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*Comparison of Cummins engine configuration against EX5600-6.

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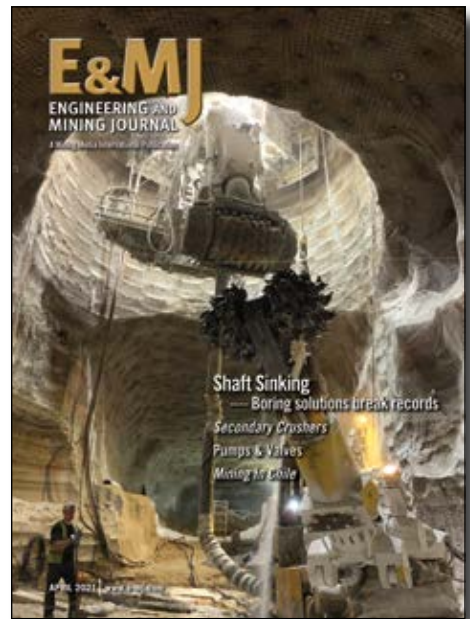
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Steve Fiscor
Publisher & Editor-in-Chief

Is the Green Energy Vision Sustainable?

Earth Day is approaching (April 22) and it appears some environmental activists are starting to turn on each other. A new documentary, *Bright Green Lies*, based on a book by the same name, will air on Earth Day. Tickets are available now at www.brightgreenlies.com. The promo says the film dismantles the illusion of green technology in comprehensive detail. "From the proposed benefits of solar panels and wind turbines, to green consumerism and electric cars, *Bright Green Lies* takes a bold peak behind the green curtain." The crowd that crushed the coal business will soon turn its attention to natural resources (i.e., metal mining).

The world faces an insatiable need for electricity from reliable and affordable sources and increasing demand is causing system wide failures. Nothing highlighted the problem more than the rolling blackouts that took place in Texas in February. Electric reliability problems that are common in places like southern Africa and Latin America are now happening more frequently in the developed world. These disruptions have cast serious doubt about the viability and sustainability of clean power generation for heavily populated areas.

Although it was not widely discussed, the rolling blackouts did not respect the Texas-Mexico border. When the world saw hopeless Texans lining up for water, food and fuel, Mexico had also lost power as far south as Cancun and Mexico City. More than half of Mexico's electricity comes from natural gas-fired plants and most of that natural gas comes from the U.S. When the natural gas delivery system from the U.S. failed, Mexico realized it was in trouble. Millions of Mexicans were freezing in the dark, too.

During March, the Mexican Federal Senate approved a bill that will modify Mexico's Electricity Industry Law (the Reform Bill), reversing some of the rights granted to private investors in the power sector. The Reform Bill was not a direct result of the blackouts, but its quick senate approval probably was. Mexican President Andrés Manuel López Obrador (AMLO) originally proposed it in January. Critics of the AMLO administration say it is the most drastic measure among a series of actions taken to dismantle Mexico's energy privatization program.

The AMLO administration supports the state-run utility and the state-run oil company. The Reform Bill gives priority to the Mexican utility CFE (Comisión Federal de Electricidad) for electricity generation. Critics also say it "deprioritizes" clean energy. The Reform Bill doesn't include provisions to increase domestic natural gas production. It is being challenged by affected companies (See News, p. 15). Previous efforts to restrict private power generation have been blocked by the courts, which ruled the policies were unconstitutional.

More of these debates will be taking place in more countries. Most of the world is not yet prepared to make the transition to an electrically powered future. It will require a major investment in transmission and distribution systems, and an almost incomprehensible amount of natural resources, and people are starting to run the numbers.

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First Majestic Silver Buys Jerritt Canyon



Jerritt Canyon owns the Jerritt Canyon gold mine in Nevada, which operates as an underground mine and has a gold processing plant. (Photo: Jerritt Canyon)

First Majestic Silver Corp. will acquire all of the common shares of Jerritt Canyon Canada Ltd. from Sprott Mining Inc. for \$470 million in shares of First Majestic plus 5 million First Majestic share purchase warrants. Eric Sprott, president of Sprott Mining, will complete a \$30 million private placement investment in First Majestic.

