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A Mining Media International Publication

Project Survey 2025
— Construction begins on several mining projects

Battery-electric Solutions for Underground Mines

Fleet Management Systems

Screening Machines

Special Report: Arizona Mining

JANUARY 2025 | www.e-mj.com

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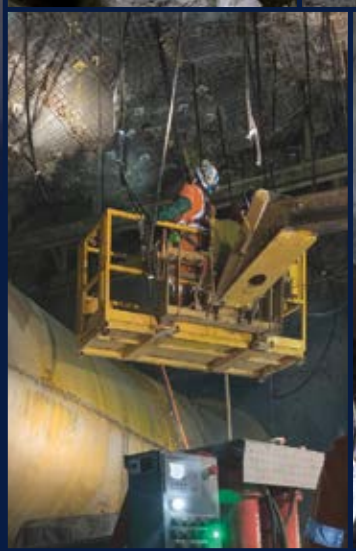

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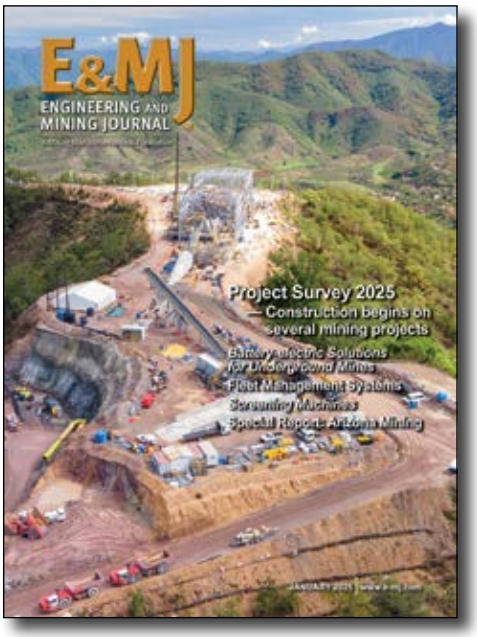
FEATURES

LEADING DEVELOPMENTS

AROUND THE WORLD



In this edition, E&MJ *publishes its Project Survey, which provides details on various mining projects worldwide by commodity. On the cover, the Terronera silver mine started construction in Jalisco, Mexico. (Photo: Endeavour Silver)*

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Steve Fiscor
Publisher & Editor-in-Chief

Prepare for a Period of Sustained Investment

Happy New Year. *E&MJ* publishes its Project Survey annually in the January edition with the help of Industrial Information Resources. They provide investment related statistics based on information from their dataset, while *E&MJ* tracks specific projects by commodity. The news is good and will likely get better with everything that's happening around the world.

The Project Survey reports 3,712 mining-related projects that will require an investment of $306.6 billion excluding coal, which is substantial (1,740 projects with an investment requirement of $99.4 billion). As the tabular data demonstrates, many of those projects are in the prefeasibility stage, even though several major projects were commissioned last year and a dozen or so moved into construction.

The survey predicts that investments in mining projects in 2025 will move sideways but continue to be strong at levels nearly twice as high as the bottom of the market in 2017. In many cases, the projects will not move forward even though an investment decision has been made. In addition to securing the investment capital, mines face exhaustive permitting and regulatory hurdles as well as environmental, social and governance (ESG) standards.

Some of that could change. A new administration is taking over in Washington, which could spur investment and reduce the regulatory burden. China is withholding critical minerals from the market, which has caused some countries to reassess their dependence on imports and consider re-shoring mining activities. Some countries, like Argentina, are setting themselves up for future development while others, like Mali, are shooting themselves in the foot.

The mining industry needs to promote responsible development that protects the environment. After years of brow-beating the mining sector over carbon emissions, those same investment firms are now moving away from net-zero initiatives. If a mine wants to promote a low-carbon footprint, that's their prerogative, but it should not be mandated by the investment community through ESG policies. Otherwise, those mines will lose market share to mines in regions that do not enforce environmental policies and investors will lose money on green metals that can't compete economically.

Governments can do their part by reducing endless environmental reviews and litigation. Permitting should be limited to the scope of the project. The regulatory and permitting process should be transparent, timely and consistent.

As economies around the world continue to recover, the demand for metals and minerals will only increase and we need to be prepared to bring more projects online quickly to accommodate this growth. Enjoy this edition of *E&MJ*.

Steve Fiscor, Publisher & Editor-in-Chief
sfiscor@mining-media.com

E&MJ ENGINEERING AND MINING JOURNAL

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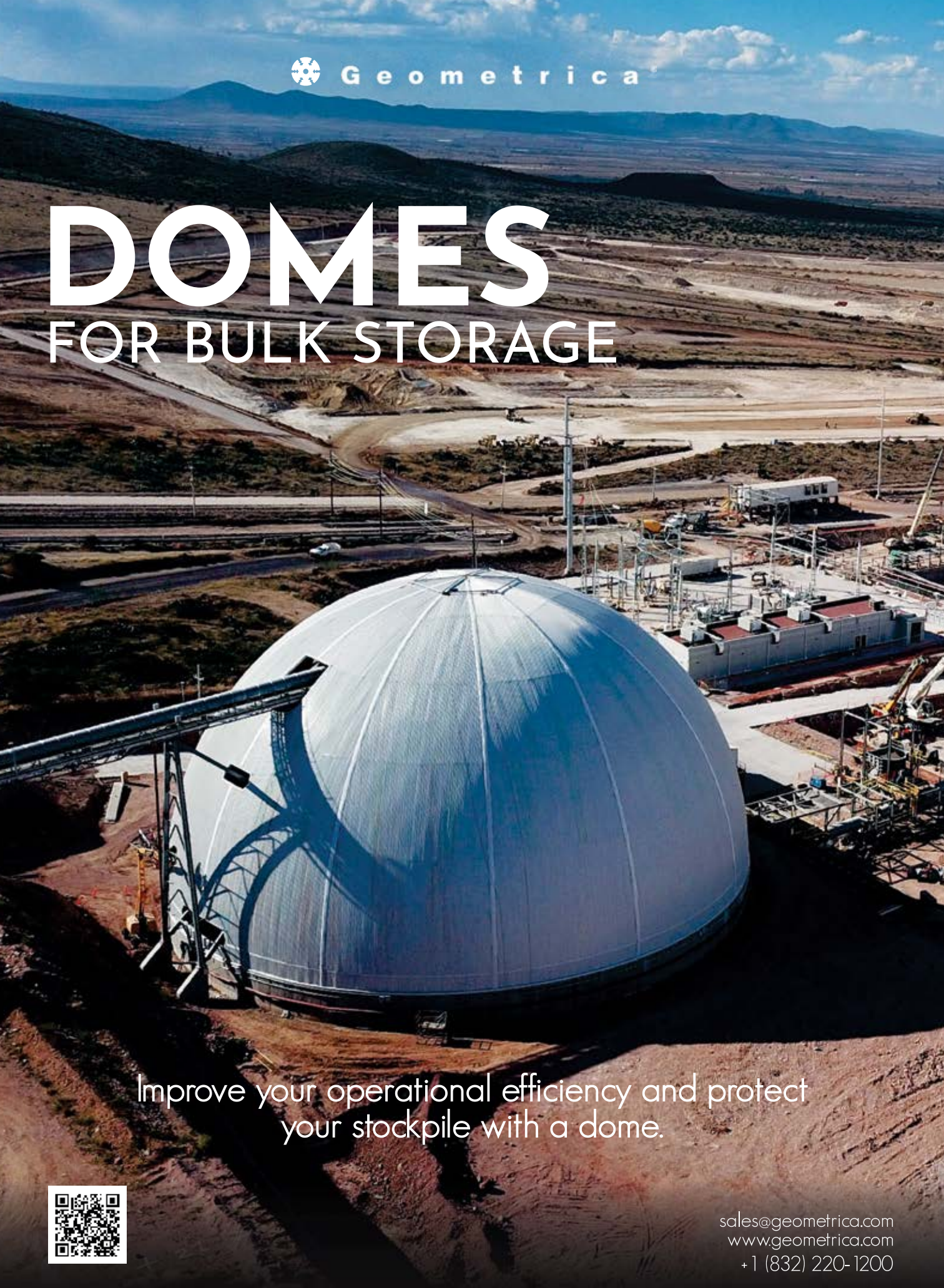
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April 6-9, 2025

Technical Program Outline (Preliminary)

Advancing Operations
Session 1: Monday April 7, 8:30-10:00 a.m.

Short Interval Control in Fleet Management at Agnico Eagle Detour Lake Mine
By Pascal Levesque, mine superintendent, Agnico Eagle Canada – Detour Lake Mine

Converting the Bagdad Mine to Autonomous Haulage
By TBD, Freeport-McMoRan

Safety - Human Impacts on Operations
Session 2: Monday April 7, 10:30 a.m-Noon

Tracking Whole Body Vibrations During Mining Operations for Safer Loading
Andres Tovar, vice president business development Americas, AMOG Consulting

Addressing the Root Causes of Fatigue: The Role of CBT-i in Enhancing Sleep Quality for Mine Workers
By Amanda Jewson, founder and CEO, Rest My Best

Decarbonization & Electrification
Session 3: Monday April 7, 1:00 p.m.-2:30 p.m.

The Role of Hybrid Haul Trucks in the Path to Decarbonization
By Brian Havens, senior manager for advanced developments, Flanders

Advanced Mine Planning and Scheduling Tools to Integrate Electric Haul Trucks and Trolley-assist Technology into Existing Mining Operations
By Ben McDonald, senior mining solutions manager, Micromine

Panel Discussion: Tire Management
Monday April 7, 3:00 p.m.-4:30 p.m.

Christian Erdelyi, mining technology solutions manager, Kal Tire
Grok Gates, director, business development, Bridgestone Americas
George Stevens, key account manager, Michelin North America (invited)

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AI & Disruptive Technologies

Session 4: Tuesday, April 8, 8:30-10:00 a.m.

Accurately Assessing Wear Visually from a Distance
By Glenn Brearey, co-founder, WearVue

An Application of AI for Optimizing Short-Term Mine Plans with Real-Time Production Data
By Zach Levinson, principal, AIRL Technologies

Preventing Downtime and Reducing Costs: Leveraging Remote Condition Monitoring to Address Operator-Induced Equipment Strain
By Shawn Shah, technical sales representative, Monico, Inc.

Proactive Maintenance

Session 5: Tuesday April 8, 10:30 a.m.-12:30 p.m.

The New Protocol to Extend Oil Drain Intervals for Haul Trucks at Kearl Oil Sands
By Philippe Dussault, P.E., Imperil Oil

A Modern Used Oil Analysis Program and Its Benefits.
By Bruce Hyatt, key account manager, Wearcheck US

Matching Oil Samples with the Sample Point Locations on the Equipment
By Brian Schmidt, national sales manager, Petro-Canada America Lubricants

Tackling Ferrous Contamination: The Silent Thief in Haulage & Loading Operations
By Dean Cryer, business development manager, Magshield

Open Forum: Operational Readiness

Tuesday April 8, 2:00 p.m.-3:30 p.m.

Workshop: Sharing Data to Enhance Operations

Wednesday April 9, 8:30-11:00

The Global Mining Guidelines Group (GMG) will discuss various methods to improve the safety, sustainability and productivity with open-pit mining operations.

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Pre-conference Golf Outing, Sunday, April 6

All attendees are invited to participate in the 2025 Haulage & Loading golf outing.

Group rate: $139 per player / $499 per foursome.

The format is a scramble tournament that tees off in a shotgun start at 8:30 a.m. The registration fee includes green fees, practice range, cart rental, a light breakfast and lunch following the round.

Boliden Buys Lundin's European Assets

Boliden announced that it intends to acquire the Neves-Corvo mine in Portugal and the Zinkgruvan mine in Sweden from Lundin Mining for $1.52 billion. The transaction, which considerably expands Boliden's mine production and provides zinc and copper concentrate for its smelters, is subject to customary regulatory approvals.

"The addition of two cash flow generative zinc and copper mines in Portugal and Sweden has a strong industrial logic as well as a strategic fit," said Mikael Staffas, president and CEO, Boliden. "Optimizing these well-invested units as well as developing the feed mix to our existing smelters will create short- and long-term value for both our business areas. Going forward we will also have greater development opportunities for near mine exploration in these attractive mining regions."

The transaction consists of an upfront cash payment of $1.37 billion plus a contingent cash payment up to $150 million. Once completed, Boliden's mine production will increase by 95% for zinc and 43% for copper, based on 2023 production figures. The transaction is expected to be completed by mid-2025.

"This sale will further strengthen our balance sheet to support our growing portfolio in South America and enable management to concentrate our focus in an area which will provide the greatest long-term value for our shareholders," said Jack Lundin, president and CEO, Lundin Mining. "It is an opportune time to optimize our portfolio through this divestiture as we drive towards becoming a top-tier copper-dominant mining company."

The Neves-Corvo mine is an underground polymetallic mine with on-site processing facilities, located approximately 200 km southeast of Lisbon, Portugal, in the western part of the Iberian Pyrite Belt. In 2023, it produced 108,800 metric tons (mt) of zinc, 33,800 mt of copper, 5,600 mt of lead and 1.9 million ounces (oz) of silver.

Neves-Corvo has been operating continuously since 1988. The mine is highly mechanized and it uses several different stoping methods with the most common being bench-and-fill and drift-and-fill. The processing facility has two plants, a copper plant that processes copper ores and has a capacity of approximately 2.8 million mt/y, and a zinc plant, which was recently expanded to 2.5 million mt/y.

The Neves-Corvo mine (above) is one of two European deep mines that Boliden wants to add to its portfolio. (Photo: Lundin Mining)

The expansion project, which was completed in 2022, also included a new crusher station, a conveyor system connecting to the 700-m shaft hoisting facilities, an upgrade to the main hoisting shaft together with extensions to the mines ventilation, pumping and electrical distribution systems. Copper and zinc concentrates are transported by rail to a dedicated port facility at Setúbal.

Zinkgruvan is an underground mine that extracts ore from several polymetallic orebodies. It has on-site processing facilities, located approximately 200 km southwest of Stockholm. In 2023, Zinkgruvan produced 76,300 mt of zinc, 4,400 mt of copper, 26,300 mt of lead and 2.3 million oz of silver.

Mine access at Zinkgruvan is principally via three shafts. The primary P2 shaft provides hoisting and man access to the 800 m and 850 m levels with the shaft bottom at 900 m. A ramp system is used to access mine levels below the shaft with the deepest level now approximately 1,270 m below surface. A ramp also connects the underground workings with the surface. The mine is highly mechanized and uses primarily a combination of longitudinal and transverse longhole panel stoping. Stopes are backfilled with either paste tailings and cement or waste rock.

The plant has two processing lines. Ore is secondary crushed and then ground in an autogenous grinding (AG) and ball mill circuit. The zinc line has a processing capacity of approximately 1.6 million mt/y. A bulk concentrate is initially produced from the zinc-lead ore before further flotation to separate zinc and lead concentrates. Concentrates are thickened and filtered and then stockpiled. The plant operates a separate line to treat zinc-lead ore as well as copper ore.

Once the transaction is completed, Boliden will operate seven mining areas and five smelters, mainly focused on zinc and copper. Four of the seven mining areas are located in Sweden and one each in Finland, Ireland and Portugal. Boliden's *pro forma* concentrate production, including the expansion of Odda and the restart of Tara, will increase from 35% to 70% of zinc smelting capacity and 30% to 40% of copper smelting capacity over the coming years.

NMA Challenges MSHA's Silica Rule

The U.S. National Mining Association (NMA) said it has partnered with five allied trade associations in filing an opening brief challenging the Mine Safety and Health Administration's (MSHA) final silica rule in the U.S. Court of Appeals for the Eighth Circuit. The association emphasized that it did not challenge the

new 50 microgram per cubic meter permissible exposure limit (PEL) and said it remains fully supportive of the new, lower limits contained in the rule. However, the NMA said MSHA unlawfully imposed significant restrictions on methods for achieving the PEL.

Specifically, the NMA argues that MSHA's PEL is arbitrary and capricious given MSHA's restrictions on exposure controls, including the prohibition on job rotation and respirators to reduce silica exposure, which render compliance infeasible. The association argues that MSHA's determination of feasibility was defective because MSHA did not assess the standard prescribed, presented no evidence that any mine is currently achieving the PEL, and arbitrarily determined that success at some mines demonstrates feasibility.

The NMA also argues that MSHA introduced mandatory medical screening requirements divorced from any miner's actual exposure and that therefore these requirements are contrary to protecting the most-exposed miners. Finally, the association argued that MSHA's demand for initial sampling from all mines, regardless of circumstance, is arbitrary and capricious. The NMA asked the court to vacate the rule. The litigation partners include: the National Stone, Sand and Gravel Association; Texas Aggregates and Concrete Association; American Exploration & Mining Association; Portland Cement Association; and American Iron and Steel Institute.

Australia Approves Cowal Extension

Australia's New South Wales Department of Planning, Housing and Infrastructure approved and granted development consent for an open-pit continuation plan for Evolution Mining's Cowal gold mine.

The development consent is for the continuation of open pit mining with extension of the E42 pit and subsequent development of three new open pits, and continuation of ore processing at a rate of up to 9.8 million metric tons per year (mt/y). The mining lease extends to 2045.

"Since acquiring Cowal in 2015, the operation has been a cornerstone asset for Evolution delivering material cash flows and high rates of returns, which will now enable its continuation to at least

PDAC Organizes an Impressive Technical Program

The Prospectors & Developers Association of Canada (PDAC) will hold its annual convention March 2-5, 2025, at the Metro Toronto Convention Centre.

The event features cutting-edge programming and a trade show with more than 1,100 exhibitors. The 2024 PDAC convention attracted nearly 27,000 attendees from 138 countries.

"This year's convention emphasizes advancements in mineral exploration and mining technology, sustainability, and shaping the future of mining by strengthening partnerships with students and Indigenous communities," said Raymond Goldie, president, PDAC.

The programming includes technical sessions, short courses and keynotes covering topics such as commodities, geoscience, capital markets, and advancements in exploration and mining. Each of the four days has a keynote address:

- Sunday (March 2, 2025) BHP CEO Mike Henry will deliver the Commodity Outlook Keynote, *Building the World of 2050*;
- Monday (March 3, 2025) Eric Sprott, CEO, Eric Sprott Family Office, will deliver the Mining Industry Outlook Keynote, *Current Issues and Opportunities in Canadian Mining*;
- Tuesday (March 4, 2025) Flavia Tata Nardini, co-founder and CEO, Fleet Space Technologies will deliver the Technology and Innovation Keynote, *End-to-End: Space and AI's Path to Radically Narrow Exploration Search Space*;
- Wednesday (March 5, 2025) the Discovery of the Year Keynote, *The Onto-CU-Au Discovery, Sumbawa, Indonesia*, will be presented by David Burt, geoscientist, Cobre Nuevo Exploration, and Bede Evans, project director, PT Sumbawa Timur Mining.

The technical program has 14 sessions. The *New Discoveries* session will showcase the Mingomba Project, a major new tier 1 copper discovery and development in Zambia, along with the Oko West deposit, discovered by Reunion Gold. It is the latest major gold discovery in Guyana and was acquired recently by G Mining. Another high-grade gold mineralization is being explored on the Odienne Project in Côte d'Ivoire by Awale Resources and its partner Newmont. At the Andina project in the James Bay region of Quebec, Winsome Resources is developing the third largest lithium resource in North America according to the company.

A session titled, *Level-up Your Project Reserves Against Uncertainty and Risks* explores how stochastic methods can be leveraged to manage and quantify project development risks at every stage — from resource estimation, mine design and scheduling to infrastructure, social risks, and ultimate financial decisions.

The *New Exploration Technologies* session will focus on some of the latest tools and methodologies that are currently being adopted by the industry for mineral exploration.

On Tuesday evening, March 4, 2025, the PDAC hosts its Awards Gala & Nite Cap at the Fairmont Royal York Hotel. This event, often referred to as the Oscar's for the mining industry, is a tribute to the greatest achievements in the global mineral exploration and mining industry. For more information visit: www.pdac.ca.

The PDAC conference has a trade show for suppliers and an exchange for investors. (Photo: PDAC)

The Cowal haul trucks move about 10 million mt/y. (Photo: Evolution Mining)

2042," Evolution Managing Director and CEO, Lawrie Conway, said.

Cowal has achieved record annual gold production under Evolution ownership. In FY24, the operation produced 312,644 ounces (oz) at an all-in sustaining cost (AISC) of $1,338/oz. The underground mine reached commercial production in April 2024 and is positioned to ramp up to 2 million mt/y in FY25. Gold production in FY25 is guided to be 315,000 to 335,000 oz at an AISC of $1,700/oz to $1,770/oz.

Agnico to Acquire O3 Mining

Agnico Eagle Mines Ltd. has offered to acquire all of the outstanding common shares of O3 Mining Inc. at $1.67/share in cash by way of a takeover bid. The offer is valued at approximately $204 million on a fully diluted in-the-money basis.

O3 Mining's primary asset is its Marban Alliance property located near Val d'Or, in the Abitibi region of Québec, and is adjacent to Agnico Eagle's Canadian Malartic complex. The Marban Alliance property includes the Marban deposit, which is an advanced exploration project that could support an open pit mining operation similar to Agnico Eagle's Barnat open pit operations at the Canadian Malartic complex.

"Consistent with our regional strategy, this transaction is a tuck-in of the Marban deposit to our Canadian Malartic complex," Agnico Eagle President and CEO Ammar Al-Joundi said. "The Marban deposit is expected to be complementary to other 'fill-the-mill' opportunities at Canadian Malartic."

The potential integration of the Marban Alliance property to the Canadian Malartic land package will create significant and unique synergies by leveraging Agnico Eagle's regional operational expertise and existing infrastructure, including the Canadian Malartic mill and existing open pit workforce and equipment fleet.

"The all-cash offer at a significant premium to market is an excellent outcome for our shareholders and is validation of the efforts made by the O3 Mining team," O3 Mining President and CEO José Vizquerra said. "Having diligently advanced the Marban Alliance project over the past 5 years, the timing is right for O3 Mining to sell to a more experienced operator that can efficiently navigate the project through permitting and construction."

O3 Mining has estimated that the Marban pit contains 52.4 million metric tons (mt) of indicated mineral resources grading 1.03 g/mt of gold for 1.7 million ounces (oz) of gold and 1 million mt of inferred mineral resources grading 0.97 g/mt gold for 32,000 oz of gold (February 2022). O3 Mining also owns the Alpha property and the Kinebik property.

Norge Acquires Skaland Graphite

Norge Mining, through its Norwegian subsidiary Norge Mineraler Holding AS, has agreed to acquire Skaland Graphite AS, the biggest natural graphite producer in Europe, from the Australian mining company Mineral Commodities Ltd. (MRC).

"Skaland is a globally important graphite asset, and its acquisition is a major strategic step for Norge Mining in becoming an integrated supplier of critical materials to the Western world," said John Vergopoulos, CEO of Norge Mining. "Skaland has been in operation for several decades and represents a strategic complement to the minerals that we plan to supply from our critical mineral project in Eigersund, located southwest Norway."

The Skaland mine, which is the world's highest-grade operating flake graphite mine, is among the world's top four graphite producers outside of China. It is located in northern Norway on the island of Senja, approximately 200 km from Tromsø. Skaland produces about 10,500 metric tons per year (mt/y) of graphite.

The updated JORC-compliant mineral resource estimate (2021) for Skaland's underground Traelen graphite mine is 1.84 million mt at 23.6% total graphite carbon (TGC) in the category of indicated and inferred for 434,000 mt of contained graphite using 10% cut-off. Laboratory-scale test work by MRC to optimize the grade of the fines gave highly encouraging results with grades of 96%-99% TGC achieved.

Norge Mining believes there is also significant potential to increase the mineral resource at Skaland through further work. The transaction is expected to close in Q1 2025 following the conclusion of customary closing conditions and regulatory approvals.

Sitting on Norway's Senja Island, the Skaland plant produces about 10,500 mt/y of graphite. (Photo: Skaland)

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USFS Approves Stibnite Mine Plan

Perpetua Resources Corp. announced that the U.S. Forest Service (USFS) has issued the final record of decision (ROD) authorizing its mine plan for the Stibnite gold project in central Idaho. The company said this crucial permitting milestone comes after 8 years of thorough investigation, interagency analysis, consultation, and extensive public feedback on the proposed mine plan of operations. With receipt of the final ROD, Perpetua said it is now focused on advancing the project toward a construction decision, including finalizing the remaining federal and state permits and securing project financing.

"We are thrilled to receive our final ROD from the USFS," said Jon Cherry, president and CEO of Perpetua Resources. "This approval elevates the Stibnite gold project to an elite class of projects in America that have cleared the National Environmental Policy Act. The Stibnite gold project can deliver decisive wins for our communities, the environment, the economy, and our national security."

The Stibnite gold project is designed to redevelop the abandoned Stibnite mine site for gold, silver and antimony, while also providing environmental restoration to the dormant site. The company's vision to "Restore the Site" is embedded throughout the approved mine plan, which includes:

- Removing legacy tailings and waste to improve water quality;
- Restoring miles of river habitat and opening miles of native fish habitat that have been blocked for more than 80 years; and
- Providing a net benefit increase in wetland acres.

Expected to be one of the highest-grade open pit gold mines in the country, the project contains an estimated 4.8-million-ounce (oz) gold reserve and is anticipated to produce 450,000 oz of gold annually over the first four years of production. In addition, the estimated 148-million-lb antimony reserve is the only identified antimony reserve in the U.S. and is expected to supply roughly 35% of U.S. demand in the first six years of operations.

Antimony is considered a critical mineral for its role in technology, defense, and energy products. Recently, China, which is responsible for nearly half of all mined antimony output worldwide, cut off antimony exports globally. By securing a domestic mined antimony supply, the U.S. can reduce its reliance on foreign antimony producers and suppliers and strengthen its strategic mineral security.

In response to a Chinese export ban, Prepetua has proposed processing ore at the Sunshine mill (above) and refining antimony in Montana. (Photo: Sunshine Silver Mining & Refining Co.)

"After years of work to make the Stibnite gold project the strongest it can be, we are incredibly proud to have reached this milestone," said Alan Haslam, vice president of permitting for Perpetua Resources. "Obtaining USFS approval for our plan has taken the combined efforts and talents of so many people, and we are humbled to watch it graduate to the next phase of development."

In related news, in response to the Chinese export ban, Perpetua Resources Idaho, Inc. entered a memorandum of understanding (MOU) to explore antimony processing opportunities with the Sunshine Silver Mining & Refining Co., which is also based in Idaho.

Under the Sunshine MOU, they will evaluate the technical potential for processing and refining antimony from the Stibnite gold project at the Sunshine Mine Complex. The MOU will initiate third-party engineering to evaluate a flowsheet to suit different antimony ore types.

"Perpetua's MOU with Sunshine Silver is a step in evaluating a fully integrated American antimony supply chain," Cherry said.

"A fully American antimony supply chain is paramount for U.S. national and economic security," said Heather White, CEO of Sunshine Silver. "We are confident that Sunshine can process and produce high-grade antimony here in Idaho as we have done in the past. Collectively, Sunshine and Perpetua plan to work under the MOU to identify a framework to develop a truly end-to-end American antimony solution."

Perpetua has also agreed to conduct metallurgical testing of antimony concentrate samples with Montana-based U.S. Antimony Corp. "If we can do this in America, then we should do this in America," said Gary Evans, chairman of U.S. Antimony Corp. "U.S. Antimony has a long history of processing antimony products for American users and is dedicated to securing future capacity to meet increasing domestic demand."

Biden Signs Good Samaritan Bill

On Tuesday, December 17, 2024, the U.S. President Joe Biden signed into law: S. 2781, the *Good Samaritan Remediation of Abandoned Hardrock Mines Act of 2024*, which promotes remediation of abandoned hardrock mines.

The bill requires the Environmental Protection Agency (EPA) to establish a 7-year pilot program for 15 Good Samaritan remediation projects that will be implemented under EPA permit and oversight. Permit compliance avoids liability issues with the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, commonly known as Superfund). The

Senate and House initial bill sponsors included Sens. Martin Heinrich (D-NM), and Jim Risch (R-ID); and Reps. Celeste Maloy (R-UT) and Mary Peltola (D-AK).

Vale Base Metals Completes Voisey's Bay Expansion

Vale Base Metals said it had completed construction and commissioning of the Voisey's Bay Mine Expansion (VBME) Project. The expansion transitioned Voisey's Bay from open pit to underground mining. The project involved the development of two underground mines, Reid Brook and Eastern Deeps, which will deliver ore for processing at the company's Long Harbour refinery, one of the lowest-emission nickel processing plants in the world.

The project's production capacity is around 45,000 metric tons per year (mt/y) of nickel with another 20,000 mt/y of copper and 2,600 mt/y of cobalt as by-products, and the full ramp-up is expected by the second half of 2026. The company said the project completion also represents a crucial milestone for enhancing the competitiveness of its Canadian operations and will contribute to reducing unit costs in the nickel business segment.

BC Officially Charges Imperial Over Mt Polley

The Supreme Court of British Columbia has laid charges in relation to the failure of a tailing storage facility (TSF) at the Mount Polley mine that occurred more than 10 years ago. In total, 15 charges have now been approved to proceed by direct indictment against Imperial Metals Corp., Mount Polley Mining Corp., and Wood Canada Ltd. (Wood Canada Limitée) for contraventions of sections 35(1) and 36(3) of the federal *Fisheries Act* (R.S.C., 1985, c. F-14).

When the TSF failed at the Mount Polley mine, it was dubbed the largest environmental disaster in Canada. *E&MJ* reported on August 7, 2014, roughly 10 billion liters of water with 4.5 billion cubic meters of tailings flowed into Polley Lake. Hazeltine Creek, an outflow of Polley Lake, a 4-ft stream, had grown to a 150-ft wide discharge flowing into Quesnel Lake and further fouling the watershed.

The first appearance date was scheduled for December 18, 2024, in the Supreme Court of British Columbia, in Vancouver, British Columbia.

Arizona Sonoran Granted Amended Industrial Air Permit

Arizona Sonoran Copper Co. (ASCU) said it received an amendment to the Industrial Air Permit from the Pinal County Air Quality Division for its Cactus project, located near Casa Grande, Arizona. The amended Aquifer Protection permit has been applied for and is currently under review by the Arizona Department of Environment and Quality, ADEQ.

The amended Industrial Air permit pertains to a February 2024 pre-feasibility study (PFS) configuration, which excluded the MainSpring deposit. A subsequent preliminary economic assessment (PEA), incorporating MainSpring, was issued in August 2024 and supersedes the 2024 PFS. The 2024 PEA contemplates an operation expected to produce 116,000 tons of copper cathode per year over the first 20 years of a 31-year mine life.

ASCU said its regular communication and involvement within the community contributed to permitting success. Additionally, as part of the continuing community engagement strategy, the company recently completed an updated polling survey demonstrating support for the Cactus project of 87% within Casa Grande and surrounding areas.

"The issuance of the amended industrial air permit is yet another key milestone in the advancement of Cactus, a standalone operation requiring only permits from the state and local government as the Cactus Project sits entirely on private land with no federal permitting nexus," ASCU President and CEO, George Ogilvie said. "Cactus is a standout lower risk copper asset based on its tier 1 location, the permitting process, onsite infrastructure (including rail, road, power and water) the sizeable copper resource estimate, associated mine plan, related economics and first quartile capital intensity.

"Our team has done a tremendous job advancing the asset and navigating the streamlined state-led permitting process," he said." We look forward to continuing to advance towards PFS in H2 2025, and subsequently submitting final amendments ahead of a final definitive feasibility study (DFS) in 2026, project financing, and the construction and development decision. Additionally, we would like to thank Pinal County Air Quality Division, and the local communities for their ongoing support for the Cactus Project."

Mount Polley tailings flow from Hazeltine Creek into Quesnel Lake. (Photo: Chief Inspector of Mines for British Columbia)

Coeur Provides Silvertip Update

Coeur Mining, Inc. recently published the initial results of its 2024 exploration program at its Silvertip polymetallic critical minerals exploration project in northern British Columbia, which included the most extensive surface program completed by Coeur since acquiring the property in 2017.

The company said the $12 million,

(Continued on p. 12)


Georgie Bezette

Rio Tinto has appointed **Georgie Bezette** as its new chief people officer, succeeding **James Martin,** who retired at the end of 2025. Bezette joined the organization in 2008 and is currently COO-people, responsible for the transformation of the people function in support of Rio Tinto's ambitious cultural change journey.


Dr. Silvana Costa

Orla Mining Ltd. named **Dr. Silvana Costa** as its new chief sustainability officer. In this role, she will have executive level responsibility for Orla's environmental, social, and governance (ESG) efforts, in addition to guiding the company's internal and external stakeholder relationships. Dr. Costa brings more than 20 years of experience across various roles within the mining industry. She has held ESG leadership roles at companies such as Teck Resources, Equinox Gold, First Majestic Silver, and New Gold. Dr. Costa succeeds **Chafika Eddine,** who left the company to pursue doctoral studies.


Stephen Quin

Osisko Development Corp. appointed **Stephen Quin,** a seasoned mining executive, as independent director to the company's board of directors effective immediately. Quin has more than 40 years of experience across all stages of the mining industry, from exploration through operations and closure. Most recently, he spent a decade as president and CEO of Midas Gold Corp. (now Perpetua Resources Corp.) advancing a large-scale gold-antimony project from a maiden mineral resource through completion of a feasibility study. Prior to that, he held senior leadership roles including president and COO of Capstone Mining Corp. and, before its merger with Capstone, president and CEO of Sherwood Copper Corp.


Emma Chapman

Teck Resources appointed **Emma Chapman** as vice president, investor relations. She succeeds the retiring **Fraser Phillips.** Chapman joined Teck in 2023 as director, investor relations, and has nearly 20 years of experience in investor relations, including serving as head of investor relations at Anglo American Platinum.


Anne Wade

Anglo American announced that **Anne Wade** will join its board as a non-executive director. Wade is chair of Man Group plc, and is a non-executive director of Summit Materials, Inc. She spent the majority of her career in the asset management industry, largely with Capital Group, focused on infrastructure investment. In her non-executive career, Anne formerly served on the boards of Holcim Ltd. and John Laing Group plc.


Camilo Cordovez Amador

Forge Resources Corp. appointed **Camilo Cordovez Amador** as vice president of finance. He brings more than 16 years of experience in investment banking, asset management, capital markets, and project development across sectors such as mining, infrastructure, real estate, and energy.


Jérôme Le Berre

Jérôme Le Berre joined *Trinity International*'s Paris office as a tax law partner. An experienced tax lawyer, Berre brings with him two decades of expertise in the energy and natural resources sectors. Throughout his career, he has advised international clients on the tax and customs aspects of their investments, particularly in Francophone and Anglophone Africa.

Tom Knutzen has decided to step down as chair of *FLSmidth & Co. A/S* (FLS) after 12 years on the board and two as chair.


Mads Nipper

Succeeding Knutzen, the FLS board has recommended the election of **Mads Nipper,** who has been a member of the Board since 2022 and serves as the current Vice Chair. Nipper has extensive experience within management of global companies. He currently serves as CEO of the multinational renewable energy company Ørsted in Denmark and previously served as CEO of Grundfos and CMO at Lego.


Alanas Kraujalis

In related news, **Joshua Meyer,** president of the FLS mining service business line, and **Annette Terndrup,** group general counsel, are stepping down from their roles and will be leaving the company. Meyer left at the end of December and Terndrup's last day with FLS will be at the end of February 2025. Until a replacement for Meyer is announced, **Alanas Kraujalis** will support with day-to-day leadership of the service business line. He currently serves as senior vice president and head of consumables and has been with FLS for more than 10 years.


Paul J. Murphy

Alamos Gold mourns the passing of **Paul J. Murphy,** a board member for more than 14 years and chairman for the past nine years. Murphy joined Alamos as a director in 2010 and served as Chair since 2015, overseeing a period of transformative growth for the company. He was a partner of PricewaterhouseCoopers from 1981 to 2010, including serving as national mining leader from 2004 to 2010. Throughout his career, Murphy worked primarily in the resource sector, with a client list that included major international oil and gas and mining companies.

(Regional News-U.S. & Canada - from p. 11)

48-hole program totaling 21,000 meters (m) of drilling, achieved its three priorities of: drilling from underground to grow the known resource along-strike and down-dip; drilling large step-out holes on major structures to increase the deposit's footprint for future resource growth; and conducting district-scale field work to identify other structures similar to Silvertip with potential to host large ore bodies.

"Silvertip's three-pronged 2024 exploration strategy successfully expanded known areas of mineralization, doubled the strike length of the Southern Silver Zone to more than 2,000 m, and identified three new large targets located on our more than 50,000 hectare land package," said Mitch Krebs, chairman, president and CEO, Coeur Mining. "We anticipate continued exploration success in 2025 as we seek to expand the size and enhance our knowledge of this world-class deposit. We remain enthusiastic about Silvertip's potential to become a future high-quality source of growth for the Ccompany and an important future source of Canadian-based critical minerals."

The company said the underground drilling program extended the Southern Silver Zone by approximately 350 m along strike and the Saddle Zone by roughly 85 m along strike. Notable assay results include:

Southern Silver Zone

- Hole 65Z23-485-012-029: 5.8 m at 123.7 grams per metric ton (g/mt) silver, 2% lead, and 1.84% zinc;
- Hole 65Z23-485-009-005: 11.3 m at 47.4 g/mt silver, 0.36% lead, and 9.85% zinc; and
- Hole 65Z23-485-012-031: 4.5 m at 794.2 g/mt silver, 14.62% lead, and 12.32% zinc.

Saddle Zone

- Hole SDZ24-485-015-001: 6.6 m at 94.5 g/mt silver, 0.91% lead, and 13.98% zinc;
- Hole SDZ23-485-013-017: 7.8 m at 64.9 g/mt silver, 0.31% lead, and 15.07% zinc, and 4.2 m at 361.1 g/mt silver, 6.66% lead, 5.75% zinc;
- Hole SDZ23-485-013-021: 3.4 m at 133.4 g/mt silver, 1.68% lead, 10.77% zinc; and
- Hole SDZ23-PAD-007-003: 7 m at

(Continued on p. 19)

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Anglo Buys Serpentina Mine

Anglo American completed the transaction to combine the Serra da Serpentina high-grade iron ore resource owned by Vale SA into Anglo American's Minas-Rio operation in Brazil, following the agreement announced on February 22, 2024. The Serpentina premium-grade iron ore resource is contiguous with and will be integrated into Anglo American's Minas-Rio operation in Brazil, in partnership with Vale. Anglo American will continue to control, manage and operate the Minas-Rio operation, including future expansions related to Serpentina.

Under the terms of the transaction, Vale will transfer Serpentina and pay $157.5 million in cash to acquire a 15% interest in the expanded Minas-Rio. Vale also has the option to acquire an additional 15% interest in the enlarged Minas-Rio for cash if and when certain events occur in connection with a future expansion of Minas-Rio, the value of which will be determined at the time of exercise of the option.

"This is a compelling example of industrial logic, putting together the contiguous resources of Minas-Rio and Serpentina to unlock significant value," said Duncan Wanblad, CEO of Anglo American. "Integration will generate material synergies through use of Minas-Rio's infrastructure to accelerate the development of Serpentina. It's an outstanding resource with a total orebody strike length more than double that of Minas-Rio with a higher iron ore grade than Minas-Rio's premium-grade ore as well as softer, friable ore, which should translate into lower unit costs and capital required for its extraction.

"Integrating Serpentina creates scope to double our production of premium-grade pellet feed products for decades to come and so help our steelmaking customers decarbonize their processes," he said. "The Minas-Rio DRI-grade product already sells into one of the most attractive growth and premium segments available in our industry today. The optimal development pathway is already being assessed as part of the prefeasibility work, with new options created by the fact that we will now be able to access Vale's rail and port logistics."

