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SINCE 1912

Skillings

Mining Review Magazine

The $90 Iron Ore Test
Who survives the next cost-curve squeeze?

The Mine-Planning Software Arms Race
Five platforms are competing to control the mine's digital workflow.

Northam Opens World's Deepest
Raise-Bored PGM Shaft

Mining's New Nerve Center

How Integrated Operations Centers are reshaping the pit-to-port operating model

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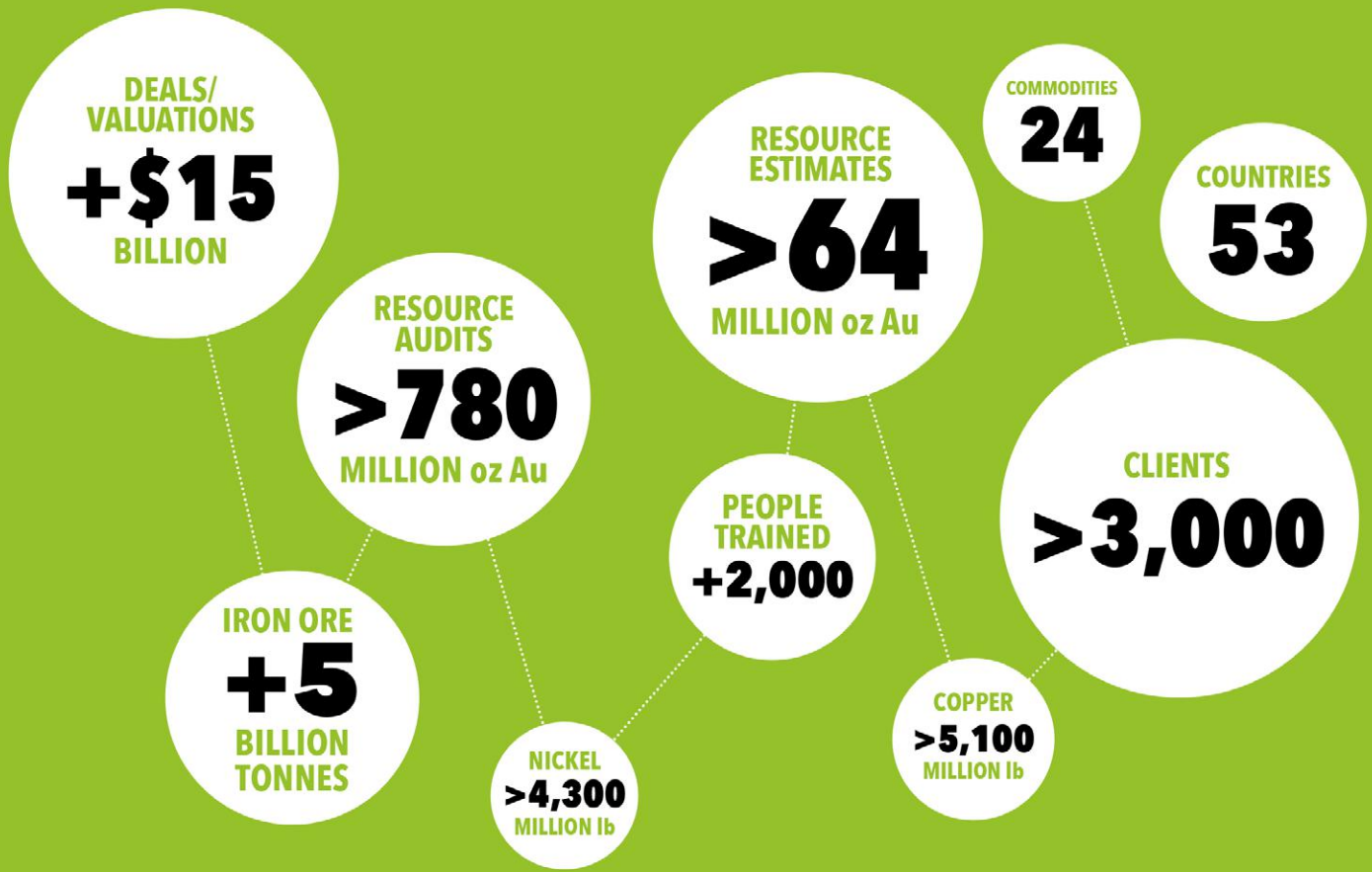

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Skillings MINING Review

Contents

Volume: 115. Issue.9. Septemper 2026

IN THIS ISSUE

Mining at the New Strategic Frontier

The September issue of ***Skillings Mining Review*** looks at an industry being reshaped by three forces: the race for critical minerals, the economics of supply, and the rapid adoption of technology across the mining value chain.

Our critical-minerals focus examines how countries and companies are responding to supply-chain vulnerabilities. From Aramco and Ma'aden's Saudi ambitions and Coal India's first overseas office in Singapore to Korea's copper strategy and America's push towards mine-to-magnet capability, the competition for strategic resources is becoming increasingly global. We also explore the emerging value of secondary resources, from black mass and mining waste to new approaches for recovering rare earths and other critical minerals.

Technology and innovation form the second pillar of this issue. AI-enabled iron-ore processing, chromatography-based rare-earth separation, advanced mine-planning software, integrated operations centres and the world's deepest raise-bored PGM shaft demonstrate how technology is changing the way mines are designed, operated and optimised.

The third theme is economic resilience. The US$90 iron-ore test, collapsing copper treatment charges, gold's capital crossroads and the projected US$50 billion underground mining equipment market examine the pressures shaping investment and profitability. Together, these stories highlight a fundamental shift: the future of mining will depend not only on what the industry can extract, but on how intelligently, efficiently and strategically it can develop the resources the world needs.

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Mining Review Magazine

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Skillings Mining Review of CFX Network LLC, publishes comprehensive information on global mining, iron ore markets and critical industry issues via Skillings Mining Review Monthly Magazine and weekly. SMR Americas, Global Skillings and Skilling Equipment Gear newsletters.

Underground Mining Equipment Market Heads Towards $50 Billion

The global underground mining equipment market is projected to reach $50.1 billion by 2035, reflecting continued investment in deeper, more productive and increasingly technology-enabled mining operations.

The market, valued at an estimated $33.38 billion in 2025, is projected to expand at a 4.14% CAGR through 2035, according to Spherical Insights. The growth reflects rising demand for underground extraction equipment as mines pursue greater productivity, operational efficiency and safer working environments.

Technology is becoming an important part of that investment. Automation, digital monitoring and

battery-electric equipment are gaining ground, while ageing fleets are creating additional demand for replacement machinery.

For equipment manufacturers, the opportunity extends beyond selling machines. As underground operations become deeper and more complex, reliability, connectivity, energy efficiency and automation are increasingly becoming part of the value equation.

NEWS BRIEFS

NORTHAM TARGETS SOUTH AFRICA'S FIRST FULLY RENEWABLE PGM MINE

Northam Platinum is targeting its Eland mine in South Africa as the country's first PGM operation powered entirely by renewable energy. The company is also pursuing a water-positive operation. The initiative forms part of Northam's broader strategy to reduce emissions and improve the environmental performance of its mining operations.

CALEDONIA ADDS 7.8 MOZ RESOURCE AT ZIMBABWE GOLD PROJECT

Caledonia Mining has announced a maiden measured and indicated mineral resource of 7.8 million ounces at its Motapa property in Zimbabwe. The company says the resource strengthens the long-term growth potential of its Zimbabwe portfolio and provides additional opportunities to expand its gold production base.

JUPITER'S TSHIPI MANGANESE MINE POSTS STRONG YEAR

South Africa's Tshipi manganese mine delivered another strong financial year, producing and selling about 3.5 million tonnes of manganese ore. Owner Jupiter Mines said the operation continued to demonstrate strong production and financial performance, reinforcing manganese's importance to South Africa's minerals-export economy.

WESTGOLD PROFIT SOARS TO $480M ON RECORD GOLD PERFORMANCE

Australian gold producer Westgold Resources reported underlying net profit after tax of A$480 million, a 452% year-on-year increase. The result was supported by record gold production and stronger prices. The performance highlights the exceptional earnings environment currently enjoyed by efficient gold producers as bullion prices remain elevated.

SOUTH AFRICAN MINERS ACCELERATE RENEWABLE POWER SHIFT

South African mining companies are increasing investment in renewable-energy projects as they seek to reduce dependence on Eskom and improve power security. Solar and other renewable projects are increasingly being developed alongside mines, allowing companies to control energy costs while also reducing emissions from electricity consumption.

SAMARCO TARGETS RETURN TO TOP PELLET-EXPORT POSITION

Brazilian iron-ore producer Samarco expects to regain its position as the world's second-largest iron-ore pellet exporter from 2028. The Vale-BHP joint venture is rebuilding production following its long recovery period, with the expansion expected to strengthen Brazil's position in the global pellet market.

ANGLOGOLD RESTARTS BRAZILIAN GOLD PROCESSING PLANT

AngloGold Ashanti has restarted a Brazilian processing plant that was shut down in 2022, allowing the company to once again process all of its Brazilian gold concentrate domestically. The move is expected to improve control over the processing chain and reduce the need to send material outside the country.

OBITUARY

DR JOHN VINCENT BRAMLEY, MINERAL PROCESSING LEADER, DIES AT 91

4 July 1935 - 22 June 2026

Dr John Vincent Bramley, former President of the Institution of Mining and Metallurgy, has died aged 91 following a short illness. Bramley spent his professional career with Laporte Industries and its minerals businesses and later became General Manager of Glebe Mines in the Peak District. A mineral-processing specialist, he was instrumental in securing approvals for a new flotation tailings facility and an underground mining operation at Milldam. He served as President of the Institution of Mining and Metallurgy in 1993-94 and was remembered by colleagues as an inspirational and caring industry leader.

SINOMINE SECURES ADDITIONAL ZIMBABWE LITHIUM EXPORT QUOTA

China's Sinomine Resource Group has secured an additional 300,000 tonnes of lithium concentrate export quota from Zimbabwe. The country has become one of Africa's leading lithium producers, while Chinese companies have established a significant presence across its battery-mineral supply chain.

Aramco and Ma'aden Expand Saudi Arabia's Mineral Ambition

Saudi Arabia is bringing two of its largest resource players together as it seeks to turn its geological potential into a broader mining industry.

Saudi Aramco and Ma'aden plan to establish a joint venture focused on mineral exploration and hard-rock mining in Saudi Arabia, strengthening the Kingdom's push to develop resources beyond oil.

The partnership builds on a non-binding agreement announced in January 2025 to explore energy-transition minerals, including lithium. Aramco brings extensive geological and subsurface data, drilling capabilities and existing infrastructure, while Ma'aden contributes decades of mining and exploration experience. Aramco has identified lithium concentrations of up to 400 parts per million in areas of its operations.

The significance extends beyond lithium. By combining petroleum-sector geological capabilities with established mining expertise, Saudi Arabia is positioning exploration itself as a strategic tool in its wider mineral-development ambitions.

GHANA MOVES TO STOP EXPORTS OF UNREFINED ARTISANAL GOLD

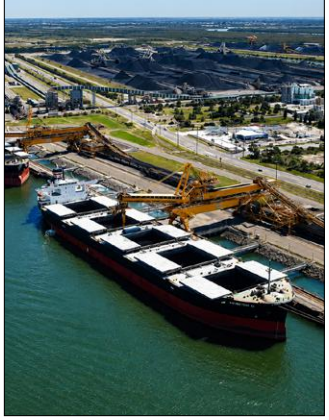
Ghana's GoldBod has ordered that artisanal gold dore purchased by self-financing aggregators must be refined locally from 1 September before export. The measure is designed to increase domestic value addition and strengthen Ghana's control over gold trading and refining revenues.

LUNDIN CUTS COPPER FORECAST AFTER CHILE STORMS

Lundin Mining has lowered its 2026 copper production guidance after a second severe winter storm affected its operations in Chile's Atacama region. The disruption highlights the growing operational risks faced by mines exposed to extreme weather and the difficulty of maintaining production schedules in challenging conditions.

SQM PROFITS BEAT EXPECTATIONS AS LITHIUM SALES RISE

Australia's Whitehaven Coal reported a 29% decline in annual profit, reflecting weaker realised coal prices. Shares fell following the result. The performance illustrates the pressure facing thermal-coal producers despite continued demand for the fuel across Asian power markets.



