project in Western Australia.⁸ As the market enters 2026, these facilities remain in a state of "care and maintenance." BHP's decision followed a period where the division recorded consistent negative cash flow, despite having invested \$3 billion to orient its production toward the EV market. The company has committed to spending approximately \$300 million annually to maintain the facilities, with a formal restart review not expected until early 2027.

By early 2026, London Metal Exchange (LME) prices began to stabilize after hitting lows of \$15,000 per ton in early 2025. However, the price environment remains challenging for high-cost sulfide mines, which lack the scale and integrated processing advantages of the Indonesian laterite hubs.⁷

Current Global Market Distribution

Indonesia continues to dominate the supply side, accounting for an estimated 63.4 % of global nickel ore production.⁶ China remains the world's largest consumer, accounting for over 63 % of primary nickel consumption.⁷

Continue Reading: Nickel Market Trends: The Race for Battery-Grade Supply

Asia as a whole remains the center of the nickel universe, accounting for nearly 87 % of global primary nickel consumption. Although Chinese demand is still anchored by its stainless-steel sector, its domestic EV battery industry is an increasingly powerful consumer. Indonesia has

also transitioned into a major nickel user. In 2025, its internal consumption rose as it developed its own downstream battery and EV manufacturing plants.⁷

Several major corporations dictate the market's current posture. Vale S.A. remains a diversified global leader, maintaining significant operations in Brazil, Canada, and Indonesia. Glencore continues to manage a wide portfolio, including the Murrin Murrin mine in Australia.

In Russia, MMC Norilsk Nickel remains a critical supplier of high-grade Class I nickel, though its trade flows have shifted significantly toward Asian markets over the last two years.

Meanwhile, emerging companies are focusing on sustainability as a competitive edge. Canada Nickel Company and Talon Metals are advancing projects in Ontario and Minnesota, respectively, targeting production methods that meet the "clean" energy standards required for the U.S. and European supply chains.

Hot Topics in Nickel Mining

Supply concentration and geopolitics

The concentration of supply is a primary strategic concern in 2026. Indonesia and China together control 75 % of global finished nickel production.⁹ This gives Indonesia unprecedented influence over supply conditions. Throughout 2025, the Indonesian government used its permit issuance process (RKAB) to manage ore tightness, successfully supporting prices even amid a global surplus.⁷

The Class I nickel challenge

A structural paradox defines the 2026 market: a surplus of Class II nickel (NPI and ferronickel) coexisting with a tight supply of high-purity Class I nickel. Although producers have successfully commercialized the conversion of NPI into battery-grade matte, the high energy costs and carbon footprint of this process remain a point of contention for Western automakers seeking to lower their Scope 3 emissions.

Battery chemistry competition

The rise of lithium iron phosphate (LFP) batteries remains a critical variable. LFP chemistries contain no nickel and are cheaper to produce, having captured a significant share of the standard-range EV market in China. However, as of 2026, high-nickel chemistries continue to lead in the long-range and premium vehicle segments, where energy density is the primary consumer requirement.

Western supply chain incentives

The U.S. Inflation Reduction Act and the European Union's Critical Raw Materials Act are now in active implementation. These policies provide tax credits and subsidies for minerals sourced from domestic mines or free-trade partners. This is creating a "bifurcated" market where "IRA-compliant" nickel from Canada or Australia is positioned as a premium product, distinct from the lower-cost but higher-emission nickel produced elsewhere.

Future Directions for Nickel Mining

The 2031 growth trajectory

Market projections continue to point toward a volume of 4.4 million tons by 2031.² Reaching this target will require the industry to move beyond the current period of care and maintenance.

Although stainless steel consumption is forecast to maintain a steady 3–4 % annual growth rate, the battery sector must overcome near-term moderation to drive the next wave of expansion.³ The International Nickel Study Group (INSG) expects primary nickel usage to grow by approximately 5 % through 2026 as the global EV market matures.^{7,10}

Technology and green refineries

Processing technology remains a key area of innovation. HPAL is now a proven, if capital-intensive, standard for treating laterite ores.

In 2026, the focus shifted toward reducing the carbon intensity of these plants. Western producers are leveraging renewable energy, such as hydroelectric power in Canada and Finland, to produce "low-carbon nickel." The E.U.'s battery regulations, now requiring carbon footprint declarations, are expected to create a permanent premium for these low-emission sources.

Secondary production

Recycling is slowly emerging as a secondary supply source. As the first generation of EVs reaches end-of-life, hydrometallurgical recycling facilities are beginning to scale. However, given the long lifespan of modern vehicle batteries, recycled nickel is not expected to contribute more than 15 % of the total supply before 2035.¹⁰ Primary mining will remain the dominant source for the foreseeable future.

Market stabilization

If current price stabilization continues through 2026, it may encourage the resumption of suspended projects. However, the International Nickel Study Group notes that the pace of demand growth remains sensitive to consumer preferences, specifically the balance between fully electric vehicles and plug-in hybrids, which contain significantly less nickel.¹⁰

Final Thoughts

As 2026 begins, the nickel mining industry is adjusting after years of rapid production growth that created more supply than the market needed. Indonesia now produces most of the world's nickel at costs other countries find hard to match, which means traditional mining regions need to offer something different, whether that's lower emissions or alignment with Western trade policies, to stay competitive.

The forecast of 4.4 million tons by 2031 still holds, though getting there won't be straightforward.

Mining companies will need to improve their processing efficiency, cut their carbon footprint, and work within an increasingly fragmented global supply chain where different regions follow different rules. The oversupply in 2024 and 2025 made business difficult for many producers, but it also pushed the industry to rethink how nickel is extracted, processed, and sold.

References and Further Reading

1. Business Recorder. (2025, January 10). *Pakistan receives \$3.6bn in remittances in December 2025*. <https://www.brecorder.com/news/40401390/pakistan-receives-36bn-in-remittances-in-december-2025>
2. Mordor Intelligence. (2024, October 18). *Nickel market volume expected at 4.4 mn tons by 2031 on strong stainless steel and EV demand*. PR Newswire. <https://www.prnewswire.com/news-releases/nickel-market-volume-expected-at-4-4-mn-tons-by-2031-on-strong-stainless-steel-and-ev-demand-says-mordor-intelligence-302655112.html>
3. Ferreira, R., & Pinto, F. (2024, December 2). *The world nickel market in 2024 – slowly diminishing surplus*. Stainless Steel World. <https://stainless-steel-world.net/the-world-nickel-market-in-2024-slowly-diminishing-surplus/>
4. U.S. Geological Survey. (2024, January). *Nickel*. Mineral Commodity Summaries. <https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-nickel.pdf>
5. Market.us. (2024, December 19). *Nickel market size, share, growth, trends & report 2030*. <https://market.us/report/nickel-market/>
6. Shanghai Metal Market. (2025). *Current status and future trends of the global nickel*

industry. <https://www.metal.com/en/newscontent/103370053>

7. Ferreira, R., & Pinto, F. (2025, July 21). *The world nickel market in 2025 – a growing surplus in an uncertain global landscape*. Stainless Steel World. <https://stainless-steel-world.net/the-world-nickel-market-in-2025-a-growing-surplus-in-an-uncertain-global-landscape/>
8. BHP. (2024, July 11). *Western Australia Nickel to temporarily suspend operations*. <https://www.bhp.com/news/media-centre/releases/2024/07/western-australia-nickel-to-temporarily-suspend-operations>
9. Crux Investor. (2025). *How Indonesia's nickel dominance & Western security concerns are reshaping investment opportunities*. <https://www.cruxinvestor.com/posts/how-indonesias-nickel-dominance-western-security-concerns-are-reshaping-investment-opportunities>
10. International Nickel Study Group. (2025, October 7). *INSG press release October 2025*. https://insg.org/wp-content/uploads/2025/10/pressrel_INSG-Press-Release-October_2025-nd782v78.pdf

Disclaimer: The views expressed here are those of the author expressed in their private capacity and do not necessarily represent the views of AZoM.com Limited T/A AZoNetwork the owner and operator of this website. This disclaimer forms part of the [Terms and conditions](#) of use of this website.