The Serpentina mine in Brazil will be integrated into the Minas-Rio operation (above), in partnership with Vale. (Photo: Anglo American)

Alpayana to Takeover Sierra Metals

Alpayana S.A.C. announced its intention to launch an unsolicited all-cash takeover bid of Sierra Metals, Inc. The Sierra Metals board said it had not received any formal written offer from Alpayana. An Alpayana press release, however, indicated a price of C$0.85 per share ($0.59/share) to acquire all shares of Sierra Metals.

Alpayana is a Peruvian mining group that specializes in underground mining. The company operates four polymetallic mines in the central highlands of Peru: Americana, Yauliyacu, Iscaycruz and Morococha. In 2022, Alpayana acquired Empresa Minera Los Quenuales (formerly part of Glencore), incorporating the Yauliyacu (Huarochirí) and Iscaycruz (Oyón) polymetallic units. In September 2023, the company acquired Compañía Minera Argentum (formerly part of Panamerican Silver) with the Morococha mining unit in Junín.

A Canadian mining company, Sierra Metals operates the Yauricocha mine in Peru and the Bolivar mine in Mexico. Earlier this year, Sierra Metals received a permit to operate below the 1120 level at Yauricocha and in 7 months the operation has been able to increase throughput to 3,600 metric tons per day (mt/d), a 30% improvement over December 2023. The company said it expects Bolivar to operate at full capacity, despite lower projected grades due to a mining sequencing plan.

Rio Tinto Commits to Rincon Lithium Project

Rio Tinto has approved $2.5 billion to expand the Rincon project in Argentina, the company's first commercial-scale lithium operation.

Rincon's capacity of 60,000 metric tons per year (mt/y) of battery-grade lithium carbonate is comprised of the 3,000-mt starter plant and 57,000-mt expansion plant. Rincon's mine life is expected to be 40 years, with construction of the expanded plant scheduled to begin in mid-2025, subject to permitting. First production is expected in 2028 followed by a 3-year ramp up to full capacity, generating significant job creation and economic opportunities for local businesses.

"We are dedicated to developing this tier 1, world-class resource at scale at the low end of the cost curve," Rio Tinto CEO Jakob Stausholm said. "We are equally committed to meeting the highest ESG standards, leveraging our advanced technology to halve the amount of water used in processing, while continuing to grow our mutually beneficial partnerships with local communities and Salta province.

Located in the heart of the 'lithium triangle' in Argentina, the Rincon project consists of brine extraction using a production wellfield, processing and waste facilities, as well as associated infrastructure. The project uses direct lithium extraction DLE technology, a process that supports water conservation, reduces waste and produces lithium carbonate more consistently than other methods.

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Coronado to Open Mammoth Mine

Coronado Global Resources Inc. reported that its subsidiary, Coronado Curragh Pty Ltd, has received the relevant regulatory approvals required to commence underground mining operations at Mammoth mine at the Curragh Mining Complex, which currently comprises two open cut mines (Curragh North and Curragh South) at Blackwater in the Bowen Basin of Queensland, Australia.

Situated at the southern end of the Curragh North pit, Mammoth will enhance the current Curragh Mining Complex operations with an underground room-and-pillar operation, the company said.. First coal was mined on Thursday, December 19, 2024, marking the official opening of Mammoth.

Coronado's CEO Douglas Thompson said the opening of Mammoth will be an exciting step for Coronado, its shareholders and Queensland mining. "It will mark our first foray into underground mining in Australia and underpins our strategy of delivering organic growth to increase production and lower costs," he said. "We have combined our well-established expertise and heritage in underground mining from our U.S. operations with industry-leading local partnerships to deliver this mine. Mammoth is expected to continue our strong track record of realizing value from our existing assets."

Komatsu Australia provided Mammoth's new underground mining fleet. Coronado said a strategic collaboration brought together Komatsu's mining equipment excellence with its vision for a high-performance underground operation.

A blue Komatsu continuous miner arrives at the Mammoth mine site. (Photo: Coronado)

First ROM Coal Mined at Plumtree North

During late November, Australia's Bowen Coking Coal Ltd. announced the first run-of-mine (ROM) coal was mined at Plumtree North, at the company's Burton complex, ahead of schedule. This first ROM coal follows the recent completion of a partially underwritten A$70 million ($44 million) facility that provided Bowen with balance sheet flexibility to fund Plumtree North's development costs, pre-payments, guarantees and general working capital requirements.

"First ROM coal at Plumtree North was originally forecasted for Q3 FY2025," Bowen CEO Daryl Edwards said. "Our thanks go out to the Burton team, mining contractor and other contractors that are involved. We are extremely grateful to all shareholders for supporting us in our efforts to continue with mine development activities at the Plumtree North Mine, which is anticipated to provide ROM coal to the Burton complex for the next 5 years."

In related news, Bowen Chair Nick Jorss announced his plans to transition back to a non-executive directorship after the company appoints a new chairperson, which is expected to happen by the end of Q1 2025. In his chairman's address, which was delivered at the year, he told shareholders that the reports of coal's death are greatly exaggerated.

"Coal has a very strong future," Jorrs said. "It provides energy for life and is essential for the production of materials that support the way we live. It keeps our lights on and our energy bills down and provides the raw materials for making the steel we all need. It builds communities and underwrites much of our prosperity in Australia."

Bowen, alongside others in the coal industry, faced some significant challenges this year, Jorss said, including significant soft prices, wet weather, rail delays and increases in costs.

"The extreme state royalties tax increase introduced by Queensland in June 2022, just as we reached first production, continues to be a major impediment for the company," Jorss said. "The state's royalty take of$60.2 million this year soaked up all our pre-royalty operating cash flow for the year, which is extremely disappointing knowing how hard our team has worked."

Canopies protect the portals at the Mammoth mine. They were purpose-built with elevated designs for better water management and include a dedicated ventilation portal. Real-time highwall geotechnical monitoring systems are in place to keep people safe. (Photo: Coronado)

REGISTRATION IS OPEN

With several major coal mining operations within driving distance, Pittsburgh is the ideal setting for the U.S. Coal Show. In 2023, nearly 1,200 coal mining professionals attended the U.S. Coal Show, including 350 mining delegates from companies like Allegheny Metallurgical, Alliance Resource Partners, American Consolidated Natural Resources (ACNR), Arch Resources, Blue Mountain Energy, CONSOL Energy, Coronado Global Resources, Corsa Coal, Iron Senergy, Prairie State Generating Co., Signal Peak, Wolverine Fuels, and Warrior Met.

A total of 65 suppliers used 18,900 ft^2 to display the latest in coal mining equipment and technology in 2023. Manufacturers brought more equipment to the show floor, including five shields, two shield haulers, a locomotive, a mantrip and plenty of ancillary equipment.

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Barrick Threatens to Suspend Operations in Mali

Barrick Gold Corp.'s operating entities in Mali, namely Société des Mines de Loulo SA and Société des Mines de Gounkoto SA, submitted a request for arbitration to the International Centre for the Settlement of Investment Disputes, to address matters of disagreement with Mali regarding the Loulo-Gounkoto complex.

The Loulo-Gounkoto complex comprises two distinct gold mining permits, Loulo and Gounkoto, which are situated in western Mali, bordering Senegal and adjacent to the Falémé River. Both Loulo and Gounkoto are owned by Barrick (80%) and the State of Mali (20%).

Although it had previously agreed on a framework to resolve disputes with Mali over the Loulo-Gounkoto complex, Barrick said it has been unsuccessful in arriving at a final resolution despite numerous good-faith attempts to negotiate and a willingness to compromise beyond its legal rights.

Mali insists on forcing Loulo-Gounkoto to adhere to its 2023 Mining Code, even though it has no application to existing operations. Barrick said local operating conditions have deteriorated significantly. Its employees have been detained without cause and gold shipments have been blocked. If shipments remain blocked, Barrick said it will suspend operations, which will have a huge economic impact on Mali.

Over the course of nearly 30 years, Barrick has invested more than $10 billion in Mali, with its mines contributing 5% to 10% of the country's GDP annually, the miner said. In 2023 alone, the gold miner contributed more than $1 billion to Mali's economy. Loulo-Gounkoto remains one of the country's largest taxpayers and employers, with most (97%) of its 8,000-strong workforce comprising Malian nationals.

Since November 25, several senior members of Barrick's Malian management team have been detained on unfounded charges, accompanied by concerning actions such as baseless tax and customs claims and the reported issuance of an illegitimate arrest warrant for Barrick President and CEO Mark Bristow. This follows similar incidents involving senior executives from other mining operators being jailed.

As this is edition was going to press, Mali had enacted a gold export ban laying claim to the gold stocks at Loulo-Gounkoto. (Photo: Barrick Gold)

"Recent developments further erode investor confidence in Mali's mining sector and will deter future investment," Bristow said. "Nonetheless, in view of our long-standing commitment to the people of Mali, we remain open to constructive engagement with the government to resolve these issues while protecting the viability of this key economic driver for Mali." Bristow emphasized the need for negotiations to be mutual, respectful of existing agreements, and aimed at preserving the long-term sustainability of the mining sector in Mali.

During November, Resolute Mining, which operates the Syama gold mine in Mali, paid the Malian government $160 million to release three of executives, including the company's CEO Terence Holohan. The Resolute executives were in Bamako to hold discussions with the mining and tax authorities regarding general activities related to Resolute's in-country business practices, and to progress open claims made against Resolute, which the company maintains are unsubstantiated. Following the conclusion of these meetings on Friday, November 8, the three executives were unexpectedly detained. Resolute recently announced that Holohan would be taking an extended leave.

Civil Unrest Impacts Mozal Aluminum

South32 Ltd. advises that due to escalating civil unrest in Mozambique, the transport of raw materials to Mozal Aluminium is being impacted by road blockages. "We have implemented contingency plans to mitigate operational impacts, and we are working with relevant stakeholders," the company said. "We are withdrawing production guidance for Mozal Aluminium as we respond to the evolving situation. The safety and well-being of our people at Mozal Aluminium is our priority. Our workforce is safe and there have been no security incidents at Mozal Aluminium."

The Mozal Aluminium operation is the largest industrial employer in Mozambique and is made up of a smelter and transport infrastructure, just west of the capital city Maputo. It imports alumina to produce approximately 314,000 metric tons per year of aluminum.

If South32 were forced to take the smelter offline, analysts have estimated that restart costs could be as high as $200 million.

(Regional News-U.S. & Canada - from p. 12)

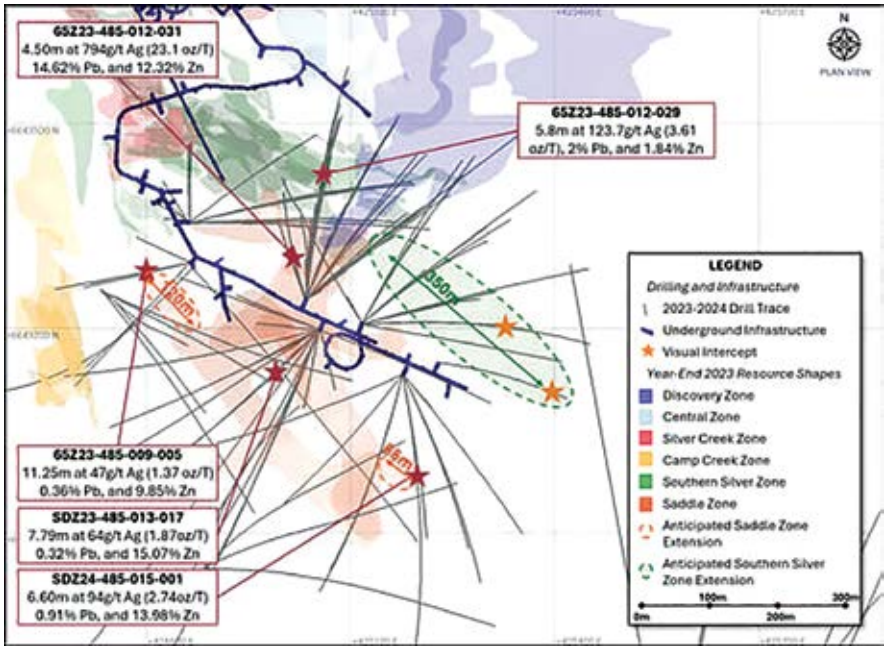
202.5 g/mt silver, 4.58% lead, and 7.0% zinc.

Coeur said the large drill step-outs on the Southern Silver Zone confirmed mineralization up to 1,000 m along strike, highlighting considerable growth potential. All five surface step-out holes were drilled up to 1,000 meters from the boundary comprising the 2023 resource and intersected significant visual massive sulphide mineralization. To date, assays have been received for two holes:

- Hole SSZ24-Pad34-001: 5.4 m at 119.1 g/mt silver, 2.79% lead, and 8.89% zinc; and
- Hole SSZ24-Pad34-002: 8 m at 197.5 g/mt silver, 2.94% lead, and 3.93% zinc, and 8.12 m at 11.3 g/mt silver, 0.11% lead, and 13.37% zinc.

The district-wide program included geophysical surveys over approximately 37,000 hectares to improve understanding of the geology and structure, which are primary factors controlling mineralization at Silvertip. Fieldwork included helicopter-supported reconnaissance geological mapping, as well as rock, soil and stream sediment geochemical surveys. Mapping has confirmed all areas have the same geological setting as the Silvertip deposit. Following on from the results of this work, Coeur secured an option from CMC Metals Ltd on approximately 10,000 hectares of additional prospective ground adjacent to Silvertip's current land package.

"The initial results of our 2024 drilling program have already successfully identified three high-priority targets that show grades and geology similar to the Silvertip carbonate replacement deposit (CRD) mineralization," said Aoife McGrath, senior vice president of exploration. "Our district-scale evaluation, including geophysical surveys plus stream and soil geochemical surveys, have set the groundwork for upcoming field programs and are already providing an enhanced understanding of regional geology and structure, in addition to the recognition of new possible mineralization centers. We expect other targets to emerge from this year's program as results are received, and I am confident that 2025 will be another very exciting year at Silvertip as we continue to explore and develop Silvertip as an emerging tier 1 CRD District."



Between March and October, diamond drilling underground at Silvertip encountered notable mineralization in both the Saddle Zone and the Southern Silver Zone.

Appellate Cout Dismisses En Banc Request on Mill Site Rule

Last week, the mining industry received good news regarding the litigation related to the Bureau of Land Management's (BLM) Mill Site Rule. Earlier this year, the D.C. Circuit Court of Appeals affirmed a lower court's determination that the law does not restrict the number of mill sites. At the time, it looked as if the mining industry had prevailed, but the plaintiffs (Earthworks) requested an *en banc* review, a full-court review, and the court dismissed that request last week. A legal battle that began in 2009 has finally ended.

FEBRUARY 3-6, 2025: **Mining Indaba, Cape Town International Convention Centre, Cape Town, South Africa.** Contact: Web: www.miningindaba.com.

FEBRUARY 23-26, 2025: **MINEXCHANGE. The annual meeting of the Society for Mining, Metallurgy and Exploration (SME), Colorado Convention Center, Denver, Colorado, USA.** Contact: Web: www.smenet.org.

MARCH 2-5, 2025: **The annual conference of the Prospectors and Developers Association of Canada (PDAC), Metro Toronto Convention Centre, Toronto, Canada.** Contact: Web: www.pdac.ca.

APRIL 6-9, 2025: **The Haulage & Loading Conference, Hilton El Conquistador, Tucson, Arizona, USA.** Contact: Web: www.haulageandloading.com.

APRIL 22-25, 2025: **EXPOMIN, Espacio Riesco, Santiago, Chile.** Contact: Web: expomin.cl/en.

MAY 4-7, 2025: **CIM Connect, Montreal, Canada.** Contact: Web: convention.cim.org.

MAY 20-22, 2025: **Global Resource Innovation Expo (GRX25), Brisbane, Australia.** Contact: Web: grx.au.

JUNE 3-5, 2025: **U.S. Coal Show, David A. Lawrence Convention Center, Pittsburgh, Pennsylvania, USA.** Contact: Web: uscoalshow.com.

Scaling Battery Electric Solutions for Underground Mines

Boliden's Jonas Ranggård unpacks the challenges and opportunities surrounding the roll out of battery-electric vehicles underground, and debunks some common battery-related myths

By Carly Leonida, European Editor

Electrification is a topic that's been steadily climbing the agenda for miners over the past five years. With corporate decarbonization targets fast approaching, operational costs increasing and a good range of battery-electric vehicles (BEVs) now commercially available for most applications, there are strong drivers for adoption, particularly at greenfield projects where the operational design and infrastructure can be optimized.

Battery technologies have come a long way too, with newer chemistries, advanced cooling for packs and fast charging options. But for OEMs and miners alike, scaling implementations of battery-powered mine trucks, in particular, is proving harder than initially thought. High prices, uncertainty surrounding the best charging solutions and the industry's apparent technological lag behind the on-road hauling sector, have left many miners waiting and wondering when to invest, or opting for diesel models instead.

Jonas Ranggård, Manager for Boliden Mines' Electrification Program, recently published a whitepaper outlining key considerations for the electrification of open-pit mines. Many points made in the paper, for instance, on battery pricing and suitability, are highly relevant for underground operations too.

"Battery electric machines for underground mines have been around for many years now, but often in a prototype or pilot form," Ranggård told me when we sat down in December to discuss the learnings within. "They're good machines but whether mining companies would be comfortable buying them at scale is another question.

"The challenge for us [Boliden] has been the lack of battery electric equipment for hauling, which is the biggest diesel consumer by far. More truck models are becoming available, but for many mines that most important piece of the puzzle remains to be solved."

Jonas Ranggård is Manager for Boliden Mines' Electrification Program.

Boliden is an early adopter of BEV technology; the company has used Volvo and Scania on-road trucks for underground hauling for many years and is now trialling battery electric versions of them. As Ranggård explained in his paper, it's becoming more common for mines to lean towards battery solutions that originate in on-road haulage.

"Sure, these vehicles are not as ruggedized [as those designed specifically for mining]," he told *E&MJ*. "They don't live as long, perhaps they don't have the same payload, but they're faster and cheaper, and they're also very cost effective to electrify because of the high-volume battery solutions that they carry."

He added that the whitepaper (which is available on Ranggård's Linkedin page for those interested in receiving a copy) was born out of learnings from a large-scale request for information — the research step conducted prior to a request for quotation — that Boliden conducted a few years ago as part of work towards its 2030 carbon dioxide reduction targets.

"We asked for approximately 20 battery haul trucks of 300-t capacity each for our Aitik operation," said Ranggård. "The whitepaper was the result of our frustration as to the answers we got. We felt like there was a large discrepancy between what was happening on the public road and what's happening in mining, and I wanted to highlight that.

"Many of the learnings are applicable for underground mines as well, especially when it comes to the adaptation of high-volume battery solutions. For example, the energy throughput cost comparison with diesel when it comes to operating expenditure (OPEX) is essential in producing an accurate business case."

Chemistries: Safety and Performance

While there are various battery chemistries available on the market, Ranggård explained that there are only two likely to be used in high volumes in both on-road and mine haulage applications in the near future: nickel-manganese-cobalt (NMC) and lithium-iron phosphate (LFP).

"Comparing NMC and LFP there are not any dramatic differences," he stated in the paper. "NMC was previously seen as the chemistry that would dominate the automotive market due to the higher energy density. What has happened in the past years though is that LFP has evolved to be 'good enough,' with its lower prices and reduced dependence on controversial metals, such as cobalt, allowing LFP to overtake NMC in the upcoming years in terms of market share."

The same is true in underground mining applications. "It's basically just a reflection of the public road," he ex-

plained to me. “Though we do see a significant shift towards LFP chemistries now. In Europe, legislation was introduced which focused on enabling NMC battery plants, and LFP was almost ruled out due to its lower energy density which means a lower travel range. However, LFP chemistries have become better, and they cost much less than NMC, so pricing has overtaken technical capability in mining companies’ decision making. I think, over time, LFP will continue to gain market share.”

Safety is another concern that can dominate sales discussions. LFP batteries have demonstrated higher safety characteristics than NMC and also some upsides when it comes to fire safety. However, as Ranggård explained in the whitepaper: “based on years of electrification on public roads — where so far NMC has been dominating — EVs are significantly less likely to catch fire than a combustion engine car. So, disqualifying battery vehicles in mining using NMC is not justified.”

Boliden has used Volvo and Scania on-road trucks for underground hauling for many years and is now trialing battery electric versions of them. (Photo: Boliden)

Why so Expensive?

As Ranggård stressed in the whitepaper: vehicle batteries are cheap, and a throughput cost higher than $100/MWh — the current price point for on-road trucking — is unjustifiable. Chinese suppliers have a significant head start in terms of both product and market maturity thanks to their close collaboration with large battery manufacturers and their high-volume, low-cost approach.

“The mining industry’s one-sided focus on productivity and payload creates a push for sub-optimal solutions that rely on dynamic charging. In fact, truck OEMs should aim for way bigger batteries to increase charging speed, driving speed, usability and a lower depth of discharge,” the paper stated.

I was surprised to learn that batteries are so cheap and told Ranggård so.

“Battery pricing is definitely affecting sales of mining trucks today,” he told me. “Boliden has been running battery-electric trucks for years and, in our experience, the OPEX increases the more we use them because the batteries are so expensive. But there’s a very important difference between being an early adopter and paying a premium for that or accepting that a solution is not cost effective. We can’t accept a situation where mining battery batteries continue to cost four times more than what we see on the public road, because that will not help the energy transition.”

Do you see a lot of mining companies hanging back, waiting for prices to come down? I asked.

“Yes, but I also see a lack of understanding of how much cheaper BEVs are in other industries,” he replied. “I fear that mining companies see the price tags of mining-specific BEVs and think that batteries are just expensive, so this concept will never take off. But that’s not true. It’s just that those specific batteries are expensive. If we look in other directions, it’s possible to source much cheaper solutions.”

The Need for Plug-n-play Batteries

Currently, no mining OEMs make their own battery cells, but most produce their own battery packs. In the automotive industry, where BEV production volumes are high, the cell is the most expensive part of the pack – packaging accounts for less than 25% of the cost. However, Ranggård explained that, when BEV production volumes are low, as they currently are for mining applications, the opposite tends to be true.

In the paper, he stated: “Mining OEMs try to carry out extremely complex development in-house that can’t be spread over a large volume of products and then try to claw back development cost from a few consumers.”

Ranggård expanded on this for me: “Because mining OEMs are sourcing battery cells in low volumes to build their own packs, they tend to pay a higher price for them,” he said. “For cell manufacturers, mining is a distraction from their core customer base, which is automotive suppliers. I think we need to treat battery solutions as, essentially, Lego blocks, and use them to create the best possible product for mining.”

In practice, this would involve OEMs creating a standardized space and interface on their vehicles for the battery pack, and then taking a flexible approach towards sourcing them based on cost and performance.

Another interesting point raised in the paper is that mining-specific ruggedized battery packs are simply not necessary. Boliden has conducted various tests to ascertain this and Ranggård debunks the myth in his paper.

“There is a misconception that the mining application is so unique it demands mine-specific packs,” he stated. “This could not be further from the truth. Sure, some extra safety barriers are needed in harsh conditions to protect from falling rocks etc, but it does

Trolley assist technology for underground haulage in use at Boliden's Ravliden operation in Sweden. (Photo: Epiroc, Boliden and ABB)

not justify designing an entire pack from scratch. Ruggedized phones are extremely rare; most people/companies just buy a common smartphone with a protective case. The same will apply for battery packs for mining."

He explained that ruggedized batteries also tend to have poor energy density, and by adding more kilowatt hours in capability, companies are also adding a lot of weight to their solution. Cheaper, mass produced but lower density batteries, don't carry that payload penalty.

"A bigger battery pack also means that mines could potentially charge their batteries faster which could offer productivity improvements," said Ranggård.

Battery Swapping vs Static Charging

Which led us nicely to the subject of battery charging solutions and their suitability. For open-pit operations, there are only two real options: static or dynamic charging. Capital expenditure (CAPEX) for trucks increases with static charging. However, the CAPEX for dynamic infrastructure almost eradicates that difference. Meanwhile, for

underground fleets, battery swapping is also an option.

"The underground market is beginning to lean away from battery swapping and towards fast charging," Ranggård told me. "When we [Boliden] began using BEVs underground, we found that we could use 'opportunity charging' to lower the need for battery swapping. We've also seen good results with dynamic charging at our Ravliden operation, but trolley assist for underground mines is a niche solution. It requires a long-life operation with a long, relatively straight ramp and relatively high tonnages.

"While that technology is a good fit for Ravliden, it's unlikely that we'll be able to use it at our other underground mines. The flexibility that static fast charging offers underground operations is hard to beat."

Electrify Haulage Now or Later?

Ranggård's whitepaper goes deep on battery pricing because, as he stated, "it's integral for planning the rollout of battery trucks and the required infrastructure. When using high battery prices, OPEX, in turn, increases due to high energy throughput costs, pushing the case for dynamic charging on a false premise."

For open-pit mines, Ranggård is pessimistic about the speed of the transition to battery-electric haulage due to the current lack of supporting infrastructure. "The problem right now for all suppliers is that, frankly speaking, it will be challenging for them to scale as there are few customers ready to roll out battery trucks beyond a pilot or test truck," he wrote of the open-pit BEV market.

"Many mining companies have made bold claims on fast decarbonization and electrification, but they haven't even electrified their shovels or drilling rigs yet. These represent lower hanging fruit than trucks and if these aren't electrified then there's a long way to go providing electric infrastructure and know-how to enable a large battery truck rollout."

Underground operations, however, have the advantage of extensive existing electrical infrastructure, for example, for ventilation, lighting and power.

"When we run simulations and calculations for underground operations, we don't typically see any dramatic power increase [with BEVs] as the ventilation can be adjusted with the removal of diesel," Ranggård told me. "The speed of the transition will go much faster underground, and there are significant potential savings when it comes to ventilation."

He added: "Overall, I'm positive that the electrification of underground mines will continue at a steady pace, but there will be large variations between different markets. I think we'll see a more dramatic increase in adoption in approximately five years, once the heavy trucking side has started to ramp up production."

As Ranggård pointed out in his paper, the 'elephant in the room' is that, while electrification makes financial sense for some markets, for others it won't for many years.

"With cheap enough diesel and expensive electricity, the business case will be non-existent, even if the batteries were free," he stated, but concluded: "When implemented correctly, they [battery electric trucks] could dramatically lower mine operating costs. Miners should continue to push to electrify, especially if they have access to low-cost (and clean) electricity."

Making Electrification Accessible to All

Sandvik outlines its latest battery-electric technologies for underground load and haul and drilling operations, including a new modular platform under development

By Carly Leonida, European Editor

"Five years ago, battery-electric vehicles (BEVs) were mostly for new mines or expansion projects that wanted to try something different," Tuulia Åhlman, BEV Business Development Manager at Sandvik Load and Haul, told *E&MJ*. "Now, they've become a viable option, even for mature mining operations."

Arttu Pirttilahti, BEV Program Manager, Sandvik Underground Drilling agreed: "Today we have several customers who are considering or have already made a move towards a fully electric mining fleet. Sandvik has had battery-electric underground drills in its offering since 2016, but in recent years there has been a clear rise in demand that we are expecting to continue for coming years."

Sandvik's Underground Drilling division launched a new lithium iron-phosphate (LFP) battery technology for its battery electric drills in 2024. The result is improved drill performance with a stable battery chemistry.

"Our LFP batteries are robust and purpose-built for harsh mining environments while providing significant improvements, such as 50% further tramming distance, 20% more tramming speed uphill, and reduced charging time by 55%," explained Pirttilahti.

"The longer tramming distances enables more mines to consider BEVs instead of diesel. Our Charging While Drilling technology also makes BEV implementation easy and these machines can operate side by side with a diesel fleet."

The LFP battery technology will be implemented as standard for all battery-electric underground drills in 2025, including new products coming in the BEV drill offering. For customers with the existing Sandvik sodium nickel (SoNick) battery technology, Sandvik has created a retrofit kit to upgrade their machines to the new LFP technology, meaning they too can benefit from the additional performance improvements.

"We will also continue to develop the LFP technology to further enhance the performance and safety capabilities," said Pirttilahti.

The Toro LH518iB is Sandvik's latest battery-electric loader. (Photo: Sandvik)

LH518iB, Integrating Electrification and Autonomy

The Toro LH518iB is Sandvik's latest battery-electric loader. This can be integrated with AutoMine for autonomous operation.

Jouni Koppanen, Product Line Manager Automation, Digital Mining Technologies Division, added: "These BEV loaders are currently in operation at many customer sites around the world, several of them running in automation. The Toro LH518iB is an excellent example of the synergy between electrification and automation. The high-power electric driveline delivers unparalleled performance without being constrained by mine ventilation limitations. The result is exceptional acceleration, faster ramp speeds, and highly efficient bucket filling, enabling superior productivity in challenging underground environments."

"Sandvik's patented AutoSwap and AutoConnect systems for BEVs further streamline operations," added Koppanen. "The AutoSwap system eliminates the need for large-scale infrastructure, such as overhead cranes, for battery replacements at the mine site. With AutoMine, operators can seamlessly execute battery swaps from a Remote Operator Station, ensuring a safe, convenient, and efficient process that optimizes uptime and operational continuity."

Åhlman added that Sandvik Load and Haul has just introduced a training simulator for the Toro LH518iB loader — the company's first for a BEV. "We expect that to be appreciated by our customers and Sandvik own employees," she said.

Sandvik also offers a variety of training simulators for underground drills, including for the DD422iE and DS412iE BEV drill models. A new training simulator will be added to the offering in early 2025, for the DL422iE battery-electric production drill.

Options to Suit all Operations

The Sandvik load and haul R&D team is currently working on a new modular electric product family, of which BEVs are an integral part.

Åhlman explained: "Not all our customers are ready to transfer from diesel-powered machines directly to BEVs. They need a stepping stone in the middle and that is where modularity kicks in.

"We're working on a product family that is based on an electric driveline, and around that, we can build different technologies and products that will meet customer demands. BEVs are one significant element in the electric and modular product family."

Åhlman stressed that ultimately each customer and mine are different and may have different needs or possibilities when selecting technologies and equipment. "BEVs are just one of many options," she told *E&MJ*. "The future will be a mix of different technologies depending on the customer's needs, and we expect that BEVs will play an important and growing part of this mix."

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Construction Advances at Hermosa

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A Message from Arizona Mining and Industry Get Our Support – AMIGOS

Mark Davis, Chairman

Sydney Hay, President

AMIGOS membership numbers are exploding! It's a great time to be in mining — an industry that's more important today than perhaps any time in our history. Technological innovations are progressing at light speed increasing demand for copper, zinc, manganese, silver, gold, lithium, rare-earth elements, and more. The future of mining is bright and exciting.

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Founded in 1974, AMIGOS stands for Arizona Mining and Industry Get Our Support, but it really means "friends." That friendship is proved daily by every AMIGOS member, not only as they provide the best-of-the-best in goods and services to mines close to home and around the globe but also as they stand up to be counted whenever the mines need support.

More than 350 members strong, AMIGOS firms play key roles in projects locally and globally, with a strong employment presence in Arizona. And, while our members work on projects throughout the world, mining must continue to thrive here at home. Our members will do all that we can to get new projects up and running while we continue to support long-time pillars of Arizona's thriving economy.

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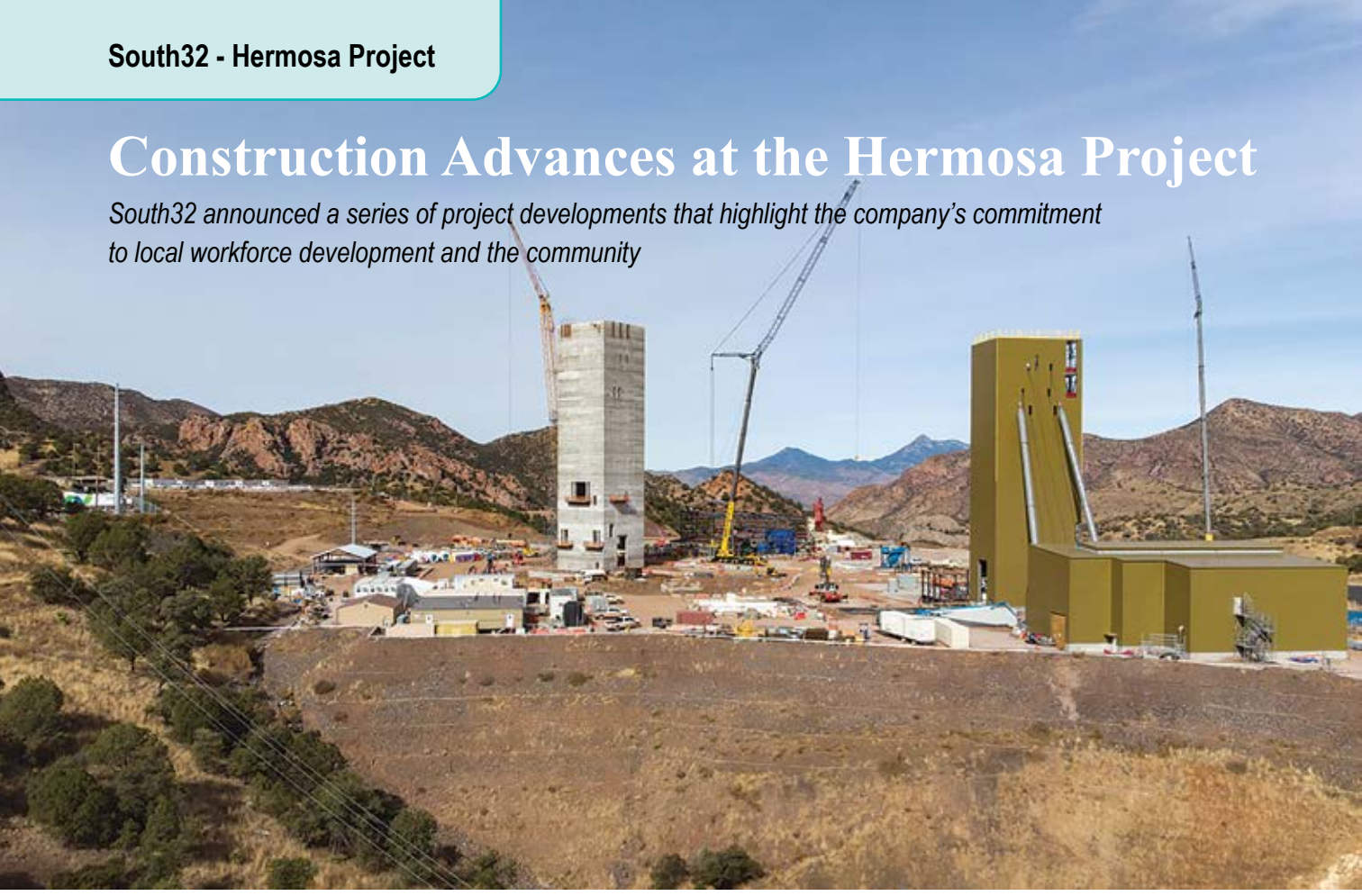
Construction Advances at the Hermosa Project

South32 announced a series of project developments that highlight the company's commitment to local workforce development and the community



The headframe for the main shaft at the Taylor deposit was recently completed. (Photo: South32)

Development activities are taking shape at South32's Hermosa project. At the beginning of last year, the South32 board approved $2.16 billion in funding to proceed with the development of the Taylor zinc-lead-silver deposit. In May the Department of Defense (DoD) under the Defense Production Act (DPA) battery grant program awarded the project $20 million to help accelerate the domestic production of battery-grade manganese, while in September, the U.S. Department of Energy (DOE) awarded the project $166 million from its Battery Materials Processing and Battery Manufacturing program, supporting the potential development of a commercial-scale battery-grade manganese production facility. More recently, South32 announced more projects that should inspire the surrounding communities.

Located in a historic mining district in the Patagonia Mountains of southern Arizona, South32's Hermosa project is currently the only advanced mine development project in the U.S. that could produce two federally designated critical minerals, manganese and zinc. The project consists of the Taylor polymetallic underground development project, the Clark battery-grade manganese deposit and an extensive, highly prospective land package with the potential for further polymetallic and copper mineralization.

Construction activities are underway and on track at the Taylor deposit. Project permitting is continuing through the U.S. FAST-41 process, which provides a permitting dashboard to allow federal agencies, project sponsors, other stakeholders, and the public to track project reviews and permitting in real time - delivering improved transparency, accountability and coordination. Exploration of other prospects in the Hermosa land package is continuing, including ongoing work to test the potential for a continuous copper system connecting the Peake deposit and Taylor Deeps.

The focus at Taylor is on shaft sinking activities and the associated infrastructure needed to access the zinc deposit. The design of the underground mine will enable South32 to develop the project with a surface footprint of just 750 acres, a fraction of the footprint of other mining projects. This is, as South32 emphasized, a key example of its commitment to sustainable development of the resources at the project site.

"Progress continues as South32 looks to help provide a sustainable, domestic source of critical minerals important to our nation's energy security while creating job opportunities in Santa Cruz County," said Pat Risner, president of South32 Hermosa. "We also recently announced key developments that will reinforce our commitment to improving lives for generations to come for Santa Cruz County residents and help South32 keep its workforce and project development on schedule."

These developments include an electrician certificate program partnership with Santa Cruz Center Pro-

visional College District and Pima Community College; a first look at the conceptual design for Centro, Hermosa's planned remote operations center in Nogales; local education initiatives; and construction activities that will help streamline access to the project site.

Accessing the Taylor and Clark Deposits

Overall site construction is about 30% complete. The main shaft headframe for the Taylor deposit has been completed and commissioning of the hoisting system for the ventilation shaft is underway. In early June 2024, a 258-ft tall headframe was constructed in an 11-day non-stop concrete pour. Hoisting ropes are currently being installed. The installation of mechanical and electrical equipment at both shafts has been completed.

South 32 has contracted with Redpath for shaft sinking activities and that work has commenced. Total depth of the ventilation shaft will be 2,702 ft, and the main shaft will be 2,947 ft. The first ore is expected by mid-2027.

The design for Taylor as assessed by the feasibility study is a dual shaft underground mine, employing a long-hole, open-stoping mining method with paste backfill. The mine has been designed to minimize its environmental impact, featuring a small footprint underground mine with efficient water use and dry-stack tailings.

South32 said the investment in the Taylor deposit will unlock value for future growth options at Hermosa, including the Clark battery-grade manganese deposit, by establishing significant shared infrastructure. It is located up-dip from the Taylor deposit.

Decline construction to access the Clark deposit has commenced and it's past the 600-ft mark. The decline will provide a means for bulk sampling and enable further underground exploration. Access to the deposit is scheduled for the end of 2025. Clark has the potential to integrate with Taylor's underground mine to realize operating and capital efficiencies. The company said the engineering and fieldwork for the zinc processing facility is progressing as scheduled.

Developing a Homegrown Workforce

South32 Hermosa's Workforce Development Taskforce members have formed an educational program design and facilitation committee with an immediate focus on bringing Pima Community College's Electrician Certificate program to the Santa Cruz Center Provisional College District. The committee will use the taskforce members' collective expertise, while leveraging the partnership between the two colleges.

Electricians are among the first jobs needed to build Hermosa but have some of the longest required educational programs. South32 said the need for employees with electrical skills is definitive and will not change based on equipment selection, infrastructure set-up, and other operational decisions.