WHITEHAVEN PROFIT FALLS 29% AS COAL PRICES WEIGH

Australia's Whitehaven Coal reported a 29% decline in annual profit, reflecting weaker realised coal prices. Shares fell following the result. The performance illustrates the pressure facing thermal-coal producers despite continued demand for the fuel across Asian power markets.

RUSAL RETURNS TO PROFIT AS ALUMINIUM PRICES RISE

Russian aluminium producer Rusal swung back to an adjusted profit in the first half of 2026 as higher aluminium prices supported earnings. The result demonstrates how commodity-price movements can rapidly alter the financial performance of large metals producers, particularly when production costs remain relatively stable.

WANGUO GOLD PLANS $701M BOND FOR OVERSEAS EXPANSION

Hong Kong-listed Wanguo Gold Group plans to raise approximately US$701 million through convertible bonds to fund overseas gold-mining acquisitions. The financing comes as gold prices remain strong and producers increasingly seek international assets to expand their resource bases.

MALI GOLD OUTPUT JUMPS 30% IN FIRST HALF

Mali's industrial gold production rose approximately 30% in the first half of 2026, exceeding government forecasts. The rebound follows a difficult 2025 for the country's mining industry, which faced increased tensions between the government and international mining companies over control and taxation of gold resources.

INDONESIA PREPARES NEW EXCHANGE FOR MINERAL COMMODITIES

Indonesia is preparing a new exchange for strategic commodities that is expected to cover nickel, coal and other major resources. The initiative is designed to increase transparency in domestic commodity trading and strengthen government oversight of strategically important mineral markets.

CODELCO NEARS AGREEMENT ON CHILEAN COPPER PROJECT

Chile's state-owned Codelco is close to an agreement with local miner Pucobre covering the Tovaku copper project in northern Chile. The potential partnership is part of Codelco's push to expand partnerships and review its asset portfolio as the world's largest copper producer seeks to maintain output.

U.S. PROPOSES DEEP-SEA MINING LEASE AUCTION

The US Interior Department has proposed an auction for deep-sea mining leases in waters surrounding the Northern Mariana Islands. The move represents another step in Washington's push to develop domestic and offshore sources of critical minerals and reduce dependence on overseas supply chains.

FORTESCUE SEES FUTURE DATA-CENTRE DEMAND FOR PILBARA POWER

Fortescue expects its growing renewable-energy infrastructure in Western Australia's Pilbara could eventually supply surplus electricity to data centres as demand for power from the digital economy expands. The company is developing a large green-energy network around its mining operations, potentially creating a new commercial use for excess renewable generation.

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America's Next Mineral Resource May Already Be in Its Waste

As Washington pushes to secure domestic supplies of critical minerals, a different kind of resource is gaining attention: the metals already embedded in discarded electronics. Modern Mining is positioning e-waste processing as a potential new source of gold and other strategic materials.

For decades, the mining industry has been defined by a familiar sequence: find an orebody, permit a mine, build infrastructure and extract material from the ground. E-waste offers a very different proposition. The resource is already above ground, concentrated inside products that have reached the end of their useful lives.That distinction is becoming more important as the United States seeks greater control over critical-mineral supply chains.

On July 30, President Donald Trump delegated Defense Production Act authority covering recoverable critical minerals and materials, arguing that materials contained in finished goods and industrial waste can be reclaimed rather than lost from the domestic supply chain. The Commerce Department subsequently announced restrictions requiring qualifying sales of black mass and tungsten waste and scrap to be allocated to US buyers from August 27.The policy shift creates a stronger strategic case for technologies capable of turning waste streams into usable metal feedstock.

A Resource Hiding in Plain Sight

The scale of the underlying resource is substantial. The UN's Global E-waste Monitor recorded 62 million tonnes of electronic waste in 2022, containing an estimated 31 million tonnes of metals worth about $91 billion. Yet only 22.3% of e-waste was documented as formally collected and recycled. Global generation is projected to reach 82 million tonnes by 2030.For miners, the significance is not simply environmental. E-waste contains gold, silver, palladium and copper, alongside other strategically important materials. Its composition can make discarded circuit boards an unusually concentrated source of certain metals compared with conventional ore.

Modern Mining is building its business around that proposition. Its technology uses a two-stage process: regional pre-concentration followed by aqueous purification. The company says its Greenville, North Carolina operation is designed to collect electronic waste locally, produce a concentrated feedstock and send that material for further purification.

Building an Urban Mining Network

Modern Mining's model is designed around distributed pre-concentrator plants rather than a single conventional mine. Its current technology plan envisages plants located close to sources of e-waste, reducing the need to transport large volumes of low-value material before concentration.The company says each planned pre-concentrator could ultimately process up to 2,100 tonnes of concentrate annually, while its broader growth strategy calls for additional plants as processing capacity expands.

These figures are company targets rather than independently verified production forecasts.That distinction matters. E-waste recovery is not a substitute for conventional mining across the commodity spectrum, and its economics depend on collection networks, feedstock quality, processing performance and access to downstream markets.But the strategic logic is becoming harder to ignore.

Mining Beyond the Orebody

The US policy shift suggests that mineral security is increasingly being considered across the entire material lifecycle—not only at the point where minerals are extracted from the earth. That creates an emerging space between mining, recycling and advanced materials processing. Companies able to recover metals from products already manufactured and consumed could become part of the domestic supply chain alongside traditional miners, refiners and processors.

For Modern Mining, the challenge now is moving from demonstrated technology and pilot-scale activity to repeatable commercial production. For the wider mining industry, the bigger question is whether the definition of a mineral resource is beginning to change.The next important deposit may not always be beneath the surface. Increasingly, some of it may be sitting in the waste stream.

Korea Uses Finance to Lock In Copper Supply

South Korea is turning state-backed finance into a tool for securing copper, linking a $1 billion loan to Glencore with guaranteed supplies for Korean companies.

The Export-Import Bank of Korea will provide $1 billion in working-capital financing to Glencore International AG, with the commodities giant agreeing to supply copper to Korean companies during the loan period. Specific volumes have not been disclosed.

The arrangement highlights the growing strategic importance of copper to an economy heavily dependent on imports.

The metal is essential to power grids, data centres, telecommunications, renewable-energy infrastructure and other advanced industries.

For Korea, the deal is more than a procurement arrangement. It shows how policy financing is becoming part of the competition for secure mineral supply, giving resource-importing nations another mechanism to manage exposure to tightening markets and supply disruptions.

US RARE-EARTH PROCESSING

Maglut Unveils Chromatography Technology

The United States has no shortage of rare-earth ambitions. Its bigger challenge is processing them. California-based Maglut Heavy Industries is betting that chromatography could provide a different route to building domestic separation capacity.

Rare earths have become strategically important to the US economy, feeding semiconductors, energy infrastructure, defence systems and advanced technologies. Yet mining the material is only the beginning. Separating individual elements into high-purity products is one of the most technically demanding stages of the supply chain—and one in which China retains a dominant position.

Maglut has emerged from stealth with ARC-1, a chromatography-based separation platform designed to process and refine rare earths domestically. The company says its water-based technology draws on separation methods developed in biotechnology and avoids the toxic solvents associated with conventional solvent extraction. Its own pilot-scale testing has reportedly produced individual rare-earth oxides at 99.9% purity or higher.

Challenging the Conventional Process

Solvent extraction has long been the established industrial route for separating rare earths, but it can require extensive chemical handling, energy and complex processing infrastructure. Maglut's approach seeks to replace that model with chromatography, using proprietary resin technology to selectively separate elements from mixed feedstock.

The attraction is clear. A successful alternative could potentially make smaller and more flexible processing operations viable in the US, while reducing some of the environmental and chemical burdens associated with conventional separation. But laboratory or pilot-scale performance is not the same as commercial production. The critical test will be whether ARC-1 can maintain purity, recovery and cost performance as volumes increase.

Processing Is the Real Battleground

Maglut's emergence comes as the US and its allies intensify efforts to build rare-earth supply chains outside China. Australia's Lynas is expanding its non-China supply network, while major projects in the US and Australia are targeting new refining and magnet-making capacity.

That makes processing technology strategically important. New mines can provide additional feedstock, but without competitive separation and refining capacity, the supply chain remains exposed.Maglut is still a young company, founded in 2025, and its ARC-1 platform remains at the stage where scale-up will determine its commercial significance.

Yet its proposition reflects a broader change in the rare-earth industry: the race is no longer simply to find more ore. It is increasingly a race to build better ways of turning that ore into the high-purity materials modern industry actually needs.

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The copper segment of ElvalHalcor S.A. is composed of six subsidiaries and seven associates/joint ventures, based in Greece, Belgium, Bulgaria, Romania and Turkey, while it operates a total of five production plants in Greece, Bulgaria and Turkey.

The copper segment of ElvalHalcor S.A. develops and distributes a wide range of products, including copper and copper-alloy rolled and extruded products with Halcor being the sole producer of copper tubes in Greece. High quality in production is achieved through strict controls applied throughout the production process. With a consistent quality focus, the company implements an ISO 9001:2015 Certified Quality Management System and leverages high technologies and expert staff.

As a result of the Group's strategic investments in research & development, Halcor is recognized as one of the leading copper producers globally, setting new standards in copper processing. The company maintains a consistent focus on quality and environmental protection and a strong commitment to the principles of sustainable development. In this context, all production facilities in the Group's plants leverage advanced technologies to bring in the market innovative products that are energy efficient and environmentally friendly.

For more information, please visit our website www.halcor.com

MINING EQUIPMENT

Perenti to Sell BTP Business for A$100 Million

Australian mining services group Perenti is selling its equipment rental and parts business BTP Group for A$100 million, sharpening its focus on higher-return opportunities across its mining services portfolio.

WORDS BY *SALINI KRISHNAN* // **DATA BY SKILLINGS RESEARCH**

Perenti has agreed to sell BTP to Beetle Industries, an investment vehicle backed by a private consortium led by Cratus Group. The transaction comprises A$80 million in cash at completion and a further A$20 million after 12 months, with completion expected by the end of October 2026, subject to funding arrangements, approvals and other conditions.

BTP has been an important part of Perenti's Mining & Technology Services division, providing equipment rental, sales and refurbishment. The business operates a substantial fleet of mining machinery and parts across Australia.

The divestment reflects a broader portfolio strategy. Perenti said BTP's performance has faced market headwinds, while its management sees greater opportunities in businesses where capital can generate higher returns. The company expects to recognise a non-cash loss of about A$64 million from the sale.

For Perenti, however, the significance of the deal extends beyond the disposal itself. Proceeds will provide additional capital flexibility to support recent contract wins at Bellevue Gold in Australia and Fourmile in the US, while strengthening its capacity to pursue further tenders and inorganic opportunities.

The transaction also highlights a continuing shift in mining services: companies are increasingly assessing equipment businesses not simply by revenue contribution, but by fleet utilisation, capital intensity and returns. For Perenti, selling BTP represents a deliberate move to concentrate capital where management sees stronger long-term growth and returns.

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The $90 Iron Ore *Test*

"At US$90/t, cost leadership protects the floor. Product quality protects the ceiling."

A US$90/t iron ore price is no longer an extreme downside scenario. As Simandou adds new high-grade supply and steel demand remains under pressure, the next phase of the market will increasingly favour producers with low costs, quality ore and strong infrastructure.

WORDS BY *MOSHINE* // **DATA BY SKILLINGS RESEARCH**

Iron ore does not need to collapse to create winners and losers. At US$90/t for 62% Fe fines, CFR China, the world's largest low-cost producers would remain profitable. But the same price would place considerable pressure on marginal mines, smaller producers and capital-intensive projects whose economics depend on a stronger market.

That is what makes the US$90/t level important. It is less a prediction than a stress test for the industry's cost curve. The biggest new variable is Simandou in Guinea. After years of development, the project has entered production, with the first SimFer shipment leaving Guinea in December 2025. SimFer is designed to ramp towards 60 Mtpa, while the wider Simandou infrastructure is intended to support up to 120 Mtpa.

Simandou matters not only because of its volume, but because of its high-grade ore. Additional high-grade supply gives steelmakers another option and could increase pressure on lower-grade or impurity-heavy products.

The majors have room to breathe

At US$90/t, BHP, Fortescue, Rio Tinto and Vale remain in a fundamentally stronger position than much of the industry.