Mining, Geology, & Construction Materials With Microtrac

The mining and geology industries form the backbone of modern infrastructure, technological development, and economic growth. These sectors depend on accurate and timely data to guide decisions in exploration, mineral processing, environmental management, and production of construction materials.



Image Credit: Shutterstock.com/domnitsky

In recent decades, particle size, shape, and surface charge analysis has become a prominent analytical approach, offering broad applicability to both fine and coarse geological materials.

Particle size and shape influence virtually every aspect of mining operations – from the transport and deposition of sediments in exploration environments to the extraction of valuable minerals in grinding circuits and the geotechnical stability of aggregates in civil engineering projects.

As mining operations strive for greater efficiency, better process control, and decreased environmental impact, the ability to quickly quantify particle size distribution (PSD) becomes increasingly valuable.

This article presents a selective overview of the mining value chain and how particle characterization knowledge can streamline the process.

Integration of laser diffraction and dynamic image analysis instruments, such as Microtrac's portfolio, provides reliable, robust data.

Basic Impact of Particle Size in Geology and Mining

Particle size affects geological materials on a fundamental level, influencing their physical, chemical, and mechanical properties. In exploration geology, grain size gives insight into depositional environments, erosional processes, and mineralization events.

During processing, grind size determines the separation of valuable minerals and the efficiency of downstream processing steps. In environmental monitoring, particle size affects sediment transport, dust generation, and tailings stability. Even in construction and geotechnical applications, particle size distribution directly affects compaction, strength, and permeability.

Traditional methods such as sieving and sedimentation have long been used to characterize particle size. However, these approaches can be slow, labor-intensive, and less effective for fine materials.

Laser diffraction systems measure the scattering angles of laser light passing through dispersed particles, wet or dry. The indirect size technique converts scattering patterns into a size distribution using a reliable model based on Mie theory.

Results are delivered quickly with low material consumption, in accordance with the requirements of ISO13320:2020. Systems like the Microtrac **SYNC** go further by integrating dynamic image analysis, allowing operators to simultaneously evaluate particle shape and morphology - data critical for understanding material properties such as mechanical strength and settling.

Applications of Particle Size in Mineral Exploration and Resource Characterization

During mineral exploration, geologists work to understand the distribution, origin, and context of mineralized zones. Particle size analysis provides a window into the geological history of a region by revealing details about sediment transport, weathering processes, and depositional environments.

Fine-grained sediments may indicate low-energy depositional settings such as floodplains or lacustrine environments, whereas coarse, angular particles may signal proximity to source material or tectonically active regions. In placer exploration, the particle-size distribution within alluvial deposits can help identify trap sites for heavy minerals such as gold or ilmenite.

Particle size distributions also assist with interpreting paleoenvironments and stratigraphy.

When combined with geochemical and mineralogical data, PSD helps delineate alteration

halos, identify dispersion patterns, and improve the spatial resolution of resource models.

Operators can generate PSD data within minutes rather than hours, enabling more adaptive sampling strategies and improving the cost-effectiveness of field programs. Figure 1 illustrates a typical PSD curve derived from a milling experiment, demonstrating the level of detail obtainable through laser diffraction.

- App note: <https://www.microtrac.com/files/462125/laser-diffraction-in-mining-and-geology.pdf>

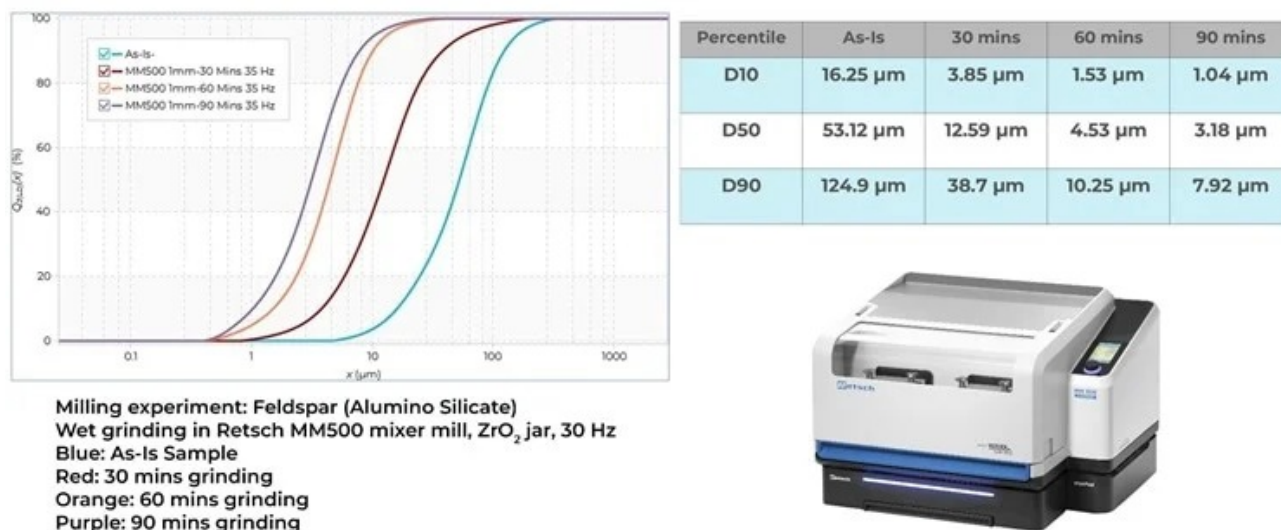


Figure 1. Particle size distribution from a controlled milling experiment. Image Credit: Microtrac

A Look Into Ore Processing and Milling Efficiency

Once ore is delivered from the mine, its processing cost and efficiency depend heavily on achieving the appropriate grind size. Comminution alone can account for 30–50 % of total energy use in a typical mineral processing plant, making real-time PSD monitoring essential for optimizing both energy consumption and mineral recovery (Anderson, 2014).

Laser diffraction provides high-frequency measurement capabilities that are well-suited for integration with automated plant control systems. By feeding PSD data directly into control loops, processing plants can regulate in real time.

These adjustments support more consistent grind sizes, reducing variability that could otherwise lead to overgrinding or insufficient extraction. Overgrinding produces excessive fines that can interfere with flotation or filtration, while undergrinding leaves valuable minerals locked within larger particles, reducing recovery.

In addition to enhancing efficiency, rapid PSD feedback enables operators to detect system upsets – such as changes in ore hardness, mill liner wear, or classifier malfunction – far earlier than traditional manual testing would allow. This leads to increased throughput, reduced

operational risk, and more stable downstream processing.

Assisting With Flotation, Leaching, or Other Beneficiation Processes

Flotation and leaching circuits rely heavily on particle size, as both processes depend on maximizing the interaction between minerals, reagents, and liquid phases (CEEC, 2021). If particles are too coarse, flotation recovery drops due to insufficient release.

If particles are too fine, they may become entrained in froth or require excessive reagent addition. Similarly, leaching kinetics depend on surface area availability, which directly correlates with PSD.