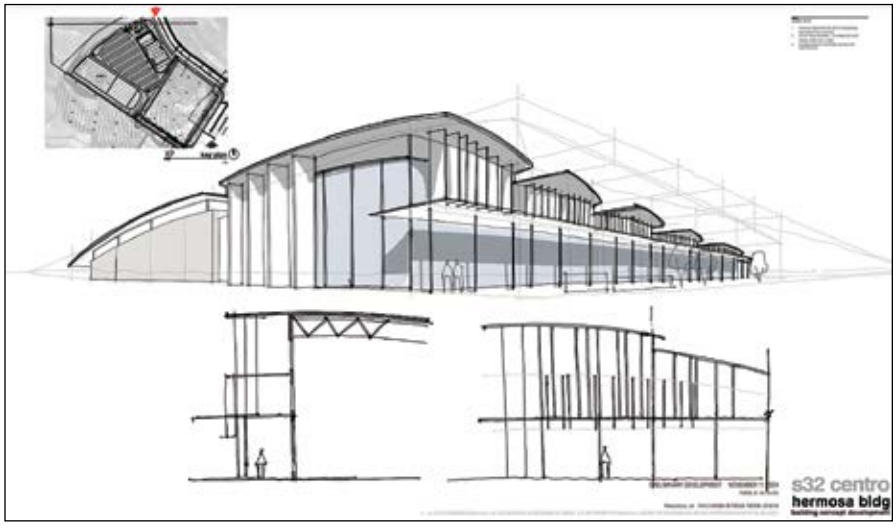
"South32 is committed to developing a homegrown workforce needed to operate Hermosa and support our broader community by prioritizing local hiring," said Skylie Estep, human resources director, North America for South32. "We look forward to replicating these workforce training opportunities, which will help us meet our target of hiring 80% of the South32 Hermosa full-time employees from Santa Cruz County. These careers will provide labor income equal to two times the average household income in the county, while creating broader economic and educational benefits in the community."

The taskforce will use the electrical program as a blueprint for future programs intended to equip Santa Cruz County residents with the technical skills needed for other skilled trade and operational careers.

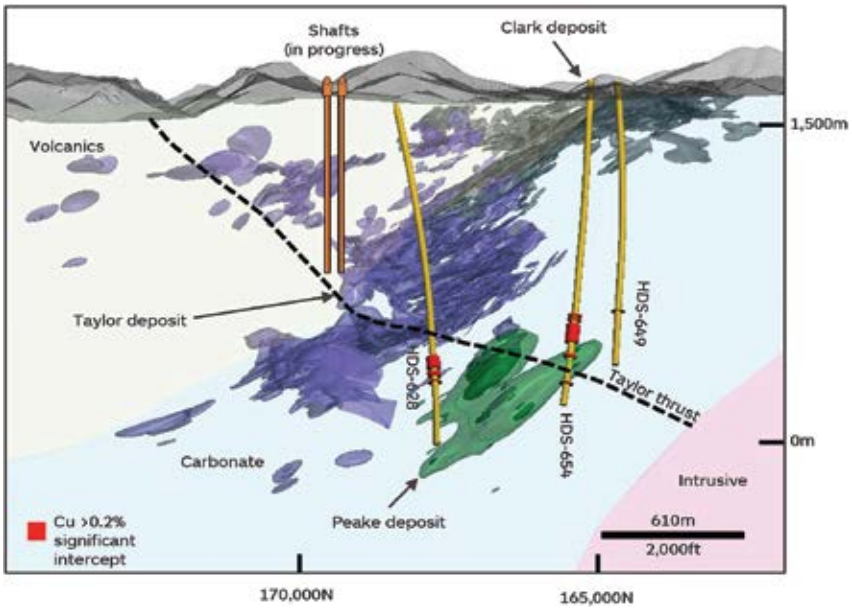
Program enrollment will begin in September 2025. The program is open to more students than needed for Hermosa in the immediate term to create opportunities for further education and employment in other industries or sectors in the community.

Designed With Perspective and History in Mind

South32 and its architectural partner, RAH Architects, released the conceptual design for Centro, the remote operations center to be built in Nogales. While still in the early stages, release of the design is meant to help demonstrate that Centro is developed



Taking inspiration from the Nogales Public Library and other landmarks, the Centro facility will be designed so that it nests into the horizon lines of the site and topography of the surrounding area. (Image: South32)



The Clark deposit lies up dip from Taylor and could share the same underground infrastructure. (Image: South32)

in alignment with South32's commitment to partner with the community.

The prospective design renderings weave elements of the southern Arizona landscape and the rich design history of the local community, taking inspiration from the Nogales Public Library and other landmarks. The end product is an initial design that nests into the horizon lines of the site and topography of the surrounding area.

"We are designing the Hermosa project with state-of-the-art technology to make it more accessible to individuals without mining experience, including extensive use of automation technology, with part of our operations running remotely at Centro in Nogales," Risner said. "It's our goal to make sure our partnership with Santa Cruz County permeates every aspect of how we design and build the facility so that the community is reflected in our work."

Designed to be a commercial building with an office-like setting, Centro will accommodate employees and the automation technology needed to remotely monitor and operate some of the underground and surface equipment located at the mine site.

Centro will host around 200 full-time employees for mine operations over several shifts in a 24-hour period as well as functional support staff. The facility will be part of a 10-acre complex that will also include a warehouse, an employee parking lot, a park-and-ride service area to take employees and contractors to the company's other sites, and a garden. Construction is expected to begin later this year.

Expanding Opportunities for Santa Cruz County Residents

South32 also announced a grant of $206,000 to the Santa Cruz County School Superintendent's Office to provide funding for five local educational programs that promote STEM and education access across the county. In total, South32 has provided more than $2 million since 2018 to support educational resources in our schools.

"School programs like Technolochicas and the Santa Cruz County Literacy Bus, that uplift our children with the technology skills and educational foundation needed to thrive in the 21st century and compete for good paying jobs, are important to promoting and enriching the well-being of our students and families," said Santa Cruz County School Superintendent Alfredo Velásquez. "The vision to make these programs and others a reality would not have been possible without the continued support of South32 and their commitment to making a positive difference in our community."

"This year's donations align with our commitment to making a positive difference through shared value and investments in our community that help expand the skills and opportunities for residents of and around Santa Cruz County," Risner said.

The five programs funded this year include:

- Technolochicas Lift, an after-school STEM education program for middle school-aged girls that connects them with successful Latinas from the field;
- Elementary Robotics, an after-school program teaching robot assembly, functions, and mechanics to students in grades 3-5;
- SCC Continuing Education Program, a program that offers workforce training, high school equivalency, and second-language programs to adult learners;
- The "Santa Cruzer" Literacy Bus, a mobile library for schools and institutions in underserved communities; and
- The Los Padres Home Visitation Program, a program supporting early childhood education services to 50 families across Santa Cruz County.

Cross Creek Connector

South32 has safely completed the Cross Creek Connector bridge following a 10-day construction period. The Connector is an access bridge and road that will allow the project to increase site transport while reducing traffic through Patagonia.

"We understand how materials traveling to and from the Hermosa project site is a concern for the community, so we prioritized safely completing the Cross Creek Connector to

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40 Ton F&L Combo	40/45 Ton ADT	777D/F/G	785B/C	789C/D	793C/D/F - 830E	797B/F		
D6T LGP	D8T LGP	D9T	D10T	D11T				
938	950	966M/744K	844K/980K/M	988H/K - WA900	992/922G			
20-47 Ton HEX	65-90 Ton HEX	120-200 Ton HEX	EX2600	EX3600	EX5500/ EX5600/PC5500	PC7000	PC8000	
16M	24M - 24							
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allow Hermosa personnel and trucks to bypass the Town of Patagonia, providing greater safety and security for the community and our team," said Andy Thompson, vice president of project delivery for South32 Hermosa.

The Investment Decision

South32's announcement of board approval of $2.16 billion in funding for the Hermosa project represents the largest private investment in southern Arizona's history, and the largest investment in the local Santa Cruz County economy to date by a factor of nearly nine.

The Hermosa project was the first critical minerals mining project added to the U.S. FAST-41 permitting process and it has the potential to be one of the world's largest zinc producers. South32 believes the investment will put Arizona in the driver's seat of the clean energy race, supplying a critical mineral needed for the expansion of renewable energy and associated infrastructure.

"The investment decision represents a major milestone for our business and aligns with our strategy to reshape our portfolio toward commodities critical to a low-carbon future," said South32 CEO Graham Kerr.

"South32's Hermosa project will strengthen the domestic supply of critical minerals needed for clean energy technologies and national defense, reducing America's reliance on foreign countries and transforming the local economy," Risner said. "It's a win for Arizona and the nation."

The operation has been designed to minimize its environmental impact. It is projected to use approximately 90% less water than other mines in the region. Additionally, the Hermosa project is embracing sustainability and advanced technology in its next-generation, underground mine design, using automation and technology to drive efficiency and lower its operational greenhouse gas emissions.

South32's investment will fund construction of a host of key infrastructure projects needed to implement that design, including water management systems, power, site facilities, underground shaft sinking, initial underground development and other work required to begin operations around the zinc deposit.

Once completed, this infrastructure would support future potential development of other deposits at the site, including the Clark deposit.

Vital exploration work continues at the Hermosa core shed. (Photo: South32)

Critical Minerals Unlock New Opportunities

Used in renewable energy battery storage, wind turbines and electric vehicles, zinc is a key component in the process to galvanize steel needed for infrastructure projects like roads and bridges. Global zinc demand growth is expected to outpace production by approximately 3 million metric tons (mt) by 2031.

Only 6% of zinc is currently produced in the United States and that total is forecasted to drop by 2030. Citing its importance for national security and economic growth, the U.S. government designated zinc a critical mineral in 2021.

The Taylor deposit has the potential to be a globally significant producer of base metals with an estimated initial operating life of 28 years. It is a carbonate replacement style zinc-lead-silver massive sulphide deposit, with an estimated 153 million mt mineral resource, averaging 3.53% zinc, 3.83% lead and 77 g/mt silver.

Development of the Taylor deposit is aligned to South32's purpose to improve people's lives now and for generations to come by supporting jobs in a community where unemployment is almost double the state average and a quarter of residents live below the poverty line.

Once in operation, the Hermosa project across its separate zinc and manganese deposits would help transform and grow the local economy and could create up to 900 good-paying jobs and support investment in the community. If both deposits move forward as proposed, at peak operation, that includes:

- Developing a homegrown workforce with the next-generation skills needed to operate the Hermosa project. The Hermosa project has an 80% local workforce goal, with the vast majority of employees living and working in Santa Cruz County to ensure downstream economic benefits for the entire region.

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- Supporting another 1,600 indirect and induced jobs across Santa Cruz County and 3,100 indirect and induced jobs statewide.
- Adding $1.4 billion to Arizona's economy annually with $999 million going directly into Santa Cruz County's economy. Hermosa-related economic activity is expected to nearly double Santa Cruz County's property tax base, providing funding for public schools, services, and community college.

DOE Selects Hermosa for Development Grant

During September 2024, the U.S. Department of Energy (DOE) selected the Hermosa project for a $166 million award negotiation from its Battery Materials Processing and Battery Manufacturing program.

While the development of the facility and manganese deposit at Hermosa is subject to further study, it represents a significant opportunity to establish a North American supply chain of battery-grade manganese in line with market development. On a cost-share basis and subject to final negotiation, the DOE will provide 30% of the cost of the manganese production facility, up to the grant award of $166 million.

Originally funded as part of the Bipartisan Infrastructure Law, the grant is part of a larger DOE announcement of $3 billion for projects across the United States that are working to ensure the nation has a viable domestic battery materials supply chain for electric vehicles (EVs) and other energy storage technologies.

"The DOE grant will help advance development of our state-of-the-art, commercial scale battery-grade manganese production facility. This project has the potential to provide a reliable, lower carbon and cost-effective domestic option for manganese products within the electric vehicle battery supply chain that currently relies entirely on imports," Risner said.

There has been no manganese ore mining in the U.S. since the 1970s, and more than 95% of the current production of battery-grade manganese is currently in China. Hermosa could be scaled up as the only fully integrated source of battery-grade manganese for EV battery chemistries sufficient to supply the emerging North American market. Based on a third-party life cycle assessment, South32's production from its deposit at Hermosa is projected to be the lowest carbon impact project in manganese chemicals in North America.

As part of meeting future demand, South32 is engaging potential customers to advance product qualifications for battery manufacturing, including potential agreements for future supply which follow from already signed non-binding Memorandums of Understanding, and continuing discussions with more than a dozen additional potential customers. This includes sharing samples from an initial pilot plant phase where it has consistently met product quality thresholds, and where technical discussions with potential customers will assist in the next phase of development. Hermosa's sustainability credentials, product quality and fully integrated local source of ore allow for domestic production that South32 expects would be cost competitive.

South32 will invest more than $30 million in workforce development, prioritization of local procurement, support for community organizations, and tribal engagement and education efforts. This is part of the $2.16 billion investment announced by the company.

"This grant highlights how important Hermosa and Santa Cruz County are to boosting America's energy security in a way that creates economic opportunities across southern Arizona," Risner said. "Hermosa's planned, state-of-the-art manganese production facility can help us safely onshore development of a critical mineral."

The funding follows a $20 million award to the Hermosa project from the Department of Defense's Defense Production Act Investment (DPAI) Program to help accelerate the domestic production of battery-grade manganese.

Because South32 could build Hermosa from scratch, the company is using state-of-the-art technology and industry best practices to enhance safety for employees and the surrounding community, which will include establishing a baseline assessment of existing community exposure.

An exact location for the facility has not yet been determined, but will be in southern Arizona, and timing and progress towards the facility's potential development will be determined by the evolution of North American market demands. Development is expected to be phased-in over the coming years.

South32 said the Hermosa project aligns with its purpose to make a difference by developing natural resources, improving people's lives now and for generations to come. Development of the manganese deposit and production facility will, in addition to South32's existing investment in the Taylor zinc development, also help support jobs in a community.

Hermosa's land package also includes several prospects for further exploration, with a high priority corridor identified on the site. The most advanced near-mine exploration target is the Peake copper-lead-zinc-silver prospect, located south of the Taylor deposit — with further exploration drilling at Peake planned across this year. Another notable prospect is Flux, which is located approximately 5 km from Taylor and Clark, immediately downdip of a historic mining area. Flux has the potential to host Taylor-like mineralization, with the results of the first drill hole considered to be supportive of further exploration potential. Exploratory drilling programs are ongoing at Peake, Flux and other prospects.

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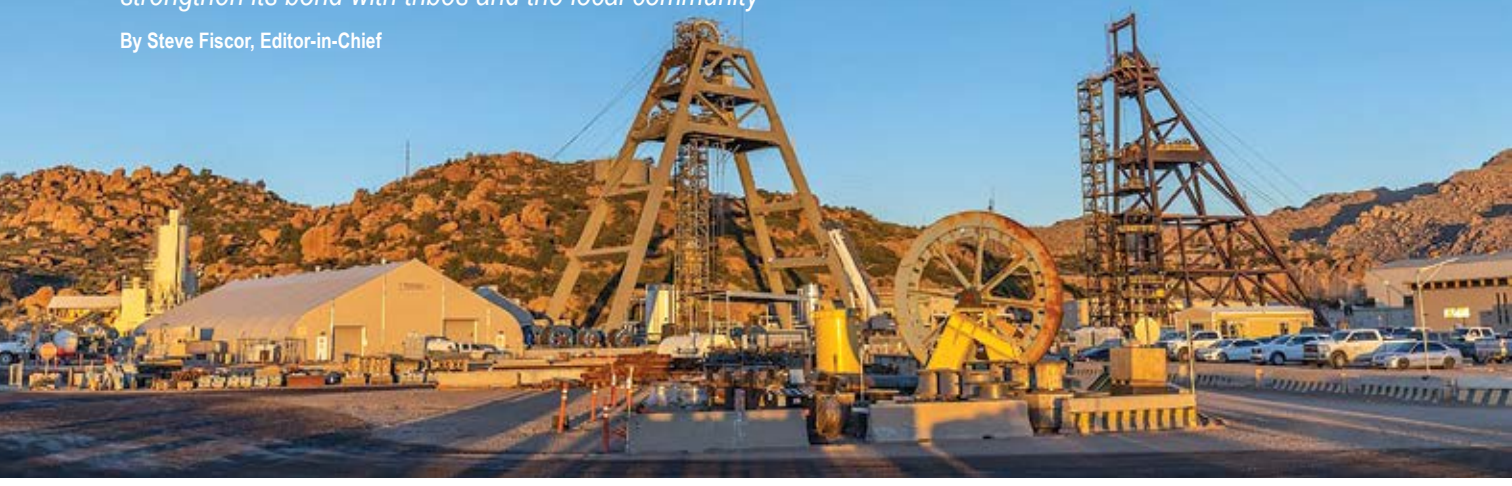
Building Bridges: Strengthening Community and Cultural Bonds in Modern Mining

Recognizing cultural heritage and the need to keep stakeholders informed, Resolution Copper continues to strengthen its bond with tribes and the local community

By Steve Fiscor, Editor-in-Chief



The No. 10 (left) and No. 9 headframes tower over the Resolution project, located near Superior, Arizona. (Photo: Resolution Copper)

Resolution Copper looks to develop a world-class underground copper mine in the footprint of the Magma copper mine, near Superior, Arizona. The project is a joint venture owned by Rio Tinto (55%) and BHP (45%). The ore in this area lies nearly 7,000 ft deep and it represents one of the most promising untapped copper deposits today. The mine has the potential to supply nearly 25% of U.S. copper demand.

Mining in this region, known as the Copper Triangle, dates back a hundred years or more. While an underground mine would have less environmental impact than an open-pit operation, several Native American tribes who have a connection with the land and the surrounding communities are familiar with the legacy of previous mines. To move the project forward, Resolution has been focused on community engagement while it manages the permitting process.

Last year, Resolution, the surrounding communities, and other organizations signed the Good Neighbor Agreement, forging a commitment for a two-way dialogue that will provide both sides with a means to meet the needs and interests of citizens, protect the environment and communities, help drive the local economy, support regional infrastructure, and plan for anticipated growth. This is one example of several processes that Resolution is using to engage with its neighbors and those that have a cultural interest the land.

During December, Vicky Peacey, president and general manager for Resolution Copper, delivered the keynote address at the annual conference of the American Exploration & Mining Association (AEMA). Peacey started her career in 2001 as a project engineer at the Bingham Canyon mine in Utah, covering engineering, technical studies, environmental and reclamation. Seeing an opportunity, Peacey moved to Michigan in 2008 to assist with Rio Tinto Nickel's Eagle mine, where she helped develop and implement a strategy to successfully permit a new greenfield underground mine, concentrator and tailings facility, which was eventually sold to Lundin Mining. In 2010, she joined Resolution, covering external affairs, permitting, and cultural heritage. Peacey was promoted to her current position in March 2023.

Peacey spoke about how mining can serve as a transformational force for economic empowerment, especially in rural communities where most mines operate. She referred to Resolution as a story of opportunity. "It's much more than a mining project and like all other new mines, it's really an opportunity to redefine mining in America," she said.

The Lay of the Land

The Copper Triangle, the area bound by the communities of Superior, Globe, Miami, Kearny, Hayden and Winkleman covering Pinal and Gila Counties, southeast of Phoenix, hosts rich copper orebodies, as the name implies. In addition to mining, it also has a diverse make-up that includes ranching as well as Hispanic and Native American cultures.

The deposit that Resolution wants to develop is not only rich in copper — 2 billion tons at 1.5% copper — it but also hosts many other critical and strategic minerals. Much of the underground infrastructure, which includes two shafts and some lateral development, has already been developed. "You could just almost point a jumbo toward the ore body and get started today," Peacey said.

The numbers tell the story, Peacey explained. "Once in operation, the mine would generate $61 billion in economic opportunity for the state of Arizona, but it's more than pounds of copper,"

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she said. "It's a story about people and families. In a region where there is double digit unemployment, we have 350 people that report to our operation and count on us for a job every single day. That job allows them to live in the communities where they were born and raised. Most (90%) of those people are from the San Carlos Apache tribe or the town of Superior and the other small cities and towns in between."

Once the mine is in full operation, Peacey estimates that it will provide 3,700 direct and indirect jobs. "We intend to grow the workforce, and train and upskill locally," she said. "It will be a tremendous opportunity for local residents, and it would empower the region economically."

Until the late 1980s, the United States was globally dominant in mined and refined copper, with nearly 100 mines, and 22 smelters and refineries, Peacey explained. "Since that time, we haven't seen new copper mines be permitted," she said. "Today, the U.S. has less than 10 operating copper mines. The U.S. only has two operational smelters and refineries today. Yet we have some of the best undeveloped deposits in the world, specifically copper, but others as well.

"It's no exaggeration to say that minerals power the world, and we are going to need a lot more minerals in the future," she said. "There is no reason to think that the U.S. can't have a vibrant mining economy. And there's bipartisan acknowledgment in America that the permitting system for large infrastructure projects needs reform."

The Permitting Process

Timeframes for permitting for wind and solar power generation, transmission lines and mining projects have grown in recent years to 10 years, and even decades in some cases. At a time when critical minerals demand is growing, permitting delays are already blocking important projects.

The federal permitting process is really comprised of two parts, Peacey explained: there's the administrative process with its environmental review documents and then judicial review. "The general mine plan of operations for Resolution Copper was deemed complete in 2014," she said. "At the same time, we received a land exchange. Federal permitting was initiated in March 2016, followed by a draft environmental impact statement (EIS) in 2019, then a final EIS and draft record of decision (ROD) in early 2021. This amount of progress in less than five years for something of our scope and scale is really quite remarkable."

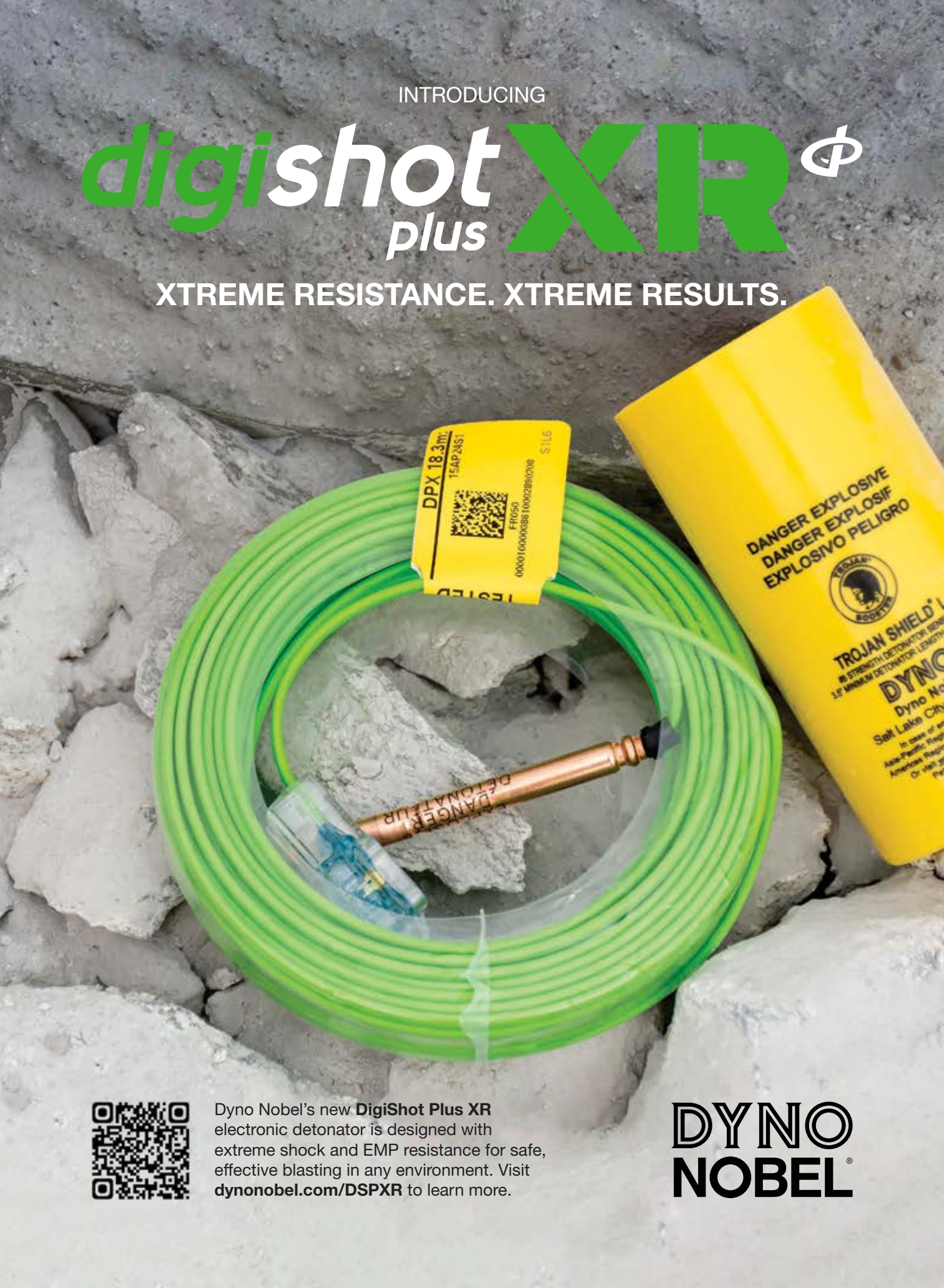
She attributed much of that success to the U.S. Forest Service (USFS). "They coordinated with a dozen state and federal agencies, 11 Native American tribes, the six local communities on our doorstep and a million other stakeholders at the same time," she said. "That was really how we got through the process." Unfortunately, all of that would be rescinded due to litigation.

Peacey said Resolution is at a crossroads where they can see a brighter future. "Thanks to the good work of industry groups like the AEMA, we're pulling together the tools and the resources to align and bridge this gap," she said. "We now have better collaboration between the industry and government and better collaboration with communities and Native American tribes."

Looking back at the last 10 years, Peacey said there was no single recipe for success, but she has learned some valuable lessons, such as early engagement with agencies, communities, and tribes. "That really worked very, very well for us," she said. "What also works is transparency and the sharing of information, everything, every analysis. We published every study on a website so everybody could see it. Everybody could understand what we were doing and what we were analyzing. It opened discussions of impacts and mitigation as well as benefit sharing."

Ultimately, the process funnels many voices into one outcome. "We have six local communities on our doorstep and 11 Native American tribes have ancestral ties to the area," Peacey said. "Some of the tribes, the O'odham, the Pueblo of Zuni and the Hopi have ancestral ties going back thousands of

Resolution Copper project restored the former Magma Copper west plant site tailings to a bright plane of topsoil and dry riverbeds. (Photo: Resolution Copper)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Rio Tinto CEO Jakob Stausholm (tallest person in the middle) stands with the volunteer group that cleaned up the Belvado baseball field. (Photo: Resolution Copper)

years and evidence of their ancestral presence are everywhere."

Historically, mining has created legacy environmental impacts, and historic operations in the Copper Triangle are no exception. Everyone in the mining business is working hard to change both mining methods and public perception, Peacey explained. "We operate mines differently today," she said. "Before we can have a dialogue with local communities about a new mine in their backyard, however, we must address the issues that linger from legacy mining. Working with local communities, Resolution has invested $75 million reclaiming the historic Magma mine.

"Some homes were located as close as a few hundred feet from the old tailings dumps," she said. "We have turned this area around and it looks much better now. In the process of doing so, we established a lot of trust with the community, which gave us an opportunity to build capacity in the Copper Triangle."

Peacey mentioned that one of the mine's contractors was a home renovation contractor based in Globe, Arizona, 10 years ago. Today, that contradictory employs hundreds of people. Most (90%) are from the San Carlos Apache tribe, and they are delivering multimillion dollar projects at Resolution and bidding across Arizona for other big mining projects.

Good Neighbor Agreement

Peacey referred to the Good Neighbor Agreement as a co-design process. "We wanted to build trust with local communities," she said "We laid everything out for them to see so they could really understand the impacts and the benefits. They met with us monthly for a period of 10 years and provided input on the design of the mine, helping us relocate pipelines, power lines, and major project facilities. The Good Neighbor Agreement formalized a process that has been in place for 10 years."

Historically, Good Neighbor Agreements have been established between U.S. Government Agencies, like the USFS, and communities to foster better communication, ensure safety and build trust. In this case, the agreement outlines in general how the communities, governmental entities, businesses, organizations and Resolution Copper intend to work together to resolve potential issues. For an area that knows the cyclic nature of the mining business and the legacy issues surrounding it, Resolution said this agreement stands in stark contrast from the days of company towns and disregard for the environment.

All six Copper Triangle communities signed the Good Neighbor Agreement, as well as Pinal and Gila Counties and about a dozen groups and organizations, Peacey explained. "It's a good faith commitment to have a two-way dialogue and transparency over the life of the project," she said. "Some of the tribes that have ancestral ties are in New Mexico, six or seven hours away. While it wasn't practical to bring everybody together in the same forum. We were able to develop relationships with Native American tribes that have deep ancestral ties to the area with the help of the USFS."

Similar to the work with local communities, the co-design process with Tribes was advanced in parallel. Before the EIS was developed, Resolution funded a 3-year ethnographic study so it could work with the tribes to identify all the traditional cultural properties and areas of significance. "There are hundreds of ancestral sites in the Southwest, and this allowed us to identify" areas of particular concern," Peacey said. "We managed to avoid 24 of the 25 traditional cultural properties and special places."

For the one area that Resolution could not avoid, Oak Flat, it managed to avoid disturbing 70% of the area by foregoing portions of the orebody and agreeing to do that in the EIS process. "Working with the tribes through our regular consultation process, we can now take that landscape level approach and then get very granular with it," she said.

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Resolution's Tribal Monitor Program was born out of this process. As part of it, the tribes performed baseline surveys and they worked alongside professional archeologists, biologists and water resource specialists, analyzing five different alternatives in detail, Peacey explained. "Tribal members collected all the information themselves," she said. "And not just ancestral sites, but seeps, springs, riparian areas, medicinal plants, animals, geologic features, and minerals. And they were able to report to their elders and consulting officials. They were their eyes and ears on the ground."

The Good Neighbor Agreement and the Tribal Monitor Program allowed true informed decision making, Peacey explained. "This is how we were able to give everyone a seat at the table and redesign the whole mine to avoid hundreds of ancestral sites, dozens of seeds and springs, all the riparian areas and many, many more areas that were important to them. It really deepened our relationships with the communities and the Native American tribes.

The Tribal Monitor Program opened the doors to other opportunities, like the co-management of heritage on private lands. The company is currently co-developing a cultural heritage management plan with the tribes.

Building Trust

Another way to build trust is to let communities and tribes monitor the company's activities, Peacey explained. "We must report the same information to federal or state agencies, so why not include the communities and tribes?" she said. "We regularly report on our activities and compare results. This has been ongoing for about five years now and it's been very, very successful. It lets you stand in the feet of tribes or communities and see the issues through their eyes. Similarly, they can stand in your shoes and see the issues through your eyes."

The local communities have ancestral ties to the land as well. The Copper Triangle has an important Hispanic heritage, Peacey explained "Because most of our workforce is largely Native American or Hispanic, we also celebrate this heritage," she said.

During consultation process with Tribal elders and the USFS, Resolution learned that a specific tree species, called an Emory Oak, was at risk. The species has cultural significance to Western Apache tribes in Arizona. "According to elders, few new, young trees were sprouting because of overgrazing, and invasive species and shrubs leaving only more mature Emory Oaks," she said. "So, we worked with Northern Arizona University, the USFS and Tribal elders to develop and implement a plan to restore Emory Oak groves across Arizona.

"What we're really trying to do in the mining industry today is coexist and there are pathways to do it as long as we all can talk and work things out," she said. "The future is bright. Domestic mining could empower rural communities and tribes, and create jobs and thriving hubs of innovation, while preserving cultural heritage. Resolution Copper is working hard to attain this future vision."

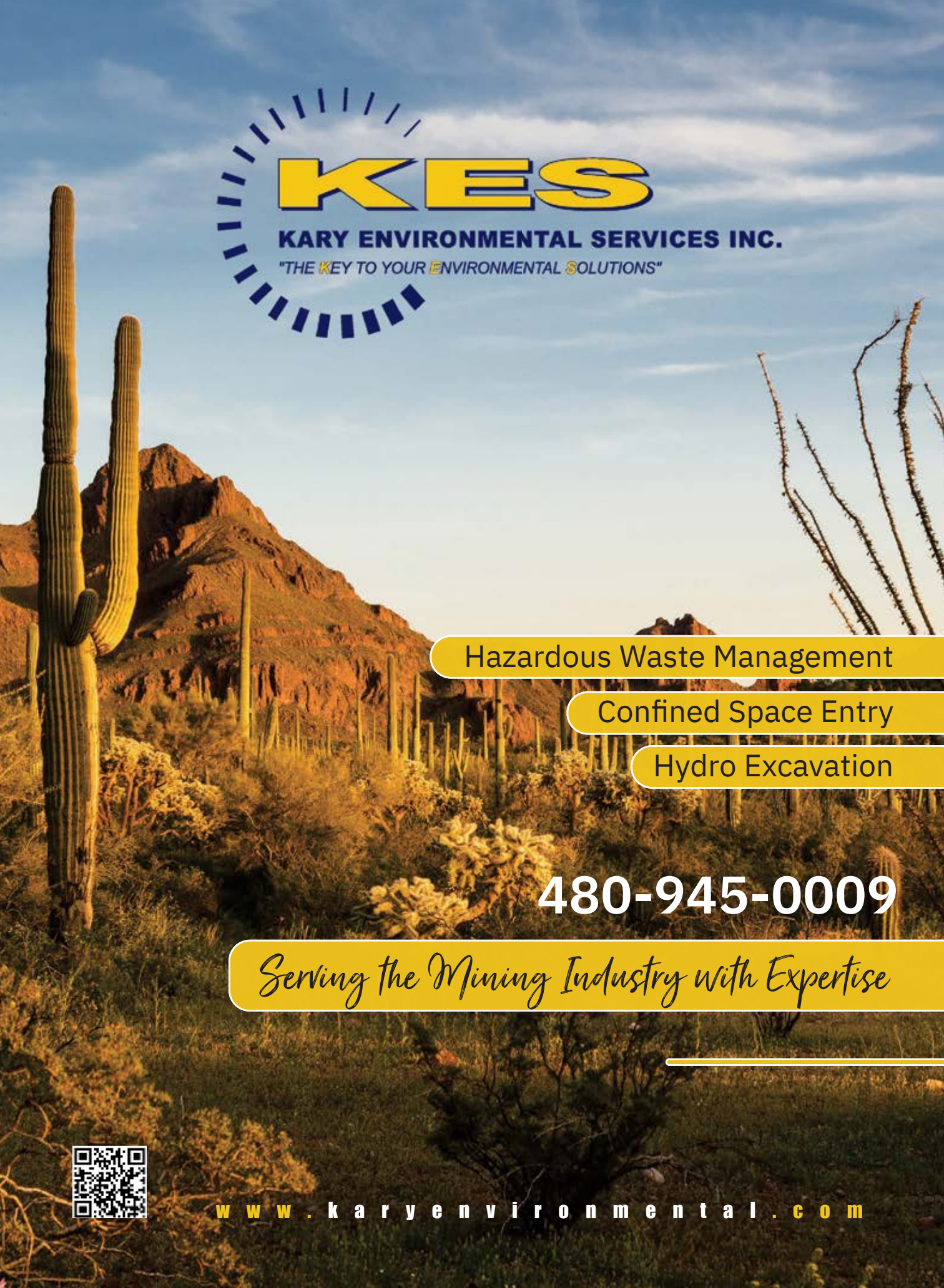
Shaft sinkers stand on the lower level of the Galloway at the bottom of the No. 9 shaft. (Photo: Resolution Copper)

No. 9 Shaft Sinking Galloway Completed

During July 2024, Resolution Copper announced the successful completion of the No. 9 Shaft Sinking Galloway project. This critical project, which involved extensive structural and electrical upgrades, brought the No. 9 Shaft up to 2024 standards.

This project was essential to ensure the safe deepening of No. 9 Shaft, involving comprehensive structural and electrical upgrades. It required the removal of three decks along with their support columns, electrical cables, and hydraulic lines. A new state-of-the-art electrical system was installed to meet Redpath's 2024 shaft sinking standards. Dedicated shaft and mechanical crews rehabilitated the remaining structural components, installed new load cells, fairleads, machined deflection sheaves, repaired concrete buckets, and completed collar steel repairs.

Collaboration was key to our success. This monumental effort took 24,481 man-hours. The site engineering team provided crucial support throughout the project, ensuring all mechanical components were meticulously inspected and maintained. The safety team played a pivotal role, offering continuous training and support to all crews, prioritizing safety every step of the way.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"Even in the digital age, some traditional processes in mining operations are indispensable due to their proven reliability, simplicity, or unique contributions," Lammers said." These traditional methods serve as our foundational bedrock, which, when augmented with modern technological advancements, can significantly enhance operational efficiency and effectiveness."

With ever-changing technological advances, mining has also adopted better tools for the extraction of minerals, taking care of safety and sustainability, Lammers explained, "technological innovation in mining is critical for several reasons. It significantly enhances operational efficiency, safety, and environmental sustainability in an uncertain labor market. By implementing cutting-edge technologies, mining companies like ASARCO can reduce its environmental footprint, increase the safety of its operations, and optimize resource extraction."

Technology will continue to advance and implementing it into mining operations will be a constant challenge for the industry, Lammers explained. "ASARCO's operations have been marked by a continuous search for improvements in efficiency, safety, and environmental sustainability," she said. "Starting with the incorporation of advanced process controls and enterprise visualization software to the adoption of machine learning and advanced data analytics, each technological advance has been aimed at enhancing decision-making, optimizing operations, providing total transparency and minimizing environmental and safety risks."

Throughout its history, ASARCO has always been characterized by being at the forefront of mining processes, and this spirit lives on today, Lammers explained. "ASARCO currently has several innovation projects underway, all aimed at enhancing model predictive controls across various processes," she said. "These projects include leveraging froth flotation cameras to fine-tune the levels and reagent additions in flotation cells, employing TIMining Aware for 3D and online visualization of the mine from remote locations, and unifying data from the Mine, Mill, and SX/EW into two comprehensive tools; AVEVA PI Vision and Microsoft Power BI."

ASARCO is committed to deepening its integration of AI and machine learning within its operations by developing predictive data models and leveraging advanced data analytics. In addition, the company is investigating leveraging robotics and autonomous mining equipment to enhance productivity.

Regarding the company's 125th anniversary and her track record with the company, Lammers takes pride in being part of ASARCO. "Having spent 23 years at ASARCO, it's profoundly gratifying to lead efforts in driving innovation and ensuring the company's relevance for the future," she said. "This role is not just about overseeing complex operations or leading technological advancements; it is about stewardship; guiding ASARCO to be a responsible member of the communities we operate in and shaping it into a place where our children would be proud to work.

"For me, working at ASARCO is more than a role; it is a commitment to maintaining a legacy of excellence and a dedication to paving the way for future generations," she said. "It is about creating a legacy that merges the stability and respect of the past with the innovation and sustainability of the future; a legacy that makes ASARCO not just a leader in the industry, but a beacon of opportunity and responsibility."