BHP's Western Australia Iron Ore operation reported a C1 cost of around US$17.66/t in the first half of FY2026, while Fortescue's hematite operations remain around the bottom of the global cost curve. Rio Tinto combines a large, established Pilbara system with exposure to Simandou, while Vale's higher-grade Brazilian ore provides additional product-quality leverage. Their advantage is not simply low mine-site cost. Established rail, port and processing infrastructure provides resilience when prices weaken. As the supplied analysis notes, the next shakeout will be determined less by the size of a resource than by delivered cost, product quality and infrastructure leverage.

Where the pressure will land

The weakest part of the market is likely to be the high-cost tail. Smaller Chinese domestic mines, remote seaborne producers and junior projects with large infrastructure requirements have much less room to absorb lower prices. A US$90/t CFR benchmark also does not translate into a US$90/t mine-gate margin: freight, royalties, sustaining capital, financing and quality discounts still have to be covered.

For development projects, the impact can arrive before production. Lower long-term price assumptions can reduce project valuations, weaken financing cases and trigger impairments.

This could also create opportunities for consolidation. Low-cost producers with strong balance sheets may be able to acquire infrastructure or resources from companies under financial pressure. But the most attractive targets will be assets that can be integrated into existing rail, port or processing systems.

Quality becomes the second battlefield

Cost alone will not determine the winners. As more high-grade material enters the market, steelmakers are likely to pay increasing attention to Fe content, impurities, consistency, pelletability and suitability for lower-carbon steelmaking.

That puts some Pilbara products under greater pressure, while strengthening the strategic value of high-

Simandu : The New Variable

Simandou is entering the iron ore market at a particularly important moment.

The first SimFer shipment in December 2025 marked the transition from a long-running development project to a producing operation. SimFer is designed to reach 60 Mtpa, while shared infrastructure across the wider Simandou system is intended to support up to 120 Mtpa. Its significance extends beyond volume. Simandou's high-grade ore gives steelmakers another source of premium feed and could influence how mills value competing products.

The project will not eliminate Australia's Pilbara advantage, built over decades of infrastructure, scale and customer relationships. But it introduces a new source of competition—and gives buyers greater flexibility when choosing between grades and suppliers.

The important question is not whether Simandou replaces existing producers, but how its tonnes change the economics of the tonnes around them.

THE COST-CURVE SNAPSHOT

Producer / segment	Indicative position	US$90/t outlook
BHP WAIO	~US$18/t C1	Strong margin protection
Fortescue	~US$18/t C1	Strong cash generation
Rio Tinto Pilbara	Low-cost	Strong, with quality exposure
Vale	Low-cost	Cost + grade advantage
Simandou	Low-cost, high-grade	New supply benchmark
High-cost producers	US$70+/t before full costs	Increasing pressure
Marginal projects	High all-in costs	Deferral/M&A/impairment risk

er-quality ores from Brazil and Guinea.

For producers, the objective is therefore becoming two-dimensional: produce cheaply and make each tonne more valuable to the customer.

Figures are indicative and not directly comparable because producers use different cost definitions and reporting bases.

The real test is free cash flow

A US$90/t market will not destroy the major producers. It will expose the gap between them and everyone else.

The strongest companies can continue funding sustaining capital, protecting infrastructure and selectively pursuing acquisitions. Higher-cost producers have fewer options: cut production, defer investment, seek partners or exit.

Simandou adds another dimension by increasing the availability of high-grade ore. Its effect will therefore be measured not only in additional tonnes, but in how it changes pricing, blending and customer preferences across the market. The iron ore industry is entering a period of sharper differentiation.

The question for investors is no longer simply who has the biggest resource. It is more fundamental:

Who can deliver the next tonne at a cost that still works when iron ore is US$90/t?

That is where the next cycle's winners–and casualties–will emerge.

CRITICAL MINERALS CAPITAL:

Who Pays for Strategic Supply?

A government can declare a mineral strategically essential without making the project commercially bankable. Lenders need predictable costs, proven technology, secure feedstock, qualified customers and dependable revenue. First-of-kind critical-minerals projects often face commissioning risk, uncertain recovery rates, unsecured feedstock and price pressure from established suppliers.

This gap between strategic value and commercial bankability makes financing as challenging as the metallurgy.

Six Tools, Six Different Risks

Grants provide upfront capital without repayment and are suited to research and demonstration projects. DOE's May 2026 announcement covered $45.7 million across 19 projects, but these were selections for negotiation, not disbursed grants. Government equity strengthens the balance sheet while giving taxpayers a stake in the upside, but also exposes them to company risk.

Direct loans provide government financing that still requires repayment and due diligence. The $150 million loan to MP Materials specifically funds its samarium separation project. Loan guarantees protect commercial lenders against a defined portion of losses, helping unlock private capital.

Offtake agreements secure future customers and reduce sales-volume risk, but their value depends on price, duration and performance terms. Price floors protect revenue when commodity prices fall, with the government typically covering the difference.

Project finance generally comes last, once permits, technology and contracted revenue are established. No single tool covers every risk. Construction, permitting, feedstock and customer qualification remain critical, so projects often combine several instruments.

MP Materials: The Combined Model

MP Materials' federal partnership combines government equity, a $150 million direct loan, a reported $110/kg NdPr price floor through 2035, a government magnet offtake and roughly $1 billion in private debt.

The government's ownership is sometimes reported as 15%, but the SEC agreement sets a 19.9% conversion ceiling, not a fixed current stake. The bigger question is whether this structure is a temporary bridge to a competitive industry or a lasting subsidy.

Who Should Carry the Security Premium?

Government pays when supply has genuine national-security value; manufacturers pay through long contracts or a premium for diversified sourcing; investors pay when returns justify the risk; consumers pay through downstream prices; sponsors pay through equity and completion guarantees.

Public capital should de-risk, not replace, commercial discipline – a project still needs real feedstock, proven process, and a genuine route to standing on its own.

INSTRUMENT	PRINCIPAL RISK ADDRESSED
Grant	Development, technology or capital risk
Equity	Company and execution risk
Direct loan	Financing availability and tenor
Loan guarantee	Lender credit risk
Offtake	Sales-volume risk
Price floor	Commodity-price risk

CRITICAL MINERALS

Black Mass Emerges as a New Source of Critical Minerals

As electric vehicles and energy-storage systems grow, spent batteries are creating a new source of lithium, nickel and cobalt. The material at the centre of this emerging supply chain is black mass.

WORDS BY *CHARLES PITTS* // **DATA BY SKILLINGS RESEARCH**

Mining has traditionally meant extracting minerals from the ground. Battery recycling is beginning to add another dimension: recovering metals from materials that have already been mined, processed and used.

Black mass—the concentrated powder produced when lithium-ion batteries are dismantled and mechanically shredded—contains valuable battery materials including lithium, nickel, cobalt and manganese. Rather than being treated simply as waste, it is increasingly being processed as a secondary mineral feedstock.

Turning Waste into Supply

Recovering these metals requires further processing. Hydrometallurgical methods use chemical solutions to separate and purify individual metals, while pyrometallurgical processes use high temperatures. The objective is the same: return valuable materials from spent batteries to the manufacturing cycle.

The opportunity is becoming strategically important as governments seek greater control over critical-mineral supply chains. The US Government Accountability Office has identified battery recycling as a potential way to reduce dependence on imported critical minerals, while policy measures are increasingly encouraging domestic recovery.

India is also supporting critical-mineral recycling from sources including lithium-ion batteries, electronic waste and industrial scrap. Recycling will not replace conventional mining. Primary production remains essential as battery demand continues to grow, while the availability of recyclable batteries depends on collection and end-of-life volumes.

But the economics of mineral supply are changing. Every tonne of lithium, nickel or cobalt recovered from a spent battery represents material that can re-enter the supply chain without another mine being developed.

For the mining industry, black mass therefore represents more than a waste product. It is emerging as a new kind of mineral resource—one already sitting above ground.

ADVANCED ELECTRONICS

Minnesota Iron Ore Finds a New Role in Advanced Electronics

Researchers at the University of Minnesota have demonstrated that a widely available grade of Minnesota iron ore can be converted into semiconductor-quality iron sulfide, opening a potential new high-value application for the state's Iron Range resources.

The study found that Direct Reduced Grade Taconite, one of the commonly used iron-ore grades in Minnesota, can be converted into high-quality pyrite, or iron sulfide, without additional purification steps.

Pyrite has attracted interest as a semiconductor because it is made from abundant, relatively inexpensive and non-toxic elements. The researchers tested three types of Minnesota iron ore and found that the Direct Reduced Grade Taconite performed particularly well. The finding challenges the assumption that highly pure starting materials are necessary to produce semiconductor-grade pyrite. The potential applications extend beyond conventional electronics. The University of Minnesota team is investigating uses in solar panels, batteries, electronics and water purification, while future work will focus on producing thin films more suitable for commercial devices. For Minnesota's mining industry, the discovery could point towards a broader opportunity: using established mineral resources to produce higher-value materials rather than limiting their role to traditional ironmaking.

What Collapsing Treatment Charges Mean for Copper

Smelting copper requires furnaces, energy, labour, environmental controls and enormous capital. None of that got cheaper in 2026. Yet the benchmark copper treatment charge the fee a smelter is paid to convert concentrate into metal settled at $0 per tonne for the year, alongside a refining charge of 0 cents per pound. That is the lowest annual benchmark ever agreed, and spot charges had already been running negative since 2024. Zero does not mean smelting became free. It means the fee smelters have historically been paid for that work has, for now, disappeared and what that reveals is a struggle over concentrate, not a verdict on copper's value.

How a Concentrate Settlement Works

A sulphide mine produces concentrate, not metal typically 20-30% copper, mixed with sulphur, iron and often gold or silver. A smelter converts that concentrate into an intermediate product; a refinery turns that into cathode. The miner gets paid for an agreed share of the contained payable metal, minus the treatment charge (TC, quoted in dollars per dry metric tonne, or "dmt," of concentrate) and refining charge (RC, in cents per pound of payable copper) plus adjustments for moisture, assay results, impurity penalties on elements like arsenic, freight, insurance and the contract's quotational period.

TC and RC are quoted separately but negotiated and discussed together, because both are deducted from the same settlement. An annual benchmark, negotiated once a year between a major miner and major smelters, sets the reference point; spot charges, agreed cargo by cargo outside long-term contracts, can and do move independently of it which is exactly what happened through 2026, with the $0 benchmark and separately negative spot terms telling two versions of the same story.

Why the Charges Collapsed – And Who Feels It

The collapse is a supply-chain mismatch, not a demand problem. On one side, concentrate has underdelivered: mine disruptions, delayed ramp-ups and grade variability the deliverability problem this issue's companion piece examines directly have constrained the tonnage reaching smelters. On the other, smelting capacity has expanded faster than concentrate supply, overwhelmingly in China: since 2005, China has accounted for more than 90% of global growth in copper-smelting capacity, lifting its share from roughly 15% to about 50% by 2025. T hat capacity needs feed to run, and when smelting capacity outpaces available concentrate, smelters compete for it by accepting weaker terms which is what pushed the benchmark to zero. Utilisation tells the same story from a different angle: smelter utilisation outside China fell below 70% by 2025 while staying around 85% inside China though utilisation and profitability are not the same measure, and a smelter running below 70% is not automatically losing money.

The consequences are not simply miners winning and smelters losing. Concentrate producers do generally benefit from a lower TC/RC, but impurity penalties, freight costs and the gap between benchmark and actual contract terms can erode that gain and a mining company that also owns smelting capacity can gain in one division while losing in the other. Custom smelters those most dependent on third-party concentrate rather than their own mine feed are the most exposed, because TC/RC revenue sits close to the centre of their business model. Diversified operators have more room to absorb the hit.

Aurubis, Europe's largest copper smelter, has reported considerably lower treatment and refining charges weighing on its results through fiscal 2025/26 first-quarter operating profit fell to €105 million from €130 million a year earlier, partly on that basis while raising its full-year guidance twice since, to €425-525 million, on the strength of metal prices, sulphuric acid revenue and copper-product sales. As CEO Toralf Haag put it in the company's own results release, Aurubis has delivered "reliability" despite the pressure – a company statement, not an independent assessment, but one borne out by the

numbers around it: TC/RC weakness has been a genuine drag, and other revenue lines have more than offset it so far.

What to Watch Next

Persistent pressure has already produced curtailment signals, if not yet a clean wave of closures. On the announcement side, China's own top smelters (through the industry-coordinating China Smelters Purchase Team) agreed in late 2025 to cut output by more than 10% in 2026 in response to the negative economics, and Beijing has halted roughly 2 million tonnes of previously planned new domestic capacity.

