TMG

MINING ▪ ENERGY ▪ INFRASTRUCTURE

BUSINESS GUIDE

How Mining is Fueling the Future

The Hidden Engine of the Alternative Energy Revolution

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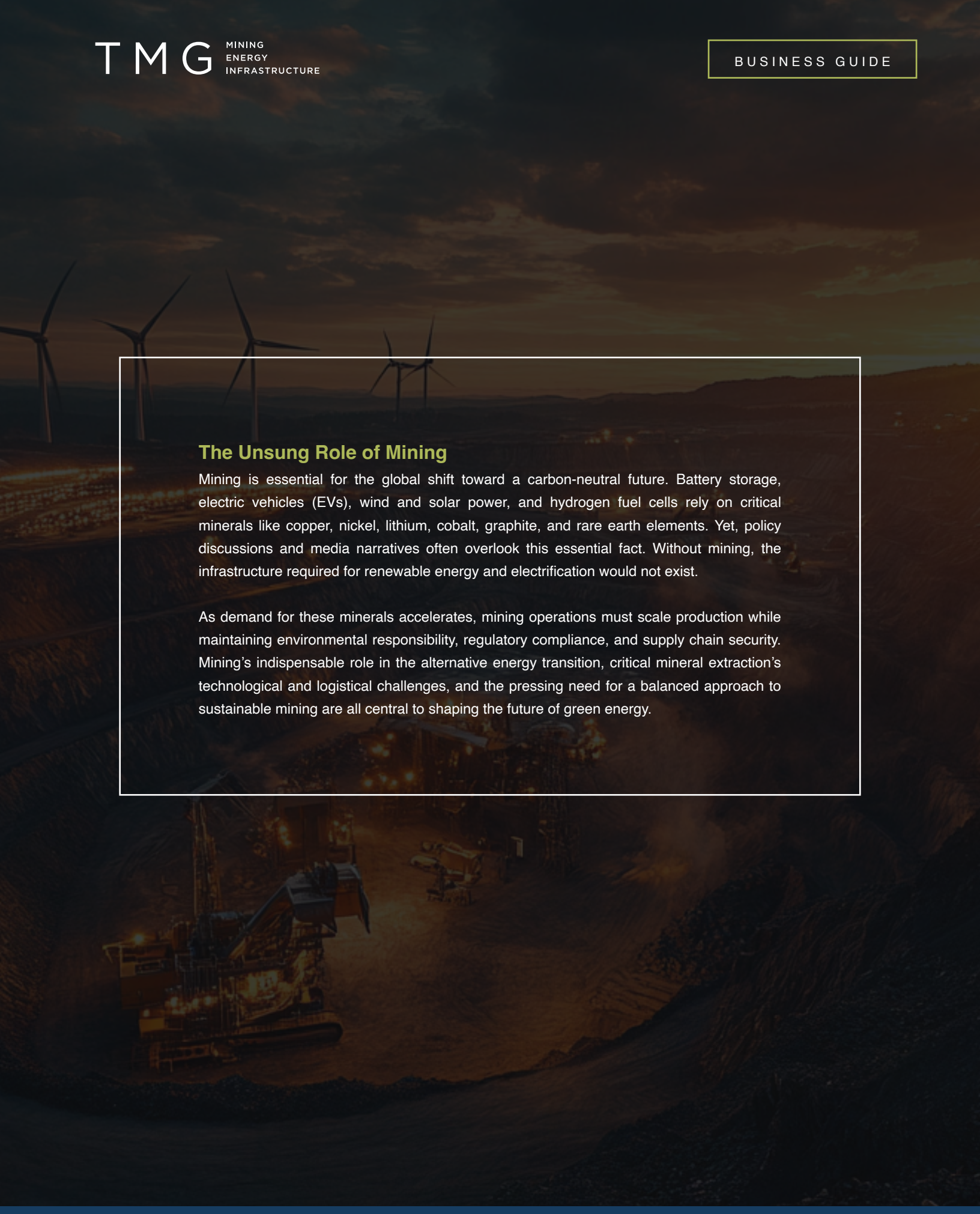