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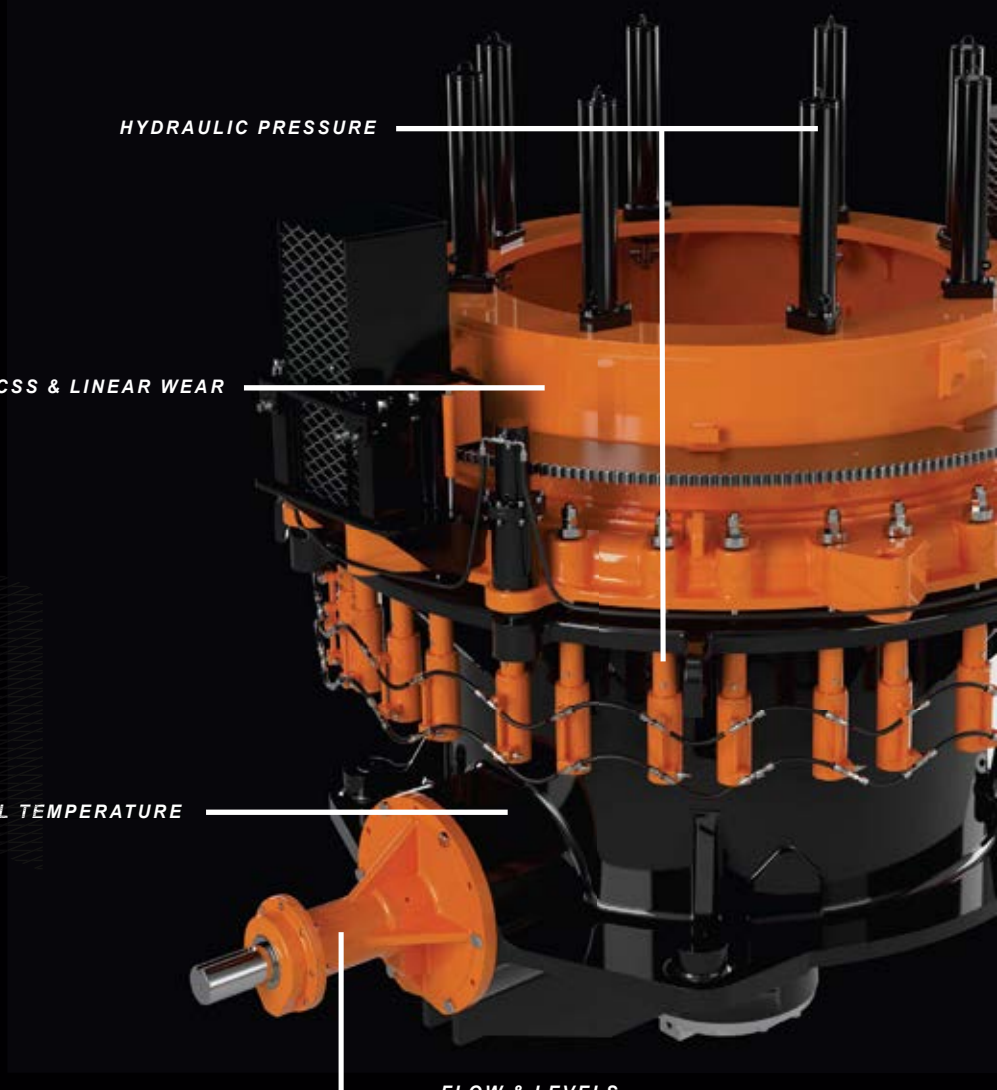

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Henry Huttleston Rogers and Leonard Lewisohn led the merger.

Rogers invited the company Guggenheim Sons, the partnership that Meyer Guggenheim and his seven sons created, to join the ASARCO venture. The Guggenheims then had four smelters and refineries, mines in Mexico, a contract to operate a Chilean smelter, and a steamship line transporting ore from Tampico, Mexico, to Perth Amboy, New Jersey, in the United States.

Intense competition between the Smelter Trust (ASARCO's former name) and M. Guggenheim Sons marked ASARCO's earliest history. The Guggenheims were concerned for their survival and focused their efforts on expanding their Mexican interests and mining properties

1900-1908 — ASARCO'S PARTNERSHIP WITH MEXICO

In 1901, the Guggenheims merged their smelter and refining plants with the Smelter Trust and gained full control of ASARCO, appointing officers and running the board of directors.

An important moment in our history unfolded as a lasting partnership was forged between Mexico and the United States.

Daniel Guggenheim, a young visionary, and Mexican President Porfirio Diaz convened at the National Palace in Mexico City to discuss their shared interests.

Díaz wanted smelters in Mexico to become self-reliant in ore processing, and the Guggenheims wanted to build the smelters. Diaz agreed that the Guggenheims could build up to three smelters and explore mines for lease or purchase anywhere in Mexico.

By 1908, the company owned five smelters, numerous mines in Mexico, and a copper refinery on the East Coast of the United States to handle Mexico's copper production. The first major Mexican mining properties under ASARCO management were Sierra Mojada in Coahuila and Santa Eulalia in Chihuahua.

1910-1920 — ASARCO IN TIMES OF CRISIS

The Mexican Revolution began in 1910, just a few years after Daniel Guggenheim met with Mexican President Porfirio Diaz to negotiate ASARCO's expansion nationwide.

The mining industry in Mexico became the victim of anarchy and was periodically forced to suspend operations. ASARCO was no exception. Operations in the plants were often suspended due to conflicts between opposing groups. The Parral Mine, situated on a hill in Chihuahua, was strategically important and a frequent battleground.

In 1910, ASARCO purchased mining properties in the U.S. near Silver Bell, Arizona, and built copper smelters in El Paso, Texas, and Hayden, Arizona.

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Interesting Fact:

In 1907, Thomas Alva Edison wrote a letter to the company expressing an interest in acquiring bismuth recovered from the refining process at the Baltimore copper refinery. The request could have been based on the desire to test an alkaline storage battery.

By 1914, ASARCO, led by Daniel Guggenheim, had mines in Alaska, Arizona, Colorado, Idaho, Nevada, New Mexico, and Utah in the United States, Mexico, and Chile, as well as smelters and refineries.

With its 17 plants across the United States, ASARCO was ready to provide copper to meet the country's needs in times of war.

ASARCO'S FIRST OPEN-PIT MINE

Technological advancements opened the door to the open-pit mining method, which permitted handling large quantities of materials, improving ore preparation techniques, enhancing ore diagnostics ability, increasing worker safety, expanding coverage, and ensuring increased extraction efficiencies.

ASARCO's first open-pit mine, Silver Bell, commenced production in 1954.

1920-1960

By 1929, ASARCO was the world's largest refiner of non-ferrous metals. However, it did not emerge unscathed from the Great Depression and subsequent crisis, which was a severe blow to all of its enterprises. Income from Mexican properties was crucial to ASARCO's survival during the Great Depression. Once again, Mexico proved to be a good neighbor and a great partner.

In the mid-20th century, ASARCO expanded their international operations to Africa, Canada, Central and South America, Saudi Arabia, and Australia.

1960-1970 MISSION AND BECOMING THE WORLD'S FOURTH-LARGEST COPPER PRODUCER

Following the opening of Silver Bell, the acquisition of the Mission Mine was another major step for ASARCO on its copper journey.

Fun Fact:

Did you know Mission was the first base metal mine discovered through geophysical methods in the western United States?

On November 16, 1961, the Mission Copper Mine and Mill opened.

Entering the 1960s, the company's expertise was geared to meet the increasing global demand for copper. With the Toquepala properties in Peru and the addition of the Mission copper mine in Arizona, ASARCO became the fourth-largest copper producer in the world by 1963.

1970-1980 COPPER IS ON THE RISE

In 1975, ASARCO moved its copper refining operations to Amarillo, Texas, from its Baltimore and New Jersey plants.

It wasn't until the 1980s that ASARCO shifted its focus to becoming a fully integrated copper producer.

1980-1999 — THE ARRIVAL OF GRUPO MEXICO

Over 20 years, from 1980 to 2000, ASARCO invested more than $700 million in upgrading technologies at its operating facilities, including plants and mines, and in 1999, the company joined forces with Grupo Mexico to become the second-largest company in copper reserves and the fifth-largest supplier of the metal worldwide.

2000-2024 RECENT TIMES

The binational history that began on the path the Guggenheims took to Mexico at the end of the 19th century came full circle when ASARCO became a Grupo Mexico subsidiary nearly 100 years later.

ASARCO has thrived amid massive change.

It has played a crucial role in producing the materials required to build extensive transportation and communication systems and the daily amenities often taken for granted.

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Construction Progresses at Florence Copper

Once commissioned, the project will produce copper with the lowest GHG intensity in North America

Construction at Florence Copper continues to progress on schedule. At this time last year, Taseko Mines finalized the funding for the project and initiated construction. The mine has now entered its peak construction period with nearly 300 contractors working on site.

Activities at the solvent extraction/electrowinning (SX/EW) plant have shifted from earth works and concrete foundation pouring to erecting structural steel and installation of processing equipment and electrical services. Development of the wellfield is advancing with five drill rigs now operating. At the end of 2024, 51 of 90 production wells had been completed. Development of the wellfield, which is a critical path item, remains on schedule to be completed in Q2 2025.

"This is a very exciting time as we begin to unlock the value of our key growth asset," said Stuart McDonald, president and CEO, Taseko Mines. "The Florence Copper project continues to be de-risked, and the first copper cathode from the project's commercial facilities is expected in Q4 2025."

At that point, Florence Copper will be the primary copper producer with the lowest greenhouse gas (GHG) intensity in North America. Taseko applied for the U.S. Department of Energy's (DoE) Qualifying Advanced Energy Project Credit 48C(e) Program, seeking a tax credit of up to $110 million, which was declined. Despite the disappointing news, McDonald said Taseko remains in a strong financial position with C$330 million ($229 million) of available liquidity at year-end, including the undrawn $110 million revolving credit facility.

Since construction commenced in 2024, the bulk of activities have been focused on earthworks, concrete, and wellfield drilling. Instal-

During December 2024, the electrowinning cells were mounted in the electrowinning building in preparation for building erection. (Photo: Taseko Mines)

Two drill rigs and a development rig work on production wells. At the end of 2024, 51 production wells had been completed and a third drill rig is now operating at site. (Photo: Taseko Mines)

lation of structural steel, tanks, and process equipment is now underway. Taseko has all the key permits in place for the commercial production facility and first copper is expected to be produced in Q4 2025.

When the commercial production facility is fully ramped up, Florence Copper is expected to produce 85 million lb/y of LME grade A cathode copper at a cash cost of $1.11/lb. Over its planned 22-year mine life, the in-situ recovery operation is expected to yield 1.5 billion lb of copper.

Earthworks and site preparation for the plant area and commercial wellfield is nearly complete and the installation of structural steel, tanks, and process equipment is underway. Construction of process and surface water run off ponds and the hiring of additional personnel for the construction and operations teams continues.

"We are pleased with progress through the first nine months of construction," McDonald said. "With approximately 75% of total construction costs now committed, we expect total costs to be within 10%-15% of the original $232 million estimate."

For the first nine months of 2024, Taseko has incurred $97.3 million capital costs. Other capital costs of $29 million include final payments for delivery of long-lead equipment that was ordered in 2022, and the construction of an evaporation pond to provide additional water management flexibility. Construction of this evaporation pond was completed in Q3 2024.

Taseko has closed several Florence project level financings to fund initial commercial facility construction costs. In July, the company received the third deposit of $10 million from the $50 million copper stream transaction with Mitsui & Co. (USA) Inc. The fourth deposit was received in October and the remaining $10 million is scheduled to be received in January 2025.

Remaining project construction costs are expected to be funded with the company's available liquidity, and cashflow from its Gibraltar mine in British Columbia. The Company also has in place an undrawn corporate revolving credit facility of $110 million.

Taseko signed a fixed-price contract with TIC — The Industrial Company to serve as the general contractor for construction of the SX/EW plant and associated surface infrastructure. All the major plant components are onsite. As of the end of 2024, Florence Copper had logged

First solvent extraction settler and launder modules were placed in September 2024. (Photo: Taseko Mines)

approximately 450,000 project hours and there have been no reportable injuries or environmental incidents.

"The fixed-price contract with TIC reduces inflationary risks, as Arizona continues to be a very active construction market," McDonald said. "Our early work on detailed engineering and procurement of long-lead items has significantly de-risked the construction schedule. We're taking a disciplined approach to the buildout of the commercial facility at Florence, while our existing operations at the Gibraltar mine continue to generate good cashflows in a strong copper price environment."

Taseko is in an enviable position as a copper producer with near-term, low-cost production growth coming from Florence Copper, which is a fully-permitted and environmentally beneficial copper project.

Florence Copper Donates to Enhance Heritage Park Playgrounds

Last summer, Florence Copper donated $50,000 to the Town of Florence to support the enhancement of the playgrounds at Heritage Park in Florence, Arizona. This donation increased the overall project budget from $250,000 to $300,000 and is focused on supporting the inclusion of playground accessibility features for local youth with disabilities and special needs.

The donation comes as part of Florence Copper's ongoing commitment to supporting and investing in the local community, with the project already committing $20,000 to the Town of Florence in 2024 to support local community events like the Fourth of July Freedom Fest. The planned upgrades to Heritage Park's playgrounds will create a more inclusive and welcoming environment for all children and families in Florence.

John Mays (green jacket), his son and Sophie Dessart (center), along with the Florence Town Council celebrated a revitalized Heritage Park with a ribbon cutting ceremony. (Photo: Florence Copper)

"We are thrilled to support the Town of Florence in this important initiative," said John Mays, general manager of Florence Copper. "Our contribution will help ensure that Heritage Park is an inclusive place where all children, regardless of their background or circumstances, can play and enjoy the outdoors. This project is near and dear to our hearts because we know that for children with disabilities and special needs, a playground is a place where they can interact and be close with their peers. As a parent of a child with special needs, I know this firsthand. At Florence Copper, we are committed to the well-being of our community and look forward to seeing the positive impact these enhancements will bring."

As this edition was going to press, Mays, his son and Sophie Dessart, manager communications and public affairs for Florence Copper, along with the Florence City Council celebrated a revitalized Heritage Park with a ribbon cutting ceremony. Mays said Florence Copper remains dedicated to its partnership with the Town of Florence.

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Arizona Sonoran Sees the Economics for the Cactus Project Continuing to Improve

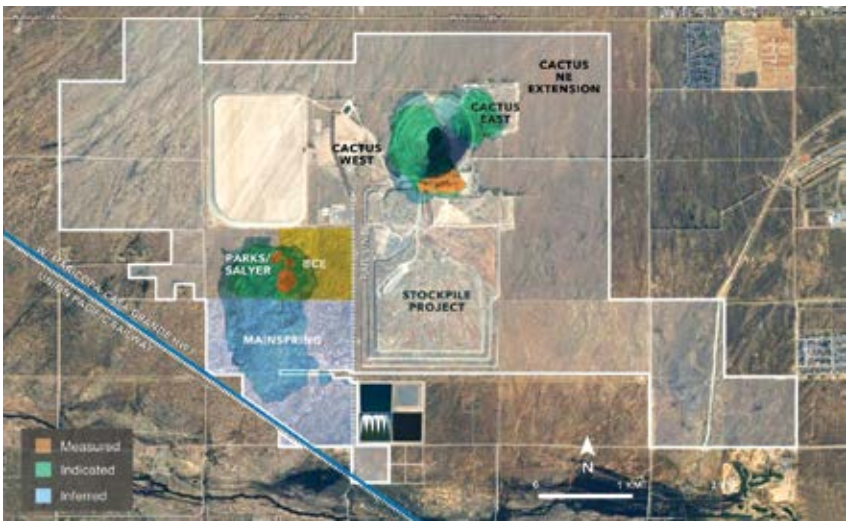
With additional resources and a revised PEA, excitement builds toward the 2025 PFS

The Arizona Sonoran Copper Co. (ASCU) is proving up and preparing to develop the Cactus project, a brownfield project located near Casa Grande, Arizona. The project, which sits on privately held land, contains a large-scale porphyry copper resource and the latest preliminary economic assessment (PEA) proposes an open pit copper mine and eventually a sublevel caving operation. Cactus would be a lower risk copper development project that benefits from a state-led permitting process and in place infrastructure and onsite permitted water access.

In February 2024, the company published a prefeasibility study (PFS) for the Cactus project that outlined a long-life copper project with low first quartile capital intensity, producing 55,000 tons per year (t/y) of copper cathode onsite via heap leach and a solvent extraction/electrowinning (SX/EW) plant. The mine plan included operating a portion of the project as an open pit mine and another portion, the Parks/Salyer deposit, as an underground mining operation.

In March, the company acquired the MainSpring property and began integrating it into Parks/Salyer. MainSpring has oxide resources located near the surface, which would allow Parks/Salyer to operate as an open pit mine and the additional oxide ore increased the project's copper reserves and copper recovery rates.

ASCU began to update its plans to include MainSpring, issuing a new mineral resource estimate (MRE) in July 2024 and publishing a new 2024 PEA in August 2024. The new PEA now contemplates an operation expected to produce 116,000 t/y of copper during the first 20 years of a 31-year mine life. Of course, adding a new deposit required new metallurgical testing to confirm ex-



The Cactus project will extract copper from four locations: Cactus East and Cactus West, the Stockpile and Parks/Salyer. (Image: ASCU)

pectations and permits would also need to be amended. All of this work will ultimately culminate in a new PFS, which is expected later this year, and an eventual investment decision.

"Cactus is a standout lower risk copper asset based on its tier 1 location, the permitting process, onsite infrastructure, including rail, road, power and water, the sizeable copper resource estimate, associated mine plan, related economics and first quartile capital intensity," ASCU President and CEO George Ogilvie said. "Our team has done a tremendous job advancing the asset and navigating the streamlined state led permitting process. We look forward to continuing to advance towards a PFS in H2 2025, and subsequently submitting final amendments ahead of a final definitive feasibility study (DFS) in 2026, project financing, and the construction and development decision."

The MainSpring acquisition and its integration has already had a profound impact on the economics for the Cactus project. The 2024 PEA estimates an initial capital expense of $668 million, a payback period of 4.9 years, and internal rate of return of 24% and a net present value (8% discount) of $2.03 billion.

Tests Indicate Improved Copper Recovery

During December, ASCU announced the results from its column leach program. The metallurgical testing indicated an average soluble copper extraction rate of 87% over 180 days of leaching from six oxide and enriched composite columns from the Parks/Salyer deposit, which included MainSpring ore. The other six columns represented the final Stockpile columns with an average soluble copper extraction rate of 86% over 100 days.

The company said the updated Parks/Salyer extraction results compare well to the soluble copper rates of 92% oxide and 85% enriched, in support of the single pad leach plan as outlined in the 2024 PEA.

"Across the Parks/Salyer, Cactus West and Cactus East deposits, we benefit from similar mineralogies and no deleterious materials as evidenced from

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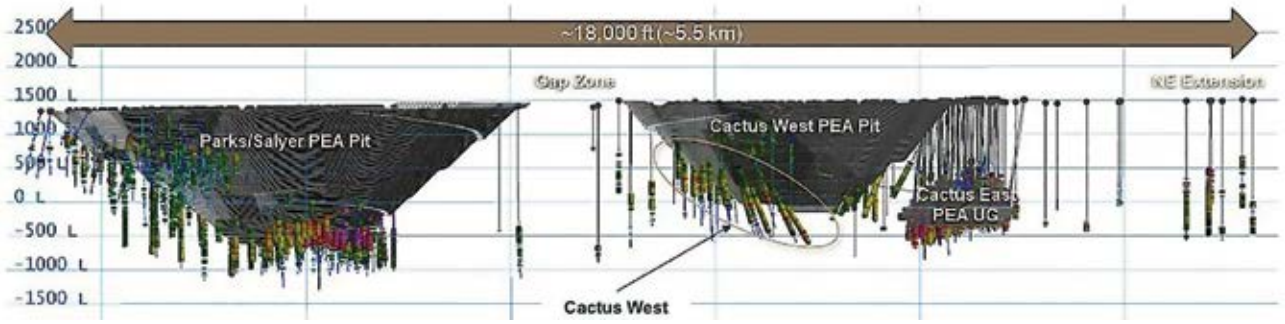

A long section shows the relationship and size of the orebodies. (Image: ASCU)

four years of metallurgical testing on the three deposits," said Steve Dixon, chief metallurgist for ASCU. "We are encouraged to see the first two columns from the new MainSpring property behaving similarly to Parks/Salyer, as expected. Overall, the Cactus Project oxide and enriched recoveries and leach times perform in line with other operating mines within Arizona's copper belt."

The 12 columns in the test were 20 feet (6 m) in height and consisted of six columns from the Parks/Salyer deposit, including two focused on the new shallow MainSpring ore and six from the Stockpile. While the Stockpile tests provide valuable information on material already extracted from the former Sacaton mine, the company said all testing moving forward will be focused on fresh material from recent drilling at Parks/Salyer.

ASCU will now implement a $3 million metallurgical program ahead of the 2025 PFS, using both Base Met and McClelland Labs. This next program focuses on upgrading the Parks/Salyer deposit metallurgical information. A total of five enriched columns, two enriched/oxide composites, and four primary sulphide (chalcopyrite) columns are planned. Primary material columns will test the impact of heat application versus ambient conditions at McClelland Lab, while Base Met will test for ambient temperature.

Amended Permits

With the inclusion of the MainSpring deposit, ASCU applied for and received an amended Industrial Air Permit from the Pinal County Air Quality Division. The company has also applied for an amended Aquifer Protection permit and it is currently under review by the Arizona Department of Environment and Quality, ADEQ.

ASCU said its regular communication and involvement within the community has contributed to its permitting success. Additionally, as part of the continuing community engagement strategy, the company recently completed an updated polling survey demonstrating support for the Cactus project of 87% within Casa Grande and surrounding areas.

Initiating the 2025 PFS Workstreams

Following a request for proposal, during October 2024, ASCU appointed M3 Engineering in Tucson, to lead the 2025 PFS and to act as metallurgical program lead. Other consultants will include AGP (mining), Clear Creek (hydrology), ALS Geotechnical (geology), and Partners in Performance (real-time modeling and optimization), all of whom have contributed to ASCU's prior studies.

The Cactus mine plan, and in particular the first five years of mining, was rescoped in an August 2024 PEA that incorporated mineralized material from the MainSpring property. The MainSpring title transfer took place in March 2024 and an initial drilling program on the MainSpring property was completed in April 2024. It identified a significant inferred copper mineral resource at the near surface and southern extension of the Parks/Salyer deposit.

The updated MRE ultimately rescoped the Parks/Salyer component of the project as an open pit mine from an underground scenario during the early years. The focus of the coming months will be upgrading the entirety of the Parks/Salyer deposit to the PFS level.

Upcoming workstreams in preparation of the updated PFS include exploration and infill drilling; mine design and scheduling, and technical studies and project support, including geotechnical and hydrological drilling, and metallurgical test work.

"Continuing to use M3 and the supporting consultants was a logical choice due to their strong working knowledge of the project, the close proximity of their engineering centers in Chandler, Tucson and Hermosillo and the long-term productive working relationship between our two project teams in the execution of multiple large projects," said Bernie Loyer, senior vice president, projects for ASCU. "M3 Engineering's focus and performance on the recently completed PEA is testimony to the efficiency of that working relationship, setting an optimum stage for the next level of study. Additionally, we continue to develop the base case scenario while working closely with our partners at Nuton Technologies to develop an integrated PFS."

Having already led the 2024 PEA, M3 and the other consultants have a strong working knowledge of the project's characteristics and opportunities, Loyer explained. Trade-off studies for continued optimization of the current scope, include:

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- In-pit and near-pit crushing and conveying;
- Shifting the Parks/Salyer open pit centroid north;
- Primary sulphide extraction scenarios,
- Options to adjust and smooth cathode production and cash flows over the life of mine, and
- Waste dump reclamation studies (backfilling).

M3 Engineering provides continuous design and construction services from project conception to final testing and integration. The company's engineers have had significant experience building SX/EW projects in the U.S. and Mexico, including Newmont's Peñasquito mine, Nevada Gold Mines' Phoenix mine, KGHM's Carlota mine, Cobre del Mayo's Piedras Verdes mine and the Taseko's Florence pilot plant.

The Revised Cactus MRE

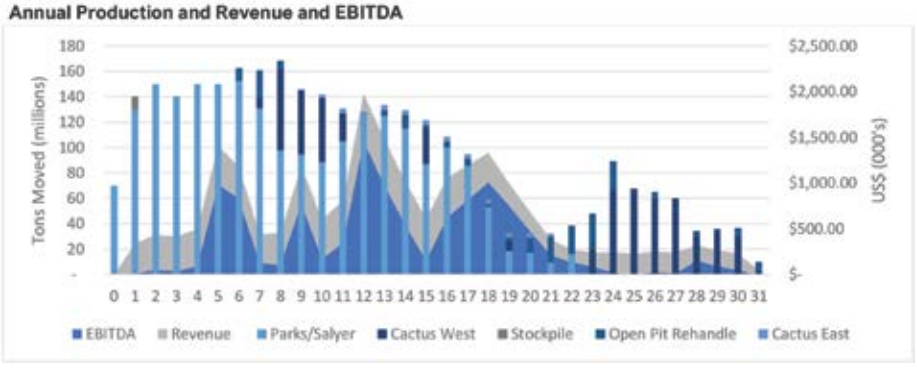
Including MainSpring in Parks/Salyer deposit will be transformational for ASCU as they rescope Parks/Salyer to an open pit mine. This became obvious when the company revised its mineral resource estimate (MRE), which made a considerably larger set of reserves available for the 2024 PEA. Near surface mineralization would reduce mining execution risks and lower operating costs, improving project economics.

"Our Cactus project is a successful copper porphyry growth story resulting from an aggressive exploration program," said Doug Bowden, vice president, exploration for ASCU. "Our mineral resource journey began with our initial PEA in 2021, and continuously expanded outward from the Cactus pit area to include Parks/Salyer and most recently MainSpring within the 5.5 km trend.

"The Parks/Salyer discovery includes significant quantities of high-grade (+1%) copper, similar to the grades in Cactus East," he said. "Through systematic step out and infill drilling following our first MRE in 2021 to today's update, our Cactus project indicates an increase to measured and indicated (M&I) by an impressive 353%, from 1.61 billion lb to 7.29 billion lb of copper, while the inferred mineral resources increased 94%, from 1.98 billion lb to 3.84 billion lb.

These mineral resource areas have responded favorably and impressively to infill drilling with a consistently high conversion rate into higher resource classifications, Bowden explained. He said he was looking forward to future infill programs as the company moves through its technical studies.

Including the MainSpring deposit, the Parks/Salyer mineral resources indicate 339 million tons grading 0.71% total copper in the M&I category and 299.2 million tons at 0.43% total copper in the inferred category. Parks/Salyer is mostly contained within an optimized resource open pit shell indicating the rescoped potential of open pit mining of the deposit with the inclusion of shallower mineralization located on the MainSpring property. There were no material changes to the Cactus East, West and Stockpile deposits for the updated MRE.



The 2024 PEA shows the impact of including MainSpring in Parks/Salyer during the early stages of production. (Chart: ASCU)

2024 PEA Summary

The 2024 PEA rescoped Parks/Salyer as an open pit operation. The inclusion of the MainSpring deposit materially improved the economics and operations of the project, producing a total of 5.3 billion lb or 2.7 million tons of copper over a 31-year mine life via heap leaching and SX/EW. The previous PFS estimated an initial mine life of 21 years, recovering 2.31 billion lb or 1.2 million tons.

By applying open pit mining costs to the Parks/Salyer MRE, it now contributes 531 million tons of feed material grading 0.53% total copper to the total 889 million tons of feed material at 0.46% total copper over the mine life. Overall, the 2024 PEA envisages a 31-year mine life with annual average throughput of 29 million tons, for an average of 86,000 t/y of copper.

Copper cathodes will be produced directly onsite via heap leach and SX/EW, including a 4-year ramp up period. Total copper recoveries are planned at an average of 73%, extracting copper from the oxides, and enriched and primary sulphides.

Onsite facilities at the mine site will consist of two open pits, one underground mining operation, a fine crushing plant incorporating all crushing, classification, agglomeration and conveying systems, heap leach pad, water supply and distribution systems, technical and operational support offices, additional electrical substation, warehousing and an SX/EW process plant. Onsite supporting infrastructure will include site power distribution, access roads, mine operations infrastructure, and heap leach facilities, of which the power and roads are already in use.

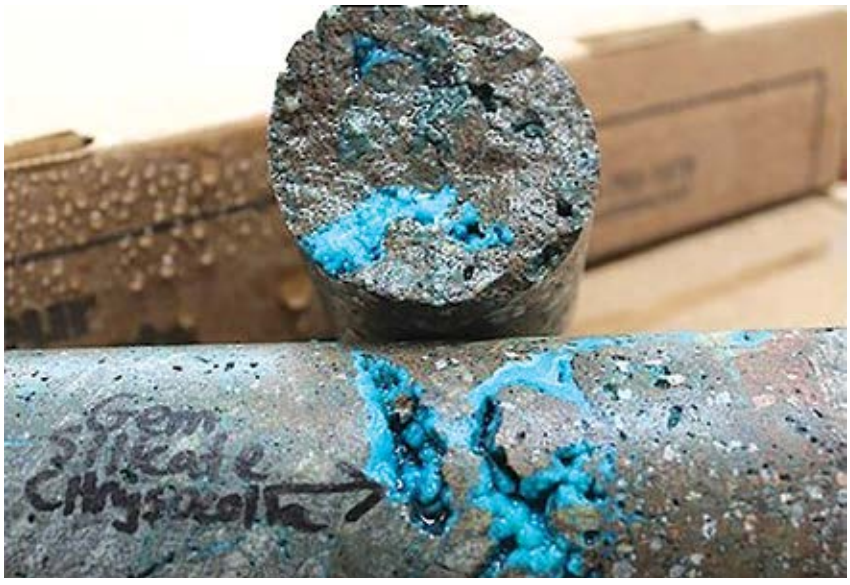
The Cactus West pit and new Parks/Salyer pit will provide most (94%) of the total material to the leach pads. The remaining 5% of ma-

terial will be sourced from the Cactus East underground deposit using a SLC mining method from the 1,200 ft (366 m) level, and 1% from the Stockpile.

Both Parks/Salyer and Cactus West will be mined using 40-ft benches, with ramps sized to allow 320-ton class haul trucks.

The SLC for Cactus East will begin in year 8 and will be completed in year 22, peaking at 3.9 million t/y. The initial Cactus East SLC level will begin at 1,325 ft (404 m) below the surface over 7 sublevels, to a final depth of 1,845 ft (562 m). Access will be via a single decline with a portal located within the existing Cactus West pit. Ore will be hauled to the surface via a vertical conveyor which can be supplemented with truck haulage to surface via the open pit if necessary.

The Cactus heap leaching process design includes crushing of all material types for leaching to a minus 3/4-in. P80 size. All material types, oxides, enriched and primary are to be leached in on a single pad with an initial leaching cycle of 180 days.



Core samples showing Chrysocolla, a blue-green hydrous copper silicate. (Photo: ASCU)

Average annual water consumption is planned at approximately 1,200 gallons per minute (gpm), the equivalent of 1,935 acre-feet per year, well within ASCU's permitted 3,600 acre-feet per year industrial use allocation, using in-place onsite wells.

The PEA envisages that overall tonnage will comprise approximately 25% oxide material, 50% enriched (secondary sulphides) and 25% primary sulphides over the life of the mine.

The University of Arizona: Building Rock-Solid Minds

By supporting and catalyzing departments across campus, the School of Mining & Mineral Resources at the University of Arizona is meeting the challenges facing mining head-on through an unmatched commitment to building the minds that will power next-generation mines

In a time when mining companies are challenged to find skilled workers, when university mining programs are struggling with enrollment across the country, and when most school-age kids have no awareness of how many minerals are required for their cell phones, the University of Arizona is doubling down on mining with the School of Mining & Mineral Resources.

Director Misael Cabrera explained that large universities have multiple colleges, which have departments with various disciplines. "Oftentimes, the knowledge inside those disciplines is stored in siloes," he said. "What we do at the School is connect and catalyze across all the colleges, departments, and disciplines interested in mining problems. In doing so, we can bring holistic solutions to problems in ways other universities cannot."

For example, Cabrera said that the School is collaborating with principal investigator Bo Yang, Ph.D., from the College of Architecture, Planning and Landscape Architecture on a soon-to-begin study for South 32. The multidisciplinary team will conduct an asset inventory and gap analysis and develop recommendations for Santa Cruz County, where its Hermosa project is located. Cabrera explained that South 32 plans to invest more than $2 billion into a county with a population of 50,000.

The University of Arizona hosts one of the largest mining related programs. (Photo: U of A)

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Mining and Geological Engineering	Lowell Institute for Mineral Resources	San Xavier Mining Laboratory
Geosciences	Geotechnical Center for Excellence	Minerals Characterization Facility
Hydrology and Atmospheric Sciences	Center of Excellence for Mine Safety	Mining Machine Automation & Autonomous Systems Lab
Environmental Science	Center for Environmentally Sustainable Mining	
Lowell Program for Economic Geology	Center for Leadership Ethics	
Global Mining Law Program	Arizona Geologic Survey	

"They have asked us to inventory the existing county capacity in terms of hospital beds, educational desks, roads, broadband, and other services. Then we will assess the impact of their significant investment and see where the gaps are," he said. "In addition to the School, the College of Architecture, Planning and Landscape Architecture, the Eller College of Business Management, and the College of Engineering are fielding talent from five departments across the campus."

The School serves as connective tissue within an impressive and growing list of mining-relevant U of A departments, centers, programs, institutes, and facilities, as well as for industry and communities. Supported partners are included in the table above.

"We do not oversee these organizations," Cabrera said. "The School catalyzes them to make the whole greater than the sum of its parts. From K-12 outreach and teacher training to cutting-edge academic courses and degrees to short professional development courses for existing miners, the University of Arizona promotes interdisciplinary workforce development in southern Arizona's Silicon Valley of Mining."

Cabrera explained that the school has a "K through gray" approach. "We start with outreach at elementary Schools with lesson plans and a teacher's academy where we train educators to teach students about minerals," he said. "We have bachelor's, master's, and Ph.D. programs. We also offer professional development courses that help upskill existing professionals by bringing together all those different groups, like the Eller Center for Business Ethics, which provides leadership and ethics for the mining industry.

Delighting Young Minds Through Minerals Education Outreach

The School's K-12 Outreach Program, funded by the Mining and Minerals Education Foundation, allows Arizona kids to learn the value of mineral resources in their daily lives. Students discover where minerals come from and witness modern mining's advancements in producing safe, sustainable resources for the planet's growing population.

The School's Outreach Coordinators provide engaging, experiential workshops, participate in high School STEM fairs, and give student and family tours of the Mining & Geological Engineering Department on the University of Arizona's inviting Tucson campus, as well as tours of the San Xavier Mining Laboratory in nearby Sahuarita. This focus on elementary education expands awareness of mining's importance to Arizona communities among students and the adults who educate them.

Piloted in the summer of 2024, "Cu at the Mine," a 5-day professional development academy for teachers and counselors, transformed 32 Arizona educators into mining advocates. Through interactive lesson planning, mine tours, and demonstrations by geoscientists and mining professionals, participants developed a well-rounded understanding of mining's technological advancements and rewarding career opportunities. According to one participant, "It was an incredible experience. Is it too late to go back and get a degree in mining? I will definitely be sharing this with my students as a potential career path."

Cutting-Edge Curriculum

The departments supported by the School have created 15 new or updated academic courses during the last five years. Offerings include courses like *Machine Learning for Mining Applications, Application of Discrete Event Simulation in Mining, Nonrenewable Resources and World Civilizations* in the Mining Engineering Department, *Structural Geology for Exploration*, and *Advanced Mapping of Mineral Deposits* in the Geosciences Department. The College of Law delivers high-relevancy courses like *International and Comparative Mining Law and Valuation of Mineral Assets and Projects*.

"Many universities have programs associated with machine learning, but we are teaching machine learning applications for the mining industry," Cabrera said. "These courses are highly relevant and leading-edge and made possible by new faculty. Kray Luxbacher, Ph. D., the Head of the Mining and Geological Engineering Department, is doing a fantastic job of bringing new faculty to support this curriculum with support from the School.

"When we create a new academic course, we will often also generate a professional development course," he said. "For us, it's not just about bachelor's degrees; it's about helping build the mining industry of tomorrow, today."

The Mining Engineering Department has 67 undergraduate students and dozens more in the master's and doctoral programs. Economic geology has doubled enrollment for its master's program to over 20. The university has 40 students enrolled in its Sustainable Mineral Resources minor. "We use enrollment as a proxy for the overall health of mining education at the University," Cabrera said. "If you add up all of the students, including those enrolled in the Sustainable Mineral Resources minor, the University of Arizona has one of largest mining-relevant programs in the country."

Led by renowned faculty at the forefront of their fields, graduate students are developing better extraction and processing methods, making mining safer and more efficient, converting mine waste into valuable products, and advancing technology throughout the entire lifecycle of mining operations.

The average scholarship amount available for Mining and Geological Engineering students is $8,000 per year. "The mining industry supports students, and there is a lot of interest in providing scholarship money," Cabrera said. "We absolutely encourage students to apply to one of the programs, and a significant amount of financial aid is available to undergraduate and graduate students."

A K-12 Outreach Program educates kids about mining. (Photo: U of A)

What sets the School apart is that it purposefully connects and catalyzes across existing departments without competing with them, Cabrera explained. Some universities have attempted unsuccessfully to combine departments to achieve the multidisciplinary approach. Cabrera and his team are taking a decidedly different approach. "We don't feel that we're competing with other universities," he said. "There are not enough students studying anything related to mining right now. We consider the other universities partners, and we're open to sharing everything we're doing, and we often collaborate with others on grant proposals, research, and outreach."

The Sustainable Mineral Resources Minor

The School attracts the workforce to the mining industry by introducing undergraduate students to mining through a minor degree that can pair with any college major. A Sustainable Mineral Resources minor was developed to bridge the growing chasm between society's escalating mineral demands

Students learn underground at the San Xavier Mining Laboratory. (Photo: U of A)

and the evolving complexities of the industry. This interdisciplinary degree equips students seeking non-mining majors with mining know-how.

"The Sustainable Mineral Resources minor is available to any major," Cabrera said. "By offering it up to any major, we are creating a workforce for the mining industry, which needs data scientists, supply chain professionals, HR professionals, business managers, anthropologists, in addition to geologists and mining engineers. The Sustainable Mineral Resources minor exposes any major to the nuts and bolts of mining so that they can hit the ground running once they start their careers."

Solving Historic Environmental Issues

"Mining today is more technical than ever," Cabrera said. "It's also more social than ever before, and the issues related to the social license to operate only increase over time. We are bridging all those gaps in very positive ways. Cabrera said he was glad to see President Joe Biden sign the Good Samaritan Remediation of Abandoned Hardrock Mines Act. He testified before Congress in support of an earlier version of the bill. The Act requires the Environmental Protection Agency to establish a pilot program and issue permits to allow Good Samaritans to remediate 15 historic abandoned hardrock mine sites.

"We are hoping that one of those sites ends up in Arizona," Cabrera said. "Like other mining states, Arizona has its fair share of abandoned mine sites where we believe volunteers and others, perhaps with the help of the university, could do some good, meaningful work.

"Abandoned mine sites provide a negative visual impact on the environment," he said. "I'm very encouraged by the Good Samaritan Remediation of Abandoned Hardrock Mines Act; it will allow volunteers and others to reclaim these lands, remove the eye sores, and demonstrate that there doesn't have to be a negative environmental or visual impact at the end of mining. This will have a positive impact, not just for the planet's health, but also for the industry's health."

Before accepting this position nearly two years ago, Cabrera spent three decades as an environmental professional. He has a lifelong commitment to the environment and is excited to see the domestic mining industry thrive sustainably while it pursues abundant economic minerals.

"Abundant economic minerals are the most important ingredient to save the planet," Cabrera said. "All the technologies that will help us save the planet require minerals. The acceleration of domestic production is important because we have environmental regulations, and we enforce them. Very few countries have both environmental regulation and enforcement."

Professional Development

The Univeristy's focus on mining education doesn't end with bachelor's, master's, or doctorate degrees; current professionals have numerous options to enhance their knowledge and advance their careers. From short courses and certificate programs to advanced degrees with field study and research opportunities, mining and mineral exploration workers can level up in ways that are uniquely tailored to their career goals.