But the announcement and the evidence have not yet lined up: as of their spring 2026 annual guidance, major CSPT members Jiangxi Copper and Yunnan Copper had actually raised their 2026 production targets rather than cut them, with only Daye Nonferrous guiding modestly lower a reminder that a coordinated pledge is not the same as a coordinated cut, and that this indicator specifically needs watching rather than taking on faith.

A cleaner example of an actual, dated curtailment: Freeport Indonesia's PT Smelting facility in Gresik its first and longest-running copper smelter, a joint venture 66% owned by Freeport Indonesia and 34% by Japan's Mitsubishi Materials, with roughly 342,000 tonnes of annual cathode capacity halted operations on 8 August 2026 for furnace repairs, with completion targeted within the third quarter; Freeport has responded by pulling forward the restart of its newer Manyar smelter, also in Gresik, to late August.

If higher-cost smelters outside China come under sustained strain while Chinese and vertically integrated operators keep running, the result could be more concentration in refining, not less the same pattern already visible in nickel. No named smelter has announced a permanent closure on TC/RC grounds to date, so treat that specific outcome as a risk to monitor, not a forecast.

The indicators worth watching are spot and benchmark TC/RCs, concentrate production and major mine restarts, smelter utilisation, actual (not just announced) output data from named smelters, and sulphuric acid and by-product markets. Copper prices measure the value of the metal. Treatment charges measure the fight over the material needed to make it and that fight, for now, still favours whoever controls the concentrate.

GLOBAL EXPANSION

Coal India to Open First Overseas Office in Singapore

India's largest coal producer is establishing its first international trading office as it looks beyond coal for iron ore and critical minerals. The Singapore hub could give Coal India a new platform to source overseas assets, build mineral-trading relationships and strengthen India's position in increasingly competitive global supply chains.

Coal India is setting up its first overseas trading office in Singapore, marking a significant step in the state-owned company's push into international mineral markets. The company has applied to Singapore authorities to register the office, according to sources familiar with the plans. The proposed operation will focus on trading iron ore and critical and strategic minerals, while also supporting Coal India's efforts to acquire mineral assets overseas. The company is evaluating opportunities in regions including Africa, Chile and Canada.

The choice of Singapore is commercially significant. The city-state is one of Asia's major commodity-trading centres, providing access to international traders, financial institutions, shipping networks and mineral buyers. For Coal India, the office can therefore function as more than a representative presence: it can become a platform from which the company evaluates assets and trading opportunities across multiple jurisdictions.

Why India Needs Overseas Minerals

The move comes against a difficult backdrop for India's critical-mineral strategy.Lithium, rare earths, copper and other minerals are increasingly important to electric vehicles, renewable-energy systems, electronics, defence equipment and advanced manufacturing. Yet India remains dependent on international supply chains for many of these materials.

The government has consequently encouraged Indian companies to secure mineral resources abroad. Coal India's own diversification strategy already includes overseas critical-mineral opportunities.

The Ministry of Coal's 2025-26 annual report says the company received board approval to diversify into overseas critical-mineral assets and had signed non-disclosure agreements related to a lithium project in Mali and other mineral tenements. Coal India has also entered an MoU with KABIL for joint acquisition and development of global critical-mineral projects.The Singapore office gives that strategy a commercial base outside India.

From Coal to a Wider Mineral Basket

Coal remains the foundation of Coal India's business, but the company is increasingly looking at commodities with very different strategic characteristics. Its overseas search includes lithium, bauxite and rare earths, alongside iron ore. The company is also examining opportunities in Africa, Chile, Canada and Australia. Reuters has reported that Coal India is considering the acquisition of a Chile-focused unit of Canada's Wealth Minerals, which holds lithium interests, although any transaction remains subject to regulatory and other conditions.

That diversification matters because critical-mineral markets are increasingly shaped by access to resources rather than simply by spot-market purchases.Owning or participating in overseas projects can potentially give Indian companies greater visibility over future supply, while trading relationships can provide another route to securing material when domestic resources are insufficient.For Coal India, the challenge will be developing expertise across commodities that differ significantly from coal in geology, processing, pricing and market structure.

A More Competitive Global Market

Coal India's move also reflects a broader change in the global mineral market. Governments and state-backed companies are becoming more active in securing overseas mineral assets. China has established a powerful position across several stages of critical-mineral supply chains, while the United States, European countries, Japan, South Korea and others are increasingly seeking alternative sources and strategic partnerships.

India's overseas push is therefore not occurring in an empty market.Competition for attractive lithium, copper, rare-earth and other mineral assets is becoming more international. Companies are not only competing for ore; they are competing for exploration opportunities, processing capacity, long-term supply agreements, infrastructure and access to producing assets.

A Singapore-based trading operation could give Coal India closer access to that competitive marketplace.It could also improve the company's ability to identify opportunities earlier, assess international suppliers and work with financial and commercial partners. But the office itself does not guarantee mineral supply. The larger test will be whether Coal India can convert its international search into commercially viable assets and long-term supply relationships.

What It Means for Indian Industry

For India, the potential significance extends beyond Coal India. A successful overseas minerals strategy could strengthen the supply options available to Indian manufacturers, battery producers, metal processors and other industries exposed to imported mineral feedstock. It could also support the government's wider effort to reduce excessive dependence on concentrated international supply chains.

But overseas assets bring their own risks. Mining projects can face permitting delays, geological uncertainty, infrastructure constraints, political changes and difficult economics. Critical minerals can also experience sharp price cycles, making asset selection and capital discipline particularly important. Coal India therefore enters a market very different from the one it has dominated for decades.

Singapore as a Strategic Launchpad

The first overseas office is modest in physical scale, but its strategic purpose is much larger. Singapore can provide Coal India with a foothold close to some of the world's most important commodity markets while connecting the company to international trading, finance and logistics networks. That could support both mineral procurement and the search for overseas assets.

The broader significance is that India's mineral-security strategy is moving from policy ambition towards commercial participation. Coal India's Singapore office will not by itself change global mineral markets. But if it becomes the operating base for a successful portfolio of overseas investments and trading relationships, it could mark an important step in India's attempt to move from being primarily a mineral importer to becoming a more active participant in the global competition for resources.

COPPER SUPPLY

Copper's Next Constraint Is Not Demand It Is Deliverability

Copper demand is rising across grids, data centres and electrification, but new mine supply remains vulnerable to delays and technical setbacks. The real question is deliverability: can planned supply actually reach the market on time and at forecast rates?

Demand is rising across electrification and infrastructure, but the mines expected to meet it remain vulnerable to delays, disruptions and slow ramp-ups.

Copper-demand forecasts increasingly point in the same direction. Grids, data centres, electrification and conventional construction all need more of it, and few analysts dispute that trajectory. The mines expected to satisfy that demand are a different story: they remain vulnerable to permitting delays, infrastructure gaps, technical setbacks and slow ramp-ups.

The IEA's Global Critical Minerals Outlook 2026 expects copper to record the largest volume increase of any energy mineral it tracks, adding roughly 7 million tonnes of demand through 2040 under its Stated Policies Scenario. On the supply side, its base case shows existing and announced projects covering about 75% of 2035 primary supply requirements, leaving a roughly 25% gap—down from roughly 30% in last year's edition as more projects entered the pipeline.

Three things about that number matter. It is scenario-based, not a physical certainty: it moves if demand, recycling or substitution assumptions change. It already gives every announced project credit for expected output, so the gap is what remains after that credit. And a project's presence in the model does not guarantee it arrives on schedule—or at all. The IEA's supply pipeline is a forecast built from company disclosures, not a ledger of tonnes already committed to market. That distinction is the entire subject of deliverability: the probability that planned copper supply is actually financed, permitted, constructed, commissioned and operated at the forecast rate within the forecast timeframe.

Near-term data underline the same point from the other direction. The International Copper Study Group's April 2026 forecast puts the global refined copper market at a 96,000-tonne surplus in 2026, widening to 377,000 tonnes in 2027—a sharp reversal from the 150,000-tonne deficit ICSG forecast as recently as October 2025.

The swing is driven less by a supply breakthrough than by weaker demand growth and higher scrap output. On the mine side, ICSG cut its 2026 mine-output growth forecast to 1.6% from 2.3%, explicitly citing slower expansion in the DRC, Chile and Indonesia and constrained production at Grasberg and Kamoa following 2025 disruptions.

A market can sit in forecast surplus and still be one disrupted mine away from tightness. That is exactly the deliverability problem this piece is about.

Grade, Recovery and the Limits of a Mine Plan

Tonnes mined is not copper produced. Head grade, ore hardness, strip ratio, recovery rate and mill throughput all move independently, and a change in any one can shift output without any change in the resource itself. Lower grades generally mean moving and processing more material for the same copper, raising

THE FIVE GATES BETWEEN A PROJECT AND PRODUCTION

Permitting and social approval.	Environmental approval, community consultation, water rights, land access and the risk of litigation or regulatory appeal sit ahead of almost every project on the pipeline list. This is not administrative friction to be waved through with enough political will — it is a material development requirement that has stopped, delayed or resized projects across every major copper jurisdiction.
Finance and investment approval.	An economic resource is not a financed project. Capital-cost escalation, the copper price a bank will underwrite against, board sign-off, government participation and binding offtake agreements all sit between a feasibility study and a final investment decision — and financing gets structurally harder in higher-risk jurisdictions, which is precisely where much of the pipeline's growth is expected to come from. QB2 itself is the cautionary case: Teck's flagship project came in roughly $4 billion over its original budget and years behind schedule before it ever produced its first tonne, a cost blowout now compounded by additional tailings-facility capital that Teck is considering pulling forward from 2027 into 2026.
Infrastructure.	A deposit without grid power, water (or a desalination line to bring it), roads, rail, port capacity and a place to put tailings is stranded regardless of its grade. Several of the largest announced projects globally are still short one or more of these.
Construction and commissioning.	Mechanical completion is not commercial production. A new plant has to stabilise throughput, recovery, grinding performance, ore blending, tailings handling and water balance before it produces saleable, on-spec concentrate — and any one of those can go wrong independently of the others.
Ramp-up to design capacity.	Nameplate capacity is not annual output from year one. Comparable large projects have historically taken years, not months, to reach sustained design performance — a pattern the two case studies below illustrate from opposite directions.

energy, water, equipment and tailings demands. But that is a mine-by-mine dynamic, not a universal decline story.

Teck Resources' Quebrada Blanca (QB) operation in Chile shows the mechanics in real numbers. In its second-quarter 2026 results, Teck reported 55,800 tonnes of copper production, its third consecutive quarter of stable performance, up from 52,700 tonnes a year earlier. Quarterly recovery was 83.3%, a slight improvement on the first quarter, alongside continued work on the site's tailings management facility.

One reporting nuance matters: Teck consolidates 100% of QB's production despite owning only 60% of the operation. Sumitomo Metal Mining and Sumitomo Corporation jointly hold 30%, while Chile's state miner ENAMI holds a non-funding 10%. Headline tonnage and Teck's attributable economic share are therefore not the same figure. QB illustrates deliverability in progress rather than deliverability achieved. Three stable quarters are meaningful evidence after a difficult ramp-up, but not proof that design performance is now permanent.

Two Deliveries, Two Timelines

Quebrada Blanca and Indonesia's Grasberg complex show delivery risk from opposite ends. QB has moved from a difficult ramp-up toward stable production; Grasberg shows how a major disruption can reset market expectations.

On 8 September 2025, roughly 800,000 tonnes of wet material entered the Grasberg Block Cave underground mine, killing seven workers. Freeport-McMoRan treated the event, correctly, as a safety failure first and a supply event second.

Freeport restarted the unaffected Deep Mill Level Zone and Big Gossan mines in October 2025, then began a phased Block Cave restart in late March 2026. By its second-quarter 2026 results, Block Cave daily output had risen from roughly 34,000 tonnes in April to 69,000 tonnes in June. But the recovery timeline has slowed. Freeport's guidance is for the district to reach about 65% of capacity in the second half of 2026, 80% by mid-2027 and full capacity by the end of 2027.