The Unsung Role of Mining

Mining is essential for the global shift toward a carbon-neutral future. Battery storage, electric vehicles (EVs), wind and solar power, and hydrogen fuel cells rely on critical minerals like copper, nickel, lithium, cobalt, graphite, and rare earth elements. Yet, policy discussions and media narratives often overlook this essential fact. Without mining, the infrastructure required for renewable energy and electrification would not exist.

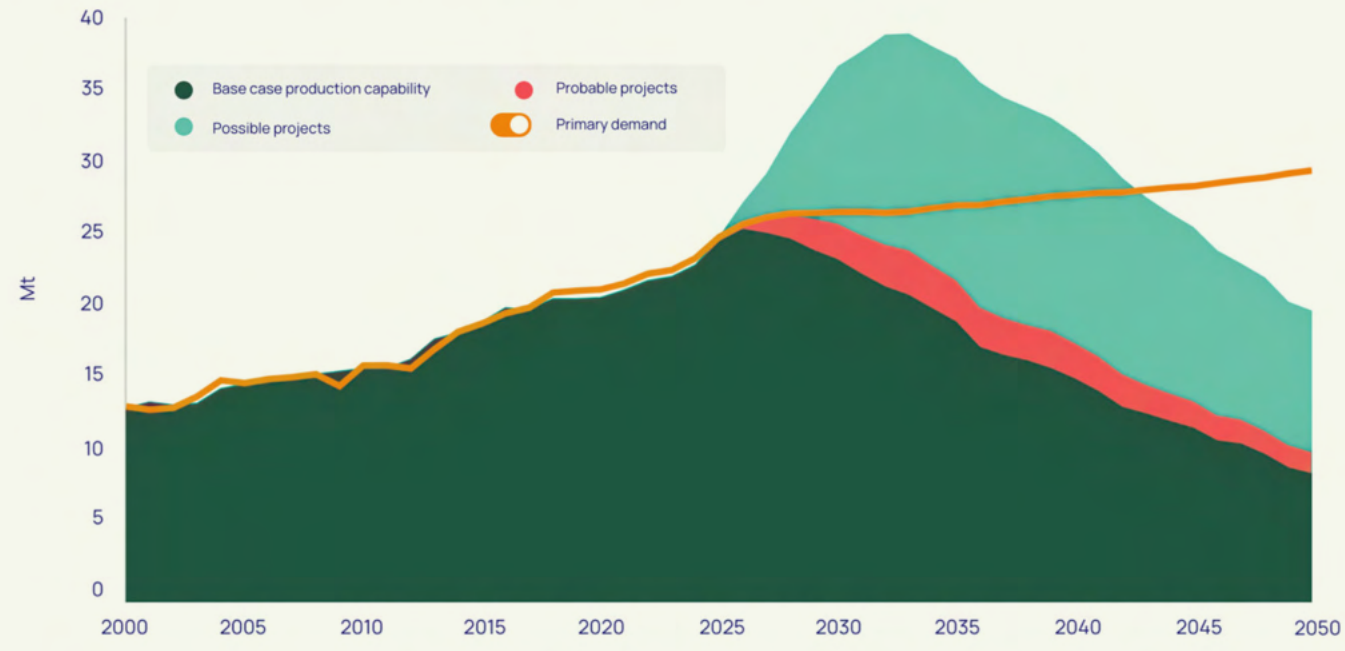
As demand for these minerals accelerates, mining operations must scale production while maintaining environmental responsibility, regulatory compliance, and supply chain security. Mining's indispensable role in the alternative energy transition, critical mineral extraction's technological and logistical challenges, and the pressing need for a balanced approach to sustainable mining are all central to shaping the future of green energy.