Dynamic Light Scattering (DLS) offers similar rapid, reproducible measurements that help maintain feed material within optimal particle size windows. This leads to improved reagent efficiency, enhanced selectivity, and higher recovery rates. Figure 2 demonstrates DLS with streaming Zeta Potential (ZP) analysis. Mapping particle charges reveals insights into slurry chemistry, dispersion behavior, and agglomeration tendencies.

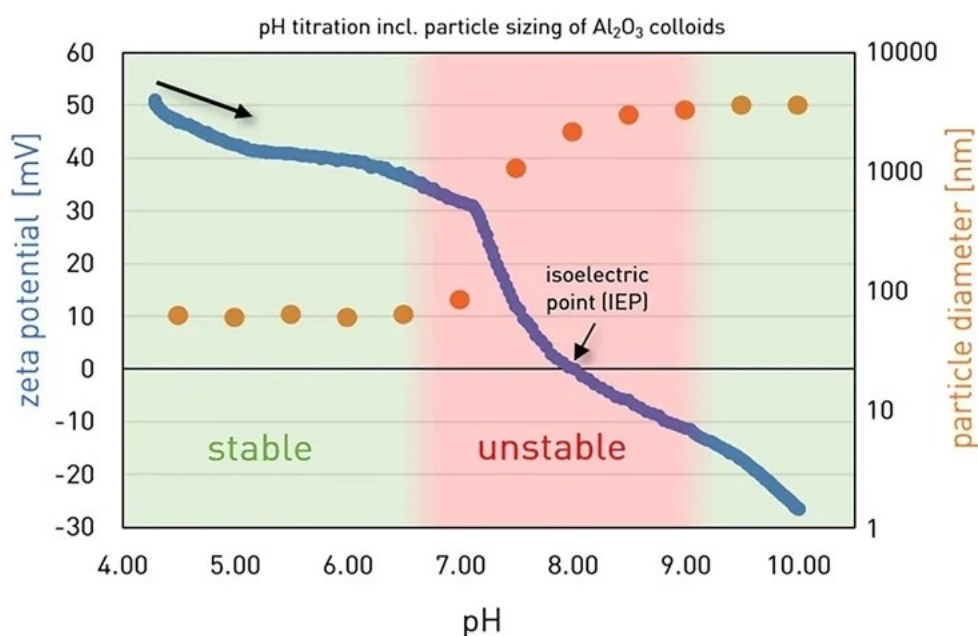


Figure 2. Streaming zeta potential of alumina suspension during NaOH titration. Image Credit: Microtrac

For complex ores or fine-grained materials, the combination of PSD and colloidal stability data supports a more nuanced understanding of flotation performance.

By identifying where fine fractions may be contributing to poor froth stability or where coarse particles are failing to attach to air bubbles, treatment plants can adjust grinding, reagent dosages, or conditioning times to improve overall efficiency.

Environmental Impacts: How Characterization Helps Monitoring and Regulatory Compliance

Mining operations face strict environmental standards governing water quality, dust emissions, sediment discharge, and tailings management. Particle size plays an essential role in all these issues. Fine particles can remain suspended for long periods in water bodies, posing ecological risks and complicating settling processes.

Similarly, airborne respirable fractions, particularly those below 10 μm in diameter, present health and visibility concerns (Huang, 2023).

Regulatory bodies such as the U.S. Environmental Protection Agency (EPA) and Environment and Climate Change Canada (ECCC) require quantifiable data for environmental reporting. The speed and repeatability of laser diffraction give operators the ability to respond rapidly to potential compliance issues.

For instance, if a tailings discharge begins to exhibit unexpectedly fine particle content, operators can quickly identify whether a grinding circuit upset, a cyclone malfunction, or a change in ore characteristics is responsible.

Dynamic Image Analysis Benefits Construction Aggregates, Cement Production, and Geotechnical Applications.

Dynamic image analysis (DIA) has become a central technique in modern particle characterization. DIA directly captures and evaluates individual particle images at high speed. This type of analysis produces statistically robust size and shape data from millions of particles in just a few minutes.

Real optical projections of particles in motion allow high-resolution size analysis, but also an understanding of how they are shaped. The size and shape results align with the practical needs of accurate gradation, consistent particle morphology, and reproducible data to control product performance.

[Microtrac CAMSIZER](#) systems apply this imaging approach to construction aggregates by using dual camera technology, as shown in Figure 5. Fine particles are recorded with high magnification, while coarse particles are captured in a large field of view, and the software merges both data sets into a seamless size distribution.

This eliminates the need for separate measurements or lens changes and ensures that wide grading materials. Sands, gravels, crushed rock, recycled aggregates, and complex mortar or plaster blends are accurately characterized in a single run. The method also handles non-free-flowing or cohesive materials effectively, especially when supported by air-pressure

dispersion modules, revealing the true fine-fraction content that traditional sieving often misrepresents.