Many of the professional development programs are available online or a combination of online with some in-field applications. As an example, the Lowell Program for Economic Geology offers a series of high-quality short courses in economic geology. The short courses are combined with fieldwork and classroom activities. With the Geotechnical Center of Excellence, almost all the programs are offered exclusively online. The Geotechnical Center of Excellence has delivered training to nearly 3,000 students from more than 50 countries.

Companies that need to upskill groups can even partner with the university to provide professional development courses and certificates that address immediate business and workforce needs.

The University of Arizona's commitment to mining and mineral resources education is unparalleled, and its alums are contributing to advancements that are taking the industry to new heights. If you'd like to explore courses and programs to take your career to the next level or bring a Minerals Education Outreach event to your community, visit mining.arizona.edu to learn more, or email: mining@arizona.edu.

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As Ore Grades Decline, Freeport Considers Expansion Projects in Addition to Its Leaching Initiatives

The company's MILESHIGH project hopes to use geothermal energy to improve leach kinetics

Freeport-McMoRan operates five open-pit copper mines in Arizona, Morenci, Bagdad, Safford (including Lone Star), Sierrita and Miami. The Lone Star project located near its Safford operation was substantially completed in 2020, and the company continues to look for opportunities to increase Lone Star's operating rates. It is currently advancing plans to increase volumes to achieve 300 million lb/y of copper from oxide ores.

Freeport is looking at a series of initiatives across its North and South American operations to incorporate new applications, technologies and data analytics to its leaching processes. In late 2023, Freeport achieved its initial incremental annual run rate target of approximately 200 million lb of copper. Incremental copper production from these initiatives totaled 164 million lb for the first nine months of 2024 (compared with 97 million lb for the first nine months of 2023).

The company said it is pursuing opportunities to apply recent operational enhancements on a larger scale and is testing new innovative technology applications that have the potential for significant increases in recoverable metal beyond the current run rate.

Freeport has substantial reserves and future opportunities in Arizona, primarily associated with existing operations. The company is currently evaluating a potential expansion project to more than double the concentrator capacity at its Bagdad operation in northwest Arizona. Bagdad's reserve life currently exceeds 80 years and supports an expanded operation.

In late 2023, Freeport completed technical and economic studies, which indicated the opportunity to construct new concentrating facilities to increase copper production by 200 to 250 million lb/y at estimated incremental project capital costs of approximately $3.5 billion. Expanded operations would provide improved efficiency and reduce unit net cash costs through economies of scale. Project economics indicate that the expansion would require an incentive copper price in the range of $3.50/lb to $4/lb per and approximately three to four years to complete. The de-

The Sierrita mine produces more than 150 million lb/y of copper. (Photo: Freeport)

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cision of whether to proceed and timing of the potential expansion will consider overall copper market conditions, availability of labor and other factors, including the progress on the current conversion of the existing Bagdad haul truck fleet to autonomous operations and expanding housing alternatives to support long-range plans.

In parallel, Freeport is reviewing plans for expanded tailings infrastructure projects required under long-range plans to advance the potential construction timeline.

The company launched pre-feasibility studies in the Safford/Lone Star district to define a potential significant expansion opportunity. Positive drilling conducted in recent years indicates a large, mineralized district with opportunities to pursue a further expansion project. Freeport expects to complete these studies in late 2025. The decision of whether to proceed and timing of the potential expansion will consider the results of technical and economic studies, overall copper market conditions and other factors.

In 2023, Freeport's copper mines in Arizona represented more the 27% of the company's total copper production. Freeport is expecting its consolidated copper sales volumes from North America to be approximately 1.24 billion lb for 2024. The average unit net cash costs (net of by-product credits) for the North American copper mines was $3.24/lb in Q3 2024, which were higher than its Q3 2023 average unit net cash costs of $2.70/lb, primarily reflecting the impact of lower copper production volumes associated with lower ore grades.

Freeport-McMoRan's Arizona Copper Mines

Copper Production (millions of lb)	2023	YTD Q3 2023	YTD Q3 2024
Morenci	575	435	381
Safford	245	189	182
Sierrita	185	142	120
Bagdad	146	111	109
Miami	12	9	7
Total Arizona	1,163	886	799
Total Freeport	4,212	3,117	3,173

The MILESHIGH Project

The Clean Energy Demonstration Program on Current and Former Mine Land (CEML), managed by the U.S. Department of Energy's Office of Clean Energy Demonstrations (OCED), aims to demonstrate the technical and economic viability of deploying clean energy projects on current (active) and former (abandoned or inactive) mine land in the U.S.

As part of this program, OCED sought applications demonstrating a range of technologies in diverse geograph-

ical regions to catalyze the next generation of clean energy projects on mine land. OCED selected five projects to begin award negotiations for a total of up to $475 million in federal funding. In December 2024, OCED awarded the MILESHIGH Project with more than $3.5 million to begin Phase 1 activities.

The MILESHIGH project, led by Freeport, plans to demonstrate the technical viability of direct-use, geothermal, clean heat to enable low-emission recovery of copper from previously mined material.

Located at the Morenci and Safford copper mines, the project would use the area's naturally occurring geothermal heat to offset the need for fossil-based heat to increase residual copper yields. Freeport also plans to install and operate a microgrid and a utility-scale battery energy storage system (BESS) at the Morenci copper mine to increase energy resilience and reliability onsite and for the surrounding community.

Overall, both the microgrid and geothermal components of the MILESHIGH project seek to decrease the mines' reliance for onsite fossil fuel backup generators and eliminate the need to add new natural gas-fired sources of heat to reduce the mines' greenhouse gas emissions and improve the energy resilience of local communities. With global electrification efforts expected to drive up copper demand, extracting these difficult-to-access resources can help secure a domestic clean energy supply chain.

Phase 1 of the project is expected to last approximately 12 months. During Phase 1, Freeport plans to make substantial progress on business agreements; conduct a risk assessment; prepare for local, state, and federal permitting; and refine the project schedule, budget, and financial model. The project will also continue community benefits activities, including engaging local communities and neighboring tribes and updating stakeholder mapping.

Copper Club Recognizes Quirk

The Copper Club, Inc. presented the 2024 Ankh Award to Kathleen L. Quirk, president and CEO of Freeport-Ran. She received the award during the club's annual dinner on June 2024, at the Plaza Hotel in New York City, New York. The award recognized her exceptional leadership and commitment to the copper industry.

"As one of the outstanding leaders in the industry, this well-deserved recognition acknowledges Kathleen's passion for the people who make our industry successful and her outstanding leadership of Freeport-McMoRan," said Copper Club Chair Stephen T. Higgins. "She has been steadfast in her commitment to our collective goal of promoting the responsible production of copper. At Freeport, this means a strong focus on partnering with host communities to deliver shared value with the aim of providing long-lasting benefits for all stakeholders."

Gunnison Copper Mobilizes Mining Fleet at the Johnson Camp Mine

The first Nuton site will begin producing copper soon

Gunnison Copper Corp. reported that its mining fleet has been mobilized, and mining activities such as pre-stripping began during December 2024. This follows the news that the company had started construction of the new leach pad, including crushing of the over-liner material, in August 2024. The company said the fully permitted Johnson Camp mine, in southeast Arizona, should produce first copper by mid-2025.

The Johnson Camp mine is a past producing open pit, heap leach operation. It includes two open pits, a fully functioning solvent extraction/electrowinning (SX/EW) plant, a complete set of pregnant leach solution and raffinate ponds. The brownfield site has supporting infrastructure (ancillary facilities, access, power, water, and communications). It is in Stage 2 of a process to restart the mine using Nuton technologies.

Gunnison started construction on a new leach pad for the Johnson Camp mine in August. (Photo: Gunnison)

Construction of the Johnson Camp mine is fully funded by Nuton LLC, a Rio Tinto venture. Gunnison is the owner and operator of the mine which has a production capacity of up to 25 million lb/y of copper cathode to directly supply critical American supply chains in the clean energy, defense, and manufacturing sectors. To facilitate the start of these activities and Stage 2, Nuton provided $7.9 million.

Nuton offers a portfolio of proprietary copper leaching related technologies and capabilities, a product of almost 30 years of research and development. These technologies have the potential to economically unlock copper from primary sulphide resources through leaching, achieving market-leading recovery rates and contributing to an increase in copper production at new and ongoing operations. One of the key differentiators of Nuton is the ambition to produce the world's lowest footprint copper while having at least one positive impact at each of its deployment sites.

Johnson Camp has a 25 million lb/y SX/EW plant, and pregnant leach solution and raffinate ponds. (Photo: Gunnison)

"We are extremely pleased with how well construction is progressing at the Johnson Camp mine," said Robert Winton, senior vice president-operations and general manager of Gunnison Copper. "We are tracking our major construction milestones and budget, including mobilization of the mining fleet and leach pad construction.

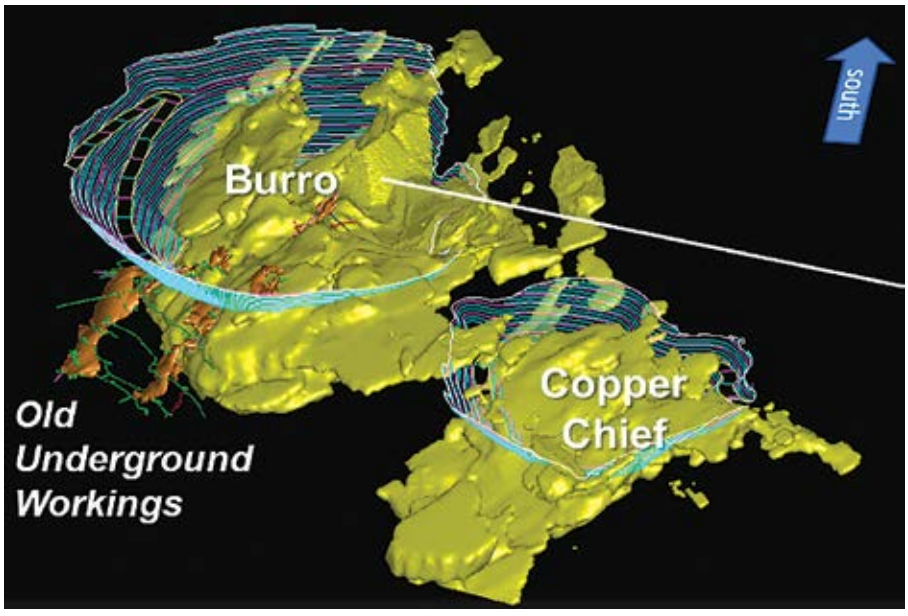
"The successful start of mining activities was made possible by our highly talented local workforce of more than 150 employees and third party contractors, reflecting our commitment to workforce development

and local area economic stimulus," he said. "From concept to first production measured in months is a testament to our partnership with Nuton and the support of the three engineering firms contributing to this industry first."

Following the decision by Nuton to proceed to Stage 2 of a process to restart the Johnson Camp mine using its copper heap leaching technologies, Gunnison completed the bulk of the planning and engineering and has mobilized crews to start construction. M3 Engineering based in Tucson has been awarded the EPCM contract. Earthworks related to the construction of the new leach pad began in August 2024, including crushing of the over-liner material. Rango Inc. from Mesa was awarded the leach pad construction and overliner crushing contract and is ramping up efforts to achieve construction milestones.

"The M3 and Rango team we have assembled is world class and committed to delivering a safe and timely project," Winton said. "The opportunity to build and operate Nuton's first demonstration of their state-of-the-art copper leaching technology is a privilege and our team is proud to deliver."

An ore control drill samples the Burro pit. (Photo: Gunnison)



An isometric shows pit shells overlain on orebodies at the Johnson Camp mine. (Image: Gunnison)

Consolidating the Cochise Mining District

Gunnison is also the first company to consolidate the entire Cochise Mining District in southwest Arizona, saying the district is under explored with significant resources and several development projects.

In addition to the Johnson Camp mine, the company has completed a comprehensive preliminary economic assessment (PEA) on the Gunnison project, which incorporates a large open pit of predominantly copper oxide mineralization approximately 2 km south of the Johnson Camp mine. The company said it would be developed as a conventional operation with open pit mining, heap leach, and an SX/EW refinery to produce finished copper cathode on-site with a direct rail link. The project would be low cost and environmentally friendly, and produce around 167 million lb/y of copper.

The PEA for the Gunnison copper project indicates a measured and indicated mineral resource containing over 831 million tons with a total copper grade of 0.31% (measured mineral resource of 191.3 million tons at 0.37% and indicated mineral resource of 640.2 million tons at 0.29%), and yielding robust economics including a net present value (8%) of $1.3 billion, and an internal rate of return of 20.9%, with a payback period of 4.1 years. Gunnison also owns a portfolio of adjacent exploration projects, including the historic South Star deposit and the Peabody Sill and the Strong and Harris deposits.

Together these projects present more environmentally friendly options for copper extraction. Extraction would require less water and low they would have a low footprint as far as greenhouse gas emissions compared to traditional sulphide mining and recovery. The mine would be located in a rural setting (predominantly ranching and mining areas) with a low population density yet excellent access to infrastructure. The projects would have no tribal land or cultural sites, no threatened/endangered species or habitat and no national/state forest land. That has contributed to Gunnison's permitting success with the Environmental Protection Agency, the Arizona Department of Environmental Quality (ADEQ) and Cochise County.

ADEQ Approves Air Quality Permit for Copper World

Hudbay gears up for the next step

Hudbay Minerals Inc. received an Air Quality Permit for the Copper World project from the Arizona Department of Environmental Quality (ADEQ) at the beginning of 2025. The issuance of this permit is a significant milestone in the advancement of the project as it is the final major permit required for the development and operation of Copper World. Located in Pima County, Arizona, approximately 50 km southeast of Tucson, Copper World is expected to produce 85,000 metric tons per year (mt/y) of copper over an initial 20-year mine life.

"With the receipt of the Air Quality Permit for Copper World, we firmly believe Hudbay now has the best fully permitted copper development project in the Americas," said Peter Kukielski, president and CEO, Hudbay Minerals. "We have completed one of the three key prerequisites in our sanctioning plan for Copper World, and we intend to advance feasibility studies and our prudent financial strategy throughout 2025 as we work toward a sanctioning decision in 2026. Copper World is expected to increase Hudbay's consolidated annual copper production by more than 50% from current levels, and the project will be a key contributor to the domestic U.S. supply chain with our plans to produce Made-in-America copper."

Today, Hudbay is the fourth largest copper producer listed on the NYSE and a majority of the company's institutional shareholders are based in the U.S., Kukielski explained. "We look forward to continuing to grow our presence in the U.S. with our planned $1.7 billion capital investment to build Copper World," Kukielski said. "Copper World's Made-in-America copper cathode is expected to be sold entirely to domestic U.S. customers and would make Copper World the third largest cathode produceri in the U.S. We believe Copper World will help meet the growing need for critical minerals in the U.S. related to increased manufacturing capacity, infrastructure development, increased energy independence, domestic battery supply chain needs and strengthening the nation's security."

Copper World Permitting Completed

Hudbay has now received all three key state permits required for Copper World development and operation, which includes:

- ***Mined Land Reclamation Plan – Completed*** – the Mined Land Reclamation Plan was initially approved by the Arizona State Mine Inspector in October 2021 and was subsequently amended and approved to reflect a larger private land project footprint. This approval was challenged in state court, but the challenge was dismissed in May 2023.

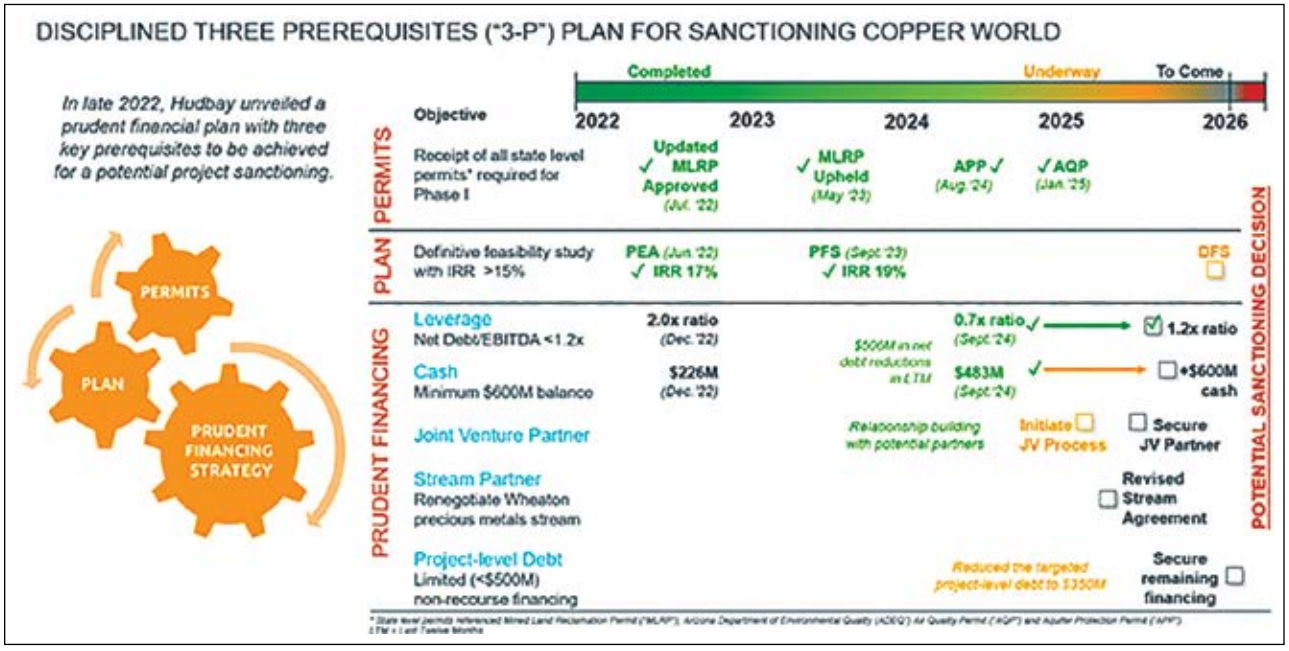


Figure 1 — Hudbay is taking a disciplined approach to financial planning for Copper World. The company's 3-P plan has three prerequisites to make a project sanctioning decision. (Graphic: Hudbay)

- ***Aquifer Protection Permit – Completed*** – the Aquifer Protection Permit was received on August 29, 2024, from the ADEQ following a robust process that included detailed analysis by the agency and Hudbay, along with a public comment period that was completed in Q2 2024.
- ***Air Quality Permit – Completed*** – the Air Quality Permit was received on January 2, 2025, from the ADEQ following a similarly robust process, including a public comment period that concluded in Q3 2024.

Hudbay said it received the two remaining permits on schedule and the company said it was pleased with the level of local support received at the public meetings. It said it looks forward to providing significant social and environmental benefits for the community and local economy in Arizona.

Over the proposed initial 20-year mine life, the company expects to contribute more than $850 million in U.S. taxes, including approximately $170 million in taxes to the state of Arizona. Hudbay also expects Copper World to create more than 400 direct jobs and up to 3,000 indirect jobs in Arizona. The operation will offer competitive wages and benefits, and the company said it intends to engage in partnerships with local apprenticeship readiness programs and community-based workforce training programs across the skilled and technical levels to fill and maintain all positions.

Disciplined Capital Allocation

As part of its disciplined financial planning approach to Copper World, in October 2022, the company introduced a plan with three prerequisites, or the 3-P plan, as shown in Figure 1, including specific leverage targets and other criteria that would need to be achieved prior to making a project sanctioning decision for Copper World. The 3-P plan has the following components:

1. ***Permits – Completed*** – receipt of all required state level permits.
2. ***Plan – On Track*** – completion of a definitive feasibility study (DFS) with an internal rate of return of greater than 15%. Hudbay commenced activities related to the feasibility study for Copper World in late 2024 and expects to advance DFS activities throughout 2025 with completion of the study in the first half of 2026.
3. ***Prudent Financing Strategy*** – On Track – multi-faceted financing strategy, including a committed minority joint venture partner, a renegotiated precious metals stream agreement optimized for the current project, a net debt to EBITDA ratio of less than 1.2 times, a minimum cash balance of $600 million, and limited non-recourse project level debt.

Since the release of the 3-P plan, Hudbay said it has taken prudent measures to transform its balance

The Copper World complex could stimulate billions in new economic activity for Arizona. (Photo: Hudbay)

sheet in preparation for a sanctioning decision.

Hudbay said it intends to commence a minority joint venture partner process early in 2025. It is anticipated that any minority joint venture partner would participate in the funding of DFS activities in 2025 as well as in the final project design and construction for Copper World.

The opportunity to sanction Copper World is not expected until 2026.

A Two-phased Approach

Copper World includes seven deposits discovered in 2021, together with the East deposit (formerly known as the Rosemont deposit). A new resource model was completed for the preliminary economic assessment (PEA) of Copper World in 2022, which contemplated a two-phased mine plan with Phase I as a standalone operation requiring state and local permits only and Phase II expanding onto federal lands requiring federal permits.

In September 2023, Hudbay released its enhanced pre-feasibility study (PFS) for Copper World reflecting the results of further technical work on Phase I of the project. Phase I has a mine life of 20 years, which is four years longer than the Phase I mine life that was presented in the PEA, largely due to an increase in the capacity for tailings and waste deposition because of optimizing the site layout.

Based on the PFS, Phase I contemplates average copper production of 85,000 mt/y over a 20-year mine life, at average cash costs and sustaining cash costs of $1.47/lb and $1.81/lb of copper, respectively. A variable cut-off grade strategy allows for higher mill head grades in the first 10 years, which increases production to approximately 92,000 mt/y of copper at average cash costs and sustaining cash costs of $1.53/lb and $1.95/lb of copper, respectively.

The estimated initial capital investment for Phase I of Copper World is approximately $1.3 billion with an additional $400 million in year four for the construction of a concentrate leach facility. At a copper price of $3.75/lb, the after-tax net present value of Phase I using an 8% discount rate is $1.1 billion and the internal rate of return is 19%.

Copper World is one of the highest-grade open pit copper projects in the Americas with proven and probable mineral reserves of 385 million mt at 0.54% copper.

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Optimization Investments Pay Dividends for Pinto Valley

Celebrating 75 years in 2024, the operation continues to strive for success

Capstone Copper owns and operates Pinto Valley, an open-pit mine located at the west end of the historic Globe-Miami mining district of central Arizona, one of the oldest and most productive districts in the U.S. Several mines and numerous prospects have been developed in the area approximately 80 miles east of Phoenix.

Pinto Valley has been in operation since July 1974. Capstone acquired the mine from BHP in October 2013. Today, the operation consists of an open pit mine, a 60,000 metric ton per day (mt/d) concentrator and a 25,000 mt/d solvent extraction/electrowinning (SX/EW) plant. Pinto Valley has the only operating mill in the Globe-Miami district and it's the second-largest employer.

The mine uses wheel loaders and haul trucks to move copper-bearing sulphide ore to the primary crusher. The processing plant is a conventional porphyry copper concentrator that produces a primary copper sulphide concentrate and a by-product molybdenum concentrate. The plant flowsheet is typical of its era with primary through tertiary crushing, ball milling and conventional flotation.

That being said, the mill has undergone several optimizations during its life. The most recent upgrade, the $31 million PV3 optimization, was completed in 2021 and focused on innovation and a series of low-capital, quick payback projects to debottleneck operational performance. This included investments in the fine crushing plant and two new ball mill shells, as well as upgrades to the tailings thickeners and tailings pumping stations. The project improved productivity and increased recoveries and mill throughput to the current 60,000 mt/d level.

A wheel loader dumps ore into a haul truck at the Pinto Valley mine. (Photo: Capstone)

The mine received a new U.S. Forest Service mine plan of operations in November 2021 and is fully permitted to operate for the duration of the current life, which extends to 2039.

Pinto Valley is currently progressing through a district growth study evaluating the inclusion of a portion of the 1 billion mt of mineral resources into the mine plan. This study could result in a mine life extension through 2050. Pinto Valley is also evaluating near-mine district consolidation opportunities in one of the most prolific mining jurisdictions in the U.S.

The operation is also evaluating other new technologies like autonomous haulage.

The Globe-Miami mining district hosts several deposits and past-producing mining operations. In 2022, Capstone completed a two-phase exploration program under an access agreement to conduct drill and metallurgical test work at BHP's Copper Cities project, located approximately 10 km east of the Pinto Valley mine. Drilling with two surface rigs, the twinning of historical drill holes was completed in 2022, with metallurgical testing continuing in 2023. This access agreement was recently extended to July 2025.

Production is Up and Cash Costs are Relatively Low

Capstone said it expects Pinto Valley to meet its 2024 guidance of 58,000-64,000 mt of copper at a cash cost of $2.50/lb to $2.70/lb. Year-to-date figures through Q3 2024 (latest available) indicate that Pinto Valley produced 45,646 mt of copper compared to 39,157 mt during the same period in 2023. Year-to-date average cash costs through Q3 2024 were $2.63/lb vs. $2.96/lb during the same period in 2023.

Copper production of 14,000 mt in Q3 2024 was 2% higher than in Q3 2023 due to higher grades (0.37% copper versus 0.34%) encountered in Castle Dome and Jewel Hill deposits. This was partially offset by lower mill throughput during the quarter (44,915 mt/d vs 47,426 mt/d in Q3 2023), which resulted from an unplanned 10 days of downtime during the quarter related to a conveyor belt rip and electrical faults.

Cash costs ($2.92/lb) were 3% higher in Q3 2024 compared to Q3 2023's $2.83/lb, primarily due to increases in operating costs ($0.15/lb) driven by contractor and mechanical parts spend in the mill, electricity cost, labor cost, lower by-product credits ($0.12/lb) and higher treatment costs

($0.06/lb), partially offset by higher production volume (-$0.07/lb) and capitalized stripping (-$0.17/lb).

The company said it continues to review and evaluate the consolidation potential of the Pinto Valley district. Opportunities under evaluation include a potential mill expansion and increased leaching capacity supported by optimized water, heap and dump leach, and tailings infrastructure. Capstone believes that district consolidation could also unlock significant ESG opportunities and may transform its approach to create value for all stakeholders in the Globe-Miami District.

Pinto Valley signed the Copper Mark Letter of Commitment in 2024 formalizing its participation in the Copper Mark assurance process.

Pinto Valley is the second largest employer in the Globe-Miami District. (Photo: Capstone)

Celebrating 50 Years of Operation

Pinto Valley has been in operation since July 1974, when the first phase of the mine's concentrator, built in 1972, was commissioned. The rest of the concentrator was brought online during October 1974.

The mine was first developed and operated by Cities Service Co. The first ore truck, shovel and drill arrived on site in 1972. The Magma Copper Co. and BHP eventually bought and operated the mine.

Since the first recorded production in 1975, Pinto Valley has produced more than 4 billion lb of copper. Today, the mine contributes more than $270 million to Arizona's economy annually. "That would be the same as holding the Super Bowl every year," said Capstone Senior Advisor for Communications and Community Relations Jamie Ramsey, a fourth-generation miner.

During November 2024, Capstone Copper invited the public to view the Pinto Valley mine and celebrate the 50-year anniversary. This family-friendly event offered the community a unique opportunity to explore the world of open-pit copper mining and learn about the mining industry's vital role in modern society.

The program included guided bus tours in and out of the pit and around the property; photo opportunities to capture the beauty and scale of the mine; and STEM activities designed to inspire and educate future generations about the science and technology behind mining.

"Our Open Day aimed to celebrate the strong relationship between the Pinto Valley and our local communities," Ramsey said. "This was a fantastic opportunity for them to learn more about the sustainable practices and state-of-the-art technologies that drive our operations.

"We were thrilled to welcome the community to Pinto Valley," Ramsey said. "This event highlights our commitment to transparency and education, as well as providing a platform to engage with our neighbors and stakeholders."

During November, Pinto Valley opened its doors to the community. (Photo: Capstone)

A New Generation Typhoon Conducts Its First Survey in Arizona

Ivanhoe Electric's exploration program further defines Santa Cruz

Ivanhoe Electric is a U.S. company that combines advanced mineral exploration technologies with electric metals exploration projects predominantly located in the United States. It uses its accurate and powerful Typhoon geophysical surveying system, together with advanced data analytics provided by its subsidiary, Computational Geosciences Inc., to accelerate and de-risk the mineral exploration process as the company seeks to discover new deposits of critical metals that may otherwise be undetectable by traditional exploration technologies.

Ivanhoe Electric Executive Chairman Robert Friedland and President and CEO Taylor Melvin recently provided an update on the activities associated with the BHP Exploration Alliance in the southwestern U.S.

"The Basin and Range province of the southwestern U.S. remains one of the most promising frontiers for porphyry exploration," Friedland said. "Together with BHP, we have deployed a new generation Typhoon system to look for potential world-class deposits that are hidden from the surface by younger cover rocks."

The Ivanhoe Electric and BHP Exploration Alliance new-generation Typhoon unit arrived in early December to one of the six AOIs to commence the Alliance's first deep-penetrating geophysical survey.

The Alliance is focused on exploring mineral deposits hidden under post-mineral cover. It received an initial funding commitment of $15 million from BHP and is operated by Ivanhoe Electric's exploration team.

"We are pleased with the rapid progress made by our exploration alliance with BHP and look forward to completing our first Typhoon survey at an Area of Interest (AOI) located in Arizona," Melvin said. "Our alliance is proving to be an effective platform to pursue exploration opportunities that are well-suited for Ivanhoe Electric's exploration technologies, looking deep below the surface for new sources of copper and other critical metals in the southwestern U.S."

The Alliance is actively exploring six designated AOIs within Arizona, New Mexico, and Utah. Any joint venture that is agreed to be established within these areas will operate under a 50:50 ownership structure.

The first Typhoon survey of the Alliance has commenced, exploring a major porphyry copper trend in Arizona.

A new-generation Typhoon unit was mobilized in early December to initiate the Alliance's first deep-penetrating geophysical survey. The initial Typhoon survey is being completed along a well-known and major porphyry copper trend, with a significant production history and a large endowment of copper in current reserves and resources in the region.

During the first phase of the Alliance, exploration teams have been deployed to advance reconnaissance work, geochemical sampling, and detailed geological mapping programs across the AOIs. In addition, more than 5,600 line-km of airborne magnetic surveying and 1,500 line-km of hyperspectral surveying have been completed so far.

From left to right, Rafael Romano, principal geoscientist, BHP; Dan Koning, senior geologist, Ivanhoe Electric; Robert Lee, principal geoscientist, BHP, and an Alliance Technical Committee member; and Andrea Cade, P. Geo., manager, technical reporting for Ivanhoe Electric and an Alliance Management Committee member, observing outcrops during a site visit to one of the six AOIs.

The results of exploration fieldwork and the 3D inversion of geophysical data were used to inform subsequent land acquisition and Typhoon planning. So far, more than 110 km^2 of unpatented mining claims have been staked across Arizona and New Mexico.

Once the initial survey is complete, the Typhoon results will be processed by Computational Geosciences Inc. The resulting data will then be integrated with other datasets to develop the Alliance's first drill targets.

Drilling Expands the Texaco Deposit at Santa Cruz

Ivanhoe Electric also discussed the company's exploration projects in the U.S., including the Santa Cruz copper project in Arizona.

"Our U.S. exploration team, led by Graham Boyd, successfully advanced multiple large-scale and early-stage exploration projects in 2024, while continually evaluating new opportunities," Melvin said. "Our technology-driven exploration platform allowed our experienced team to expand the known copper mineralization at the Texaco Deposit in Arizona, discover a copper-gold-molybdenum porphyry system at Hog Heaven in Montana, and gain a better understanding of our Tintic Project in Utah. We are using the seasonal winter break in drilling to evaluate our 2024 results, review new potential projects, and prioritize our 2025 exploration plans in the U.S."

Exploration programs at Ivanhoe Electric's projects during 2024 included approximately 29,000 m of exploration drilling at the three projects, in addition to approximately 5,000 m of drilling at earlier stage projects.

Exploration drilling at the Santa Cruz copper project intersected new chalcocite-enriched mineralization at the Texaco Deposit.

Exploration drilling in 2024 at the Santa Cruz copper project focused on the Texaco Deposit and the Southwest Exploration Area, with eight drill holes totaling approximately 8,700 m completed (Figure 1). Both drilling campaigns were guided by previous Typhoon surveys.

Recent assay results from Texaco drill holes SCC-242 and SCC-248, at the same 0.80% total copper cut-off grade used for the Texaco mineral resource estimate, confirm the presence of copper mineralization on the northeastern and northwestern edge of the Texaco Deposit.

- Hole SCC-242: 63.4 m grading 1.70% copper from 895.6 m, including 25.7 m with 2% total copper from 897.4 m;
- Hole SCC-248: 10 m grading 1.19% copper from 859 m, and 24 m at 1.06% copper from 877 m, and 6 m with 1.71% copper from 916 m; and

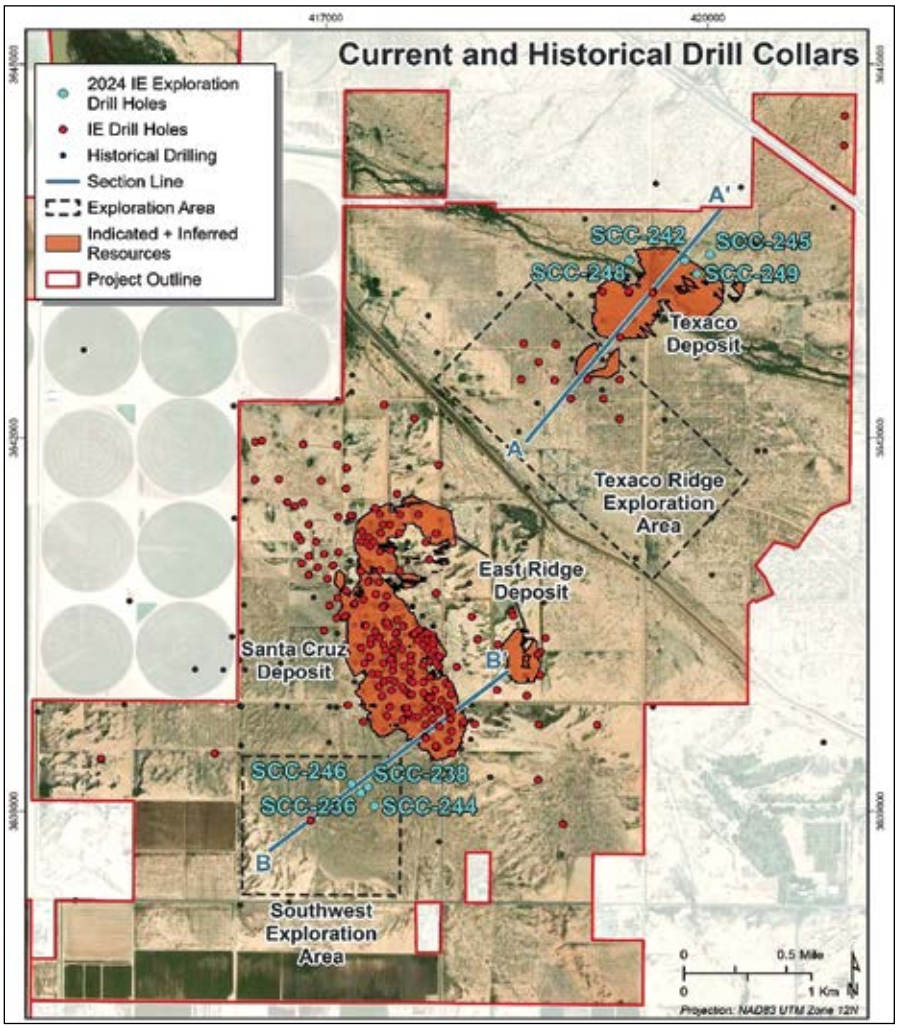


Figure 1 — Plan view map of the Santa Cruz Copper Project showing completed drill holes since the December 2022 MRE contained in the September 2023 Initial Assessment, the location of drill holes from the 2024 exploration program, and the location of cross-sections A to A' and B to B'.

- Hole SCC-249: 35.6 m grading 1.37% copper from 923.4 m, including 26.1 m at 1.56% copper from 923.4 m.

Exploration drilling in the Southwest Exploration Area included four drill holes. It was recognized after Ivanhoe Electric drilled an anomaly generated by Typhoon and intersected sulphide copper mineralization under cover more than 1 km southwest of the Santa Cruz deposit.

Drill hole SCC-236 was completed 600 m southwest of the southernmost extent of the currently defined mineral reserve estimate at the Santa Cruz copper project. SCC-238 was collared 75 m northeast of SCC-236. Using the Santa Cruz mineral reserve estimate's total copper cut-off grade of 0.70%, no intercepts are reportable from drill hole SCC-236, and one intercept is reportable from SCC-238.

Further exploration drilling in the Southwest Exploration Area will be considered after the results of recent 3D seismic and ambient noise tomography surveys are processed and interpreted.

The Texaco Deposit is expected to have an updated mineral reserve estimate as part of the Santa Cruz copper project's preliminary feasibility study, which is on track to be completed by the end of Q2 2025.

Ivanhoe Electric said it believes the United States is significantly underexplored and has the potential to yield major new discoveries of critical metals.

Ensuring Safety for Arizona's Mining Contractors

Key Strategies for a safer workforce

By Paul Marsh, Arizona State Mine Inspector

Arizona has long been a mining state, and while the landscape of the industry has evolved, mining remains a cornerstone of its economy. Today, contractors make up more than 75% of the mining workforce in the state, handling a variety of specialty tasks that require unique expertise. However, as mining dynamics shift, ensuring the safety of these contractors becomes increasingly vital.

Mining contractors often face higher risks than their counterparts who are directly employed by the mines. Tragically, the last five fatalities at Arizona mines involved contractors. The State Mine Inspector's Office places special emphasis on inspecting contractors during every inspection, but the reality is that mining contractors are not always inspected as frequently as needed.

In many cases, contractors are tasked with specialized work that demands specific tools, training, and knowledge — yet onsite safety personnel may not always be familiar with these processes. This gap can result in insufficient safety supervision or inspections, further increasing the potential for accidents.

Moreover, contractors often work across multiple mine sites, each operated by different companies with distinct safety protocols, creating additional challenges for overseeing safety. This constant change of work environment can lead to added stress for contractor crews, especially as they comply with safety regulations and unfamiliar work sites.

To improve safety for Arizona's mining contractors, it's critical that both contractors and mine operators take proactive measures to mitigate risks. Here are a few steps to ensure contractor safety remains a priority in 2025 and beyond.

Safety training is essential, but it shouldn't be repetitive or dull. (Photo: Office of the Arizona State Mine Inspector)

1. Conduct an Honest Assessment

One of the first and most important steps in improving safety is performing a thorough and honest assessment of your operation. How often do you review your safety protocols, equipment, and work conditions? It's easy to overlook risks when everything seems to be operating smoothly, but a regular safety audit can help identify areas that require attention.

A safety audit should cover all aspects of the work environment, including equipment maintenance, worker behavior, and environmental factors. Additionally, contractor-specific risks, such as the use of specialized equipment and unique tasks, should be assessed. If your site has not been audited recently, now is the time to begin this critical process.

2. Improve Communication

Safety cannot thrive without strong communication. Have you created an environment where contractors feel comfortable voicing safety concerns? Whether it's a concern about equipment, safety procedures, or potential hazards, workers must have clear, open channels for communication.

Ensure that contractors are encouraged to report safety issues without fear of retribution. Regular check-ins and feedback mechanisms, such as anonymous reporting systems, can facilitate this process. Additionally, it's important that supervisors listen attentively and act swiftly to address concerns. Building a culture of open communication helps establish trust and ensures that safety protocols are continuously reviewed and improved.

3. Turn Near Misses into Opportunities

Near miss incidents — when an accident almost occurs but doesn't result in injury — are often dismissed as minor. However, near misses should be seen as early warning signs that

point to potential dangers in the workplace. If left unaddressed, near misses can lead to serious accidents, injuries, or fatalities.