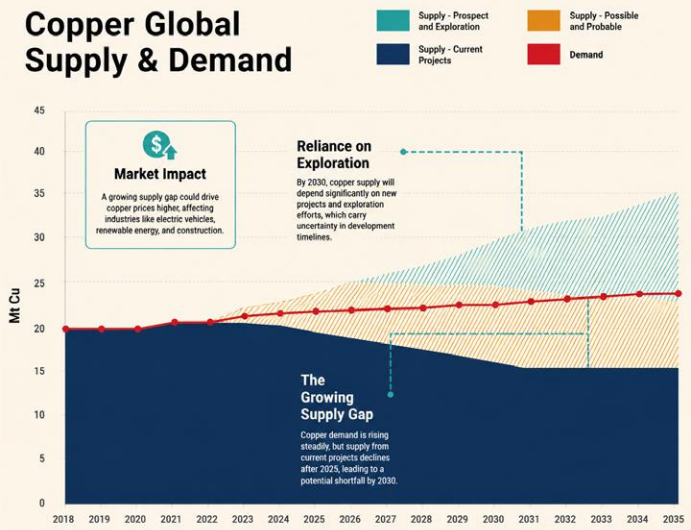
That is materially slower than the 85%-by-second-half-2026 recovery the company had projected as recently as January 2026. Full-year 2026 group copper-sales guidance has consequently been cut to roughly 3.1 billion pounds from an earlier 3.4 billion. The two operations demonstrate different aspects of the same problem: stable quarters can build confidence in delivery, while technical or operational disruption can push expected tonnes years into the future.

Concentrate Scarcity and the Smelter Squeeze

Mine underdelivery does not have to show up first as an obvious refined-copper shortage. It can show up as a smelter-feed problem. Sulphide mines produce concentrate, which smelters convert to metal for a treatment and refining charge. Tight concentrate availability has driven that charge to the floor: the 2026 annual benchmark, agreed between

What the IEA's 25% Copper Gap Actually Measures

The IEA's Global Critical Minerals Outlook 2026 base case projects that copper supply from existing and announced projects will cover roughly 75% of 2035 primary supply requirements under its Stated Policies Scenario leaving a gap of about 25%. That figure has narrowed from the roughly 30% gap the agency modelled in its 2025 edition, as more projects have entered the pipeline. It is worth being precise about what it actually measures.



What "supply" includes.

The 75% already credits existing and announced projects with their expected output it is not comparing today's mine production against 2035 demand.

Not every announced project is assumed to succeed in full, but the model does assign each one a probability-weighted contribution, which means the 25% gap is what remains after the pipeline has already been given credit.

What "primary supply requirement" means.

This is not total demand. It starts from modelled copper consumption and subtracts expected secondary (recycled) supply and processing losses before arriving at what mines specifically need to deliver.

Recycling growth narrows the requirement directly.

What could move the gap.

It could narrow if projects arrive on schedule, if recoveries and expansions outperform guidance, if recycling scales faster than modelled, or if demand growth or substitution reduce copper intensity.

It could widen if projects are delayed, if disruptions like Grasberg's recur, if grades or recoveries disappoint, or if grid and data-centre demand exceeds current projections.

The takeaway.

The 25% figure is a warning about the adequacy and reliability of the project pipeline behind long-term copper forecasts not a prediction that a quarter of the world's copper buyers will go without metal in 2035.

Chilean miner Antofagasta and Chinese smelters, settled at US$0/t–down from US$21.25/t in 2025 and the lowest ever agreed.

Spot charges, negative since 2024, have been reported on some pricing indices at more than US$100/t below zero by mid-2026. China now accounts for roughly half of global copper-smelting capacity, up from about 15% in 2005.

The strain is showing on both sides of that concentration: China's leading smelters have agreed to cut production by more than 10% in 2026, while Beijing has halted roughly 2 million tonnes of previously planned new domestic smelting capacity.

Outside China, the exposure is structural rather than cyclical. The United States now has only two operating copper smelters–Rio Tinto's Garfield plant in Utah and Freeport's Miami plant in Arizona–both more than a century old.

A US$0/t benchmark does not mean smelting is free. It means the treatment charge itself has stopped functioning as a meaningful cost signal, while smelters outside China compete for scarce concentrate.

Watch Execution, Not Announcements

Copper does not become available because a demand model says it is needed, or because a company announces a resource. It becomes available when permits are final, finance is binding, construction is complete, infrastructure exists, first concentrate ships, and recovery and throughput hold at design levels over consecutive quarters. Everything short of that is a forecast, not a delivery.

For miners, smelters and the manufacturers who buy from both, that distinction now matters more than any demand chart. Demand forecasts tell us how much copper the world may need; deliverability determines how much actually arrives.

DIGITAL MINING

Vale and ABB Expand AI Across Brazil's Iron-Ore Operations

Vale is expanding the artificial intelligence, automation and electrification technologies used at its Conceição II plant to other iron-ore processing operations in Brazil, signalling a shift from digital pilot projects towards wider deployment across mining operations.

Vale and ABB plan to replicate the technologies deployed at the Conceição II Model Plant in Itabira, Minas Gerais, across other processing facilities. Conceição II combines advanced automation, thousands of sensors and data analytics to monitor and adjust operations in real time.

The plant has more than 7,000 automated measuring instruments and sensors, over 100 cameras and a system capable of analysing more than 400 production variables. This allows operating parameters to be adjusted as conditions change, moving process control beyond conventional operator intervention.

Results Drive Expansion

According to Vale, the technology has increased productivity at Conceição II by 25%, raised production of higher-quality direct-reduction feed by 40% and reduced iron losses in tailings by 26%. The company also reports less need for manual intervention in hazardous areas.

These results demonstrate why AI is becoming relevant beyond experimentation. Its value is ultimately measured through productivity, recovery, product quality, efficiency and safety.

The challenge now is reproducing those gains across different plants, ore characteristics and operating environments.

More Than Artificial Intelligence

The Vale-ABB partnership combines AI, automation, digitalisation, electrification and IT/OT integration. Connecting enterprise systems with industrial equipment allows information from sensors and machines to influence operational decisions in near real time.

For iron-ore processing, this can improve control over changing feed characteristics, plant performance, equipment condition and product quality.

Continuous monitoring can also support predictive maintenance by identifying abnormal equipment behaviour before failures occur.

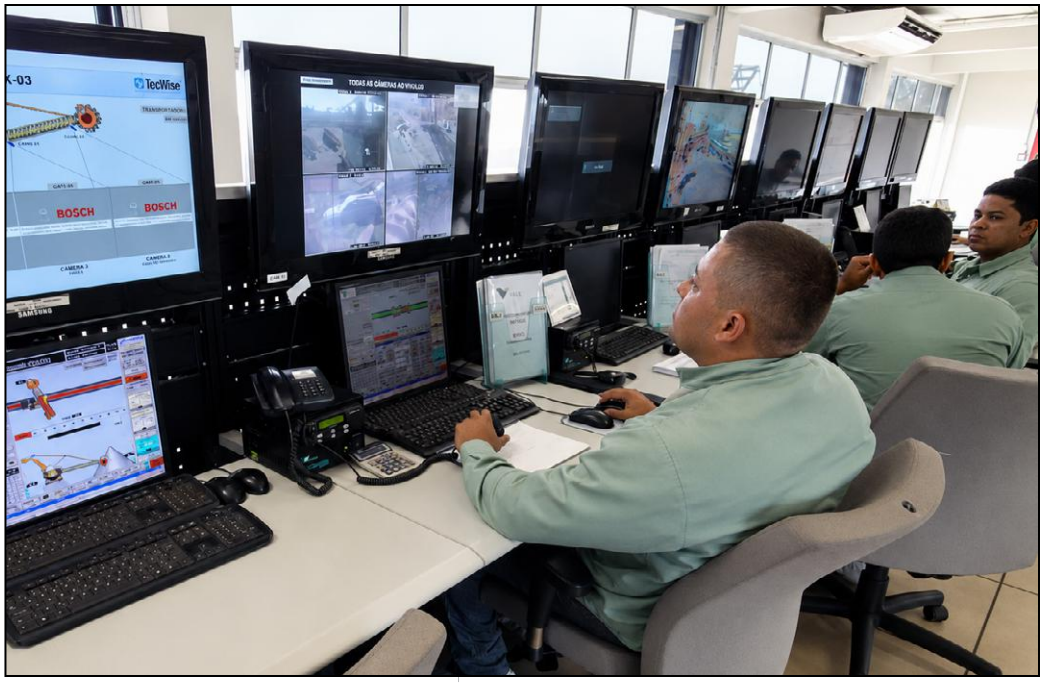
The Scale-Up Test

Technology that works at one plant does not automatically deliver identical results elsewhere. Data quality, equipment configuration, workforce capability and ore characteristics all influence performance. Cybersecurity and employee training will also become increasingly important as more operational decisions become digitally assisted.

Vale and ABB are therefore testing whether Conceição II can become more than a successful demonstration—a repeatable operating model for modern iron-ore processing.

If the gains can be reproduced across Vale's network, the significance will extend beyond Brazil. AI could increasingly become part of the basic infrastructure of mineral processing, helping mines produce more efficiently while reducing waste, energy use and worker exposure to hazardous environments.

The real measure of success will not be how intelligent the system is, but how effectively it improves every tonne produced.



From Perth to Santiago and Johannesburg, mining companies are moving critical decisions away from individual sites and into Integrated Operations Centers. By connecting mines, processing plants, railways and ports in real time, these hubs promise something more valuable than remote control: faster decisions across the entire production chain.

DIGITAL OPERATIONS

Mining's New Nerve Center

How Integrated Operations Centers are reshaping the pit-to-port operating model

WORDS BY *SALINI KRISHNAN* // **DATA BY SKILLINGS RESEARCH**

The physical mine still produces the ore, but some of mining's most important operating decisions are increasingly being made hundreds–or even thousands–of kilometres away.

Integrated Operations Centers (IOCs) are bringing fleet dispatch, processing, maintenance, rail, port and safety information into a common operating environment. The shift is significant: instead of optimising individual assets, miners can increasingly manage the entire value chain as one connected production system. The Pilbara provides the clearest example. BHP's Perth Integrated Remote Operations Centre connects four processing hubs, five mining hubs and more than 1,000 km of rail and port infrastructure.

Rio Tinto's Perth Operations Centre remotely manages mines, autonomous trucks, trains, plants and drills across distances of up to 1,500 km. Its Pilbara network includes 18 mines, nearly 2,000 km of rail and the AutoHaul autonomous railway.

"Mining's next productivity contest may be decided not by who owns the largest machines, but by who can see a constraint first–and respond fastest."

Speed Becomes the Advantage

The real value of an IOC is not the number of screens in the control room. It is the speed at which information becomes action. A crusher problem can affect truck queues, train schedules, stockpiles and ultimately a vessel-loading window. In a conventional structure, those decisions may pass through several departments. An integrated center can identify the constraint and coordinate a response across the system. That reduction in decision latency is becoming an operating advantage.

The supplied analysis cites Rio Tinto reporting approximately 15% productivity improvement from automation, while BHP's Jimblebar autonomous haulage operation has been associated with around 20% lower site haulage costs compared with conventional WAIO operations. These figures are specific operating comparisons rather than universal IOC benchmarks.

The Next Step Is Intelligence

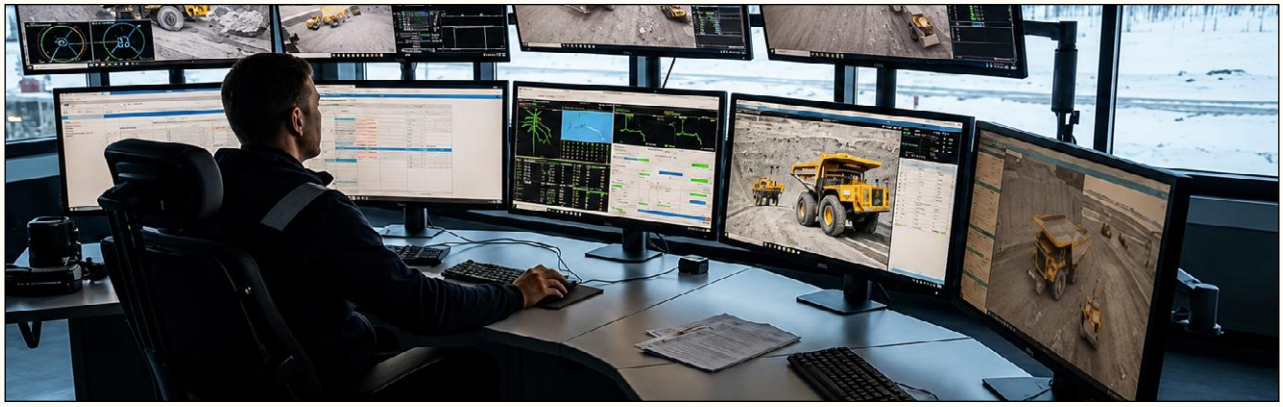
The model is already moving beyond the Pilbara. Teck's QB2 Integrated Operating Centre in Santiago oversees an operation roughly 1,800 km away and more than 7,000 instruments. Regional and specialist models are also developing in Canada and South Africa.