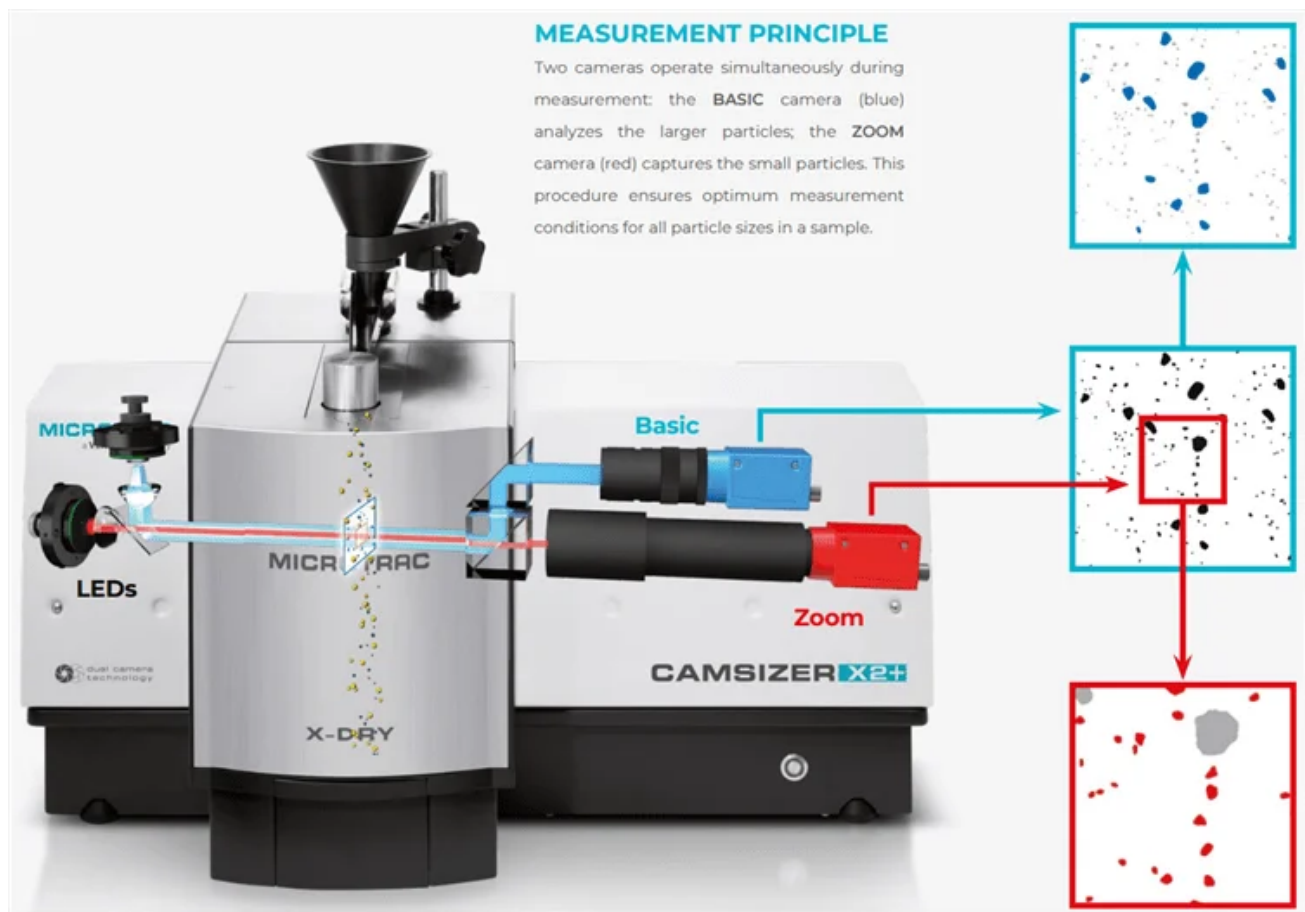


Figure 3 shows the dual camera technology, an integration of the basic and zoom cameras inside the Camsizer X2+. Image Credit: Microtrac

CAMSIZER DIA technology is a high-value technique for the construction materials sector, offering a modern alternative to sieve analysis with higher information content. For construction professionals, this means more reliable control of compaction behavior, water demand, permeability, strength development, and long-term durability of concrete and mortar.

For others in civil engineering labs, it delivers more dependable analytics and a deeper understanding of how particle size and shape drive material performance across the entire construction value chain.

- App note: [cement-particle-analysis-with-laser-diffraction.pdf](#)
- App note: [analysis-of-building-materials-mixtures-camsizer-x2-for-wide-distributions.pdf](#)

Conclusion

Across mining, geology, and construction materials industries, understanding particle size and shape remains fundamental to optimizing performance, meeting regulatory expectations, and maintaining dependable product quality.

These characteristics influence nearly every stage of the value chain, from extraction and beneficiation to compliance and performance. As industries face increasing pressure to reduce environmental impact and improve products, the ability to reliably assess particle size and shape becomes a strategic advantage.

These properties offer direct insight into material behavior, helping industry professionals anticipate performance issues, adjust processes proactively, and ensure that both products and byproducts meet the specifications demanded by customers, regulators, and evolving market expectations.

In this way, particle characterization serves as an essential link between raw material variability and consistent industrial outcomes, supporting safer, more efficient, and more sustainable operations across the sectors that rely on particulate materials.

References and Further Reading

Anderson, C.D. (2014). Fundamentals of rare earth flotation surface chemistry: Electrokinetic phenomena. *Mining, Metallurgy & Exploration*, 31(3), pp.176–176. DOI: 10.1007/bf03402276. <https://link.springer.com/article/10.1007/BF03402276>.

CEEC (Coalition for Eco-Efficient Comminution). (2021). *MINING ENERGY CONSUMPTION 2021*. Available at: <https://www.ceecthefuture.org/resources/mining-energy-consumption-2021>

Huang, X. (2023). The Impact of PM10 and Other Airborne Particulate Matter on the Cardiopulmonary and Respiratory Systems of Sports Personnel under Atmospheric Exposure. *Atmosphere*, [online] 14(11), p.1697. DOI: 10.3390/atmos14111697. <https://www.mdpi.com/2073-4433/14/11/1697>.

ISO. *ISO 13320:2020*. Available at: <https://www.iso.org/standard/69111.html>



This information has been sourced, reviewed, and adapted from materials provided by Microtrac.

For more information on this source, please visit [Microtrac](#).

AI in Mining Market: Overview, Trends and Outlook

As of January 2026, the mining industry has moved beyond tentative experimentation with digital tools. Over the last 12 months, artificial intelligence (AI) has transitioned from a niche luxury for Tier-1 miners to a foundational operational requirement across the global sector. The industry is leveraging machine learning, computer vision, and autonomous systems to maintain commercial viability amid the exhaustion of easy-to-reach deposits and increasing pressure to meet stringent environmental, social, and governance (ESG) standards.



Image Credit: Parilov/Shutterstock.com

According to data from Precedence Research, the global AI in mining market was valued at approximately USD 35.47 billion in 2025. It is currently projected to reach USD 828.33 billion by 2034, representing a compound annual growth rate (CAGR) of 41.92 %.¹ This significant capital inflow reflects a shift in strategy: miners are no longer simply seeking more land; they are seeking more data.

Primary Application Areas of AI in Mining

The integration of AI in mining is most visible across three primary stages of the value chain: exploration, extraction, and processing.

Mineral exploration

Exploration has historically been the industry's most significant financial gamble, with traditional discovery rates for world-class deposits sitting below 1 %. AI is narrowing these odds. Machine learning models now analyze decades of geological data, including seismic surveys, satellite imagery, and soil geochemistry, to identify subsurface anomalies that human interpretation often misses.

[KoBold Metals](#) recently utilized its proprietary AI platform to advance the Mingomba copper project in Zambia. By processing vast datasets, the company identified what is expected to be one of the highest-grade copper mines discovered in decades, significantly shortening the exploration timeline.² The startup, backed by investors such as Bill Gates and Jeff Bezos, raised \$537 million in early 2025, bringing its valuation to nearly \$3 billion.³

Similarly, [Earth AI](#), a California-based exploration company, operates a vertically integrated platform that uses predictive analytics and proprietary hardware to discover battery metals. The company has reported a 75 % success rate in identifying new prospectivity for minerals such as indium, nickel, and palladium, dramatically outperforming traditional methods that often rely on trial-and-error drilling.⁴

Extraction and autonomous operations

In the extraction phase, the focus has shifted toward the "connected mine". Throughout 2025, autonomous haulage systems (AHS) became standard in large-scale open-pit operations. Companies such as [Rio Tinto](#) and [BHP](#) have expanded their fleets of driverless trucks, which use LiDAR and AI-driven path-planning to operate 24/7.

Read More: Using Artificial Intelligence for Mineral Processing and Exploration

Rio Tinto's "Mine of the Future" program in Western Australia's Pilbara region remains a primary case study. Central to this is [AutoHaul](#), the world's first fully autonomous long-distance heavy-haul rail network, where AI systems control locomotives hauling iron ore across 1700 kilometers of track. Beyond haulage, AI-enabled drilling rigs now adjust their pressure and angle in real-time based on rock hardness.

[Caterpillar](#) has deployed its MineStar platform at sites like the Bloom Lake Mine to automate drilling and hauling, improving precision and reducing mechanical wear.⁵

Processing and ore sorting

Downstream, AI-driven computer vision is used to assess ore quality on conveyor belts. Modern AI sensors distinguish between high-grade ore and waste in milliseconds, allowing for "bulk ore sorting" before the material reaches the mill.

At [BHP](#)'s Escondida mine in Chile, the implementation of Azure Machine Learning (in partnership with [Microsoft](#)) has provided real-time recommendations for concentrator operations. This deployment generated an operational uplift of \$18.9 million by improving copper recovery rates.⁶ To consolidate these gains, BHP launched its first Industry AI Hub in Singapore in May 2025 to develop predictive analytics for its entire global supply chain.¹

Recent Developments and Regional Landscape of AI in Mining

The year 2025 marked several landmark developments. Shortly after BHP's hub launch, in June 2025, the Indian Ministry of Mines successfully completed its first AI-driven mineral exploration project in Rajasthan ¹

From a regional perspective, the Asia-Pacific region continues to lead the market, holding a 40 % share as of early 2026. This is driven by China's massive investment in "smart coal mines" and Australia's leadership in autonomous extraction.