Jerritt Canyon owns and operates the Jerritt Canyon gold mine located in Elko County, Nevada. The mine currently operates as an underground mine and has one of three permitted gold processing plants in Nevada that uses roasting in its treatment of ore. This processing plant has a capacity of 4,500 metric tons per day (mt/d) and is currently operating at an average rate of approximately 2,200 mt/d due to limited ore production from two underground mines. The property consists of a large, underexplored land package consisting of 30,821 hectares (119 square miles).

In 2020, Jerritt Canyon produced 112,749 ounces (oz) of gold at a cash

cost of \$1,289/oz. First Majestic said it has identified several opportunities to enhance both the cost and production profile of Jerritt Canyon as well as near-term brownfield potential between the SSX and Smith mines and long-term property wide exploration potential.

“While we remain focused on maintaining our peer-leading exposure to silver, Jerritt Canyon is a unique opportunity to create value for First Majestic’s shareholders and provides a new geographic operating platform while preserving our pristine balance sheet,” First Majestic CEO Keith Neumeyer said. “We look forward to working with the operating team at Jerritt Canyon and are excited about the opportunities we have identified to enhance operations to unlock value.”

Together with its existing three operating silver mines in Mexico, First Majestic said the combined company will be a premier North American silver and gold producer with expected pro forma annualized attributable production of 30

million to 33 million silver equivalent oz based on historical production rates.

“This deal is a win-win for both parties and we look forward to having continued exposure to Jerritt Canyon’s bright future through our increased ownership in First Majestic,” Sprott said. “We have a long-standing respect and high regard for Keith Neumeyer and his leadership in the silver industry, an industry with which we have had an increasing involvement over the past two years. We also see this as a big step forward for Jerritt Canyon where it can flourish under the larger umbrella of First Majestic.”

Evolution Mining Purchases Battle North Gold

Canadian gold miner Battle North Gold Corp. and Evolution Mining Ltd. have entered into an agreement where Evolution will acquire all of the issued and outstanding shares of Battle North at a price of C\$2.65 (US\$2.13) per common share in cash, for total con-

sideration for all issued and outstanding shares pursuant to the transaction of approximately C\$343 million (\$275 million). Battle North owns the shovel-ready Bateman gold project located in the Red Lake gold district in Ontario, Canada.

The consideration represents a 46% premium over the closing price of the Battle North common shares on the Toronto Stock Exchange on March 12 and a 54% premium based on the volume-weighted average price of the Battle North common shares over the last 20 trading days.

“The all-cash offer is at a significant premium to market and reflects the extraordinary efforts of the Battle North team to create value at the Bateman Gold Project and ultimately deliver an outstanding outcome for Battle North’s shareholders,” Battle North President and CEO and Director George Ogilvie said. “We believe that there are unique and undeniable merits to combining the Red Lake assets of Battle North and Evolution and this transaction reduces development and execution risk.”

Evolution owns Red Lake, which includes Red Lake, Campbell and Cochenour mines. Executive Chairman Jake Klein said the acquisition provides Evolution with the opportunity to expand its footprint by leveraging the infrastructure of the two operations.

Klein said this was an ideal window to consolidate the properties ahead of the construction of the Bateman mine, which is now in its early stages.

The additional processing capacity from the new Bateman mill will also accelerate the company’s ability to achieve the objective of producing in excess of 300,000 ounces of gold per year from Red Lake, Klein said.

Subject to the conditions being met, the transaction is expected to close in the second calendar quarter of 2021.

Nouveau Monde Proceeds With Phase 2 of Fully Integrated Anode Material Production Facility

Nouveau Monde Graphite Inc. completed a front-end loading engineering analysis (FEL-1) for Phase 2 of its large-scale commercial lithium-ion anode material project in Bécancour,

Québec, Canada. It said it will continue to execute its strategy of becoming the Western World’s largest producer of high-quality anode materials to be used mainly in batteries for electrical vehicles and renewable energy storage. As it expands, Nouveau Monde said it will also preserve its firm commitment to carbon neutrality.

“Nouveau Monde is firmly on its way to become one of the world’s most important anode materials producers, delivering high-quality anode materials from our sophisticated processing and beneficiation plants in Bécancour,” Chairman Arne H. Frandsen. “Our successful upstream integration with our Matawinie mineral project is

designed to ensure that we have access to the right quality feedstock for decades to come.”