The next stage will be less about remote control and more about closed-loop optimisation–connecting orebody data, equipment condition, processing performance, energy use and logistics so that one change informs the next. The technology can be purchased. The harder advantage is organisational: clean data, reliable communications, clear decision rights and people empowered to act Mining's next productivity contest may therefore be decided not by who owns the largest machines, but by who can see a constraint first–and respond fastest.

Operating area	Conventional model	KIntegrated Operations Center	Strategic value
Fleet dispatch	Site-based adjustment	Real-time network visibility	Less queuing, higher utilisation
Plant response	Multiple operational handoffs	Centralised monitoring and intervention	Faster recovery from disruptions
Maintenance	Scheduled/reactive	Condition and predictive monitoring	Reduced unplanned downtime
Mine-to-rail planning	Functions coordinated separately	Mine, stockpile and rail viewed together	Better supply-chain synchronisation
Safety	Primarily site-based monitoring	Remote monitoring, geofencing and automated alerts	Faster intervention, lower exposure
Production planning	Periodic plan-versus-actual review	Continuous short-interval control	Faster corrective decisions

Actual performance depends on automation maturity, communications, governance and the authority given to the operations center. The source cautions against treating indicative response times as universal industry benchmarks.

The Mining Workforce Moves to the Control Room



Integrated Operations Centers are changing not only where mining decisions are made, but who makes them.

The modern control room increasingly brings together IOC controllers, automation engineers, data analysts, systems integrators, predictive-maintenance specialists and traditional mining professionals.

Fortescue's 24/7 Hive, for example, coordinates autonomous haul trucks, processing plants, rail, port, scheduling and energy systems from one integrated environment. That does not eliminate operational expertise; it changes how it is applied. Future operators will increasingly need to interpret machine alerts, digital models and live production data alongside conventional mining conditions.

The workforce shift is therefore from operating individual assets to understanding interconnected systems—combining mining judgement with automation, data and control expertise.

The Uranium Bottleneck Beyond the Mine

More mines mean more uranium concentrate (U_3O_8, or yellowcake). They don't mean more reactor fuel. Concentrate must pass through conversion, enrichment, deconversion and fabrication each a specialised, separately licensed industry before loading into a reactor. Fuel security depends on that whole chain, not mine output alone.

Conversion turns yellowcake into uranium hexafluoride (UF_6), the gas enrichment requires. Enrichment raises fissile uranium-235 concentration using centrifuges; capacity is measured in separative work units (SWU), not tonnes a plant can be short on SWU even with abundant raw uranium on hand. LEU (below 5% U-235) fuels most operating reactors.

HALEU 5%–19.75% U-235 is required by many proposed advanced reactors and is a distinct product line, not a stronger version of the same one.

After either enrichment, product UF_6 must be deconverted to a solid oxide or metal before fabrication shapes it into the pellets, rods or assemblies a specific reactor needs fuel qualified for one reactor generally can't serve another, and not every HALEU reactor uses the same fuel form. Capacity at one stage cannot substitute for a shortfall at another.

The Security Problem

Conversion and enrichment capacity is geographically concentrated, and the US has relied on Russian LEU enrichment for part of its supply. The 2024 Prohibiting Russian Uranium Imports Act banned that trade from August 2024, with a narrowing waiver window closing entirely on 1 January 2028 the ban is already active, not pending.

New centrifuge capacity takes years to license and build. HALEU carries an added risk: demand is arriving before commercial-scale domestic supply exists Centrus has produced it only at demonstration scale so far. DOE says commercial HALEU supply remains limited, and in January 2026 finalised ten-year task orders $900 million each with American Centrifuge Operating and General Matter to build commercial HALEU capacity, plus a matching order to Orano for LEU. These are milestone-based contract ceilings, not cash spent or fuel delivered: Centrus's award wasn't a signed, binding contract until July 2026.

Measure the Chain, Not the Mine

Judge fuel security by conversion throughput, enrichment capacity in SWU, deconversion and fabrication output, working inventories and qualified suppliers at each stage not uranium production alone. Mines are the easiest part of this chain to expand, and matter least on their own.

DIGITAL MINING

The **Mine-Planning** Software Arms Race

Five platforms are competing to control the digital workflow from orebody modelling to mine operations.

WORDS BY *MO SHINE* // **DATA BY SKILLINGS RESEARCH**

The mining industry's competitive battle is moving into the digital planning environment, where geological data is transformed into mine designs, schedules, production targets and investment decisions. As software vendors expand and consolidate, miners are increasingly choosing not just applications, but entire planning ecosystems.

From Software Tools to Digital Ecosystems

Mine-planning software was once judged primarily by its ability to model an orebody, design a pit or stope and generate a production schedule. That calculation is changing.

Today's mining companies increasingly want geology, mine design, scheduling, reconciliation and operational data to work from connected and controlled datasets. Cloud collaboration, offline capability, fleet integration and links to enterprise systems are becoming part of the purchasing decision.

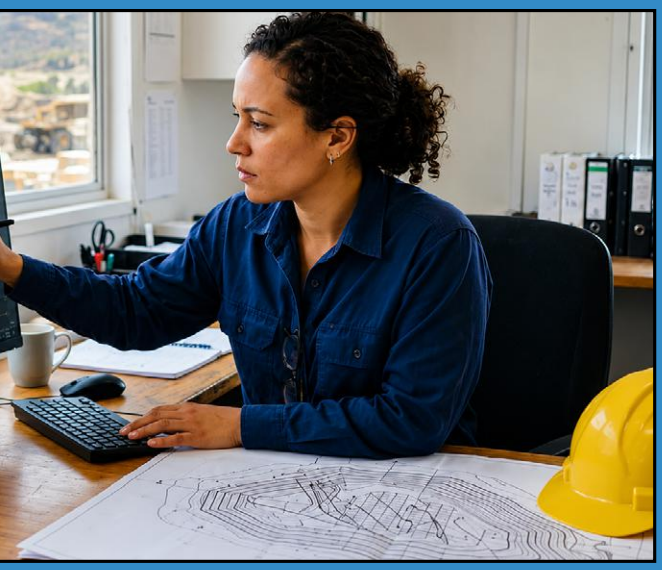
That shift is driving consolidation. Sandvik acquired Deswik in 2022, while Weir acquired Micromine in 2025. Dassault Systèmes continues to position GEOVIA within its broader 3DEXPERIENCE ecosystem. Meanwhile, Hexagon is connecting HxGN MinePlan with its operational and fleet-management technologies.

Five Platforms, Five Strengths

The competitive landscape is not dominated by a single platform. Maptek Vulcan remains particularly strong in 3D geological modelling, visualisation and open-pit workflows. Deswik places greater emphasis on scheduling, optimisation and connecting design directly with production sequencing.

GEOVIA Surpac brings broad multi-commodity geology and mine-design capability, supported by Dassault Systèmes' enterprise architecture and deployment across more than 120 countries. Datamine Studio retains a strong position in resource modelling, geostatistics and coal and underground planning.

HxGN MinePlan takes a different route, connecting life-of-mine planning and scheduling with operational



systems and fleet data. Its value lies in closing the gap between what the plan predicted and what the mine actually delivered.

The Real Battle Is Integration

No platform currently controls the entire journey from geology to finance. Different technical, operational and corporate systems still need to exchange information.

That is unlikely to change soon. Instead, the mining software architecture is moving towards hybrid, modular ecosystems: local systems provide site resilience, while cloud platforms support collaboration, governance, analytics and scenario modelling.

For mining companies, this makes software selection a strategic decision rather than an IT purchase. The platform determines how quickly planners can test scenarios, challenge assumptions, redesign schedules and translate geological information into capital decisions. The orebody may be underground. Increasingly, the competitive advantage is being built in software.

TABLE I FIVE PLATFORMS AT A GLANCE

Platform	Core strength	Key advantage	Cloud / ecosystem direction
Maptek Vulcan	3D geology & modelling	Strong visualisation and open-pit workflows	Desktop-first with cloud integration
Deswik	Scheduling & optimisation	Strong cash generation Connects design, scheduling and constraints	Connected/hybrid ecosystem
GEOVIA Surpac	Geology & mine design	Multi-commodity global capability	3DEXPERIENCE-connecte
Datamine Studio	Geostatistics & resource modelling	Strong technical and planning workflows	Connected planning and data governance
HxGN MinePlan	Life-of-mine planning	Links planning with operational/ fleet data	Hybrid, connected to MineOperate

Adoption and positioning are qualitative; vendors do not publish consistently comparable independent global market-share data.

THE PROCESSING GAP

Why Mining More Will Not Secure the Critical Minerals Supply Chain

WORDS BY *CHARLES PITTS* // **DATA BY SKILLINGS RESEARCH**

Governments have spent three years approving mines. In July, the International Energy Agency delivered the counterpoint: the ore extracted from those mines is, in most cases, still travelling to a small handful of countries to become something industry can actually use. China and Indonesia between them accounted for more than three-quarters of all growth in global refined mineral supply over the past two years. For manganese, nickel and graphite, almost none of that growth came from anywhere else.

A mine is not a supply chain. It is the first link in one. The 2026 data makes a specific, testable claim: mineral security is being measured at the wrong end of the chain. A country can hold lithium, copper or rare-earth deposits and still be entirely dependent on a foreign processor to turn that resource into battery chemicals, refined metal or a magnet. This is not an argument against new mines. It is an argument that mine development and processing investment have to be funded, permitted and timed together – because right now, they are not.

What Happens After the Mine Gate

A mine produces ore. Ore is not a product. It is beneficiated and concentrated on site to raise the proportion of the target mineral and strip out waste rock – a copper concentrate typically runs at 20-30% copper, a long way short of the 99.99% ("four nines") cathode grade a wire or cable manufacturer actually orders. From there, the material must be chemically processed, smelted, refined or separated into a form that meets a strict industrial specification. Battery, magnet and semiconductor manufacturers each work to their own chemical-purity and consistency tolerances, and a concentrate or intermediate that falls outside spec is not a discounted product – it is unsellable to that customer. This is where the chain forks by mineral. Copper concentrate goes to a smelter, then a refinery, to become cathode copper. Lithium ore or brine becomes spodumene or brine concentrate, then lithium carbonate or hydroxide. A rare-earth concentrate has to be split into its individual oxides – neodymium, praseodymium, dysprosium, terbium – before being converted into metal and alloy, and finally pressed and sintered into a magnet. Graphite has to be purified and shaped, then coated, before it can sit in a battery anode. Each of these conversions requires different chemistry, different equipment and different qualified suppliers. Treating "processing" as one word hides the fact that it is four or five distinct, capital-intensive industries stacked on top of each other. Mining creates feedstock. Processing is what turns feedstock into something a factory can actually order and receive on spec.

The Scale of the Concentration Problem

The IEA's Global Critical Minerals Outlook 2026, published in July, put a

number on what had been a working assumption. Refining concentration hit a new record in 2025: the average market share of the single top-refining country across key energy minerals reached 70%, up from 68% in 2020. Strip out rare earths, where the US and Malaysia have made genuine progress, and the concentration figure is worse – the leading refiner's average share rose to 72% in 2025, up from 70% in 2023. Over the same two years, China and Indonesia together produced more than three-quarters of all growth in global refined supply, and for manganese, nickel and graphite specifically, virtually the entire increase came from a single dominant supplier.

The pipeline data is the more uncomfortable finding. New project announcements suggest diversification is under way, but the IEA's analysis of that pipeline shows the investment is heavily weighted toward mining and thin on the processing stages that would actually convert it into usable material. In rare earths, refining and separation capacity being built outside the dominant supplier is equivalent to roughly two-thirds of expected mined output by 2035 – but planned magnet production is only around one-third of that. In lithium, planned cathode-material capacity outside the dominant supplier sits at about one-third of projected mining capacity over the same horizon. Put plainly: the world is on track to dig up more feedstock than it will be able to convert, and the conversion bottleneck is structural, not temporary.