China produces more than 50 % of 18 minerals globally and holds significant reserves of 35 others.¹ However, North America is the fastest-growing region, spurred by the urgent need for lithium, cobalt, and nickel for the energy transition and a high density of AI software providers.^{1,7}

Want to save for later? Click here.

Key Commercial Players

The market is currently defined by a mix of traditional equipment manufacturers (OEMs) and specialized software firms:

- Equipment Manufacturers: [Caterpillar Inc.](#) and [Komatsu Ltd.](#) provide hardware-software

integration for autonomous fleets. [Sandvik AB](#) and [Hexagon AB](#) focus on underground automation and digital twins. Hexagon's HxGN MineOperate uses AI for real-time fleet analytics, while Sandvik's AutoMine system leads in autonomous underground vehicle operation.⁸

- Large-Scale Miners: [Tata Steel](#) and Anglo American have integrated AI into core operations. [Anglo American](#) has deployed AI-enabled digital twins at its Quellaveco mine in Peru to optimize water usage and predict operational bottlenecks.¹

Market Trends and Outlook for AI in Mining

As we look toward the 2030s, three trends are defining the market:

1. The Proliferation of the Digital Twin

Miners are increasingly creating virtual replicas of physical mines. These models are fed real-time data from sensors across the site, allowing engineers to run simulations. [Newmont](#) has implemented metallurgical digital twins at its Lihir gold plant using Metso's Geminex technology, enabling real-time process optimization and cost reduction.¹

2. ESG and Sustainability Monitoring

Environmental compliance is no longer a secondary concern. AI is now the primary tool for monitoring tailings dam stability and carbon emissions. By 2030, AI-driven energy management is expected to be the standard for mining companies to reach "Net Zero" targets, as algorithms optimize energy loads between renewable grids and onsite storage.⁶

3. The Skills Gap and Workforce Evolution

Although AI reduces manual labor in hazardous areas, it has created a surge in demand for data scientists. Meeting net-zero targets is expected to require 700,000 new workers in the critical minerals sector by 2030 – an 88 % increase from 2022 levels.⁷ Companies like [KoBold Metals](#) are already hiring data scientists from big-tech backgrounds to work alongside traditional geoscientists.³

Challenges to Adoption

Despite growth, hurdles remain. The high initial capital expenditure (CapEx) required for AI infrastructure can be prohibitive for junior miners. Data silos, where information from different machines cannot be integrated, also hinder full-scale automation. Finally, cybersecurity has become a major risk; as mines become more connected, they become more vulnerable to digital disruptions, necessitating investment in industrial cyber defense.^{1, 2}

Final Thoughts

The transition of mining from manual, experience-based decision-making to data-led, autonomous operations is a necessity for companies competing in a low-grade, high-cost environment. With a market trajectory heading toward USD 828 billion by 2034, AI is redefining the fundamental economics of the industry, turning mining into a high-tech discipline that is safer, more efficient, and increasingly aligned with global sustainability goals.

References and Further Reading

1. Precedence Research. (2025). *AI in Mining Market Size to Hit USD 828.33 Billion by 2034*. [Online] Available at: <https://www.precedenceresearch.com/ai-in-mining-market>
2. Metal Tech News. (2025). *KoBold's AI prospecting secures billions*. [Online] Available at: <https://www.metaltechnews.com/story/2025/01/08/mining-tech/kobolds-ai-prospecting-secures-billions/2092.html>
3. Mining Technology. (2025). *AI-powered mining startup KoBold Metals secures \$537m in funding*. [Online] Available at: <https://www.mining-technology.com/ai/ai-kobold-537m-funding/>
4. AZoMining. (2025). *The Role of AI in Mineral Exploration*. [Online] Available at: <https://www.azomining.com/Article.aspx?ArticleID=1882>
5. Omdena. (2025). *AI in Mining: Top 24 Global Mining Companies*. [Online] Available at: <https://www.omdena.com/blog/top-24-global-mining-companies-driving-ai-transformation-in-2025>
6. Farmonaut. (2025). *Case Studies Of AI In Mining: 7 Top Innovations 2025*. [Online] Available at: <https://farmonaut.com/mining/case-studies-of-ai-in-mining-7-top-innovations-2025>
7. Microsoft Industry Blogs. (2025). *Driving digital transformation in mining with AI and adaptive cloud*. [Online] Available at: <https://www.microsoft.com/en-us/industry/blog/energy-and-resources/mining/2025/05/29/embracing-ai-and-adaptive-cloud-to-drive-digital-transformation-in-mining/>
8. CSG Talent. (2025). *AI in Mining: Transforming the Future of Resource Extraction*. [Online] Available at: <https://www.csgtalent.com/insights/blog/ai-mining-transforming-future-resource-extraction/>

Disclaimer: The views expressed here are those of the author expressed in their private capacity and do not necessarily represent the views of AZoM.com Limited T/A AZoNetwork the owner and operator of this website. This disclaimer forms part of the [Terms and conditions](#) of use of this website.

Saving Lives in Mining: The Safety Innovations Powering the Zero Harm Goal

The mining industry has historically been defined by high-risk environments, where the proximity of personnel to heavy machinery and volatile geological conditions creates a constant threat of injury or fatality. However, the sector is undergoing a shift as the Mining Equipment, Technology, and Services (METS) sector focuses on engineering out hazards. Several companies are significantly reducing workplace accident frequency and extending these life-saving innovations to humanitarian efforts by prioritizing the development of non-toxic mineral analysis, precise emergency drilling, and advanced explosive detection. Let's take a closer look.



Image Credit: WILLIAM LUQUE/Shutterstock.com

Chrysos Corporation: Eliminating Toxins in the Laboratory

One of the most significant life-saving advancements in mining history is the transition away from the "fire assay" method for mineral analysis. For centuries, fire assay has been the industry standard for measuring precious metals. However, the process is inherently hazardous, requiring laboratory technicians to work with lead flux, acids, and extremely high temperatures. The risk of lead poisoning, a chronic condition that can lead to neurological damage, kidney failure, and cardiovascular issues, is a constant threat to those in traditional mining labs, where dust and fumes from the furnace can be inhaled or absorbed.¹

Chrysos Corporation (ASX:C79) has addressed this risk through its PhotonAssay technology. Instead of using chemical reagents and intense heat to melt samples, PhotonAssay utilizes high-energy X-rays to activate gold and other elements. This method is non-destructive and, crucially, removes the human element from contact with dangerous substances. The company has effectively engineered out the primary causes of laboratory-related morbidity in the mining sector by automating the process and using physics rather than chemistry.

The removal of lead from the testing cycle has immediate health implications for staff. As noted by Chrysos Managing Director Dirk Treasure: *"The most important benefit... is on operators... Lead contamination is a big problem in fire assay laboratories around the world... Customers completely remove that as a concern by transitioning to PhotonAssay and I'm proud to say that we are keeping operators safer with our technology"*.¹

Beyond immediate lead exposure prevention, the technology improves the working environment by eliminating the extreme heat associated with traditional assay furnaces. In a conventional setting, the management of lead contamination is a significant operational burden that requires constant blood monitoring for staff. By removing the toxin at the source, Chrysos ensures that the long-term health of laboratory operators is not compromised for the sake of geological data.^{1,2}

MagnaTerra and MRead: Molecular Detection for Explosive Safety

MRead, a technology incorporated into MagnaTerra, has developed a specialized handheld sensor that utilizes Magnetic Resonance (MR) to

identify nitrogen-based explosives. In a mining context, this allows for the safe identification and handling of bulk explosives used in blasting operations. This ensures that unexploded charges or "misfires" are identified before they pose a risk to excavation teams or heavy machinery operators.