The Critical Minerals Powering Alternative Energy

Copper: The Foundation of Electrification

Copper is the foundation of electrification due to its unmatched electrical conductivity. It is essential in solar panels, wind turbines, EV batteries, and power grids. The average electric vehicle requires 83 kg (183 lbs) of copper—more than four times the amount used in internal combustion engine vehicles. Not to mention the amount of copper needed to build all of the requisite infrastructure for recharging. Offshore wind farms use up to 10 metric tonnes of copper per megawatt (MW) of capacity.

However, declining copper ore grades mean that larger volumes of material must be mined to meet demand, increasing processing capacity and energy use. Even with advanced recovery innovations, the industry faces a significant supply gap. Copper demand could double by 2050, requiring substantial investments in new mining projects.

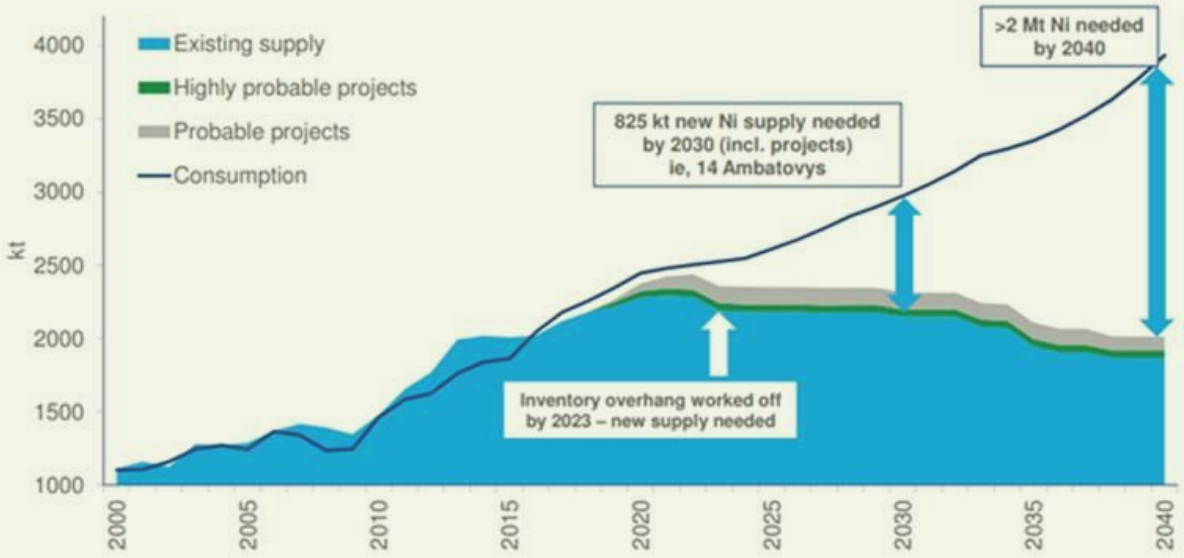


Source: Wood Makenzie, The future of the copper market

Nickel: Strengthening Battery Chemistry

Nickel is critical to high-performance lithium-ion battery cathodes, particularly NMC (Nickel-Manganese-Cobalt) and NCA (Nickel-Cobalt-Aluminum) chemistries. High-purity Class 1 nickel is necessary for battery production, but most of the world's reserves exist as low-grade laterite ores, which require energy-intensive processing.