Case Study: Rare Earths and the Mine-to-Magnet Problem

Rare earths are the clearest illustration of why "mine count" is the wrong metric. A rare-earth mine produces a mixed concentrate. That concentrate has to be separated into individual oxides – a chemically intensive, multi-stage solvent-extraction process that very few facilities outside China currently run at commercial scale. The oxides are then converted to metal and alloyed, and only then can a magnet manufacturer press, sinter and machine them into a finished component. Each stage has its own capital intensity, its own specialist workforce, and its own qualification cycle with the automotive, defence or electronics customer that will eventually buy the part – a cycle that industry participants generally describe in years rather than months, given the consequences

of a magnet failure in an EV drivetrain or a guided weapon system.

That is why separation and magnet-making are harder to establish than a mine: a mine is a geological and engineering problem with a known playbook; a magnet plant is a chemistry, metallurgy and customer-trust problem competing against an incumbent that has decades of process learning and an integrated cost base. A domestic mine that ships its concentrate abroad for separation has not solved its country's rare-earth dependency – it has simply relocated the point of vulnerability one stage downstream. China's own use of that leverage is current and live: Beijing introduced export controls on seven heavy rare earth elements in April 2025 and expanded them in October 2025; the expanded measures were suspended for one year, until November 2026, but the underlying controls have not been withdrawn.

The US policy response illustrates both the intent and the scale of the gap it is trying to close – and the gap between an announcement and a completed plant. On 19 May 2026, the Department of Energy's Office of Critical Minerals and Energy Innovation selected 19 projects for negotiation, sharing $45.7 million; DOE's own release is explicit that only two of those 19 are the pilot-scale processing facilities (one rare earth, one magnesium), with the other seventeen funding earlier-stage, bench-level technology across a wider set of materials.

The rare-earth pilot went to USA Rare Earth (Nasdaq: USAR), selected for up to $19.3 million in DOE funding toward a continuous ion-exchange separations plant in Stillwater, Oklahoma – against $31.2 million in non-DOE (private) funding, for a $50.5 million total project value. As DOE's own selection notice states, this is a selection for award negotiation, not a completed or disbursed award; DOE can still cancel or amend it before funding flows.

The Department's justification for the wider programme cited USGS figures showing more than 95% of US rare-earth supply currently comes from foreign sources. Against that backdrop, a single $19.3 million pilot-scale separations plant is a genuine first step, not a substitute for the roughly $60 billion in magnet-rare-earth investment the IEA estimates will be needed outside the dominant supplier over the next decade.

Case Study: Copper and the Strategic Smelter

Copper shows that even a large, liquid, geologically diverse commodity can develop a severe midstream chokepoint. Mined copper concentrate is not usable copper; it has to be smelted and electrolytically refined

before it can go into a wire or a busbar. Since 2005, China has accounted for more than 90% of all growth in global copper-smelting output, lifting its share of global smelting capacity from around 15% to roughly 50% by 2025.

That expansion has now outstripped the growth in mined concentrate available to feed it.The result shows up in treatment and refining charges (TC/RCs) – the fee a smelter earns for turning concentrate into metal. The annual benchmark, negotiated between Chilean miner Antofagasta and major Chinese smelters, was settled at $0 per tonne for 2026 – the lowest level ever agreed in that annual negotiation – down from $21.25 per tonne for 2025; spot TC/RCs have separately been trading negative since 2024. A $0 benchmark does not mean smelting has become free; it means smelters are no longer being paid a processing margin on concentrate at all, and are increasingly dependent on revenue from by-product recovery instead – the IEA specifically flags this shift toward by-product reliance as a source of added volatility. That is why the IEA now treats copper and zinc smelters as strategic midstream infrastructure in their own right rather than simple metal producers – they also provide by-product recovery and scrap-recycling capacity that a mine cannot replace. Smelters outside China, competing on that fee structure against Chinese capacity, are the ones under the most direct commercial pressure.

Why Processing Projects Are Difficult to Finance

A processing plant is a harder financing proposition than a mine on almost every metric that matters to a lender. It needs guaranteed feedstock, since a smelter or separation plant is worthless without a reliable concentrate supply. It is energy- and water-intensive, exposed to commodity-price swings on both its input and output, and dependent on complex, sometimes unproven metallurgy that carries real process risk. Specialist equipment and a trained workforce are scarce outside the handful of countries that already run this capacity, environmental permitting is slow, and the customer base for a qualified, on-spec material is often a short list of buyers who default to the cheapest, already-qualified incumbent supplier.

The IEA has now quantified the cost gap this creates: refining projects built outside the dominant supplier face capital costs 20% to more than 150% higher, and operating costs around 50% higher on average, than equivalent projects in the incumbent country. That leaves the central financing question unresolved: who commits capital to a structurally higher-cost plant when the customer on the other end of the offtake agreement can still buy the same material more cheaply from the country that already has the infrastructure, the workforce and the scale?

What a Credible Solution Looks Like

The IEA's own policy analysis points toward specific, de-risking mechanisms rather than a generic call for more spending: long-term offtake agreements that give a lender revenue certainty; price floors and contracts for difference that protect a project from commodity swings; concessional government loans, loan guarantees and direct equity participation to lower the up-front capital hurdle; strategic stockpiles that create a buyer of last resort; and binding customer commitments to diversified sourcing, which is arguably the hardest lever to pull because it asks a manufacturer to pay more, deliberately, for supply security rather than unit cost.

That premium is the honest framing. Diversified supply chains will likely cost more than concentrated ones, at least for the next decade, and that additional cost functions as insurance against a disruption whose downside is large enough to justify paying it: the IEA estimates that if China's expanded rare-earth export controls were fully implemented, they could put roughly $6.5 trillion a year of downstream production outside China at risk across the automotive, high-tech and defence sectors.

That is a conditional, not a current, figure – the October 2025 expansion of those controls is currently suspended, until November 2026 – but the underlying exposure it measures does not go away because enforcement is paused. The counterargument deserves equal weight: subsidising uneconomic capacity indefinitely wastes public money and can leave governments owning idle plants. A project earns support by having secured feedstock, proven technology, a qualified customer and a credible path to competitive operation – not by having a groundbreaking ceremony.

MEASURE THE CHAIN, NOT THE MINE COUNT

Mineral-security strategies should stop grading themselves on mines permitted, deposits identified and funding announced. Those are inputs. The tests that matter are downstream: qualified processing capacity actually commissioned and running at credible utilisation, binding offtake agreements signed, customer-qualified material shipped, and measurable reductions in dependence at the specific chokepoints — separation, smelting, cathode and magnet manufacturing — that the IEA has now identified by name. The world may need more mines. Whether mineral security actually improves will be decided by what happens to the ore after it leaves them.

Gold at the Capital Crossroads

The World Gold Council recorded an average LBMA (PM) gold price of $4,506.29 an ounce in Q2 2026, 37% above a year earlier, despite an 8% pullback from Q1's record. By 21-22 August, spot gold was above $4,600, approaching January's intraday record near $5,600.

That level of cash flow gives producers more options. The key question heading into Mining Forum Americas in Colorado Springs (27-30 September) is not how much gold miners generate, but whether each dollar creates more value per share.

What Miners Can Do With the Cash

Three choices compete for the same dollar: reinvestment, shareholder returns and debt reduction. Brownfield expansion, mine-life extensions and exploration around existing infrastructure can offer strong returns because the infrastructure is already in place, unlike new mines that carry construction and ramp-up risk.

Dividends and buybacks reward shareholders and impose discipline, but excessive distributions can under-fund reserve replacement. Paying down debt reduces interest costs and volatility, although investors may view excessive deleveraging as avoiding worthwhile growth.

M&A: Growth or Expensive Replacement?

Strong gold markets increase acquisition pressure because permitted, de-risked deposits are scarce. Coeur Mining's all-stock acquisition of New Gold, announced in November 2025 at roughly $7 billion and completed on 20 March 2026, illustrates the strategy.

Coeur issued approximately 392.7 million shares and has since raised 2026 guidance to 680,000-815,000 ounces of gold, 18.7-21.9 million ounces of silver and 50-65 million pounds of copper. It has also authorised a $750 million buyback and introduced its first dividend.

At the asset level, Mako Mining's $43.6 million purchase of Nevada's Mt. Hamilton project from Sailfish Royalty shows a smaller version of the strategy, paid through two gold-stream commitments rather than cash or shares. The risk remains: competitive bidding can transfer much of an acquisition's future value to the seller.

Royalties and Streams Move Toward the Centre

A royalty provides a percentage of revenue or production without funding operating costs. A stream provides upfront capital in exchange for the right to purchase future metal at a below-market price.

Wheaton Precious Metals' April 2026 agreement with KGL Resources for Jervois illustrates the model: $275 million upfront across six installments for 75% of payable gold until 45,000 ounces, then 37.5%, with Wheaton paying 20% of spot price per ounce. The first $16 million was paid on 16 June 2026.

The structure gives miners construction funding without conventional debt or equity dilution, but at the cost of future production upside.

Who Should Carry the Security Premium?

Key metrics include ROIC, free cash flow per share, acquisition discipline and whether cost guidance assumes today's gold price persists. The Denver Gold Group-hosted forum brings producers, developers and royalty companies together at the Broadmoor from 27-30 September.

Gold prices will eventually turn. The companies best positioned when they do may not be those that spent or distributed the most, but those that converted today's high prices into value capable of surviving the next cycle.

Can America Build a Mine-to-Magnet Industry?

Mountain Pass, California, is America's principal operating rare-earth mine and mining is the easy part. Ore has to be concentrated, the concentrate separated into individual rare-earth oxides, those oxides converted to metal and alloy, and the alloy pressed and qualified into a finished magnet before it is worth anything to a carmaker or a defence contractor. The United States now has ore, growing separation capacity, and a operating magnet plant. What it has never had is a complete, commercially self-sustaining route connecting all of it. The question this piece asks: is that changing, or is Washington simply underwriting a collection of strategically necessary facilities that only function with public money attached?

MP Materials, which mines and separates at Mountain Pass and makes magnets at its Independence facility in Fort Worth, Texas, is the clearest operating case. In its second quarter of 2026 (reported 13 August 2026), MP reported NdPr production of 840 metric tons, up 41% year over year, and sales of 1,006 metric tons, up 127%.

Independence began commercial NdFeB magnet manufacturing in December 2025 and has been shipping magnetic precursor products commercially since; but the flagship automotive milestone commercial magnets to General Motors remains in qualification, with GM in-vehicle testing under way and initial commercial shipments still guided for the fourth quarter of 2026, not yet delivered. On heavy rare earths, MP achieved mechanical completion of its dysprosium/terbium separation circuit in May 2026 and was, as of the August earnings call, still introducing feed rather than producing – commercial Dy/Tb output remains guided for "later this year," with a 200-tonne annual nameplate once running.

Until that starts, MP's own heavy-rare-earth-bearing concentrate continues to be processed through third-party channels rather than separated domestically the company has stockpiled it domestically since April 2025 rather than exporting it to China, but stockpiling raw concentrate is not the same as separating it. Construction has begun on the larger 10X magnet facility in Northlake, Texas (estimated total cost 1.25billion),followingan~80 million site acquisition; the Department of War's own transaction agreement with MP explicitly states the company has made no guarantee on 10X's completion timing or production capability, and that missing an estimated milestone is not itself a contractual breach.

Federal Policy Is Filling the Economics Gap

MP Materials' Transaction Agreement with the Department of Defense (renamed Department of War), filed with the SEC on 9 July 2025, is more

precisely structured than "equity plus a loan" suggests. DoW purchased $400 million of Company Preferred Stock outright, with a mechanism requiring MP to raise at least $350 million more from private markets within 45 days of closing or sell DoW additional preferred stock to cover the shortfall; DoW also received a warrant for 11.2 million common shares, capped so its total stake cannot exceed 19.9% of outstanding common stock on conversion. Separately, DoW extended a $150 million loan for MP's Samarium Project.

The Price Protection Agreement – not fully visible in the public contract exhibit, but consistently reported in MP's own subsequent earnings disclosures sets a $110-per-kilogram NdPr floor through 2035; MP has recognised real cash from it, $17.6 million in Q2 2026 alone.

The Offtake Agreement is a direct government purchase commitment specifically for magnets produced at the 10X facility not a broader guarantee that other customers will buy MP's output – and DoW has also committed to help MP procure heavy rare earths for that facility, treating the cost as a passthrough production cost. Notably, the contract itself states DoW takes no board seat and agreed to standstill provisions preventing it from influencing MP's governance.