The life-saving potential of this technology extends far beyond the mine site into humanitarian demining. Detecting landmines and improvised explosive devices (IEDs) is a slow and lethal task for personnel in post-conflict zones. Traditional metal detectors often struggle with "clutter", metallic fragments such as nails, shrapnel, or mineralized soil, that lead to false positives. These false alarms slow down the clearing process and increase the operator's risk window, forcing them to treat every signal as a potential threat.

Read More: Are Mining Incidents Less Common and What Technology is Helping?

The MR technology used by MagnaTerra is "molecule-specific." This means the device can distinguish between a harmless piece of metal and the unique chemical signature of actual explosives.¹ This specificity reduces the risk of accidental detonation during clearance operations because it allows operators to prioritize real threats with higher confidence.

The technology protects the lives of demining teams and the civilians who eventually return to those lands by providing a technical solution that can "see" through soil and identify the specific molecular makeup of a threat.³ The ability to accurately identify nitrogen compounds at the molecular level represents a shift from simple metal detection to intelligent hazard identification.

IMDEX: Precision Drilling as a Rescue Lifeline

Although many METS innovations focus on daily safety, some are defined by their performance in extreme emergencies. IMDEX (ASX:IMD) has developed the DeviDrill, a wireline directional core-drilling system that enables the creation of multiple branch holes from a single "mother hole." Though this is primarily used for efficient resource mapping, its precision has proven vital in catastrophic underground failures.

The most prominent example of this technology's impact occurred during the 2010 Copiapó mining accident in Chile. When 33 miners were trapped 700 meters underground following a massive cave-in, the primary challenge was reaching a small refuge chamber with absolute precision. Standard vertical drilling is prone to "drift," where the drill bit deviates from its intended path over long distances due to varying rock hardness or geological pressure. A miss of even a few meters at that depth would have meant failing to reach the miners in time.

Technologies such as IMDEX's DeviDrill directional drilling system have been credited with enabling the precision needed to steer the drill bit and maintain an accurate trajectory to reach the trapped men.¹ This accuracy allowed the rescue team to establish a "plan B" hole that successfully breached the refuge.

[Click here to download a free PDF copy of this page](#)

Once the hole was established, it served as a conduit for communication, medical supplies,

and eventually the extraction capsule itself. The case study of the Chilean rescue remains a benchmark for how directional drilling can be repurposed from a geological tool into an emergency intervention system.⁴ The probability of reaching the trapped workers would have been significantly lower without the ability to correct the drill path in real-time.

Conclusion

The integration of these technologies represents a shift from traditional safety slogans toward a "safety by design" engineering reality. Companies like Chrysos Corporation are utilizing X-ray physics to identify risks before they manifest as chronic illnesses, while firms like MagnaTerra and IMDEX are improving physical safety through molecular detection and high-precision mechanical engineering.

The METS sector is fundamentally changing the risk profile of the mining industry by removing workers from toxic environments, providing tools to safely clear explosive hazards, and offering precise solutions for underground rescues. As these technologies become more accessible, the industry moves closer to the goal of zero harm, ensuring that miners and the communities surrounding them are protected by the best available science.

References and Further Reading

1. Stockhead (2026) *Mining METS leaders add golden touch to clean tech and life-saving innovations*. [Online] Available at: <https://stockhead.com.au/tech/mining-mets-leaders-add-golden-touch-to-clean-tech-and-life-saving-innovations/>
2. Chrysos Corporation (2024) *The Benefits of PhotonAssay: Safety, Speed, and Accuracy*. [Online] Available at: <https://chrysoscorp.com/photonassay/>
3. MagnaTerra (2023) *MRead: Revolutionising Explosive Detection with Magnetic Resonance*. [Online] Available at: <https://magnaterra.com.au/technology/>
4. MDEX Limited (2023) *Directional Drilling in Critical Applications: The San Jose Mine Rescue*. [Online] Available at: <https://www.imdexlimited.com/case-studies/chilean-mine-rescue>

Disclaimer: The views expressed here are those of the author expressed in their private capacity and do not necessarily represent the views of AZoM.com Limited T/A AZoNetwork the owner and operator of this website. This disclaimer forms part of the [Terms and conditions](#) of use of this website.

Driving Precision and Sustainability in Mining

Quality control in the mining industry is essential for efficient resource extraction, compliance with increasingly stringent regulations, and sound economic decision-making.

It is important that mining laboratories deliver accurate, reproducible analytical results while routinely processing large, highly abrasive, and heterogeneous materials.

Reliable sample preparation is key to ensuring that analytical data truly represents the ore body or processed material. This may include crushing, splitting, fine grinding, and sieving.

Growing environmental expectations continue to push the mining sector toward more circular material strategies. For example, while mine waste and tailings were historically treated as liabilities, these are now increasingly considered and assessed as potential raw materials for new applications or secondary resources.

Current research has highlighted that advanced processing and milling technologies play a role in converting these types of materials into valuable products.



RETSCH Jaw Crusher BB 600. Image Credit: RETSCH

Pre-Crushing Solutions for Hard, Abrasive, and Heterogeneous Materials

Mining samples often contain exceptionally hard, brittle, or mixed mineral components, requiring wear-resistant yet powerful crushing solutions.

- Jaw crushers offer dependable primary size reduction, with adjustable gap widths for controlled final particle size.

Retsch offers a diverse portfolio of jaw crushers suitable for laboratory- and pilot-scale mining applications, combining robust construction, ease of operation, and straightforward cleaning.

The company's portfolio can accommodate a wide range of sample volumes, feed sizes, and throughput requirements.



RETSCH Jaw Crusher BB 250. Image Credit: RETSCH

For instance, the **benchtop BB 50** is suitable for routine laboratory preparation. It accepts feed sizes up to 40 mm and can reduce material to as fine as 0.5 mm.

The BB 600 supports high-capacity sample preparation in mining operations, accommodating process feed sizes up to 350 × 170 mm and offering a throughput of up to 3500 kg per hour.

Intermediate models like the BB 250 and BB 400 provide sufficient feed capacity and a front-door design that enables straightforward cleaning. This is a key benefit when processing several different ore types.

The BB 500 is designed to support applications requiring fine final particle sizes down to 0.5 mm and high throughput, as well as offering optional heavy metal-free grinding tools.

Jaw materials such as tungsten carbide and zirconium oxide minimize wear and prevent trace metal contamination, making them ideal for use with highly abrasive ores.

Operators can tailor the final particle size to downstream analytical requirements by adjusting the jaw gap.

In daily laboratory practice, a two-step crushing approach often reduces total processing time compared to forcing coarse particles directly through a narrow gap. This is achieved first with a larger gap and followed by a finer setting.



200 g Iron ore in BB 50 with a gap of 0.1 mm in 1 min. Image Credit: RETSCH



200 kg/h in BB 500 with a gap of 0.1 mm in 2.5 min. Image Credit: RETSCH



10 kg Diorite in BB 300 with a gap of 1 mm in 1.5 min. Image Credit: RETSCH



20 kg Mangan ore in BB 300 with a gap of 10 mm and 1 mm in 3 min. Image Credit: RETSCH

Cyclone Integration: Dust-Free Discharge and Maximum Recovery

Cyclone separators reduce dust emissions, limit heat buildup, and ensure reliable material discharge emissions, considerably enhancing crushing and milling efficiency in mining laboratories.