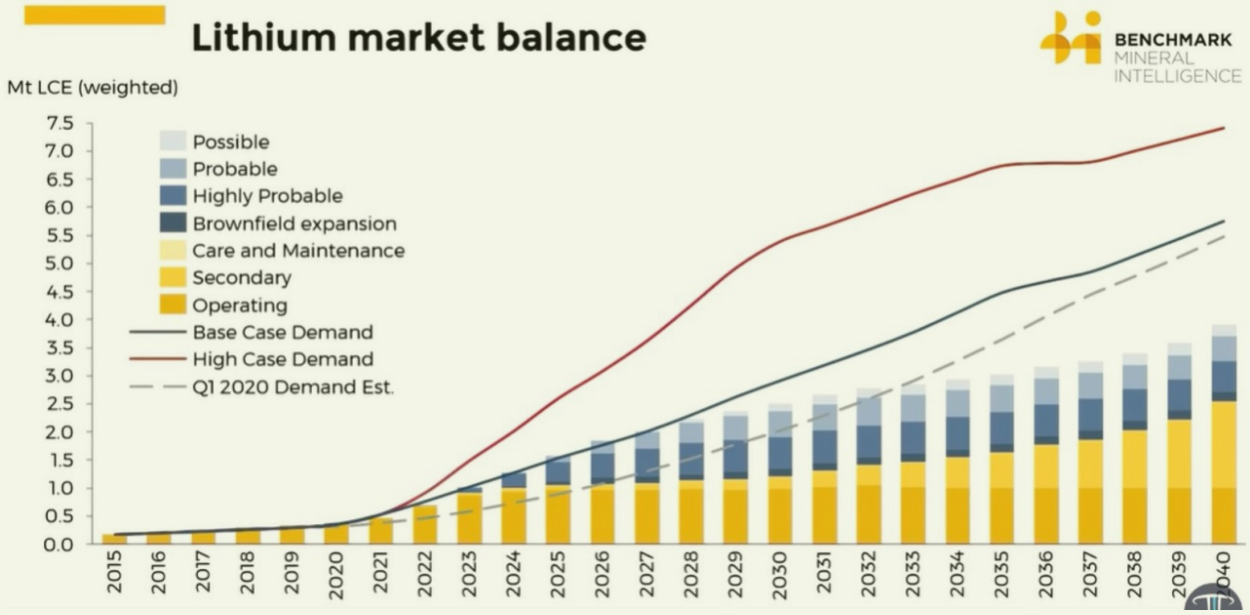
Hydrometallurgical extraction techniques such as high-pressure acid leaching (HPAL) and emerging bio-mining solutions are helping reduce emissions. However, the nickel supply chain remains strained. As automakers shift to higher-nickel batteries to extend EV range, securing sustainable and cost-effective nickel sources will be a key challenge.



Lithium: The Fuel of the Battery

Lithium-ion batteries are the backbone of EVs and grid energy storage. Lithium is primarily extracted through two methods: brine deposits in Chile, Argentina, and Bolivia, which require evaporation ponds that consume large amounts of water, and hard rock spodumene mining in Australia and Canada, which involves energy-intensive refining.

New direct lithium extraction (DLE) technologies aim to reduce environmental impact by improving recovery efficiency and minimizing water use. However, lithium refining is heavily concentrated in China, creating geopolitical risks and supply chain vulnerabilities.



Cobalt: The Supply Chain Bottleneck

Cobalt enhances battery energy density and longevity, but over 70% of the world's supply comes from the Democratic Republic of Congo (DRC). Ethical concerns around artisanal mining and child labor have prompted automakers and battery manufacturers to seek alternative sources and many are now considering implementing traceability protocols for the global sourcing and supply chain of critical minerals.

Efforts to reduce cobalt dependency have included shifting to LFP (Lithium Iron Phosphate) batteries, which eliminate cobalt but reduce energy density, and expanding battery recycling programs to recover cobalt from used cells. Despite these efforts, cobalt remains a critical component of high-performance batteries, and new sources outside the DRC will be needed.

Graphite: The Unsung Hero of Batteries

Lithium-ion battery anodes are made almost entirely of graphite, yet the role of this material is often overlooked. Natural graphite reserves are abundant, but China controls over 70% of the world's graphite refining capacity. To address this, new investments in synthetic graphite production and alternative anode materials, such as silicon-based anodes, are gaining traction. However, synthetic graphite production requires significant energy inputs, often sourced from fossil fuels, creating a paradox in sustainable battery production.