Make it a practice to analyze each near miss, identify the root cause, and implement corrective measures. Encourage your contractors to report near misses without fear of blame. By treating these incidents as valuable learning opportunities, you can address potential safety risks before they escalate into major issues.

4. Make Training Regular and Engaging

Safety training is essential, but it shouldn't be repetitive or dull. Engaging, hands-on training that keeps contractors involved will improve retention and ensure that safety becomes second nature. For contractors, safety training should not only cover basic procedures but also include specialized training for tasks that may be unique to their role.

Don't rely solely on the MSHA 24-hour and 8-hour refresher training. While these are important, they should be supplemented with additional, scenario-based training that mimics real-life situations. You can also incorporate videos, storytelling, or humor to make the training more engaging and relatable. This proactive approach to training helps keep contractors prepared for any situation.

5. Foster a Culture of Safety

Creating a culture of safety is crucial for long-term success. Safety should be embedded into the core values of your organization, and everyone—regardless of whether they're a direct employee or a contractor—should feel responsible for maintaining a safe work environment. Encourage contractors to take ownership of their safety and to actively contribute to identifying and resolving safety hazards.

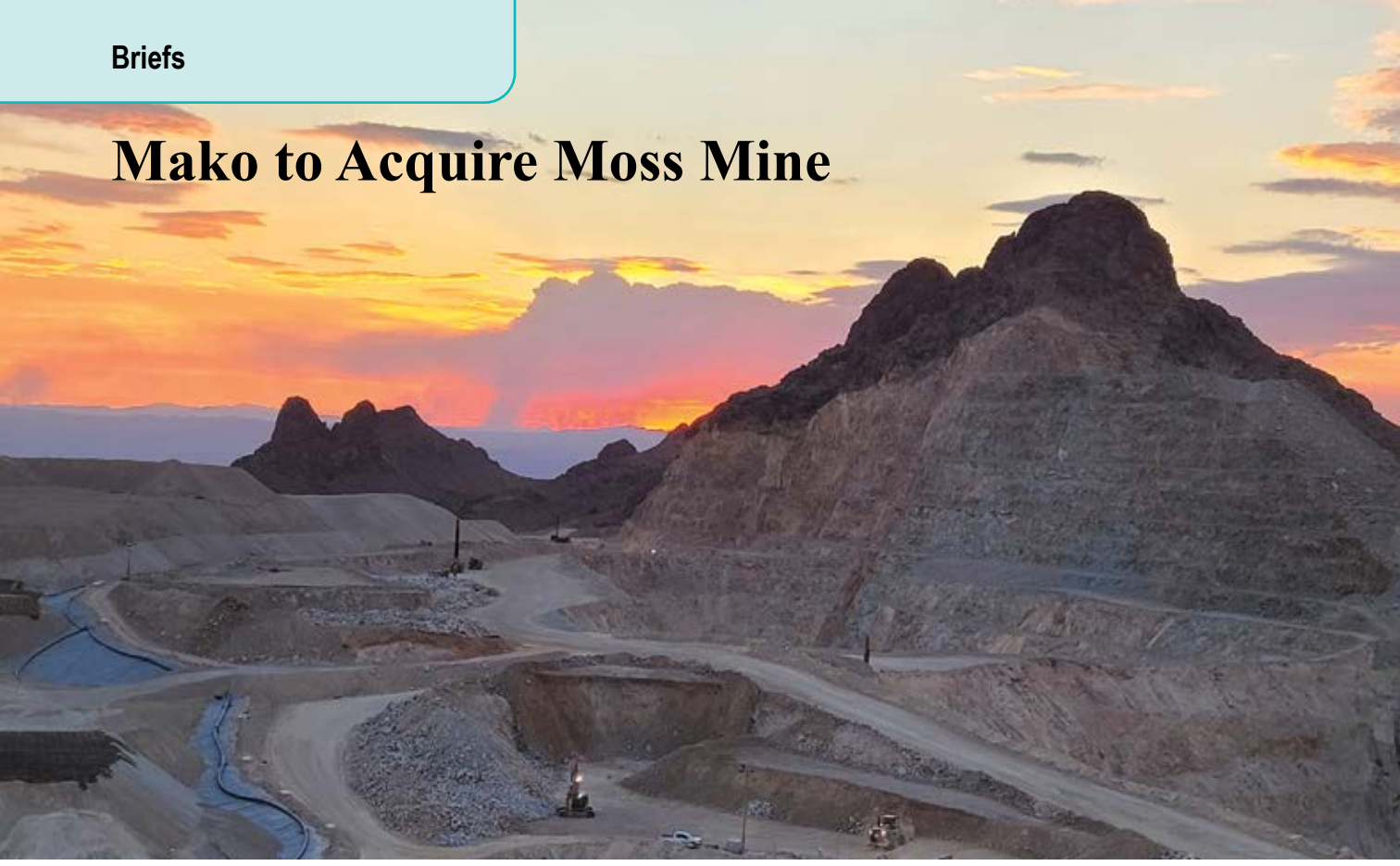
Acknowledging and rewarding safety contributions can also motivate workers to maintain a strong focus on safety. Whether it's through formal recognition programs or informal thanks for pointing out hazards, creating a positive feedback loop encourages everyone to participate in safety initiatives.

Conclusion

As contractors play an increasingly prominent role in Arizona's mining industry, it's essential to prioritize their safety. With specialized tasks, unique risks, and constantly changing work environments, contractors face a variety of challenges that require tailored safety solutions. By conducting regular assessments, improving communication, addressing near misses, providing engaging training, and fostering a culture of safety, we can help ensure that Arizona's mining contractors stay safe and healthy in their critical work.

Remember, contractor safety is not just an obligation — it's an investment in the well-being of the workforce and the success of the mining operation.

Mako to Acquire Moss Mine



Combining its operating knowledge and its controlling shareholder's experience with distressed properties, Mako thinks it can turn the Moss mine around. (Photo: Elevation Gold)

Mako Mining Corp. entered a non-binding letter of intent to acquire the Moss gold mine located in the historic Oatman District in Arizona from Elevation Gold. The purchase price is expected to be in the range of $4.9 - $6.4 million, all payable in cash. The difference in price is related to a dispute on a net smelter return royalty for the property. The proposed transaction is expected to close by February 2025.

Elevation entered the bankruptcy protection process at the end of July 2024 and mining operations at the Moss mine ceased. The process allowed the company to eliminate more than $60 million of liabilities associated with the Moss mine. Elevation continued to recover gold and silver from its leach pads throughout the bankruptcy process.

The proposed transaction will allow Mako to add a producing asset located in a top tier jurisdiction funded solely out of cash flow generated from the last quarter of Mako's current mining operations. Mako currently operates the high-grade San Albino gold mine in northern Nicaragua and owns the Eagle Mountain project in Guyana. Wexford Capital is a controlling shareholder in Mako.

"Combining the company's experience in building and operating small and medium scale mines in the Americas, with the bankruptcy and distressed investing expertise of the controlling shareholder, with the profitability and pipeline that exists within our current portfolio, puts Mako into a very select class of companies," said Akiba Leisman, CEO, Mako. "We will be looking to expand our opportunities, especially with the new mining friendly U.S. administration about to take office."

Mako said it plans to restart mining operations upon completion of the proposed transaction once it has had an opportunity to optimize the mine plan and debottleneck the crushing plant. This is expected to be achieved within a few months of closing.

Faraday Continues to Define Copper Creek

Faraday Copper is a Canadian exploration company focused on advancing its flagship project, the Copper Creek project, located in Pinal County, Arizona. Copper Creek is one of the largest undeveloped copper projects in North America with district scale exploration potential.

With extensive historical exploration, over 200,000 m of drilling and modest past production, Faraday sees significant exploration upside. The company said there are several hundred known breccia occurrences mapped at surface, of which less than 20% have been drill tested and only 17 are included in the mineral reserve estimate (MRE).

During the Phase II drill program, assay results confirmed the potential for gold to occur in economic concentrations. Gold is not currently included in the MRE. A sampling program to gather sufficient data coverage for potential

gold inclusion in future technical studies is largely complete. The results from the Childs Aldwinkle and Copper Prince breccias, as well as the Keel underground zone have been returned. The company continues to evaluate other areas for potential inclusion of gold in future mineral resource updates.

During February 2024, Faraday reported results from a metallurgical program focused on grind size optimization that demonstrated the viability of coarse particle flotation, gold recoveries in concentrate and test work on near surface oxide mineralization.

The ongoing Phase III drill program commenced in Q4 2023 and the current focus of drilling is on the near-surface mineralization in the American Eagle and Rum areas.

At the beginning of 2025, Faraday reported the results of five Phase III drill holes. Two holes were drilled in the American Eagle area,

Exploration drilling continues at Copper Creek to further define the resource. (Photo: Faraday Copper)

two in the Rum area and one was a reconnaissance hole east of Area 51.

Two drill holes, FCD-24-077 and FCD-24-082, expanded the known near-surface mineralization in the American Eagle area. Drill hole FCD-24-082 intersected mineralization in the Prada breccia and the results demonstrate that the Boomerang breccia is mineralized at depth. At Boomerang, the drill intercepted 40 m at 0.78% copper, 0.018% molybdenum, and 2.28 g/mt silver from 459 m.

"It is exciting to see that our on-going drill program continues to deliver positive results," said Paul Harbidge, president and CEO, Faraday Copper. "These results confirm additional near-surface mineralization above the existing resource in the American Eagle area, including the identification of high-grade copper at the Boomerang breccia. Moreover, significant copper was identified in veins outside the breccia domains. All 15 drill holes, reported in the American Eagle area to date, have intersected copper mineralization above cutoff grade with numerous high-grade zones present. Additionally, drilling has demonstrated exploration potential well outside of the resource area, including east of Area 51 and at depth in the Rum area."

Antler Project Benefits from Promising Drill Results

New World Resources, an Australian group developing the Antler project, near Yucca, Arizona, submitted its aquifer protection permit and reported the most recent results of its drilling campaign.

The company said its reserve upgrade drilling program has been extremely successful in increasing the confidence in the thickness and grade of the mineralization to be mined in the first 3-5 years of operations. A recent intercept of 18.6 m grading 2.8% copper, 9.4% zinc, 0.9% lead, 41 grams per metric ton (g/mt) silver and 0.29 g/mt gold or 5.9% copper equivalent (Cu-eq) enhances the robustness of the geological model ahead of pending resource update.

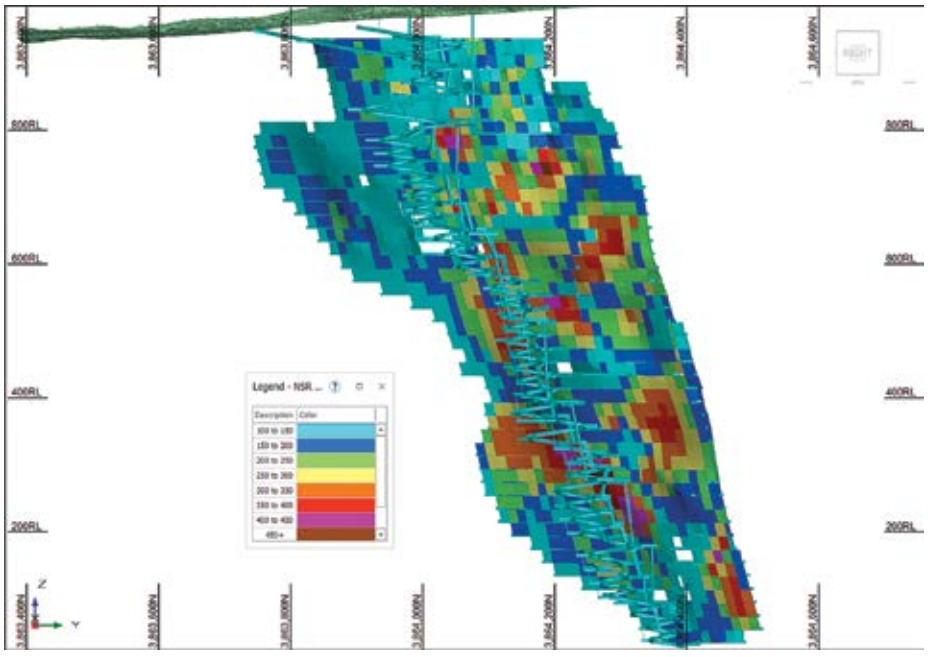
As a result of this drilling program, a sizeable component of the Antler mineral resource will likely be upgraded to the measured category when the JORC Mineral Resource Estimate is updated in Q1 2025. A composite sample of representative drill core is now being assembled for advanced metallurgical test work.

"Antler continues to consistently deliver high-grade mineralization with recent in-fill drilling yielding one of the thickest and highest-grade intercepts seen to-date," said Nick Woolrych, managing director, New World Resources. "Overall, the reserve definition drilling program exceeded our expectations, which allows New

World to proceed confidently to DFS and into development."

New World applied to the Arizona Department of Environmental Quality (ADEQ) for an aquifer protection permit. This permit is a long-lead item and, during October 2024, ADEQ confirmed that the application was technically complete.

"It is very encouraging that New World has achieved another determination of completeness by the ADEQ in such a rapid timeframe, with no modifications required to our original application," Woolrych said. "This achievement highlights the exceptional work of New World's development team and consultants and underscores the supportive approach of Arizona's State and Federal regulators. Truly, there is no better place to develop a copper project!"



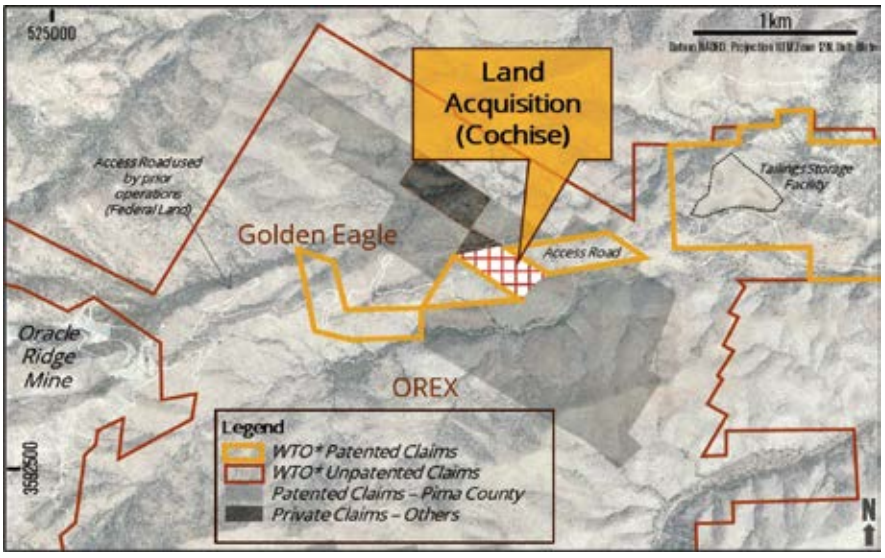
A 2024 PFS evaluated the development of an underground mining operation for the Antler project. (Image: New World Resources)

A prefeasibility study (PFS), released during July 2024, evaluated the development of an underground mining operation, together with construction of a processing plant, pastefill plant, a fully-lined dry-stack tailings storage facility and associated infrastructure.

The JORC Mineral Resource Estimate (MRE) for the Antler deposit currently comprises 11.4 million metric tons (mt) grading 2.1%

copper, 5% zinc, 0.9% lead, 32.9 g/mt silver and 0.36 g/mt gold or 4.1% copper equivalent (Cu-eq). This makes it one of the highest-grade copper deposits in the world on a Cu-eq basis, according to New World Resources.

The Antler deposit remains open at depth and along strike. The company said it is committed to ongoing local and regional exploration and is currently continuing to drill to test numerous priority targets. Additional discovery could potentially extend the life of the mining operation at Antler and/or result in a larger production profile, both of which would likely further enhance the already very robust economics of developing the Antler project.



The Cochise claim provides access and infrastructure between the Oracle Ridge mine and the tailings facility. (Map: Eagle Mountain)

Eagle Mountain Acquires Cochise Patented Claim

Eagle Mountain Mining successfully completed the acquisition of a strategic land package for its Wedgetail project during December 2024. Eagle Mountain is a copper-gold explorer focused on the exploration and development of its Wedgetail and Silver Mountain projects in Arizona. The company paid $200,000 to complete the acquisition, and title for the property has been transferred to Wedgetail Operations LLC, a wholly owned subsidiary of Eagle Mountain.

The Cochise private patented provides strategic access and infrastructure between the Oracle Ridge mine and the tailings facility, along

with valuable water rights. "The completion of the Cochise claim acquisition marks a key milestone for Eagle Mountain," said Tim Mason, CEO, Eagle Mountain Mining. "We have now acquired the last privately held property between our tailings storage facility and the Oracle Ridge mine. We are confident this acquisition will have a positive impact on the long-term success and sustainability of the Wedgetail project."

In February 2024, the company exercised a first right of refusal to acquire the approximately 15 acres of the Cochise patented claim adjacent to existing patented claims owned by Eagle Mountain. The acquisition is for 100% of the surface rights.

The acquisition terms are $325,000 comprising a down payment of $200,000 and a secured seller's loan of $125,000 over a 5-year period at 6% interest per year, with monthly repayments. The purchase of Cochise avoids approximately $190,000 of further lease payments which were payable under the lease agreement with the vendor.

The company has now finalized the legal agreements, transferred the down payment and received the legal title for the Cochise patented claim. Based on the access route shown on the map on page 60, the company now owns the remaining piece of private property not already owned or perpetually controlled, or on public federal land.

The Company does not have mineral rights to Cochise at this time, however exploration activities are currently being planned to broaden the understanding of OREX and Golden Eagle targets. These activities can be supported by using the recently acquired claim for drill sites and associated equipment storage. Furthermore, Cochise hosts the Sanderson gold mine which shares similar geology to nearby claims. The Sanderson mine operated as an underground operation between 1936 and 1941.

Arizona Metals Closes on Bought Deal Public Offering

During December 2024, Arizona Metals Corp. closed on its previously announced bought deal public offering of 15,927,700 common shares at a price of $1.70/share, which generated more than $27 million for the company. Arizona Metals said it plans to use the proceeds to fund exploration expenditures at its Kay Mine project and Sugarloaf Peak property, both of which are in Arizona.

The Kay Mine property is located in Yavapai County, on a combination patented and BLM claims totaling 1,665 acres that are not subject to any royalties, and 193 acres of private land. An historic estimate by Exxon Minerals in 1982 reported a "proven and probable reserve of 6.4 million short tons at a grade of 2.2%

copper, 2.8 g/t gold, 3.03% zinc, and 55 g/t silver."

During May 2024, Arizona Metals purchased an Arizona State Land parcel totaling 40 acres, located 400 m northeast of the Kay Mine property. The Property was purchased for $366,100 by way of an auction process. At the time, the company said it had commissioned independent biological and archaeological studies which both demonstrated zero adverse impacts or remediation requirements. The property includes the surface and water rights, among other rights and benefits. The company has also staked unpatented lode and placer claims that secure mineral rights to this land.

"The acquisition of the property is another significant de-risking step in moving the Kay Mine Deposit closer to a production decision," said Marc Pais, CEO of Arizona Metals. "Including the 71 acres of patented land that host our Kay Mine deposit, this acquisition will increase our total holdings of private and patented land to 264 acres. The property is contiguous with and adjacent to the 153 acres of patented land (including water rights and wells) acquired up to November 2023. The additional land we are acquiring increases the private land suitable for future mine infrastructure by 26% and is in-line with our vision of a minimally disruptive operation while also allowing for an expanded operational footprint.

"We believe that our Kay Mine project has the potential to become one of Arizona's newest and highest-grade copper-gold-zinc-silver mines, with the main deposit and potential for all infrastructure to be located on private land," he continued. "This would allow for a relatively small footprint while also providing high-paying jobs to the local community of Black Canyon City. The Kay Mine project already has the benefit of being only an hour north of Phoenix, with excellent access to infrastructure, including rail, roads, water, and power. The acquisition will provide the potential for an expanded operation, increased flexibility in mine design, and accelerated permitting timelines."

World Copper Initiates Strategic Review

World Copper Ltd. a Canadian company developing the Zonia project, initiated a strategic review process during November 2024 and has engaged Origin Merchant Partners to assist it in its review. OMP will work with World Copper's management and board to evaluate a range of strategic alternatives that may be available to the company to grow and maximize value for all shareholders.

"This strategic process has derived from numerous interested corporate entities that have approached World Copper," World Copper CEO Gord Neal said." Adverse market sentiment has seen junior resource companies with excellent economic assets become extremely undervalued. This process creates an opportunity for larger resource players to seek transactions that can benefit all shareholders."

Zonia is copper oxide project in central Arizona. In November 2024, the company published an amended resource estimate that contains indicated resources of 112.2 million tons grading 0.297% total copper containing 668 million lb of copper, and inferred resources of 62.9 million tons grading 0.255 % total-copper containing 320 million lb of copper.

Fortescue Launches Arizona Hydrogen

During 2024, Australia iron ore miner Fortescue marked a new phase in the development of the company's $550 million venture into green hydrogen production in the U.S. It celebrated the first of its planned green energy investments in North America, Ari-

Fortescue breaks ground on Arizona Hydrogen. (Photo: Fortescue)

zona Hydrogen, with a groundbreaking ceremony in Buckeye, Arizona.

At the 158-acre facility site, Fortescue Executive Chair and Founder Dr. Andrew Forrest praised the Biden Administration's commitment to the energy transition, but cautioned there is more work to be done.

"The U.S. has made serious strides in attracting global investment in green hydrogen and decarbonization projects, like Fortescue's solar and wind-powered Arizona Hydrogen facility. Fortescue is unashamedly a first-mover in this space, the world needs us to move quickly," Forrest said.

"But, we need to be encouraged to that, not punished. There are rules right now under consideration with the Biden Administration that would make already announced projects like this one dramatically more expensive and smaller, resulting in fewer economic opportunities and slower progress on decarbonization. I support the Biden Administration's goal to produce hydrogen in a way that prioritizes sustainability, however 45V, in its current form, is a straitjacket on the industry and works against the Biden Administration's own climate goals."

According to new economic data from NDP Analytics, during the two-year construction phase, Arizo-

na Hydrogen has the potential to create up to 2,244 direct, indirect, and induced jobs that could earn $124.2 million in wages. The facility could add $187.8 million to Arizona's GDP and generate a potential $31.7 million in income and sales taxes for state and local governments.

During the operation phase, Arizona Hydrogen is expected to employ 40 people at the facility itself, as part of a potential 431 direct, indirect, and induced jobs that could earn $29.3 million in wages. Arizona Hydrogen could also add $59.2 million to Arizona's GDP, and generate $9.1 million income and sales taxes for state and local governments annually.

Arizona Hydrogen is slated to produce up to 11,000 tons of liquid green hydrogen annually and is strategically positioned to significantly contribute to the decarbonization of the heavy-duty on-road transportation sector. The southwest market consumes approximately 5 billion gallons of diesel annually in heavy-duty transport, making PHH a vital player for reducing emissions in the mobility sector."

In recognizing and honoring the traditional lands of the Akimel O'otham and Pee Posh people, we have a profound connection and shared responsibility as stewards of the earth. Companies like Fortescue, are helping to pave the way for a more sustainable and equitable future for our generations to come," said Stephen Roe Lewis, Governor of the Gila River Indian Community.

"Buckeye is happy to welcome Arizona Hydrogen to the Sustainable Valley," said Buckeye Mayor Eric Orsborn.

"Fortescue's investment in our community helps Buckeye, and the entire state of Arizona, continue to grow efficiently and sustainably for generations to come."

"Today is an exciting milestone for the future of Arizona's clean energy economy," said Sandra Watson, President and CEO of the Arizona Commerce Authority.

"Arizona Hydrogen strengthens Arizona's position as a national sustainability leader at the forefront of clean energy technologies and innovation. We are grateful to Dr. Forrest and the entire Fortescue team for their commitment to Arizona, and we look forward to supporting Fortescue's long-term success in Buckeye."

Ads List

MINING IS AT OUR CORE

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Fleet Management That's Fit for the Future

E&MJ *explores some of the biggest challenges and opportunities in mine fleet management today*

By Carly Leonida, European Editor

Mine fleet management systems, or FMS, form the backbone of mobile equipment operations the world over, providing insights that managers and operators require to best meet their safety, productivity and sustainability goals.

"There are three broad challenges that FMS users face today," explained Jarym Kowalchuk, Head of Product, Load and Haul at Hexagon's Mining division. "Ineffective system adoption, lack of connection to the value chain, and leveraging data that comes out of the system."

In terms of ineffective adoption, Kowalchuk explained that there's often a gap between what today's FMS are capable of and the ability of the organization to leverage the system's advanced capabilities to realize its full potential.

"Today's FMS are designed to address the challenges of monitoring, managing and optimizing complex systems on a mine site for equipment and material movement," he said. "Many mines are opting for a system with advanced capabilities, and taking internal training and change management opportunities to realize the greatest value possible."

He added that the interfaces between operational functions, such as drilling and blasting, loading and hauling and crushing and mineral processing, are often where the greatest opportunities lie for cost savings and efficiencies. Each process area has some degree of optimization occurring within it, i.e., FMS target the optimization of load and haul movements, but rarely is there any cross-functional optimization.

"There's a huge opportunity to connect all of these processes through advanced optimization and FMS can play an important part in that," said Kowalchuk. "Modern mines use a suite of different solutions from different vendors and it's an ongoing challenge to extract data from these systems in a timely manner and in a context that makes sense. Vendors and miners have been making investments to address these challenges, but many still exist."

Finding the right FMS that aligns with a mine's unique operational model is crucial for maximizing its benefits. (Photo: Haultrax)

Making the Most of Data Insights

Hexagon's belief that seamless data usage across the value chain will allow mines to unlock significant value means this capability is front and centre in its product design.

"Effectively, accessing and using the data from our solutions not only allows customers to realize their full value, it also accelerates effective implementation," Kowalchuk explained. "For example, with good data and analytics, the time from implementation to measuring value can be shortened from years to months or even weeks in some cases."

Systems integration can also help mines to identify data correlations that might not otherwise be possible, for instance, between a safety event or breakdown that happened in a particular location and the current condition of the equipment or road. Often, mines never manage to identify the root cause of such issues, but the extra level of insight that connected processes provide can help to address this.

A growing number of mining operations are now opting for cloud-hosted or hybrid FMS deployments which support enhanced data sharing and cross-functional analytics.

"We're seeing this happening more and more across the industry," Kowalchuk told *E&MJ*. "However, it's important that systems providers work closely with clients on this journey, so that the reliability and security of their data and production systems aren't compromised. Hexagon now has a dedicated cybersecurity team that provides support and guidance for our customers and products."

He added that many smaller mine operators, particularly those that use lite versions of FMS are now going directly to the cloud for deployments, whereas larger, more complex operations which require a comprehensive, feature-rich solution would do better to move to the cloud in stages.

"For these operations, if there were any latency or the connection with the cloud was lost and the FMS became temporarily unavailable, that would be unacceptable," said Kowalchuk. "So, it's better to take cloud one step at a time."

One of Hexagon's latest releases is a combined hardware and software improvement to its high-precision machine guidance solution. "We just released a next generation antenna which unlocks L5 band capabilities," Kowalchuk told *E&MJ*. "This enhances signal tracking and availability for high-precision equipment during atmospheric scintillation. It's a robust system with built in forecasting models, and it supports NovAtel's TerraStar correction service that can be provided to the equipment when the real-time

kinematic (RTK) GPS system on site isn't performing. We've found this is important for customers in areas like West Africa, North Africa and LATAM who are currently experiencing a high level of scintillation."

Hexagon recently released the latest version of its OP Pro machine guidance solution. This offers a simplified, modern user experience that reduces the amount of time and effort operators must spend extracting information from the screen.

"We also have a new reporting and analytics suite in the pipeline for mine asset health," added Kowalchuk. "This includes new machine intelligence modules which allow mines to identify emerging issues with equipment before they cause any damage or impact production. We're currently partnering with customers to test these capabilities before release. So far, they've found that, with limited on-site training or subject matter expertise, they're able to install these modules and identify issues and opportunities immediately."

Additionally, Hexagon is developing a new fit-for-purpose fleet management solution. This allows customers to install OP Pro in stages, scaling the deployment to better match their requirements and needs over the life-of-mine (LOM).

Kowalchuk believes that, going forward, artificial intelligence (AI) and the capabilities it provides will have a growing impact on mine fleet management.

"Fleet management is a great candidate to benefit from the capabilities that come with AI, and it's likely that optimizing engines, user experience workflows and processes, like short interval control (SIC), will be significantly enhanced by AI over the next decade or two," he told *E&MJ*. "Advanced sensors and sensor fusion could also unlock a lot of value in fleet management and performance, particularly for autonomous operations."

Creating Connected Mine Sites

While machine guidance systems and FMS have proven their ability to drive improvements in productivity and accuracy on their own, their capabilities and value can be increased dramatically when integrated together.

"For example, mines wishing to manage and improve their material blending can leverage a FMS, such as our DISPATCH system, in combination with a high-precision machine guidance system, such as ProVision for loading equipment," the team at Komatsu explained in a 2024 blog post. "The improved shovel accuracy afforded by the machine guidance system ensures that the material loaded into trucks aligns with the mine plan, while the FMS ensures the correct routing of that material to appropriate stockpiles or crushers."

Mines that leverage the DISPATCH FMS also have the optional Blending and Dynamic Material Inventory Reporting modules at their disposal, which further optimize the material blend by automating blending at crushers, maximizing stockpile management and efficiency, reducing material re-handling, monitoring and tracking grades, and tracking the amount of material at blast, stockpile and dump locations.

"Implementing a high-precision machine guidance system for drills, which provides continuous navigation to help drill operators satisfy accurate hole patterns, depths, angles, and spacing, can further improve the reliability of the material being dug," the team wrote.

"The ProVision system for drills can optimize material fragmentation and resource management by ensuring the right material is blasted, and with the appropriate explosives. This ensures that the mine is extracting the desired grade and material type, while improving digability for shovels at the dig face and minimizing stoppages at the crusher as a result of incorrect blends or improperly fragmented material."

Integrating fleet management and machine guidance systems can also help with any reconciliation efforts that a mine must undertake to explain deviations from plan.

"With fleet management and machine guidance, we can now say, with a pretty strong level of confidence, that we moved X many hundreds of thousands of tons, from this location to this location," Steven Peugh, Commercial Strategy Manager said. "This confidence can help miners troubleshoot reasons they may not have moved as much ore as planned by streamlining and reducing the entire reconciliation process, allowing them to instead investigate their recovery rates, grades, and other factors that may have led to the deviation from plan."

By exchanging data and consolidating it into one common language, application programming interfaces (APIs) that allow mines to connect third-party mining technologies can help to optimize production, equipment uptime, efficiency and more.

The Komatsu team has developed various APIs for systems encompassing mine planning, payload management, and for supervisory control. The latter is achieved via the Core API which exchanges data between the DISPATCH and/or ProVision systems and any supervisory and control system, such as enterprise resource planning (ERP) systems like SAP.

The API enables immediate publication of production, time tracking (for time model usage), and dispatcher input event notifications, and allows for a complete feedback loop among external or downstream systems. It also increases modelling accuracy within third-party systems, thereby helping to improve plan compliance. Sharing data between supervisory systems and production systems, in real time, enables the API to help operations optimize their overall productivity.

FMS consultants offer services to support existing or prospective technology implementations. (Photo: Haultrax)

"Maintenance departments can also leverage the API to optimize their workflows. Integrating DISPATCH and ERP data enables us to use business logic to determine what to do with a 'down' equipment status," said Mark Webb, Commercial Strategy Manager.

Another example is crusher management, which can be handled using the Crusher API. This uses supervisory control and data acquisition (SCADA), programmable logic controller (PLC), and DISPATCH FMS data to optimize productivity by reducing queues and bottlenecks at the crusher. The API provides real-time visibility into crusher status, performance, and feed rate, while automating advancements of crusher-related load and haul cycle states.

The team concluded: "The APIs help to refine mining optimization by enabling the real-time connection of technologies across the mining value chain. By connecting upstream and downstream processes, across all makes and models of equipment and technology, the APIs open the door to mine-wide optimization and interoperability."

Building upon the DISPATCH FMS's capabilities, Komatsu unveiled the new Modular ecosystem at MINExpo 2024 in Las Vegas. This is an expanding set of interconnected platforms and products designed to simplify existing workflows and optimize data utilization. The ecosystem's open architecture design allows customers to create a "single source of truth" for common data used across their mining operations, including data from connected Komatsu products as well as third-party vendors and other equipment.

The first new offerings, which are currently available for customer demos with commercial release on the horizon, include four apps to simplify existing DISPATCH workflows.

Democratizing the Benefits of Fleet Management

Another important challenge that Arizona-based FMS provider, Model Mining, is working to overcome, is that FMS can be prohibitively expensive and/or complex to install, operate and maintain. This can act as a barrier, precluding smaller operators and contract miners from accessing the benefits that these systems provide.

Marcelo Romero, Founder of Model Mining, explained: "We know these solutions are needed in the industry, but their complexity often requires too many people and resources, and a big investment either to deploy or upgrade existing versions. This makes FMS only accessible for a relatively small group of mines or corporations.

"There also needs to be more scalability and interoperability in these solutions. If a customer with an existing FMS wants to expand the solution to all fixed or mobile assets at a mine, they will usually have to spend a fortune. Most well-known suppliers focus their software developments only on trucks and shovels, and don't have affordable solutions for auxiliary equipment, light vehicles and fixed assets, like light tower trailers. If a customer wants to integrate two or three FMS solutions into a single operation, it could be very difficult."

The business case needs of smaller operators and contractors can differ significantly from those of tier one and mid-tier miners. "Existing FMS on the market don't necessarily fit medium or small operations because they don't have the budget and resources to operate complex and expensive solutions," Romero told *E&MJ*. "This is where our solutions can help."

Model Mining's mission is to reduce FMS complexity, which is why its flagship solution is named 'SimpleFMS.' "Our hardware is so simple that customers can install it themselves with minimal remote supervision," said Romero. "Our customers don't always have people to maintain an FMS system, which is why we have tools to monitor the system remotely and advise the customer of any necessary changes."

The SimpleFMS comes with native data storage and forwarding capabilities. This technology allows mobile assets to work in areas of the mine with little or no communication for hours, even days, and update the stored information when the device regains connection to the network. This capability reduces the need for staff to constantly move wireless trailers around.

"SimpleFMS automatically tracks equipment activity, eliminating manual entries and reducing distractions," Romero explained. "Customers can install the SimpleFMS black box first, and later, when they decide, they can install the SimpleFMS app. Because SimpleFMS can run as a "black box," there is no need to train operators. It's a web-based solution, so users can see the application from their computers or mobile devices from the mine or home."

Model Mining currently has customers in Papua New Guinea, the Dominican Republic, Chile, and Bolivia, and is soon expanding to Peru and the US. Its clients are mainly medium and small mining operations and earth-moving companies.

BODAS Connect hardware from Bosch Rexroth. (Image: Bosch Rexroth)

Romero told *E&MJ*: "For SimpleFMS customers, the solution has brought many direct benefits, including increased productivity and better visibility of total material movement, hour by hour or shift by shift. Understanding clearly how truck and shovel availability and usability impact the production (basically having an SIC overview during the shift) is really important. The information SimpleFMS generates lets customers see which machines are most productive based on production cycle conditions.

"They can also control and monitor equipment availability and usability. The solution provides one source of truth for operations, maintenance and planning departments, and it can be used to monitor contractor's equipment availability."

"As part of our 2025 technology development roadmap, we will soon offer high-precision management solutions for shovels, drills and dozers, as well as payload monitoring systems and fuel level sensors," said Romero. "We also want to add more automated logic based on sensorized equipment. The solution should be like a smartwatch that detects whether a person is running, walking or swimming."

A new version of the SimpleFMS app which runs on a rugged tablet is also in the works.

"We will have a new user interface-user experience (UI-UX) office application to help users manage production cycles and increase equipment productivity," Romero added. "And, of course, we will continue to add more machine learning to our solution."

Integrating IoT and Telematics

As mines transition towards greater levels of automation, electrification and sus-

tainability, precise coordination across diverse systems is required. According to Vinicius Povineli, Mobile Electronics and Connectivity Product Manager at Bosch Rexroth, there are significant opportunities to integrate advanced digital solutions, like real-time telematics, which help to optimize resource usage, reduce downtime and improve productivity.

"Telematics and IoT [Internet of Things] solutions enable seamless data collection and analysis across the entire mining fleet," he explained. "By providing real-time insights into machine health, fuel efficiency, and operational performance, these tools help to minimize unplanned maintenance, reduce costs and improve safety. The IoT also facilitates predictive maintenance, ensuring issues are addressed before they cause significant disruptions."

BODAS Connect from Bosch Rexroth is a robust telematics and IoT solution that simplifies fleet and machine management for off-highway equipment. Its key features include real-time monitoring of machine performance and health, predictive maintenance capabilities, remote diagnostics and firmware updates, data visualization and analytics tools.

Povineli told *E&MJ*: "BODAS Connect is compatible with a range of mobile mining equipment. For 2025, Bosch Rexroth is enhancing BODAS Connect with over-the-air (OTA) services utilizing the UDS protocol for seamless remote diagnostics and updates. Additionally, we're introducing new dashboards with advanced data visualization and user management features, such as keyless machine access based on operator schedules. These updates aim to improve machine accessibility, security, and operational efficiency across the fleet."

Haultrax's FMS in operation. (Photo: Haultrax)

A number of large mining operations have adopted IoT solutions to streamline their fleet management. Povineli said that these mines have seen significant improvements in uptime, cost savings through optimized maintenance, and increased safety due to better visibility of machine performance. Operators often report reduced downtime and better decision-making driven by real-time analytics.

He added: "The future of mine fleet management lies in greater integration, automation, and sustainability. As digitalization advances, mines will rely on connected, data-driven systems to optimize operations and reduce environmental impact. Solutions like BODAS Connect will play a pivotal role in transforming fleet management while helping mining operations achieve higher productivity and resilience."

Translating Analytics Into Availability

Availability is a crucial metric in mining operations, representing the percentage of time a piece of equipment is available for use when required. Dale Murugan, Managing Director of Australia-based tech specialist, VoarTechs, examined this in more detail in a recent blog post.

"In simpler terms, it [availability] reflects how often machinery is ready for operations during its scheduled working hours," he explained. "A high availability percentage means that the equipment is more often ready to work, leading to better productivity and, ultimately, higher profits."

In mining, profitability is directly tied to the amount of material moved and processed. This material is moved by machines, and the more available these machines are, the more material they can move. Murugan explained: "Low availability means fewer machines are operational, which results in less material being moved, leading to reduced productivity and, consequently, lower revenue."

Murugan said that the benchmark for a good availability percentage can vary depending on the type of equipment and the specific mining operation. However, an availability of around 85% is generally considered a good target in the industry for many types of equipment, including trucks, shovels and drills. This percentage indicates that the equipment is available for use most of the time, allowing for optimal operation without significant delays.

"It's essential to note that availability should be reported by fleet type, as the operational demands and maintenance needs can vary greatly between, for example, a drill and a haul truck," he said. "Tracking and improving availability across different fleet types can lead to more efficient and productive mining operations."

The data needed to calculate availability typically comes from a FMS, such as MineStar or Modular. These collect vast amounts of data on equipment usage, including scheduled operating times and downtimes.

"By leveraging analytics through the use of a dedicated dashboard, mining companies can see availability percentages across time and gain insights into how their equipment is performing," said Murugan. "This data-driven approach allows for more informed decision-making, helping to identify areas where availability can be improved, thereby boosting overall productivity."

He added that, despite the widespread use of FMS in mining, many companies do not fully leverage the wealth of data these systems collect.