These devices facilitate almost total sample recovery while allowing the flexible placement of collection containers up to 30 l in volume. Reduced dust exposure and cleaner air also directly contribute to safer working conditions while improving compliance with occupational health standards.

Cyclone suction units are available for the BB 50, BB 250, BB 400, and BB 500 enabling clean, efficient sample preparation workflows when using these instruments.



RETSCH Jaw Crusher BB 50 with cyclone. Image Credit: RETSCH

Accurate Subsampling and Efficient Particle-Size Analysis



Up to 60 l of sample material can be fed to the hopper of the sample divider PT 300. Image Credit: RETSCH

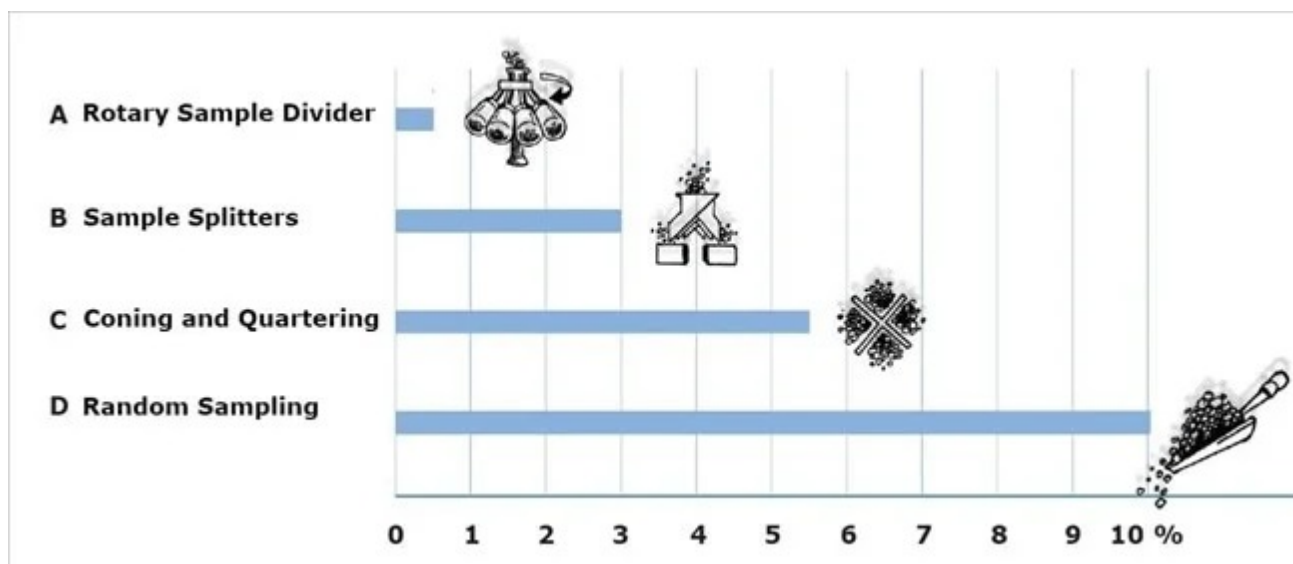
Representative sample division and accurate particle-size classification are essential for ensuring reliable analytical outcomes after a sample has been crushed.

Improper sample splitting during mining quality control continues to be one of the most widely encountered sources of analytical error. The [PT 300 sample splitter](#) has been designed to accommodate volumes of up to 60 l in a single operation, enabling the representative division of bulk mining samples.

Manual splitting methods typically require repeated handling, exposing operators to dust. The rotating PT 300 processes large sample volumes in one pass and uses a vibratory chute to ensure uniform material flow.

The division process generally takes less than 10 minutes and produces reproducible, statistically valid subsamples.

The PT 300 provides a reliable foundation for mining laboratories routinely handling ore, tailings, or aggregate samples in the 20-60 kg range, enabling fine grinding and analysis while reducing operator variability and effort.



Bulk material, feed size < 5 mm. The diagram shows qualitative variations among part samples for various methods of sampling and sample division. Image Credit: RETSCH

The [Vibratory Sieving Machine AS 450 controls](#) has been engineered to enable high-capacity particle size analysis under challenging conditions. Its three-dimensional vibratory motion combines circular motion with vertical acceleration, maintaining a consistent amplitude of up to 2.2 mm even under heavy loads of up to 25 kg.

Integrated CET technology ensures that material is uniformly distributed, irrespective of sample weight. The AS 450 control delivers significantly lower oversize rates and superior reproducibility compared with traditional electromagnetic or imbalance-driven shakers, supporting efficient laboratory workflows by reducing the need for manual resieving.



RETSCH Vibratory Sieve Shaker AS 450 control. Image Credit: RETSCH

Air jet sieving machines are designed for the precise, rapid separation of fine powders below

200 µm. Not only does the generated air stream ensure accurate sieving, but it also effectively deagglomerates electrostatically charged or cohesive particles.

Air jet sieving supports the rapid quality control and process monitoring of ores, tailings, and mineral powders in mining laboratories, without the need for wet dispersion or mechanical agitation.

This approach helps minimize sample loss and contamination, provide reproducible results, and ensure compliance with key particle size specifications for downstream processing.



RETSCH Air Jet Sieving Machines AS 200 jet and AS 200 jet pro. Image Credit: RETSCH

Fine Grinding for High Precision XRF and XRD

XRF, XRD, and similar analytical techniques require the use of extremely fine, homogeneous powders to achieve accurate, reproducible results.

Specialized fine-grinding equipment is needed to achieve this level of preparation for hard, brittle mining materials. Ball mills are commonly used for this purpose, offering both homogenization and efficient size reduction.

Retsch offers a range of mixer mills and planetary ball mills designed to accommodate various analytical requirements and sample quantities.

The Drum Mill TM 300 enables efficient processing for large sample volumes of up to 5 l. Vibratory disc mills are widely used to enable rapid homogenization of mining samples. Models such as the RS 200 and RS 300 also offer reliable preparation for subsequent analysis, depending on sample volume.



RETSCH Mixer Mill MM 400, Planetary Ball Mill PM 100, Vibratory Disc Mills RS 200 and RS 300, and Drum Mill TM 300. Image Credit: RETSCH

[Check Out the Interactive Copper Ore Poster Here](#)



10 g Ore in MM 400 in 2 min, < 100 μ m. Image Credit: RETSCH



120 g Iron ore in RS 200 in 1 min, < 100 μm . Image Credit: RETSCH



3 kg Iron ore in RS 300 in 12 min, < 100 μm . Image Credit: RETSCH



1 kg Ore in DM 200 in 6 min, < 400 μm . Image Credit: RETSCH

The disc mill DM 200 has been designed to facilitate the fine crushing of highly abrasive materials, including ores and minerals. Long service life and consistent performance are ensured by its wear-resistant grinding tools, which enable particle sizes down to 50 μm .

Laboratories that do not require intermediate sample splitting between pre-crushing and fine grinding can connect jaw crushers such as the BB 50 or BB 250 directly to the DM 200.

When used alongside cyclone units, this setup delivers continuous airflow for sample transport and collection, enabling fine, homogeneous sample preparation in a single batch and streamlining workflows.



RETSCH Combo unit: Jaw Crusher BB 250 and Disc Mill DM 200 with cyclone system. Image Credit: RETSCH



Video Credit: RETSCH

Reliable XRF analysis requires a smooth, flat sample surface. This ensures consistent interaction between X-rays and the sample while also minimizing scattering and signal loss.

There is a risk of uneven surfaces leading to measurement inaccuracies because of the variable distances between the sample and the detector.