Rare Earth Elements: Essential for Wind & EV Motors

Rare earth elements (REEs), including neodymium, praseodymium, dysprosium, and terbium, are crucial for permanent magnets used in wind turbines and electric motors. A 3 MW wind turbine requires approximately 600 kg of rare earth magnets, while EV motors depend on them for efficiency.

REE mining presents significant challenges due to low ore concentrations, complex separation processes that produce hazardous waste, and China's supply chain dominance, which controls over 85% of the global REE refining capacity. Western nations are exploring domestic mining projects, recycling rare earth magnets, and developing alternative motor technologies to secure future REE supplies.

Aluminum: The Overlooked Battery Essential

Aluminum plays a crucial role in lithium-ion batteries by enhancing conductivity and structural stability while reducing overall weight. Unlike cobalt, aluminum is abundant; however, its refining process is energy-intensive and heavily reliant on China, which dominates global production. Supply chain vulnerabilities and environmental concerns surrounding extraction and processing have prompted battery manufacturers to investigate more sustainable refining methods and alternative sources. As the demand for lithium-ion batteries continues to surge, securing a stable and responsible aluminum supply will be essential for advancing energy storage technologies.

Scaling Mining Operations: The Demand-Supply Dilemma

The demand for critical minerals is projected to increase fivefold by 2040, making large-scale expansion of mining operations necessary. However, traditional mining projects take more than 10-15 years to move from exploration to production, creating a severe mismatch between demand and available supply. To meet global copper demand by 2030, we need to build at least one primary copper mine per year in each of the next 5 years. However, there is only one fully permitted primary copper project in North America that has entered the execution phase since 2020.

Accelerating mining operations requires fast-tracked permitting while maintaining rigorous environmental and social standards. Investment in AI-driven exploration technologies is also essential to improve efficiency and identify new deposits faster. Advances in sustainable extraction techniques, such as in-situ leaching and carbon capture in mining operations, are becoming increasingly important in balancing production growth with environmental responsibility.

Mining companies face growing pressure to minimize their environmental footprint. Sustainability efforts have led to innovations in tailings management to prevent environmental contamination and implement carbon-neutral mining operations. Hydrogen-powered haul trucks, solar-powered mining sites, and stronger mine rehabilitation programs are all being explored to reduce long-term ecological damage. Still, the industry must work closely with regulators and local communities to ensure that mining operations do not undermine conservation efforts.

With China dominating the refining and midstream processing of critical minerals, supply chain security has become a priority for governments and corporations worldwide. Many nations are working to establish domestic mining initiatives in North America, Australia, and Europe to reduce dependence on foreign suppliers. Strategic partnerships with mineral-rich nations are being formed to diversify supply chains, while investments in battery recycling and urban mining are gaining traction to recover valuable materials from end-of-life products. These measures are critical to securing a stable supply of raw materials for the alternative energy transition.

The Role of TMG in the Energy Transition

The shift to renewable energy and electrification will only succeed if the mining industry can keep pace with the demand for critical minerals. Scaling up mining operations while maintaining environmental responsibility, regulatory compliance, and supply chain security requires careful planning, investment, and technical expertise.

At TMG, we specialize in helping mining companies navigate these challenges by providing expert guidance on project execution, risk mitigation, and operational strategy. Whether accelerating permitting processes, optimizing supply chain logistics, or integrating sustainable mining practices, our team ensures that projects remain viable and competitive in an increasingly complex global market.

If your company is preparing to expand mining operations or facing obstacles in project execution, TMG has the expertise to help you succeed. Contact us today to discuss how we can support your mining projects and drive the future of sustainable resource development.

SPEAK WITH AN EXPERT

TMG specializes in executive and management consulting for the mining and oil and gas sectors, offering tailored oversight and strategic guidance across all project stages to ensure optimal outcomes from conception to execution.