"By not analyzing this data, they miss out on critical insights into key operational metrics like availability," Murugan explained. "For example, if a company notices that certain pieces of equipment consistently have low availability, it can investigate the root causes — whether it's a frequent breakdown code, inefficient scheduling, or prolonged maintenance times. All of this can be easily understood within seconds with the use of a well-designed dashboard. Addressing these issues can lead to significant improvements in equipment availability, and by extension, in the overall efficiency of the mining operation."

Ultimately, equipment availability is not just a number; it's a reflection of an operation's efficiency and a direct contributor to its profitability. According to Murugan, maintaining an availability rate around the industry benchmark of 85% is crucial, but striving for continuous improvement can yield even greater rewards.

"By leveraging advanced FMS and harnessing the power of data analytics, mining operations can transform raw data into actionable insights," he said.

Taking a Systemized Approach to Deployment

There's more to a successful implementation than simply acquiring FMS technology.

"Without a well-defined implementation strategy tailored to your specific operations, the chances of achieving success become limited," Shyamal Sharma, Managing Director at Haultrax, explained in a recent article. "A successful technology implementation project takes careful planning, expertise, and execution."

Haultrax has 12+ years' experience implementing tier-one FMS across Australia, as well as developing its own solutions, FleetOps and FleetControl.

Sharma said: "With advancements in technology, the increasing complexity of fleet operations and the associated increase in environmental regulations, plus corporate responsibility and political pressure, engaging a mining consultant has become a practical solution to navigating industry requirements while optimizing project performance."

FMS consultants offer services to support existing or prospective technology implementations. They provide expertise and guidance on how to embed the correct use of the technology with both people and processes. According to Haultrax, working alongside a FMS consultant can offer several benefits:

- **Correct technology selection:** To maximize benefits, the chosen FMS technology must align with the operator's inherent culture and operational practices. It should build upon and enhance their competitive advantages, rather than imposing rigid operational requirements. A FMS can consultant assist in selecting technologies that align with each company's operational model.
- **Informed decision-making:** With a FMS consultant's guidance, mines gain the ability to make informed decisions regarding fleet management. They can analyze data and provide insights into fleet operations, allowing mines to identify areas for improvement and optimize operations for cost reduction and increased efficiency.
- **Proactive issue identification:** A consultant can help identify trends and potential issues before they occur. For example, analysing various data points such as vehicle utilization, maintenance costs, driver behavior, and fuel consumption enables data-driven decision-making and continuous improvement of fleet operations.
- **Resource allocation and cost reduction:** Consultants can assist in reducing expenses and optimizing resource allocation by developing cost-effective strategies to minimize downtime, reduce idle time, and enhance equipment productivity. Through optimizing fleet routes and schedules, it's possible to identify underutilized vehicles and suggest asset reallocation to improve overall efficiency.
- **Safety improvements:** FMS consultants can provide training and support to drivers and monitor driver behavior in real-time using telematic solutions. By implementing safety measures and reducing liability risks, they contribute to creating a safer work environment and ensuring compliance with company culture.

View of the SimpleFMS short interval control module. (Image: Model Mining)

Sharma explained: "To successfully implement a FMS, changes are required to the processes around the technology. Without integral alignment between people and supporting processes, the benefits of a FMS are often not achieved."

Haultrax assists customers with the appropriate identification, selection, planning, deployment and operational support of productivity initiatives and mining technologies. The company's staged process of technology delivery considers the readiness of subsystems, business processes and operational integration to avoid common mistakes.

"Finding the right technology that perfectly aligns with a mine's unique operational model is crucial for maximizing its benefits," said Sharma. "A FMS consultant can assist in selecting and implementing the ideal technology that seamlessly integrates with a miner's business culture and existing processes, empowering them to leverage competitive advantages."

Hivekit Extends Scope in 2025

German and UK-based software developer, Hivekit, released a new vendor agnostic operations management system for the mining and metals industry in 2024. Hivekit is a cloud-based platform that tracks people, vehicles, machines and data sources, and visualizes them in a three-dimensional digital twin. It allows operators to assign tasks and commands and automates large parts of a mine's operations.

"2024 was an exciting year for us," Co-Founder, Wolfram Hempel, told *E&MJ*. "We're on the brink of rolling out Hivekit at two major gold mines — one open-pit and one underground.

"As for new fleet management features… we're evolving Hivekit into a comprehensive platform that goes beyond asset tracking and process automation. Our vision is to facilitate a high-performance culture for mines built on transparency, accountability and continuous improvement."

He continued: "To that end, we're integrating scheduling and shift management directly into Hivekit. This will allow mine managers to seamlessly connect resource and staff management with shift planning and execution. It also automates task assignment and tracking, empowering teams to use real-time site data to compare actuals against planned targets. Combined with Hivekit's custom dashboard builder, flexible reporting and automation rules, this will become a fundamental enabler of continuous plan-execute-measure-improve cycles."

Scheduling capabilities will be integrated into the Hivekit platform in 2025. (Image: Hivekit)

2025 Global Mining Project Spending Outlook

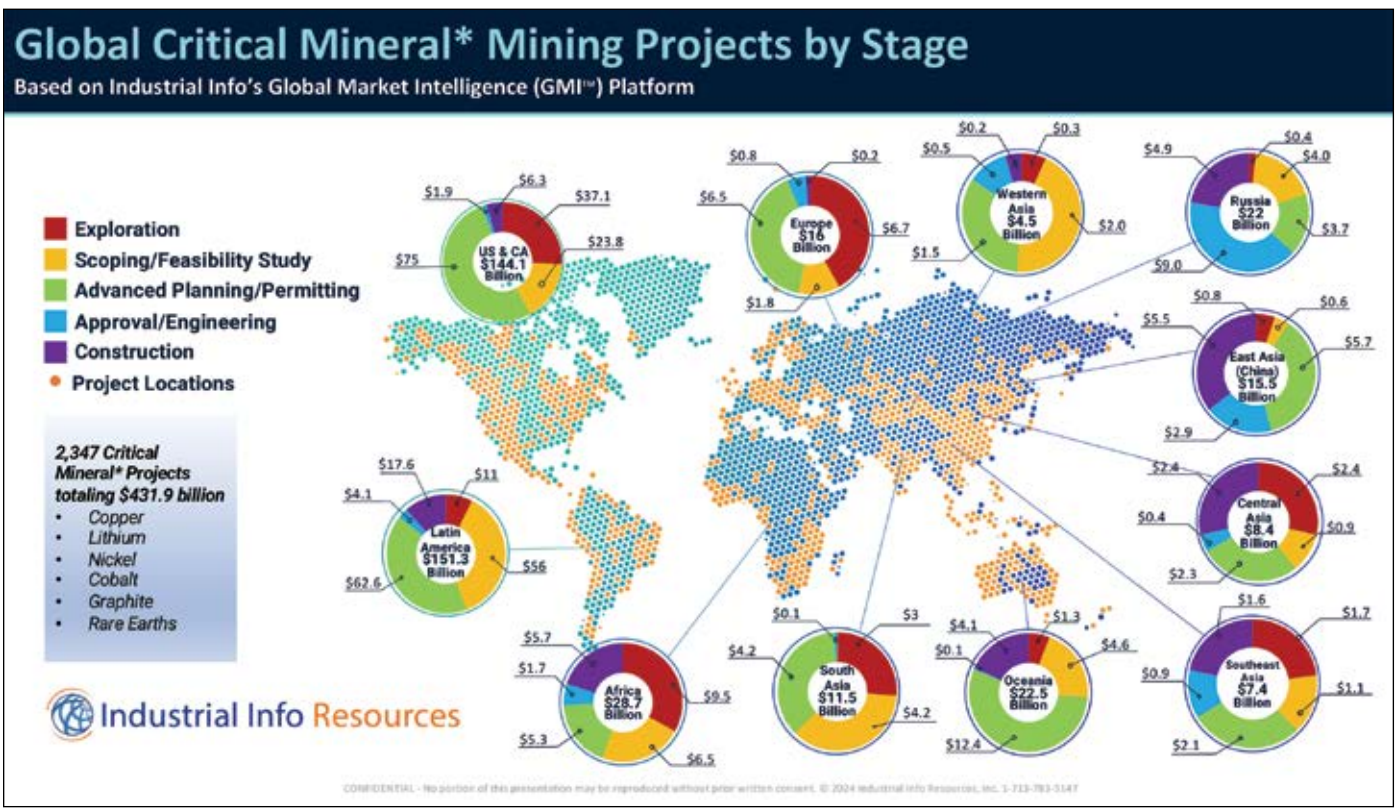
Even with iron ore and battery metals moving sideways, mining-related project investment will be strong in 2025

By Joe Govreau

As we begin 2025, the current health of project spending in the global mining industry is very good. Equipment and service providers are benefiting from a seven-year period of growth, which has witnessed project spending more than double since the bottom of the market in 2017. During the period of 2017-2024, eight of the top global mining majors (Anglo American, Barrick, BHP Group, Freeport-McMoRan, Glencore, Newmont, Rio Tinto and Vale) have increased capital spending from a combined $23.9 billion in 2017 to $48.4 billion in 2024. During this period, project activity has been driven by several major trends including the energy transition, resource security, decarbonization and productivity optimization. All of these trends continue to have a tremendous impact on decisions as far as when and where to develop, and what commodities to focus on in 2025.

Project spending appears to be peaking and may slow a bit this year as market drivers such as moderate base metals prices and a slowing energy transition constrain activity. GDP growth for 2025 is aligned with slow and only moderate economic growth around the world. Current economic indicators such as metal prices and GDP growth trends support projects moving sideways in 2025, but at a relatively high level when compared to the bottom of the market in 2017.

China, which consumes 50% of most commodities, is a major factor to consider as its slowing economy impacts metals and minerals demand. In addition to the slow China economy impacting demand, a good number of new mines, especially for battery metals like lithium, nickel and cobalt, have come online over the past 2-3 years, increasing supply in relatively small markets (when compared with iron ore and coal), as well as slower-than-expected adoption of electric vehicles in the West, and other energy transition technologies is impacting the market in



the near term. Most of this new capacity coming online is in China or owned by Chinese corporations (i.e., lithium in Zimbabwe and cobalt in DRC and nickel in Indonesia). As a result, we will continue to see battery metal mining projects being delayed, cancelled or placed on hold. However, some projects will continue to move forward, especially in markets like the U.S. and EU, where significant government stimulus and a desire for resource security, amidst a growing trade war with China, continue to support reshoring, near shoring and friend shoring project activity for critical minerals.

The Global Critical Mineral Mining Projects by Stage map shows the distribution by region and project stage for six of the top critical minerals (see map on pg. 30): copper, lithium, cobalt, graphite and rare earth elements. There are more than 2,300 projects totaling $431.9 billion in active critical mineral projects. The Americas have a dominant position when it comes to project activity for these critical minerals with 68% of the value of projects falling in the Americas, with Latin America having $151.3 billion and the U.S. & Canada having $144.1 billion. Following the Americas is Africa with $28.7 billion and the Oceania region with $22.5 billion.

The role that the energy transition and decarbonization is playing in driving metals demand cannot be underestimated and so new mining projects will continue to come through the pipeline as miners plan for expected demand growth. Mine expansions and grassroot developments will continue to be committed to even though near-term demand looks flat. Long lead times for bringing new mines from permitting through to production remains a challenge, and many countries are supporting fast tracking or stimulus measures to support new projects, especially those that shore up supply chains for critical minerals in order to lessen geopolitical risk.

The exhaustive permitting, regulatory and environmental, social and governance (ESG) requirements placed on developing new mines mean that companies are placing more importance on optimizing and expanding existing operational assets. Automation and utilization of AI to improve operational efficiency, reduce costs, improve maintenance, exploration and safety are all major areas of focus.

Table 1 — 2025 Mining Projects by Commodity

Commodity	Dollars	Projects
Coal	$99.4 billion	1,740
Copper Ore	$63.3 billion	400
Gold & Silver Ores	$59.8 billion	858
Iron Ore	$38.7 billion	574
Lithium	$25.6 billion	169
Potash, Soda & Borate Minerals	$18.4 billion	59
Other Metal Ores	$17.2 billion	212
Ferroalloy Ores Mining, Except Vanadium	$15.6 billion	201
Crushed & Broken Limestone	$14.2 billion	394
Lead & Zinc Ores Mining	$8.7 billion	144
Uranium-Radium-Vanadium Ores	$7.7 billion	82
Crushed & Broken Granite	$7.2 billion	103
Other Nonmetallic Minerals	$6 billion	120
Phosphate Rock	$5.6 billion	71
Crushed & Broken Stone	$5.4 billion	113
Oil Sands	$5.1 billion	13
Industrial Sand	$3 billion	72
Construction Sand & Gravel	$2.3 billion	58
Clay, Ceramic & Refractory Minerals	$1.8 billon	53
Dimension Stone	$1.2 billion	16
Global Total	**$406 billion**	**5,452**

The energy transition and electrification of transportation and industry will require a tremendous buildout of the power generation and transmission infrastructure. Add to that the increase in demand expected from the current buildout of data centers serving the AI/automation revolution. There are currently more than 3,700 data center projects representing about $890 billion under development worldwide, according to Industrial Info's Global Market Intelligence (GMI). Most of these are grassroot or expansions of existing data centers. If all of these are built it will add 112 gigawatts of electricity requirement. This will have a tremendous impact not only on electricity demand but on steel, copper, aluminum and other electrification metals — all good news for the mining industry as new mines will be needed to supply these metals.

The concept that the energy transition will lead to the elimination of fossil fuels, and that those will be replaced by renewables, mainly wind and solar, has proven unrealistic, given the limitations of meeting electricity demand growth with renewables. Wind and solar will continue to grow, but we can expect to see more natural gas-fired generation and nuclear power as stable baseload power sources. Advances are being made in the form of small modular reactors and other nuclear technologies. There are currently 385 nuclear reactors under development worldwide representing 290 gigawatts of additional power, according to GMI. This will impact uranium demand and the sector is already seeing increased activity with mining projects that have been dormant for years being dusted off and reexamined. The easiest way for mining firms to lessen their carbon footprint is to replace fossil fuel usage with renewable energy, and now even nuclear power is being considered with

Table 2 — Top 20 Countries for Mining Projects in 2025

Country	Dollars	Projects
China	$134.7 billion	1,437
Canada	$36.2 billion	196
U.S.A.	$24.2 billion	344
India	$23.5 billion	757
Australia	$22.2 billion	467
Argentina	$17.5 billion	40
Russia	$16.1 billion	96
Peru	$11.5 billion	173
Chile	$10.7 billion	62
Brazil	$8.3 billion	151
Indonesia	$8.1 billion	405
South Africa	$5.5 billion	70
Iran	$5.4 billion	71
Philippines	$4.2 billion	57
Pakistan	$4.2 billion	2
Saudi Arabia	$3.9 billion	34
Egypt	$3.8 billion	36
Papua New Guinea	$3.4 billion	13
Kazakhstan	$3.1 billion	69
Mexico	$3 billion	50

the advent of small-scale nuclear reactors. Several companies are exploring nuclear power to replace coal-fired boilers, including Tata Chemicals at a trona mine in Wyoming.

There are more than 5,400 projects totaling $406 billion scheduled to begin construction in 2025, according to GMI. If past is prologue, the majority of this will not come to fruition as planned, because projects will be cancelled, placed on hold, or delayed due to permitting, financing or other market conditions. Such is the nature of mining projects.

As the energy transition is flummoxed, coal continues to be the number one commodity for project activity in 2025, accounting for almost 25% of the global activity based on the value of projects (See Table 1 on pg. 31). It is not surprising that two-thirds of the coal mining project activity is in China, with India, Indonesia and Australia making up the bulk of the remainder. India's coal mining giants, including Coal India Ltd., Singareni Collieries and NLC India, have indicated they will build 43 new coal mines over the next five years. This comes at a time when there are notable declines in spending for coal mining projects in Australia, Poland and the U.S.

Copper mining projects will be big in 2025 with an expected demand increase from the energy transition and electrification trend spurring project activity. Barrick is scheduled to begin main construction on the $4 billion Reko Diq copper-gold project in Pakistan after beginning early works in 2024. Argentina has jumped to the number one position for copper projects in 2025 with more than $10 billion across seven projects planned to begin construction during the year. Argentina's President Javier Milei passed a law in June 2024 called the Incentive Regime for Large Investments (RIGI), promising lengthy tax breaks (30 years of tax credits) for investments, which has increased interest in the development of large copper mines and other big projects in the country. BHP and Lundin bought the Filo project and are developing the more advanced Josemina project in Argentina. In addition to Argentina and Pakistan, major copper projects are scheduled to begin construction during the year in Russia, Chile, China and the U.S. BHP Group has said it will spend $14 billion in the near future on copper projects in Chile.

Reaching a historic high of more than $2,700/ounce in November 2024, gold is benefiting as a safe haven for investors off ongoing geopolitical uncertainty around the world. Gold mining projects will continue to be developed in good or bad economies and 2025 will be no different, as gold and silver ores come in as the third largest market for project activity, with 858 projects totaling $59.8 billion planned. Canada, the U.S. and Peru are the top three countries for gold mining projects in 2025.

Iron ore mining project activity has declined significantly over the past few years after a large period of investment in countries like Australia and Brazil, which have significantly increased production. The slowdown in China's economy and steel consumption is not helping the market. China, India, Australia, Iran, Brazil and Russia are the top countries for iron ore development.

Lithium, the poster child for the energy transition, has risen to fifth-largest market for project activity in 2025 with 169 projects totaling $25.6 billion planned, but we expect significant project fallout in 2025 due to current market conditions. Lithium prices have dropped significantly over the past year and half mainly due to a large number of new mining and processing projects that have come online, and slow adoption of EVs in certain parts of the world. Many of the higher cost producers, such as the hard rock spodumene mines in places like Australia, have closed or scaled back operations to wait for the return of positive market conditions. Companies like Albemarle and Piedmont Lithium have significantly altered capital spending plans. Even lower cost producers like SQM in Chile, which extracts lithium from salar brines instead of traditional hard rock mining, are even feeling the pinch because of low lithium prices. Chinese producers like CATL have also scaled back production. The low

price environment is not expected to change much over the next year or two as more capacity continues to come online from projects now under construction. A lot of lithium projects are moving sideways with delays as a result. However, some projects will continue to move forward, betting on long-term growth in demand, including the Keliber project in Finland and the Thacker Pass project in Nevada. The common denominator is that these projects received government support funding or loans. The Keliber project, for example, received green loan financing of 500 million euros.

Looking at the top 20 countries for mining project activity, China leads with more than 1,400 projects totaling $134.7 billion, led by coal and iron ore development (See Table 2 on pg. 32). Canada and the U.S. are second and third with significant critical mineral and gold development.

India is rising with $23.5 billion in planned activity for 2025 mainly for coal, iron ore and copper.

Australia had been one of the top two countries for mining project activity but has slowed considerably over the past couple of years, mainly due to the slowdown in demand for its main two exports, coal and iron ore from China and other Asian nations.

Indonesia has 405 mining projects totaling $8.1 billion scheduled to begin construction in 2025. The majority of this is in the coal mining sector followed by gold and copper. The Indonesian government has approved a 30% increase in the country's coal production quota, providing incentives for coal miners to boost capacity and develop new facilities over the next two years. Indonesia is the largest nickel producer in the world. Nickel prices are impacting nickel-related projects in the region. Recently, a $2.6 billion high pressure acid leaching (HPAL) project was canceled, and expansions of nickel mine capacities are facing delays as a result.

As they seek to diversify their economies from the oil industry, Iran, Saudi Arabia and Egypt are increasing mining activity in the Middle East and showing strong spending activity on the top 20 list.

In summary, mining project activity in 2025 will move sideways, but continue to be strong at levels nearly twice as high as the bottom of the market in 2017. The slowing energy transition and increased competition from new supply will delay some projects, but the industry could see aboost in demand driven by the data center construction boom. Decarbonization will continue to drive project activity as companies look to electrify and reduce their carbon footprints. Trade uncertainties and regional geopolitical conflicts focus priority on projects supporting domestic supply chains and resource security for critical minerals. The optimization of existing mines to improve efficiency, safety and cost through automation and AI will continue to be a focus.

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Major Mining Projects, Year-end 2024*

Project Name	Location	Status	Type	Products	Owner	Project Cost (US$M)**
BASE METALS						
Copper						
Baimskaya	Russia	FS, Delayed	OP	Cu, Au	KAZ Minerals	8,500
Reko Diq 1 & 2	Pakistan	FS	OP	Cu, Au	Barrick	7,000
Pebble	USA	PEA, Delayed	OP	Cu, Au, Mo	Northern Dynasty	6,770
Resolution	USA	PFS	UG	Cu, Mo	Rio Tinto, BHP	6,000
Tampakan	Philippines	FS	OP	Cu, Au	Sagittarius	5,900
El Pachon	Argentina	FS	OP	Cu, Mo	Glencore	5,600
Galore Creek	Canada	PFS	OP	Au, Ag	Newmont, Teck	5,208
Kamoa-Kakula IDP 3 & 4	Dem. Rep. Congo	Construction	OP, conc	Cu	Zijin Mining, Ivanhoe, DRC Govt	4,600
Centinela 2	Chile	Construction	OP, conc	Cu	Antofagasta Minerals	4,400
Casino	Canada	FS	OP, HL	Cu, Au, Ag, Mo	Western Copper	3,620
Frieda River	Papua New Guinea	FS	OP	Cu, Au	PanAust, Highlands Pacific	3,600
El Arco	Mexico	PFS	OP, conc, SX-EW	Cu	Southern Copper	3,540
NuevaUnion	Chile	FS	OP	Cu, Au	Newmont, Teck	3,500
Josemaria	Argentina	FS	OP	Cu	Lundin	3,091
Los Bronces IP	Chile	Permitting	OP, UG	Cu	Anglo American	3,000
CuMo	USA	PFS	OP	Cu, Mo	Multi-Metal Development	2,800
Cascabel	Ecuador	PFS	UG	Cu, Au, Ag	SolGold	2,700
Schaft Creek	Canada	PEA	OP	Cu, Au	Teck, Copper Fox	2,650
Los Chancas	Chile	FS	Conc, SX-EW	Cu	Southern Copper	2,600
Michiquillay	Peru	FS	OP	Cu, Mo	Southern Copper	2,500
Los Azules	Argentina	PEA	OP	Cu, Au	McEwen Copper	2,462
Vizcachitas	Chile	PFS	OP	Cu, Mo	Los Andes Copper	2,440
MARA	Argentina	PFS	OP	Cu	Yamana, Glencore	2,400
La Granja	Peru	PFS	OP	Cu	First Quantum, Rio Tinto	2,400
Santa Domingo	Chile	FS	Complex	Cu, Co, Fe, Au	Capstone	2,180
Mason	USA	PEA	OP	Cu, Mo	Hudbay Minerals	2,100
Las Bambas	Peru	Expansion	OP	Cu	MMG	2,000
Lumwana	Zambia	FS, Expansion	OP	Cu	Barrick	2,000
Filo del Sol	Chile	PFS	OP	Cu, Au	BHP, Lundin Mining	1,805
Antapaccay-Coroccohuayco	Peru	PFS	OP	Cu	Glencore	1,500
Berg	Canada	PEA	OP	Cu, Mo, Ag, Au	Surge Copper	1,472
Tia Maria	Peru	Construction, delayed	OP	Cu	Southern Copper	1,400
Santo Tomas	Mexico	PEA	OP	Cu	Oroco Resource	1,340
Copper World	USA	PFS	OP	Cu, Mo, Ag	Hudbay Minerals	1,300
Kansanshi S3	Zambia	Expansion	OP	Cu, Au	First Quantum	1,250
Diamante-Andesita	Chile	Construction	UG	Cu	Codelco	1,240
Zafranal	Peru	FS	OP	Cu, Au	Teck	1,230
Zaldivar	Chile	Permitting, expansion	OP	Cu	Antofagasta	1,200
Arctic	USA	FS	OP	Cu, Zn, Pb	Ambler Metals	1,177
Santa Cruz	USA	PEA	UG	Cu	Ivanhoe Electric	1,150
West Musgrave	Australia	Construction	OP	Cu, Ni	BHP	1,100
Cadia PC1-2	Australia	FS	UG, plant	Cu, Au	Newmont	1,100
San Nicolas	Mexico	PFS	OP	Cu, Zn	Teck, Agnico Eagle	1,100
Costa Fuego	Chile	PEA	OP, UG	Cu, Au	Hot Chili Ltd	1,050
Cañariaco	Peru	PEA	OP	Cu	Alta Copper	1,040
NewRange	USA	Permitting	Complex	Cu, Ni, PGM, Co	Teck, Polymet	945
Mina Justa	Peru	IA	UG	Cu	Minsur, Copec	924
Copper Creek	USA	PEA	OP, UG	Cu, Mo, Ag	Faraday Copper	798
Chuquicamata	Chile	IA	UG	Cu	Codelco	720
White Pine North	USA	PEA	UG	Cu, Ag	Kinterra, Highland Copper	615
Eva	Australia	FS	OP	Cu	Harmony	603
Kwanika-Stardust	Canada	PEA	OP, UG	Cu, Au	NorthWest Copper	600
Los Pelambres 2	Chile	Expansion	OP	Cu	Antofagasta Minerals	500
Kennecott NRS	USA	Construction	UG	Cu	Rio Tinto	498
Escalones	Chile	PEA	OP, HL	Cu	World Copper	438
Alacran	Colombia	PFS	OP	Cu, Au, Ag	Cordoba Mining, JCHXX	435
Copperwood	USA	FS	UG	Cu	Highland Copper	391
McIlvenna Bay	Canada	FS	UG	Cu, Zn Au, Ag	Foran Mining	368
Kutcho	Canada	FS	OP, UG	Cu, Zn	Kutcho Copper	360
El Pilar	Mexico	Construction	OP	Cu	Southern Copper	310
Tucumã	Brazil	Construction	OP	Cu	Ero Copper	294
Van Dyke	USA	PEA	ISR	Cu	Copper Fox	290
El Domo-Curipamba	Ecuador	FS	OP, UG	Cu, Au	Adventus, Salazar	236
Florence	USA	Construction	ISR	Cu	Taseko Mines, Mitsui	230
Silangan	Phillippines	Construction	OP	Cu, Au	Philex Mining	224
Zonia	USA	PEA	OP	Cu	World Copper	198
Chibougamau	Canada	PEA	UG	Cu, Au	Doré Copper Mining	181
Carmacks	Canada	PEA	OP	Cu, Au	Granite Creek Copper	162
Pumpkin Hollow	USA	Restart	UG	Cu	Nevada Copper	115
Parys Mountain	UK	PEA	UG	Cu, Zn	Anglesey Mining	99
Tower & Rail	Canada	PEA	UG	Cu, Zn	Rockcliff	81
Johnson Camp	USA	PEA	OP	Cu	Gunnison Copper	59
Nickel, Cobalt & Molybdenum						
Crawford Phase 1 and 2	Canada	FS	OP	Ni, Co, Pd	Canada Nickel	3,500
KNP	Australia	PFS	OP	Ni, Co	Ardea Resources, Japanese consortium	3,100

Project Name	Location	Status	Type	Products	Owner	Project Cost (US$M)**
Sonic Bay	Indonesia	IA, pending	Refinery	Ni, Co	BASF, Eramet	2,600
Wingellina	Australia	PFS	OP	Ni, Co	NiCo Resources	2,500
Baptiste	Canada	PFS	OP	Ni, Co, Fe	FPX Nickel	2,182
Turnagain	Canada	PEA	OP	Ni, Co	Giga Metals, Mitsubishi	1,900
Sunrise	Australia	FS	OP, conc	Ni, Co	Sunrise Energy Metals	1,830
Sorowako	Indonesia	FS	Smelter	Ni	Vale Indonesia, Huayou	1,800
Nickel Shäw	Canada	PFS	OP	Ni, Cu	Nickel Creek Platinum	1,700
Rönnbacken	Sweden	PEA	OP	Ni, Co	Bluelake Mineral Group	1,400
Dumont	Canada	FS	OP	Ni, Co	Waterton	1,018
Malmbjerg	Greenland	IA, pending	OP	Mo	Greenland Resources	820
Araguaia 2	Brazil	FS	OP	Ni	Horizonte Minerals	694
Kabanga	Tanzania	FS	UG	Ni, Cu, Co	Lifezone Metals	658
Vermelho	Brazil	FS	OP	Ni	Horizonte Minerals	652
Eagles Nest	Canada	FS	UG	Ni, Cu, PGE	Ring of Fire Metals	609
Thompson Creek	USA	Restart	OP	Mo	Centerra	400
Broken Hill	Australia	PFS	OP	Co	Cobalt Blue	384
Mt. Thirsty	Australia	PFS	OP	Ni, Co	Greenstone, Conico	330
Crean Hill	Canada	PEA	OP, UG	Ni, Cu, Co	Magna Mining	330
Samapleu	Côte d'Ivoire	PEA	Complex	Ni, Cu	Sama Resources	282
Ulsan	South Korea	IA	Refinery	Ni	Korea Zinc, Trafigura	140
Zinc/Lead						
Hermosa-Taylor	USA	Construction	UG	Zn, Pb, Ag	South32	1,230
Citronen	Greenland	FS	UG	Zn, Pb	Ironbark	654
Pine Point	Canada	PEA	OP, UG	Zn, Pb	Osisko Metals	653
Hilarion	Peru	PFS	UG	Zn, Pb	Nexa Resources	585
Gamsberg 2	South Africa	Expansion, construction	OP	Zn	Vendanta Zinc	405
Prairie Creek	Canada	Permitting	UG	Zn, Pb, Ag	NorZinc	368
Macmillan Pass	Canada	PEA	OP	Zn, Pb	Fireweed Metals	296
Prieska	South Africa	FS	OP, UG	Zn, Cu	Orion	267
Ayawilca	Peru	PEA	UG	Zn, Pb, Ag	Tinka Resources	264
Lagoa Salgada	Portugal	FS	UG	Zn	Ascendant Resources	164
Gorno	Italy	Scoping	UG	Zn	Alta Zinc	114
Rosh Pinah RP-2	Namibia	FS, expansion	UG	Zn, Pb	Trevali	111
Santander Pipe	Peru	PEA	UG	Zn	Cerro de Pasco	52
IRON ORE						
Simandou 1 & 2	Guinea	FS	OP	Fe	WCS	16,000
Simandou 3 & 4	Guinea	FS	OP	Fe	Simfer	11,600
Zanaga 1 & 2	Republic of Congo	FS	OP	Fe	Zanaga Iron	4,700
Serra Sul 120	Brazil	Expansion, construction	OP, plant	Fe	Vale	2,700
Hawsons	Australia	PFS	OP	Fe	Hawsons Iron, Pure Metals	1,400
Southdown	Australia	PFS	OP	Fe	Grange Resources	932
Shymanivske 1 & 2	Ukraine	PEA	OP	Fe	Black Iron	771
Lobe	Cameroon	Scoping	OP	Fe	Sinosteel, Cameroon Govt	676
Mont Sorcier	Canada	PEA	OP	Fe, V	Voyager Metals	574
Lake Giles	Australia	FS	OP	Fe	Macarthur Minerals	569
Razorback	Australia	PFS	OP	Fe	Magnetite Mines	506
K. Hill	Botswana	PEA	OP	Mg	Menzi Battery Metals	284
Nimba 1	Guinea	PFS	Complex	Fe	SMFG	108
PRECIOUS METALS & DIAMONDS						
Gold						
Donlin	USA	Permitting	OP	Au	Barrick, NovaGold Resources	7,400
KSM	Canada	PFS	OP, UG	Au, Cu, Ag, Mo	Seabridge Gold	6,400
Norte Abierto	Chile	FS	OP	Au, Ag	Barrick, Newmont	6,000
Sukhoi Log	Russia	FS	OP	Au	Polyus	3,300
Walfi-Gopu	Papua New Guinea	FS	UG	Au, Cu, Ag	Newmont, Harmony	2,800
Yanacocha Sulphides	Peru	Delayed	OP	Au	Newmont, Buenaventura, Sumitomo	2,500
Livengood	USA	PFS	OP	Au	International Tower Hill	1,930
Cangrejos	Ecuador	PFS	OP	Au	Lumina Gold	1,454
Stibnite	USA	PFS	OP	Au	Perpetua Resources	1,263
Courageous Lake	Canada	PFS	OP	Au	Seabridge	1,138
Windfall	Canada	FS	UG	Au	Osisko, Gold Fields	1,100
KCGM Mill Optimization	Australia	Expansion	Mill	Au	Northern Star Resources	959
Gramalote	Colombia	FS, suspended	OP	Au	B2Gold	925
Volcan	Chile	PEA	OP, HL	Au	Hochschild	900
Mount Todd	Australia	FS	OP	Au	Vista Gold	892
Media Luna	Mexico	Construction	UG	Au	Torex Gold	875
Skouries	Greece	Construction	OP, UG	Au, Cu	Eldorado Gold	845
Horne 5	Canada	FS	UG	Au	Falco Resources	844
Tulu Kapi	Ethiopia	FS	OP, UG	Au	Kefi Gold & Copper	785
Island 3	Canada	Construction, expansion	UG	Au	Alamos Gold	756
Cerro Blanco	Guatemala	FS	UG	Au, Ag	Bluestone Resources	750
Springpole	Canada	PFS	OP	Au, Ag	First Mining Gold	718
Back River	Canada	Construction	OP	Au	B2Gold	655
Fenelon	Canada	PEA	UG	Au	Wallbridge	645
Lynn Lake	Canada	FS	OP	Au	Alamos Gold	632
Cariboo Phase 1 & 2	Canada	FS	UG	Au	Osisko Mining	588
Koné	Côte d'Ivoire	FS	OP	Au	Montage Gold	544

Project Name	Location	Status	Type	Products	Owner	Project Cost (US$M)**
Adumbi	DRC	PEA	OP	Au	Loncor	530
Eskay Creek	Canada	FS	OP	Au, Ag	Skeena Resources	525
Duparquet	Canada	PEA	OP, UG	Au	First Mining Gold	521
Chulbatkan	Russia	PFS	OP, HL	Au	Polyus	500
Kurmuk Phase 1 and 2	Ethiopia	Construction	OP	Au	Allied Gold	500
Nyansanga	Tanzania	FS	OP, UG	Au	OreCorp	474
Martha/Gladstone/WKP	New Zealand	PEA	OP, UG	Au	OceanaGold	447
Veduga	Russia	PFS	OP, UG	Au	Polymetal	447
San Gabriel	Peru	Construction	UG, plant	Au	Buenaventura	430
La Mina	Colombia	PEA	OP	Au	GoldMining	425
La Cumbre 1 & 2	Colombia	PEA	OP, HL	Au, Ag	Batero Gold	418
Wasamac	Canada	FS	UG	Au	AEM, Pan American Silver	416
Ikkari	Finland	PEA	OP, UG	Au	Rupert Resources	405
Castle Mountain 2	USA	FS	HL, plant	Au	Equinox Gold	389
Twin Hills	Namibia	FS	OP	Au	Osino Resources	365
Lawyers	Canada	PEA	OP	Au, Ag	Thesis Gold	364
Valentine Lake	Canada	FS	OP	Au	Marathon Gold	361
Metates	Mexico	PEA	OP, HL	Au, Ag	Chesapeake Gold	359
Fox Complex	Canada	PEA, expansion	UG, plant	Au	McEwen Mining	358
Goliath	Canada	PFS	OP	Au	Treasury Metals	335
Marban	Canada	PFS	OP	Au	O3 Mining	326
Meyas Sand	Sudan	FS	OP	Au	Perseus Gold, Sudan Govt	321
Los Filos	Mexico	FS, expansion	UG, plant	Au	Equinox Gold	318
Coffee	Canada	PFS	OP, HL	Au	Newmont	317
Loma Larga	Ecuador	Permitting	UG	Au, Cu, Ag	Dundee	316
Hod Maden	Turkey	FS	UG	Au, Cu	SSR, Horizon Copper	309
Volta Grande	Brazil	FS, delayed	OP	Au	Belo Sun	298
Lihir Phase 14A	Papua New Guinea	FS	OP	Au	Newmont	296
Twin Hills	Namibia	PFS	OP	Au	Osino Resources	283
Gabbs	Nevada	PEA	HL	Au, Ag, Cu	P2 Gold	278
Spanish Mountain	Canada	PFS	OP	Au, Ag	Spanish Mountain Gold	273
Boto	Senegal	FS	OP	Au	Managem, Senegal Govt	271
Goldboro	Canada	FS	OP	Au	Signal Gold	271
Chimo	Canada	PEA	UG	Au	Cartier Resources	252
Klaza	Canada	PEA	OP, UG	Au	Rockhaven Resources	244
CK Gold	USA	PFS	OP	Au, Cu	US Gold	221
Fremont	USA	PEA	UG	Au	Stratabound Minerals	203
Posse (Mara Rosa)	Brazil	Construction	OP	Au	Hochschild Mining	200
South Railroad	USA	FS	OP, HL	Au	Orla Mining	190
Lemhi	USA	PEA	OP	Au	Freeman Gold	190
Borborema	Brazil	FS	OP	Au	Aura Minerals	188
Cabaçal	Brazil	PEA	OP	Au	Meridian Mining	180
Ixtaca	Mexico	FS	OP	Au, Ag	Almaden	174
Goldfields	Canada	PEA	OP	Au	Fortune Bay	173
Bomboré Phase II	Burkina Faso	FS, expansion	OP, plant	Au	Orezone Gold	167
DeLamar	USA	PEA	OP, HL	Au, Ag	Integra Resources	161
West Kenya	Kenya	Scoping	OP, UG	Au	Shanta Gold	161
Porvenir	Nicaragua	PFS	UG	Au, Ag, Zn	Mineros	161
Kiniero	Guinea	Construction	OP	Au	Robex Resources	160
La India	Nicaragua	FS	OP	Au	Condor Gold	160
Diamba Sud	Senegal	Scoping	OP	Au	Chesser Resources	159
Aurizona	Brazil	PFS	UG, OP	Au	Equinox Gold	154
Mogale TSF	South Africa	Construction	Hydro	Au	Pan African	145
Burnstone	South Africa	Construction	UG	Au	Sibanye-Stillwater	130
ATO 2	Mongolia	FS	OP	Au	Steppe Gold	128
Tres Cruces	Peru	PEA	OP, HL	Au	Steppe Gold	125
Fenix	Chile	FS	HL	Au	Rio2	117
Beartrack-Arnett	USA	PFS	OP HL	Au	Revival Gold	109
Havieron	Australia	Construction	UG	Au	Greatland Gold	106
Tulkubash	Kyrgyzstan	FS	OP	Au	Chaarat Gold	104
Silver						
Pitarrilla	Mexico	Scoping	OP, UG	Ag	Endeavour	741
Cordero	Mexico	PFS	OP	Ag, Pb, Zn	Discovery Silver	455
Cerro Las Minitas	Mexico	PEA	UG	Ag	Southern Silver	341
Silver Sand	Bolivia	PEA	OP	Ag	New Pacific Metals	308
Terronera	Mexico	Construction	UG	Ag, Au	Endeavour	175
Los Ricos	Mexico	PEA	OP, UG	Ag, Au	GoGold Resources	148
Tangana	Peru	PEA	UG	Ag, Au	Silver X	61
El Tigre	Mexico	PEA	OP	Ag, Au	Silver Tiger Metals	59
PGMs						
Ngezi	Zimbabwe	Construction, expansion	UG/smelter/refinery	Pt	Implats	1,800
Mogalakwena	South Africa	Construction	UG, conc	PGM	Anglo American	1,500
Marathon	Canada	FS	OP	Pd, Cu	Generation Mining	739
Garatau	South Africa	Construction	UG	Pt, Pd	Zijin Mining	700
Waterberg	South Africa	FS	UG	PGM (4E)	Platinum Group Metals	617
Darwendale	Zimbabwe	Suspended	UG	Pl (4E)	Great Dyke Investments	500
Two Rivers Merensky	South Africa	Construction	UG	PGM (6E)	African Rainbow Minerals, Implats	330