The PP 40 pellet press delivers smooth, strong pellets with individually adjustable pressing

forces up to 40 tons. Programmable pressing steps ensure pellet stability and support precise, reproducible elemental analysis, even with challenging mining matrices.

A pressure force of 30 tons is sufficient to achieve optimal intensities in the XRF signals, depending on the element being analyzed and the matrix components. Some exceptions require higher pressure forces up to 40 tons, however.

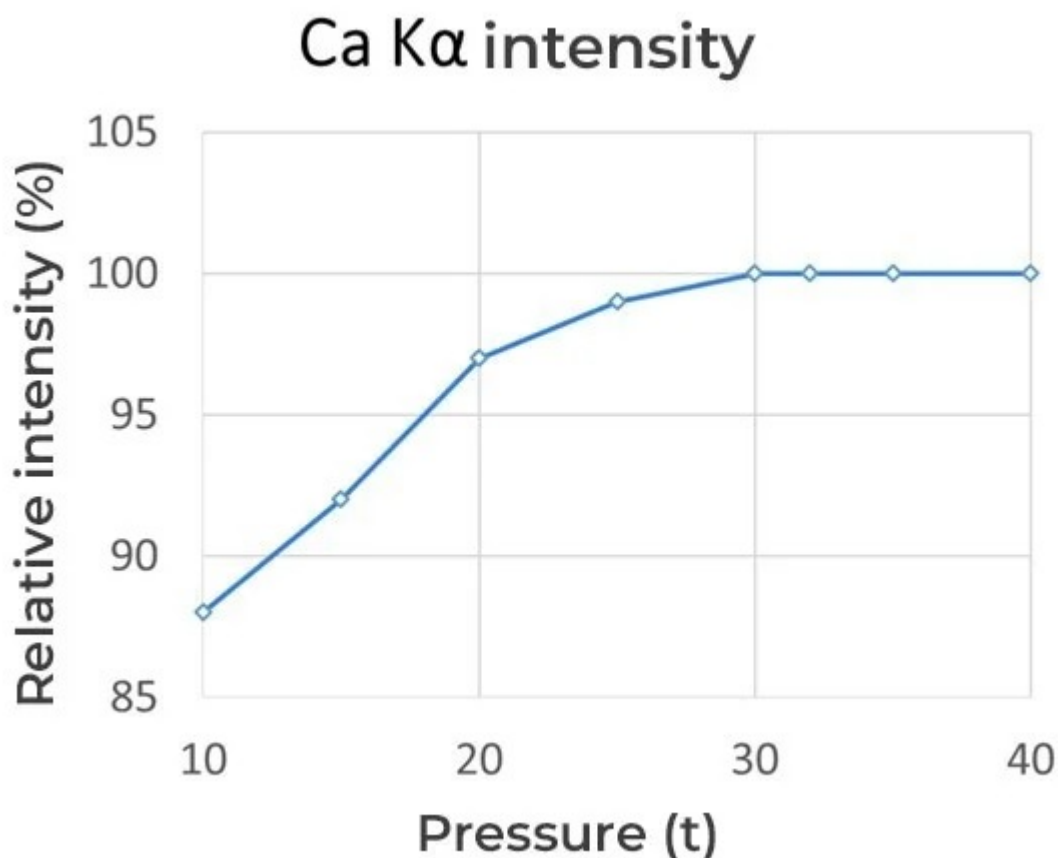


Image Credit: RETSCH

XRD Mill McCrone

XRD analysis is highly sensitive to particle shape, size, and amorphization. The XRD Mill McCrone is designed to meet these requirements, delivering:

- Exceptionally narrow particle size distributions
- Minimal damage to crystal structures
- Friction-based grinding with a total of 48 zirconium oxide elements
- Final fineness below 10 μm , making it ideal for phase identification



RETSCH XRD Mill McCrone. Image Credit: RETSCH

The McCrone mill can be used to prepare minerals, cement, clinker, and related materials with minimal structural disturbance and high reproducibility, supporting reliable mineralogical analysis in materials research and mining.

Research Innovations in Mine Waste Recycling

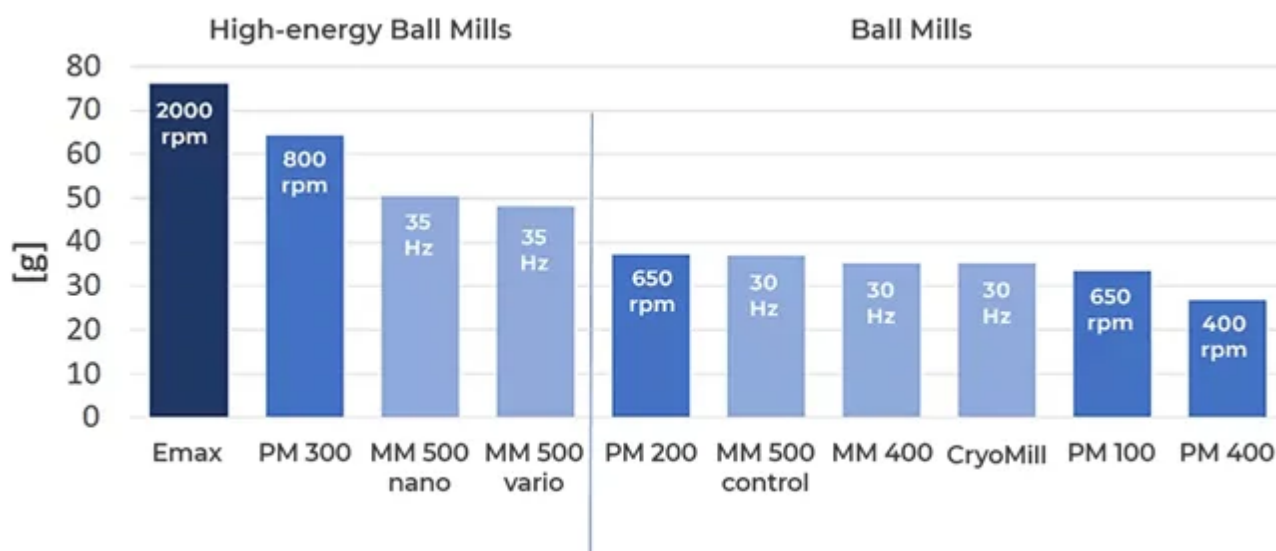
Mining tailings represent both opportunities for secondary resource recovery and environmental challenges. Current research is increasingly focused on transforming these historically wasted materials into functional products.

The Horizon Europe START Project outlines the processing of tailings rich in tetrahedrite from historic European mines into thermoelectric materials suitable for use in sustainable energy harvesting.

High-energy milling via the Emax is key to this mechanochemical transformation, highlighting the use of advanced grinding technologies in supporting innovation in the recycling of mine waste.



RETSCH High-energy Ball Mill Emax. Image Credit: RETSCH



The Emax delivers the highest energy input of all Ball Mills. Image Credit: RETSCH

Conclusion

Accurate, reproducible sample preparation is essential in modern mining settings. Properly prepared samples are the foundation of reliable mineral analysis, regulatory compliance, and efficient resource use.

Leveraging a comprehensive portfolio of jaw crushers, cyclone systems, sample dividers, disc mills, sieve shakers, and specialized fine-grinding solutions enables mining laboratories to establish a robust, scalable foundation for each stage of the analytical workflow.

These tools are key to supporting precision in current mining applications and more sustainable mining practices in the future.

Acknowledgments

Produced from materials originally authored by RETSCH.



This information has been sourced, reviewed, and adapted from materials provided by RETSCH.

For more information on this source, please visit [RETSCH](https://www.retsch.com).