Separately, the Department of War's Office of Strategic Capital conditionally committed $700 million in November 2025 $620 million to Vulcan Elements, $80 million to ReElement Technologies for separation, metallisation and magnet capacity, aiming at a combined 10,000 metric tons of NdFeB magnet material (not finished magnets) within several years. Per OSC's own release, "no OSC funds are disbursed until all parties have completed or met the conditions for disbursement" and that conditionality has already proven real: Reuters reported in July 2026 that ReElement is no longer pursuing its $80 million portion after failing federal due-dilgence requirements.

Vulcan's $620 million remains intact as of the most recent reporting; the company already operates a small commercial pilot plant in Research Triangle Park, NC, and is under active construction on a much larger 10,000-tonne facility in Benson, NC (roughly 918million-1 billion), targeting meaningful production online by 2027 a company claim, not yet independently verified output.

And in June 2026, DOE selected Colorado School of Mines/ElementUSA (66 million, Oklahoma) for award negotiations on unconventional-feedstock demonstration plants selections, not disbursed funds, per DOE's own language; Phoenix Tailings separately picked up a further $500 million conditional OSC loan in June 2026.

The Commercial Viability Test

Even with all this, USGS's Mineral Commodity Summaries 2026 records that US net import reliance on rare earths actually rebounded to 67% in 2025 domestic mining growth has not yet outpaced demand growth.

The open questions remain whether US facilities can secure heavy rare earths without routing back through Chinese processing, win long-term commercial (not just defence) customers willing to pay for diversified supply, and survive a period of depressed Chinese pricing once price floors and offtakes eventually expire.

Defence demand can anchor early capacity but is unlikely to provide the volume that makes large-scale manufacturing efficient on its own. The counterargument deserves equal weight: concentrating this much federal support on a small number of producers may buy security while narrowing competition and stacking execution risk on very few balance sheets.

Conclusion

America is assembling the physical links of a mine-to-magnet chain for the first time in decades, a real one. Whether it becomes an industry rather than a permanently subsidised strategic asset will be measured by sustained separated-oxide output, commercially qualified magnets, plant utilisation and repeat customers who chose the product on its merits – not by funding announcements or nameplate capacity.

NORTHAM OPENS WORLD'S DEEPEST RAISE-BORED PGM SHAFT

Zondereinde's 1,382 m No. 3 Shaft demonstrates how mechanised access could reshape the economics and safety of ultra-deep underground mining.

WORDS BY *MO SHINE* // **DATA BY SKILLINGS RESEARCH**

Why the No. 3 Shaft Matters to the Western Extension

The Zondereinde No. 3 Shaft is more than an underground access project. It is part of Northam's strategy to unlock the Western Extension, which contains more than 20 million ounces of PGMs and extends the mineable strike by 3.6 km.

The shaft brings personnel, materials and services closer to an area previously dependent on infrastructure approximately 4 km away.

That distance matters underground, where every additional journey consumes valuable production time. Earlier access can improve face time, simplify logistics and support development of new stoping areas.

The project is also expected to create approximately 600 additional direct, sustainable jobs, illustrating that mechanisation does not necessarily mean fewer workers—it changes where their skills are deployed.

Northam Platinum has commissioned a new landmark in underground mine development. On 17 July 2026, the company officially opened the No. 3 Shaft at its Zondereinde operation in Limpopo, South Africa–a 1,382 m-deep, 4.8 m-diameter personnel, materials and services shaft now recognised as the world's deepest raise-bored PGM shaft of its type.

The achievement is significant beyond the record itself. The shaft forms part of Zondereinde's Western Extension, which adds 3.6 km of mineable strike and more than 20 million ounces of PGMs across the Merensky and UG2 reefs.

The expansion is expected to extend the mine's life by approximately 40 years, with Northam having invested R6.3 billion in the project by the shaft's commissioning.

Taking People Away from the Face

Raise boring changes the conventional shaft-sinking equation. Instead of crews repeatedly drilling, blasting and supporting the excavation face, a pilot hole is drilled between underground levels before a large reaming head enlarges it. Broken rock falls to the lower level for removal.

The result is a highly mechanised excavation process in which personnel do not need to work directly at the cutting face. Northam's achievement therefore carries a powerful safety message: the machine creates the excavation while people operate and maintain the system from safer locations.

The method is particularly attractive for brownfields developments where underground access already exists. Its major limitation is precisely that requirement: raise boring needs bottom access for the pilot hole and removal of cuttings. Conventional sinking therefore remains important for greenfield developments and complex shaft configurations.

The Cost and Schedule Advantage

A published industry cost model cited in the source places a 4 m conventional shaft at approximately 12,300 per metre, compared with about 6,083 per metre for a similarly sized raise-bored excavation. These

> “The real competitive advantage is not reaching greater depth. It is reaching productive workings faster, with fewer people exposed.”

are directional figures rather than project quotations, but they illustrate the potential economic advantage where geological and access conditions are favourable.

For ultra-deep mines, the benefit extends beyond construction cost. Bringing access closer to the orebody can reduce travel time, improve materials delivery and increase productive face time.

Zondereinde's Western Extension was previously serviced from infrastructure roughly 4 km away. The new shaft changes that logistics equation while supporting ventilation, services and future development.

Factor	Conventional sinking	Raise boring	Mechanical boring
Starting condition	Can start from surface	Requires bottom access	Can operate from surface, depending on system
Method	Drill, blast, muck & support	Pilot hole + upward reaming	Continuous mechanical excavation
Face exposure	Higher	Minimal	Reduced
Key advantage	Flexibility	Safety, speed, lower labour exposure	Large-diameter mechanised excavation
Main limitation	Labour & cycle complexity	Bottom-access requirement	High capital & mobilisation
Best application	Greenfield/ complex shafts	Brownfields, raises & services	Deep, large-scale shafts

From Mechanisation to Intelligent Excavation

The next evolution is likely to combine raise boring with sensors, machine telemetry and operator-supervised automation. Monitoring thrust, torque, vibration, penetration and pilot-hole alignment can help identify changes in ground conditions and equipment performance.

Northam's No. 3 Shaft is not evidence that fully autonomous shaft sinking has arrived. It is evidence that mechanised deep access is becoming commercially credible. With the planned No. 4 Shaft expected to reach approximately 1,500 m, Zondereinde may soon provide another test of how far the technology can go.

2025 GLOBAL CRUDE STEEL PRODUCTION TOTALS

Total world crude steel production was 1,849.4 Mt in 2025.

Rank	Country	2024	2023	%2024/ 2023
1	China	960.8	1 005.1	-4.4
2	India	164.9	149.4	10.4
3	United States	82.0	79.5	3.1
4	Japan	80.7	84.0	-4.0
5	Russia (e)	67.8	71.0	-4.5
6	South Korea	61.9	63.6	-2.8
7	Türkiye	38.1	36.9	3.3
8	Germany	34.1	37.3	-8.6
9	Brazil	33.3	33.9	-1.6
10	Iran (e)	31.8	31.4	1.4
11	Viet Nam	24.7	22.0	12.2
12	Italy	20.7	20.0	3.6
13	Indonesia (e)	19.0	18.6	1.9
14	Taiwan, China (e)	17.1	19.2	-10.8
15	Mexico (e)	13.5	14.3	-5.9
16	Spain (e)	12.0	11.9	0.7
17	Canada (e)	11.5	12.3	-7.2
18	Saudi Arabia	10.8	9.6	12.3
19	Egypt	10.6	10.7	-0.8
20	France (e)	9.8	10.8	-8.7
21	Malaysia (e)	9.0	9.0	-0.2
22	Austria	7.6	7.1	5.9
23	Ukraine	7.4	7.6	-2.2
24	Poland (e)	7.2	7.1	0.8
25	Belgium (e)	7.2	7.1	0.5
26	Netherlands	6.5	6.4	1.4
27	Algeria (e)	5.3	4.5	17.9
28	Australia	5.2	4.7	12.1
29	Thailand (e)	5.0	4.9	2.6
30	Bangladesh (e)	4.5	4.5	0.0
31	South Africa	4.5	4.7	-4.7
32	Kazakhstan	4.3	4.2	2.2
33	Argentina	4.0	3.9	4.2
34	Sweden	4.0	4.0	-0.7
35	United Arab Emirates	3.8	3.7	3.3
36	Finland	3.7	3.7	2.1
37	Slovakia (e)	3.7	3.9	-5.6
38	Pakistan (e)	3.6	4.1	-12.2
39	Iraq (e)	3.0	3.0	0.3
40	Oman (e)	3.0	3.0	0.0
	Others	41.8	44.1	-5.3
	World	**1849.4**	**1886.8**	**-2.0**

e – annual figure estimated using partial data or non-worldsteel resources. * The world total production figure in this table includes estimates of other countries that only report annually.

Source – World Steel Association. 2025 Steel Statistical Yearbook published

STASTISTICS

JULY 2026 CRUDE STEEL PRODUCTION

World crude steel production for the 70 countries reporting to the World Steel Association (worldsteel) was 149.2 million tonnes (Mt) in July 2026, a 0.3% decrease compared to July 202

Africa produced 2.0 Mt in July 2026, up 6.1% on July 2025. Asia and Oceania produced 109.4 Mt, down 1.2%. The EU (27) produced 10.5 Mt, up 3.8%. Europe, Other produced 3.7 Mt, up 5.8%. The Middle East produced 3.8 Mt, down 13.4%. North America produced 9.6 Mt, up 4.9%. Russia & other CIS + Ukraine produced 6.7 Mt, up 2.2%. South America produced 3.6 Mt, up 2.8%.

The 70 countries included in this table accounted for approximately 98% of total world crude steel production in 2025. Africa, Asia and Oceania, European Union (27), Europe,other, Middle East, North America, Russia & other CIS + Ukraine, South America.

TOP 10 STEEL-PRODUCING COUNTRIES

China produced 76.9 Mt in July 2026, down 3.6% on July 2025. India produced 14.4 Mt, up 1.9%. The United States produced 7.4 Mt, up 4.4%. Japan produced 6.9 Mt, up 0.4%. Russia is estimated to have produced 5.7 Mt, up 3.3%. South Korea produced 5.7 Mt, up 6.4%. Türkiye produced 3.4 Mt, up 7.0%. Germany is estimated to have produced 2.8 Mt, up 3.0%. Brazil produced 2.8 Mt, up 0.1%. Viet Nam produced 2.7 Mt, up 34.7%.

TABLE 1. CRUDE STEEL PRODUCTION BY REGION

	JUN 2026 (MT)	% CHANGE JUN 26/25	JAN-JUN 2026(MT)	% CHANGE JAN-JUN 26/25
Africa	2.0	6.1	14.6	9.5
Asia and Oceania	109.4	-1.2	799.6	-0.9
EU (27)	10.5	3.8	76.0	0.4
Europe, Other	3.7	5.8	25.7	5.5
Middle East	3.8	-13.4	29.6	-8.1
North America	9.6	4.9	65.9	5.4
Russia & other CIS + Ukraine	6.7	2.2	45.5	-6.0
South America	3.6	2.8	24.1	0.0
Total 70 countries	**149.2**	**-0.3**	**1,081.2**	**-0.6**

TABLE 2. TOP 10 STEEL-PRODUCING COUNTRIES

	JUN 2026 (MT)	% CHANGE JUN 26/25	JAN-JUN 2026 (MT)	% CHANGE JAN-JUN 26/25
China	76.9	-3.6	577.0	-3.1
India	14.4	1.9	101.1	6.1
United States	7.4	4.4	50.2	6.0
Japan	6.9	0.4	47.3	-0.3
Russia (e)	5.7	3.3	38.1	-6.1
South Korea	5.7	6.4	37.4	2.7
Türkiye	3.4	7.0	23.2	7.9
Germany (e)	2.8	3.0	21.4	8.1
Brazil	2.8	0.1	19.1	-1.2
Viet Nam	2.7	34.7	17.9	28.0

The 70 countries included in this table accounted for approximately 98% of total world crude steel production in 2025. Africa: Algeria, Egypt, Libya, Morocco, South Africa, Tunisia Asia and Oceania: Australia, China, India, Japan, Mongolia, New Zealand, Pakistan, South Korea, Taiwan (China), Thailand, Viet Nam European Union (27): Austria, Belgium, Bulgaria, Czechia, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden
Europe, Other: Macedonia, Norway, Serbia, Türkiye, United Kingdom Middle East: Bahrain, Iran, Iraq, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen North America: Canada, Cuba, El Salvador, Guatemala, Mexico, United States Russia & other CIS + Ukraine: Belarus, Kazakhstan, Russia, Ukraine South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela

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