Project Name	Location	Status	Type	Products	Owner	Project Cost (US$M)**
Marula	South Africa	Expansion	UG	Pt	Implats	295
River Valley	Canada	PEA	UG	Pd	New Age Metals	268
K4	South Africa	Construction	UG	PGM	Sibanye-Stillwater	228
Diamonds						
Star-Orion	Canada	PEA	OP	Dia	Star Diamond	1,410
Karowe UGP	Botswana	Construction	UG	Dia	Lucara	683
Chidliak	Canada	PEA	OP	Dia	De Beers	435
Diavik A21 Phase One	Canada	Construction	UG	Dia	Rio Tinto	40
ENERGY & BATTERY METALS						
Uranium						
Arrow (Rook 1)	Canada	FS	UG	U	NexGen	1,300
PLS	Canada	FS	UG	U	Fission Uranium	1,155
Gryphon	Canada	PFS	UG	U	Denison Mines	545
Norasa	Namibia	FS	OP	U	Forsys Metals	433
Tumas	Namibia	FS	OP	U	Deep Yellow	372
Madaouela	Niger	FS	OP	U	GoviEx Uranium	343
Wheeler River	Canada	FS	ISR	U	Denison, JCU	322
Etango-8	Namibia	FS	OP	U	Bannerman	317
Mulga Rock	Australia	FS	OP	U	Deep Yellow	255
Wiluna	Australia	Scoping	OP	U	Toro Energy	220
Tthe Heldeth Túé	Canada	PEA	ISR	U	Denison Mines	112
Salamanca	Spain	FS	OP	U	Berkeley Energia	96
Kayelekera	Malawi	FS	OP	U	Lotus Resources	88
Tafoya-Marquez	USA	PEA	UG	U	Anfield Energy	79
Lithium & Rare Earth Elements						
Jadar	Serbia	FS, delayed	UG	Li	Rio Tinto	2,400
Boardwalk	Canada	PEA	Brine extraction	Li	LithiumBank	2,092
Zero Carbon	Germany	FS	Brine extraction	Li	Vulcan Energy	1,620
Rainbow Lake	Canada	PEA	Brine extraction	Li	Volt Lithium	1,549
South West Arkansas	USA	PFS	Brine extraction	Li	Standard Lithium	1,300
San Jose	Spain	Scoping	UG	Li	Infinity Lithium	1,287
Thacker Pass	USA	Construction	OP	Li	Lithium Americas	1,060
Kemerton	Australia	Construction, expansion	Plant	Li	Albemarle	1,000
Carolina	USA	FS	OP, conc	Li	Piedmont Lithium	988
Beauvoir	France	FS	UG	Li	Imerys	983
Mt. Holland	Australia	PFS	OP, refinery	Li	Covalent Lithium	950
Wolfsberg	Austria	FS	Complex	Li	Critical Metals	873
Arizaro	Argentina	PEA	Brine extraction	Li	Lithium Chile	823
Tonopah	USA	PEA	OP	Li	American Lithium	819
Tennessee	USA	FS	Plant	Li	Piedmont Lithium	809
Sonora 1 & 2	Mexico	FS	OP, plant	Li	Bacanora	800
Rhyolite Ridge	USA	FS	OP	Li	Ioneer, Sibanye-Stillwater	785
Tolillar	Argentina	PEA	Brine extraction	Li	Alpha Lithium	777
Rincon	Argentina	Scoping	Brine extraction	Li	Rio Tinto	769
Keliber	Finland	Construction	OP/UG	Li	Sibanye-Stillwater	713
Crater Lake	Canada	PEA	OP	Sc	Imperial Mining	712
Cinovec	Czech Republic	PFS	UG	Li	CEZ, EMH	644
Clearwater	Canada	PEA	Brine extraction	Li	E3 Metals	600
Sal de Vida 2	Argentina	PFS, expansion	Brine extraction	Li	Allkem	524
Kvanefjeld	Greenland	FS, delayed	OP	RE	Energy Transition Minerals	505
Clayton Valley	USA	PFS	OP, plant	Li	Century Lithium	493
Rose	Canada	FS	OP	Li	Critical Elements Lithium	471
PAK	Canada	PFS	OP	Li	Frontier Lithium	468
Longonjo/Saltend	Angola, UK	Scoping	OP, plant	RE	Pensana	450
Pastos Grandes	Argentina	FS	Brine extraction	Li	Lithium Americas	448
Wicheeda	Canada	PEA	OP	RE	Defense Metals	440
Deep Fox-Foxtrot	Canada	PEA	OP, UG	RE	Search Minerals	422
James Bay	Canada	Permitting	OP	Li	Allkem	381
Pilgangoora P1000	Australia	Construction, expansion	Plant	Li	Pilbara Minerals	372
Zinnwald	Germany	PEA	UG, plant	Li	Zinnwald Lithium	336
Kindersley	Canada	PEA	ISR	Li	Grounded Lithium	335
Goulamina	Mali	FS	OP	Li	Leo Lithium, Ganfeng	325
Songwe Hill	Malawi	FS	OP	RE	Mkango Resources	311
Phalaborwa	So. Africa	PEA	Hydro	RE	Rainbow Rare Earths	295
Bandeira	Brazil	PEA	UG	Li	Lithium Ionic	233
Ewoyaa	Ghana	PFS	OP	Li	Atlantic Lithium	185
Grota do Cirilo	Brazil	FS	OP	Li	Sigma Lithium	123
Raleigh Lake	Canada	PEA	OP	Li	International Lithium	112

** Information listed above has been compiled from available public sources, including corporate reports and presentations, press releases and regulatory filings.*
E&MJ and its publisher, Mining Media International, assume no responsibility for errors, omissions or suitability for purpose.
*** Original capital cost estimate is shown in most cases; mature projects may show updated late-stage capital estimate.*
FS - Feasibility Stage; PFS - Preliminary Feasibility Stage; PEA - Preliminary Economic Assessment; IA - Investment Approval; OP - Open pit; UG - Underground; HP - Heap Leach; Conc - Concentrator

Screening Innovations Increase Throughput, Efficiency

Newer designs handle higher tonnage, while updated digital solutions support data-driven preventative maintenance

By Jesse Morton, Technical Writer

The big screening innovations to drop at MINExpo and in 2024 target increased throughput and efficiency, and reduced energy consumption. Suppliers also say that, compared to predecessor competitors, the new solutions require less maintenance, offer more uptime, and bring safety benefits.

ELITE Banana Screens

Weir announced the ENDURON ELITE banana screen at MINExpo. The solution has been well received by the market, which comes as no surprise, an expert at Weir said.

"From an operational perspective, our customers, particularly those located in remote locations, have been very enthusiastic that this will allow them to simplify their maintenance activities and allow them to reduce their inventory management," said Corné Kleyn, global product manager, vibrating screens. "We've already been awarded some significant contracts, including a $67 million order to provide, among other equipment, ENDURON ELITE wet and dry screens to Barrick's greenfield Reko Diq copper-gold project in Pakistan."

Above, the new ENDURON ELITE screen is designed for iron ore operations and for customers that prioritize high throughput. (Photo: Weir)

Large, high-tonnage screens are "on hard rock and iron ore mines all over the world," he said. "And our new double-deck ENDURON ELITE banana screens are huge, with deck sizes up to 4.3 m by 8.5 m and weighing up to 50 mt."

Some of the new design features are "genuinely innovative and industry-firsts," Kleyn said.

"The ENDURON ELITE screens have been designed based on stress analysis for giga-cycle fatigue, including natural frequency identification and tuning, resulting in large operating windows," he said. "They are manufactured to withstand the effects of dynamic loading, with careful consideration being paid to wear distribution and the lining materials used."

The screen is driven by "just two patented ETX exciters, whereas most machines of comparable size on the market today require three exciters," Kleyn said. "These ETX exciters feature the largest vibration-duty bearings in the world."

The two exciters are mounted comparatively closer to the sideplates, which reduces the force acting on the middle of the exciter beam. "Moving the exciters closer to the sideplates also reduces the localized bending movement at the beam and sideplate interface," he said. "In contrast, screens with three exciters experience higher levels of deflection in the exciter beam, which results in heavier exciter beam designs."

The varying slope angles of ENDURON ELITE screens give varying angles of throw. "This is beneficial to the changing PSD on the deck as material gets removed through the apertures," Kleyn said.

"The steep slope angle at the feed end ensures the fine material is rapidly stratified," he said. "This creates inter-particle space within the material layer, allowing the fine material to easily reach the deck surface and stratify through the screen media panel apertures."

Near the discharge end, the angle flattens and the angle throw becomes more vertical, which reduces material velocity. "That is ideally suited to near-size screening," Kleyn said. "A typical banana screen will separate the majority of P50 material within the first third of the deck," he said. "The second third removes the P80 material, while the last third is used for near-sized screening, which concentrates on the material closest to the cut-size, often P90 and above."

ENDURON ELITE screens can be used for secondary cone crusher screening, tertiary screening, large-throughput fine screening, product screening, feed preparation, and de-sliming. "But, perhaps most notably, it excels in screening HPGR discharge applications," Kleyn said.

"This application typically requires very large screens because HPGR circuits operate with up to a 200% recirculation load, resulting in high screen-feed rates," he said. "Moreover, because the cut size of typical HPGR screens ranges from 1 to 4 mm, larger screens than those usually employed in typical mining applications are required to ensure optimal performance."

Kleyn said ENDURON ELITE screens "deliver significant advantages in terms of improved efficiency and reduced energy consumption." The screens can also simplify maintenance, and are reportedly easier to lift, install and remove.

The MINExpo release capped "a multi-year project that started with understanding where there were gaps in the screening market and how our customers' screening challenges fit with their broader operational challenges," Kleyn said.

With declining grades, existing mines need to process higher tonnages to

meet demand. “And this requires higher screening capacity,” he said. “This then became the basis for developing our design philosophy.”

STM Two-mass Vibratory Screens

In September, General Kinematics reported Sedibelo Resources’ Pilanesberg platinum mine in South Africa realized several benefits after adopting a hybrid, 1.5-deck STM-SCREEN two-mass vibratory screen to answer challenges posed by high-moisture ore. The move increased both retention time and screening capacity by 40%, the supplier reported. The screen significantly reduced ore moisture content, and reduced power consumption by 70%.

The miner began seeking solutions when its existing screens needed replacement, an event that basically recurred annually. “The moisture content of the ores was higher than they would have liked,” General Kinematics said in a press release. “Increasing material retention while reducing downtime due to maintenance were their two primary goals with this project.”

The STM-SCREEN was installed in “their old equipment’s footprint, which was 3.6 m wide by 6.1 m tall,” the supplier said. “The installation went smoothly, with no changes to existing structures and chutes required, and the machine was up and running shortly after.”

Benefits were quickly realized. “Pilanesberg platinum mine reported they were highly satisfied with the results of the two-mass STM-SCREEN, which increased their efficiency while also assisting them in achieving more sustainable operations,” General Kinematics said. “The mine reported the STM-SCREEN was quieter than previous screens, reducing noise pollution and eliminating vibrations in office buildings.” And the two-mass screen requires less maintenance than did the predecessor units.

General Kinematics delivered on its promise, leadership at the mine said. “Screening efficiencies are up, downtime is reduced, energy consumption has been improved, and dynamic loading on the steel DMS structure has significantly been reduced,” said Barry Davis, general manager, surface operations. “I see the application of this alternative screening technology as a true game-changer in the South African mining industry.”

Sedibelo Resources’ Pilanesberg platinum mine in South Africa describes its 1.5-deck STM-SCREEN two-mass vibratory screen, above, as a game changer. (Photo: General Kinematics)

The report on Pilanesberg is predated by similar stories. In 2021, the supplier reported Copper Mountain Mining Corp.’s (CMM’s) mine near Princeton, British Columbia, Canada, improved screening efficiency and throughput while cutting maintenance costs after adopting a STM-SCREEN screen.

The solution “retains material for approximately 26 to 33 seconds versus a typical brute-force screen that retains material for approximately 6 to 8 seconds,” General Kinematics said. “Equally as important is the ability of the STM-SCREEN to process at a higher bed depth without sacrificing throughput,” it said. “The increased retention time of the evenly spread material allows for increased screening efficiency at the required capacities.”

With the STEM-SCREEN screen, CMM reportedly cut maintenance costs by $800,000 annually. “Unscheduled downtime associated with screen structural failures has been slashed to near zero,” the supplier said. “Capacity increased from an average of 1,800 metric tons per hour (mt/hr) to over 2,400 mt/hr.”

General Kinematics attributes the success of the STM-SCREEN design to the company’s two-mass technology. “Two-mass refers to a style of vibratory equipment where one mass, the exciter, is used to mobilize a second mass, the trough,” the supplier said. “The engineering principles behind two-mass technology are inherently more suited for the rigors of heavy-duty screening applications.”

Two-mass technology is load-responsive and capable of “a consistent stroke during material surges, enabling the unit to screen minerals the same regardless of material load,” General Kinematics said. “The dual in-board vibratory motors eliminated the need for expensive belts, shafts, and bearings associated with brute-force models.”

The proven technology confers several benefits, leadership at the supplier said. “It can deliver higher throughput in the same footprint with increased efficiency,” said Derek Kerkera, technical director. “That can be a 30% to 40% increase in throughput in the same footprint, while also increasing efficiency, reducing horsepower needs, and dramatically increasing life of the machine.”

Two-mass technology ensures the durability of STM-SCREEN solutions. “Current competitor designs typically require rebuilds, change-outs, and complete replacements in a short duration of time,” Kerkera said.

“Most seem to be around the one year mark with some substantially less,” he said. “Our two-mass design allows the screen to run for several years without structural failures of any kind.”

General Kinematics' two-mass vibratory technology was first developed and released more than 60 years ago. The first solutions were for foundries. For the mining industry, the company initially made feeders and "slowly evolved larger and larger equipment over the years," Kerkera said.

"In the past 10-15 years, we have increased our sites and installations around the world with different designs," he said. "Each time we see a new possibility to make our machines better, we introduce a new model design."

Recent designs have "our patented duro springs," Kerkera said. "Each and every time we make a change to our design, we have seen an increase in life of the machine."

EF, BSE Series Banana Screens

Metso said the EF and BSE Series banana screens will soon be available in more regions. The company said the solutions are seeing increased demand by miners seeking dry-screening or similar solutions.

"The BSE or EF 6G (six gravity) large elliptical-motion banana/multi-slope screen designs provide a solution for difficult-to-screen applications that were previously considered not viable," said Pia Vuorela, director, global product management, vibrating equipment. The screens allow "some operations to exclude the water processing required for sticky materials or even enable projects that were not feasible due to water restrictions."

Metso recently launched "the EF Series screen with a unique technology to significantly improve safety and longevity," Vuorela said. "EF exciter technology ensures uptime and reduced maintenance need, improving safety."

EF Series screens have "two counter-rotating circular-motion mechanisms of different sizes," Metso literature said. "The optional electronic synchronization allows for stroke-angle adjustment to optimize processing."

The bearing technology was developed to better handle the stroke-angle changes. "To enable this, the exciters must be located along the side plate," Vuorela said. "To ensure no restriction on bearing lifetime, Metso developed unique exciter technology, leveraging extensive knowledge from cone crusher bronze bushing technology."

The exciters give "the machine virtually unlimited bearing life under any operating condition," she said. "Additionally, downtime for maintenance is reduced as no roller bearing changes or lubrication refills are required."

The exciter technology and banana screen also "enable the construction of wide machines," Vuorela said. "Although the EF has the advantage of stroke-angle control and new vibrator technology, adopting EF technology might encounter some restrictions due to the requirement of an external lubrication unit, similar to those used in cone crushers," she said. "Therefore, to offer the large 6G elliptical-motion banana/multi-slope technology screen to all customers, Metso provides both the BSE and EF Series."

The BSE Series screen is an evolutionary successor to the "widely field-proven box exciter banana screen design, now working with elliptical motion and 6G acceleration," Vuorela said.

"The elliptical motion is achieved through a patented solution of box exciters with asymmetrical counterweights, correctly located along the screen body to provide a uniform ellipse across the entire screen," she said.

Metso said the elliptical motion of the BSE Series screens "combines the advantages of circular and linear motion, and particles receive forces in all directions." The action and "the high transport speed efficiently eliminate blinding and pegging."

The BSE Series multi-slope deck screen, "with 6G acceleration and elliptical motion, is designed to optimize high-moisture screening, resulting in a 15%-30% increase in throughput with high efficiency in dry-screening high-moisture applications," Vuorela said.

BSE Series screens offer safety and productivity improvements over predecessor and competitor designs.

"The familiar mechanism design in the EF series, combined with a banana/multi-slope screen design that self-synchronizes in an elliptical motion, allows for safe operation at and above 6G," she said. "More importantly, this can be done more reliably than any equivalent linear motion banana screen, thanks to our fully monitored control system." BSE Series screen design allows for the "manufacture large capacity screens, such as 3.6 m by 14.6 m in tandem arrangement."

The development of EF and BSE solutions traces back to 2008 and, at the time, newly trending demand for sustainable screening solutions for high-moisture iron ore. "After extensive testing and various solutions, we found that the optimal technical solution for difficult screening demands is the combination of banana/multi-slope type of screen with 6G acceleration and elliptical motion on high open area flexible rubber media," Vuorela said.

"To provide high capacity and minimize screening-building civil works, large machines like 3.6 m or 4.2 m in width are required, combining all these features,"

Above, MF Series banana screens are designed for high throughput with substantial undersize product in the feed. (Photo: Metso)

she said. “For this demanding specification, Metso offers the two lines of screens.” Both BSE and EF technology is available to retrofit-upgrade “existing systems, offering at least 20% higher capacity or improving the efficiency of common linear or circular-motion 4- to 4.5-G screens, in both dry and wet applications, and not just for challenging materials.”

In the same interview, Metso said it will soon expand the availability of fire-retardant rubber screening media, which reduces the risk of screen house fires. The new year is also expected to bring renewed focus on digital tools that support proactive, data-driven service interventions.

In 2022, Metso made the cloud-based Metrics condition-monitoring system available for screening solutions. Metrics “enables operators, controllers and service professionals to see real-time analysis of vibrating screen performance and bearing condition,” the supplier said.

With Metrics “condition monitoring, screens can be run optimally, increasing uptime,” said Jan Wirth, director, technology. “Remote monitoring with digital tools, like Metrics, also contributes to safety by reducing the need for maintenance personnel to physically visit screens,” he said. “We are actively seeking customer collaboration in the fields of digitalization and circular economy.”

ACS-s, DeckMapp Condition Monitoring

At MINExpo, Sandvik showcased the ACS-s condition monitoring system for vibrating screens and feeders, and launched the DeckMapp digital platform for screen deck maintenance management. Sandvik said its digitalization solutions “significantly enhance the efficiency and sustainability of crushing and screening operations.”

The ACS-s system provides real-time data to inform maintenance decisions. Using up to 32 sensors, system sensitivity and detection resolution can be scaled and customized according to machine and plant requirements.

Using LAN or a built-in antennae, it can connect to a network. “Using fieldbus connectivity, ACS-s can be configured as an integrated feed to your Plant Control System,” Sandvik literature said. “ACS-s allows live data and alerts to be visualized in your Plant Control System so operators can action any potential issues with equipment immediately.”

It can also be integrated with SAM, Sandvik’s cloud-based digital assistant, “designed to support operational excellence,” Sandvik said. “SAM captures data from all connected Sandvik equipment, offering a comprehensive overview of the entire operation,” it said. “Operators can monitor equipment status, communicate across teams, receive alerts and notifications and proactively order spare parts, all from a centralized platform.”

ACS-s can be accessed using a mobile device, and can be configured to instantly send alerts and analysis. “Sophisticated sensors and data processing via SAM transform raw data into easy-to-understand visualizations that make it easy to understand both the nature of a problem and a productive course of action,” Sandvik said.

An expert with Sandvik said ACS-s can help a customer prevent unscheduled downtime caused by equipment failure. “Vibrating screens and feeders operate in extremely harsh environments accelerating massive loads with forces of up to 5G,” said Peter Newfield, global head of marketing, screening solutions.”

“Routine maintenance and correct loading are critical to long-term, reliable operations. Errors in maintenance and operations can lead to equipment component damage,” he said. “Early detection and diagnosis of damaged components is vital in the prevention of catastrophic machine failure and protracted plant downtime.”

“From a sustainability perspective, it’s always better to intervene early and make minor repairs than to deal with costly machine damage following a catastrophic failure,” he said. “These types of failures can lead to the replacement of major machine components or even complete equipment replacement, with the damaged elements being sent to scrap.”

Newfield described ACS-s as “next generation,” allowing “operators to keep an eye on the condition of vibrating machines 24/7.” It empowers operators to address “small problems before they become big ones.”

For plant operators, the new cloud-based DeckMapp offers a single source of truth for all activities within the screen media lifecycle. It “is set to transform screen deck maintenance and drive substantial improvements in the efficiency and operational performance of mineral processing plants,” Sandvik said.

The ACS-s condition monitoring system for vibrating screens and feeders can be integrated with SAM, a cloud-based digital assistant, accessible by smartphone. (Photo: Sandvik)

With it, teams can “view deck history, share deck plans, visualize panel wear patterns and capture feedback, as well as access maintenance plans and activity reports,” the supplier said. It can be used to guide operators through data entry.

“DeckMapp enhances data quality and formalizes maintenance processes, thereby eliminating information inconsistencies that can adversely affect production and profitability due to rework and extended task durations,” Sandvik said. “DeckMapp delivers real-time updates to ensure all team members are aligned, further reducing the risk of miscommunication and operational inefficiencies.”

As a centralized source of screen maintenance information, DeckMapp “improves the productivity of maintenance personnel as they can access and record the most up-to-date information in one location from whatever device they have at hand: smart phone, tablet or PC,” Newfield said. “This saves time and reduces the chance of outdated information being used to make critical maintenance decisions.”

The optional WearApp add-on wear-assessment system uses artificial intelligence to analyze images of worn panels. It calculates the wear, panel efficiency, and remaining life. “This revolutionary application not only saves substantial time, but also delivers far greater accuracy over traditional manual wear-assessment methods,” Sandvik said.

“Changing media at the perfect moment reduces the amount of screening media consumed while maintaining optimal screening efficiency,” he said. “This leads to productivity gains by reducing the length and frequency of deck maintenance operations while reducing the risk of unscheduled plant downtime due to screen panel failure.”

Jansen Orders Hoist With 'Largest Production Capacity in the World'

One of the friction hoists being installed at the Jansen potash project in Canada. (Photo: BHP Jansen)

BHP contracted with ABB to deliver, install and commission three friction hoists and an electrical system for a Blair service hoist for the Jansen potash project in Saskatchewan. Each hoist will have Ability Safey Plus, the world's first fully SIL 3-certified safety solution, ABB reported.

The service shaft and production shaft have been sunk in preparation for the hoisting systems. ABB supplied two hoists to the service shaft, including the cage. ABB also delivered the hydraulic braking system, electrical controls, and the powertrain for a temporary Blair cage hoist being commissioned in the production shaft, which will be in operation for two years while the higher-capacity production hoist is prepared. The latter will then be installed and is expected to be up and running by 2027.

"One of the two production hoists will have the largest production capacity in the world, able to transport payloads of 75 metric tons (mt)," ABB said. Its six ropes will be able to support the heavy loads from 1 km underground at a maximum speed of 18.3m/s, supported by dual 7,700-kW motors.

The hoists and hoisting systems will play a crucial role at the project, said Simon Thomas, vice president, projects, potash, BHP. "The new contract further strengthens our existing strategic partnership with ABB, and we look forward to continuing to work together as we plan to drive productivity, safety, and sustainability."

Indian Iron Project Orders FLS HPGRs

FLS reported it received an order for high-pressure grinding rolls (HPGRs) for an iron ore project in India. The units are 3 m dia. by 2 m wide, ranking them among the largest in the world, the supplier said.

The order includes installation, commissioning and start-up support, and a service agreement. It "is a clear testament to the strength of FLS's market-leading HPGR technology and our best-in-class life cycle services," FLS said.

The equipment is expected to be installed and commissioned during 2026. FLS said it received eight orders for a total of 15 HPGR commitments in 2024.

Montage Gold Buys Metso Mill Solutions

Metso said it won a $52 million order from Montage Gold for delivery of key minerals processing equipment for the Koné gold project in Côte d'Ivoire.

The order includes a large, dual-pinion, 22-MW Premier grinding mill, and an HRC 2400e HPGR. The ball mill will be equipped with metallic mill lining and Polymer Hydrostatic Shoe Bearing system. The HRC will be equipped with flanged roll technology enabled by Metso's mechanical skew control system.

For the crushing circuit, Metso will deliver a Superior MKIII 54-75 primary gyratory crusher and Nordberg MP1250 cone crushers. Metso will also deliver high rate thickeners with the Reactorwell feed system.

Most of the solutions are part of the Metso Plus offering.

The due diligence process for the order included detailed trade-off studies and site visits, leadership at the mine said. "It was also a pleasure to visit their factory and meet the dedicated employees who are committed to delivering our installation on time and within budget," said Peder Olsen, president, Montage Gold. "We look forward to a strong partnership with Metso, driven by their advanced technology, and their strong commitment to service and ongoing support."

Montage Gold ordered an HRCe HPGR and Premier ball mill, above. (Image: Metso)

Four Simba E6 WLs, similar to the above, have each drilled 1 million meters at Malmberget mine. (Photo: Epiroc)

Simba Rigs Drill 1 Million Meters

Epiroc reported four teleremote-controlled Simba E6 C WL production drill rigs have surpassed 1 million drill meters in LKAB's Malmberget mine in northern Sweden. Two more machines are expected to reach the same milestone.

Purchased in 2012, the rigs use Epiroc's automation solution Automatic Boom Control, ABC Total, with a teleremote-control system, enabling an operator to run multiple machines at the same time. Mine leadership said the rigs deliver as promised and as needed.

"We are very happy that our Simba drill rigs keep delivering results year after year," said Björn Öderyd, drilling manager, LKAB. "Epiroc's high level of service, performed by skilled technicians, is exactly what is required for today's automated and sophisticated drill rigs."

Immersive Expands Training Offerings

Immersive Technologies reported it won contracts to provide workforce training solutions for four significant underground mining projects in the USA, Canada, Chile, and Indonesia. These solutions encompass machine simulation, digital learning technologies including virtual reality, 3D virtual machines, and training program development.

Leadership at the supplier said the company increased its investment in new conversion kit development for the growing range of underground machines.

"We also launched a new 'Premium' simulator platform optimized for underground applications at MINExpo 2024, positioned alongside new digital learning technologies to address the specific needs of underground customers," said CEO David Anderson. "Underground mining is growing fast and 2024 has delivered new strategic customers, which validates our increased underground research and development investment over the last few years."

RAM Partners With Cambelt

RAM Enterprise announced a strategic partnership with Cambelt International that will combine the former's expertise in conveyor installation, maintenance, and service with the latter's technologies to offer high-incline conveying systems.

In the partnership, RAM will install and commission Cambelt products, and conduct site inspections and deliveries for Cambelt. RAM Enterprise said the partnership will directly benefit customers. "This partnership will allow us to provide our clients with industry-leading material handling solutions that are not only durable but also designed for high-performance applications, including vertical and steep-angle conveying," said Laila Miguel, company president.

Cambelt is known for its one-piece flexible sidewall conveyor belting.

GroundProbe to Sell Trimble Solutions

Trimble and GroundProbe, part of Orica Digital Solutions, said customers can purchase the former's monitoring solutions through the latter's distributors. The suppliers also announced new integrations between Trimble and GroundProbe sensors and software, Trimble 4D Control and MonitorIQ.

GroundProbe said incorporating sensors into one environment gives professionals a more complete picture of site conditions.

"Our work with Trimble allows GroundProbe and Orica Digital Solutions to offer a range of Trimble's advanced robotic and automatic total stations, 3D laser scanners and software solutions for our global customers," said Ben Moke, CEO, GroundProbe. 'Our organizations share a vision of providing open, connected and secure information that helps customers streamline workflows, boost efficiency and better manage risk."

Laila Miguel (left), president at RAM Enterprise, signs an agreement with Justin Barker, vice president sales and marketing for Cambelt International. (Photo: RAM)

New Tool Simplifies Wear Analysis

By Steve Fiscor, Editor-in-Chief

Occasionally, innovative minds create solutions that are simple, effective, and remarkably cost-efficient. Glenn Brearey and Matt Rigby, co-founders of WearVue®, have done exactly that.

Both Brearey and Rigby previously worked as general managers at Schlam, gaining extensive experience in mining and heavy industries. Although their paths diverged after Schlam, they reconnected later while consulting. During this time, Brearey invented WearVue, a revolutionary color-coded wear monitoring system. Recognizing its potential, Rigby stepped in to commercialize the invention, helping to refine and scale it into the disruptive technology it is today.

WearVue was registered as a business in September, and by November, the company had secured a BHP vendor number, a challenging yet rewarding achievement. By December, WearVue received its first purchase order from BHP, an incredible milestone for a company just a few months into its journey.

WearVue was born out of a clear need: to simplify wear monitoring while ensuring the system is both scalable and environmentally sustainable. At its core is a patented Green-Yellow-Red color-coded system, designed to provide intuitive visual feedback on wear levels.

By integrating principles of Kanban and Just-In-Time (JIT) maintenance, WearVue ensures that resources are utilized effectively, preventing unnecessary delays while avoiding overstocking or under-preparation.

WearVue's capabilities are further enhanced by the addition of VueVision®, an IoT-enabled platform powered by AI. VueVision transforms wear monitoring into a data-driven process, delivering real-time predictive analytics that help companies shift from reactive maintenance to proactive strategies. This evolution not only reduces unexpected downtime but also aligns with modern digital transformation goals.

VueVision will be offered as a Software-as-a-Service (SaaS) platform, creating opportunities for scalable integration into operations while unlocking additional insights through advanced analytics.

WearVue's color-coded system provides visual feedback on wear.

"Color is a universal language," Brearey explained. "Everyone stops at red, cautions at yellow, and it's the fastest thing the mind interprets. Imagine a system where anyone can see the amount of wear with the naked eye."

For haul truck trays, WearVue can be installed either as part of the factory build or as a retrofit solution:

- **Factory Installation:** When BHP orders a new Komatsu 930E-5, they specify WearVue inserts for the tray. "Factory workers machine the pockets and all sensor positions to a precise thickness, ensuring they are highly accurate," Brearey said. "When the plates are assembled, the sensor bodies are glued intothe pockets."
- **Retrofit Installation:** For existing trays, technicians mark the pockets, drill them, and glue the sensors into place.

The color-coded system offers a clear and immediate visual representation of wear patterns in the tray. "For instance," Brearey explained, "the indicators are 20 millimeters (mm) long, with each color signifying a specific wear length we can then calculate and predict wear. While truck trays are a primary application. Other high-wear items at mines are also being transformed by this technology.

One example is ground engaging tools (GET), which are subject to extreme wear and tear. While some GET management systems rely on cameras, Brearey explained that WearVue's three-color sensors could enhance these systems.

Chutes, another area prone to high wear, are often in confined spaces that make visual inspections difficult and unsafe. WearVue simplifies the process by providing color-coded visual feedback, enabling quick, accurate assessments without the need for physical entry.

Similarly, conveyor rollers can benefit from WearVue's system. Brearey described how color-coded sensors could provide an instant overview of wear. "Imagine looking at the overland conveyor and seeing all the idlers are yellow — it's time to reorder 10,000 idlers," he said.

Crusher inspections are among the most dangerous maintenance tasks in mining. Brearey highlighted how WearVue can eliminate guesswork. "Some mines replace wear liners every three months, regardless of their condition," he explained. "With WearVue, technicians can see exactly when replacement is necessary, avoiding premature changes and reducing downtime."

WearVue continues to explore new applications, offering solutions that prioritize safety and efficiency while transforming wear monitoring into a proactive, data-driven process.

WearVue is designed to be both accessible and scalable, with its current system providing intuitive three-color visual feedback for human operators. However, the addition of AI-powered tools takes its potential even further, enabling advanced automation and greater efficiency.

For example, an AI camera pre-trained for WearVue could be installed at a truck dump to monitor the sensors during tipping, Brearey explained, "If the camera can't see the green or yellow dots it saw previously, it means a hang-up in the tray is blocking the view of the sensors." In such cases, the AI-enabled system could trigger a robotic water cannon to wash a specific area, rather than cleaning the entire tray. While this won't eliminate hang-ups mine-wide, it introduces a scalable and focused solution for areas where the AI system is implemented.

WearVue's journey as an emerging start-up has been bolstered by key collaborations. Brisbane-based Evolve Group and Perth-based SFDesign, specialists in industrial design and plastics, provided invaluable support. Loctite is assisting with adhesive technologies, and Curtin University has stepped in to support WearVue's AI initiatives.

Hybrid Land Cruiser Recharges in 10 Min.

Switch Technologies unveiled the "world's first" light truck powered by Echion Technologies' ultra-fast charging XNO active anode material technology. The Toyota Land Cruiser 79 Series, with a plug-in hybrid configuration, was showcased at the Australian Automation and Robotics Precinct in Perth, Australia.

The unit is equipped with cells manufactured by Li-FUN, an XNO cell development partner. Switch Technologies said the cells enable lithium-ion batteries to "safely fast charge in less than ten minutes, maintain high energy densities even at extreme temperatures, and deliver high power across a cycle life of more than 10,000 cycles."

The XNO battery modules and packs, along with drivetrain modifications and control systems to hybridize the Land Cruiser, were developed in roughly 9 months. Switch said it subsequently launched a comprehensive test and validation program.

Land Cruiser models are popular with Australian miners.

SwitchTechnologies.com

Study: Dollies, Trailers Cut Vibration

Sleipner reported a study by the Finnish Institute of Occupational Health that concluded that using Sleipner dollies instead of driving an excavator lowers the exposure of drivers to whole-body vibrations that pose health risks.

"The excavator used for the test was a Komatsu PC 2000 and, when using dollies, the excavator was pulled with a Komatsu 830 E haul truck," Sleipner said. "During the measurements — 26 minutes on dollies and 20 minutes on tracks — the driver and the person conducting the measurements were in the excavator cab."

The findings suggest that when using Sleipner dollies, none of the Finnish regulatory thresholds are exceeded during a 12-hour working day, the supplier said. In contrast, when tramming on crawler pads, the thresholds are exceeded after just three hours of exposure.

The dollies proved to be "an excellent way to mitigate vibration," said the report's author Ville Hyvärinen, an occupational hygienist with the institute.

The findings are also applicable to moving other crawler-mounted equipment, Sleipner said. "When moving the bulldozer and drill, whole-body vibration can be effectively reduced by using Sleipner's DB Series lowboy trailers."

Sleipner.com

TeleStacker Automation Upgrades

Superior Industries announced upgrades to its TeleStacker Conveyor PilePro Automation designed to enhance productivity, usability, and durability.

Version 14.0 of the technology reportedly offers a higher resolution display, readable in sunlight; remote monitoring capability; integrated operational instructions for fast troubleshooting; integrated instructional schematics and videos; and optimized, rugged housing.

The upgrades can be applied to existing solutions and are available through local dealers and distributors.

Superior-Ind.com

Articulated Truck Telemetrics System

Rokbak reported its Haul Track telematics system fits seamlessly into an operation, boosts uptime, and supports data-driven decisions on maintenance that can cut costs and lengthen truck lifespan.

The system comes standard on the RA30 and RA40 ADT articulated dumpers. Its gives access to actionable insights for fleet management decisions, Rokbak said.

For example, the online portal includes tools such as Fleet Manager and Fleet Tracker, which allow users to customize dashboards according to their priorities and targets, set maintenance parameters, and receive automated reports and email alerts.

Rokbak.com

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Precious Metal Prices Rise in 2024 While Prices for Some Metals Soften

By Steve Fiscor, Editor-in-Chief

As the new year begins, it's a worthwhile exercise to see what strides have been made in the last year and even the last five years. For gold miners and those that hoard the yellow metal, these have been good times. Gold prices are starting 2025 at $2,639 per ounce (oz). That is $590/oz higher than $2,049/oz at the start of 2024 and $1,101/oz higher than the beginning of 2020. Silver followed a similar path. It's starting the year at nearly $30/oz, which is ahead of nearly $23/oz in 2024 and $18/oz in 2020.

For platinum group metals, the theme is mixed. For the last five years, platinum has been range-bound between $900/oz and $1,000/oz. It has fluctuated some, but it's has been priced lower than palladium for much of that period until recently. That's not good news for palladium. It is starting the year at $933/oz, $11/oz less than platinum, $127/oz less than this time last year, and $1,016/oz less than the price at the beginning of 2020.

With base metals, the prices for aluminum and copper climbed year-on-year and across the last five years. Lead and nickel appear to be flat. If one were to do a deeper dive, they would see that nickel went on a wild ride that encouraged and then bankrupted some mine developers only to arrive at nearly the same price five years later. Tin and zinc prices have climbed steadily over the past five years. Like nickel, zinc prices experienced some swings during that period too.

Metal Price Comparisons	Jan-25	Jan-24	Jan-20
Gold	$2,639.40	$2,049.05	$1,538.30
Silver	$29.58	$22.96	$18.09
Platinum	$944.00	$970.00	$987.00
Palladium	$933.00	$1,060.00	$1,949.00
Rhodium	$4,575.00	$4,425.00	$6,075.00
Ruthenium	$465.00	$440.00	$250.00
Aluminum	$2,475.00	$2,273.50	$1,772.00
Copper	$8,701.00	$8,463.00	$6,165.50
Lead	$1,898.00	$2,076.00	$1,904.00
Nickel	$14,770.00	$16,372.00	$14,075.00
Tin	$28,625.00	$24,622.00	$17,150.00
Zinc	$2,864.50	$2,562.50	$2,299.00
Molybdenum	$46,354.00	$43,670.00	$20,240.00
Cobalt	$22,046.00	$28,307.35	$32,500.00
Lithium Hydroxide	$10,025.00	$15,450.00	—
Fe CFR North China	$99.44	$145.00	$93.17

The prices for molybdenum have more than doubled in five years, while cobalt prices have steadily declined. *E&MJ* was not tracking lithium hydroxide (LiOH) in 2020, but prices for LiOH have declined sharply before stabilizing more recently.

Similar to most metals except the precious metals, the price for iron ore depends on Chinese demand. A massive export industry has been established to ship iron ore from Western Australia and Brazil to Chinese steel mills. When that market slows, the prices for iron ore soften. Looking at the price for iron ore, it's easy to see the peaks and troughs.

E&MJ PRICES INDEX

(January 3, 2025)

Precious Metals ($/oz)		Base Metals ($/mt)		Minor Metals ($/mt)		Exchange Rates (U.S.$ Equivalent)	
Gold	$2,639.40	Aluminum	$2,475.00	Molybdenum	$46,354	Euro (€)	1.029
Silver	$29.58	Copper	$8,701.00	Cobalt	$22,046	U.K. (£)	1.242
Platinum	$944.00	Lead	$1,898.00	Lithium Hydroxide	$10,025	Canada ($)	0.692
Palladium	$933.00	Nickel	$14,770.00			Australia ($)	0.621
Rhodium	$4,575.00	Tin	$28,625.00	**Iron Ore ($/dmt)**		South Africa (Rand)	0.053
Ruthenium	$465.00	Zinc	$2864.50	Fe CFR China	$99.44	China (¥)	0.137

Gold and silver prices provided by KITCO Bullion dealers (www.kitco.com). Platinum group metals prices provided by Johnson Matthey (www.platinum.matthey.com). Non-ferrous base and minor metal prices provided by London Metal Exchange (www.lme.co.uk). Iron ore prices provided by Platts Iron Ore Index. Currency exchange rates were provided by www.xe.com.

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