It has announced Phase 2 of the project, with a projected low-operating cost profile.

“Our significant forecast incremental annual operating profit potential is a testimony that it is possible to embrace sustainable development and profitability to the benefit of all stakeholders,” Frandsen said.

Nouveau Monde has acquired a 200,000-m² parcel in the industrial park of Bécancour, adjacent to its Phase 1 plant located within the facilities of Olin Corp. The Phase 1 plant of the Bécancour VAP project is currently under

Porgera Will Reopen Later This Year; Papua New Guinea, Barrick Reach Agreement

The Porgera gold mine will resume operations this year after the Papua New Guinea (PNG) government and Barrick Niugini Ltd. (BNL) agreed on a partnership for its ownership and operation. Porgera has been on care and maintenance since April 2020 when the government did not renew its mining lease.

Under the agreement signed by Gov. General Sir Bob Dadae and Barrick Gold President and Chief Executive Mark Bristow, Porgera will be a new joint venture owned 51% by PNG stakeholders and 49% by BNL. BNL will remain the operator of the mine.

PNG stakeholders and BNL will share the economic benefits of mine on a 53% and 47% basis and BNL will provide the capital to restart the mine. The government will retain the right to acquire the remaining 49% of the mine from BNL at fair market value after 10 years.

Prime Minister James Marape said the agreement, reached after months of negotiation, was a historic development.

Porgera is an open-pit and underground gold mine located in the Enga province of Papua New Guinea, about 600 kilometers northwest of Port Moresby. BNL is a joint venture company in which Barrick and Zijin Mining Group each own 50%.



The Porgera mine (above) will become a joint venture owned 51% by Papua New Guinea and 49% by BNL.

construction, with a planned nameplate capacity of 2,000 metric tons per year (mt/y) of anode material and scheduled to make its first production within 12 months.

The Phase 2 of the Bécancour VAP project is designed to receive approximately 60,000 mt/y of flake graphite from Nouveau Monde's own Matawinie mineral project, or from alternative third-party sources of supply deemed suitable, to be transformed into 42,000 mt/y of anode material, 3,000 mt/y of purified flakes and 14,000 mt/y of micronized graphite representing a valuable process byproduct.

The incremental annual operating profit potential of the Phase 2 of the Bécancour VAP project, when at full capacity, is forecast to be up to \$200 million — depending on the retained raw material supply scenario, which will be in addition to the operating profit potential generated by the direct sales to third-party customers of flake graphite produced by the Matawinie mineral project.

Front-end Loading prefeasibility engineering analysis (FEL-2) is under way with the goal to be completed within 12 months. The current plan provides for the Phase 2 plant to commence commissioning of its first capacity in Q1 2025.

Ontario Develops First-ever Critical Minerals Strategy

The Ontario government is developing its first-ever Critical Minerals Strategy to help generate investment, increase the province's competitiveness in the global market, and create jobs and opportunities in the mining sector. It will also support Ontario's transition to a low-carbon economy both at home and abroad.

"By developing this strategy, we will strengthen Ontario's position as one of North America's premier jurisdictions for responsibly sourced critical minerals, including rare earth elements," said Greg Rickford, minister of energy, northern development and mines and minister of indigenous affairs. "We are confident this will generate investment, reduce red tape, create jobs and advance indigenous participation in the sector. Local and global markets, including Ontario-based industries, are looking

for reliable, responsibly sourced critical minerals and we are ready to capitalize on this growing market demand."

Rickford said Ontario is well-positioned to become a global supplier, producer and manufacturer of choice for certain critical minerals, including nickel, copper, cobalt and platinum group elements.

"With an abundance of the critical minerals in northern Ontario, along with a competitive business climate, innovation and talent, Ontario is well-positioned to become a leader in the future of electric vehicle (EV) and battery manufacturing," said Vic Fedeli, minister of economic development, job creation and trade. "In fact, recent proposed investments of almost \$6 billion over the last several months in Ontario's auto sector will make our province a global hub for EV manufacturing, making us stronger and more resilient as we continue to work toward economic recovery."

The province released a discussion paper for public consultation on the Environmental Registry of Ontario. A consultation with industry and indigenous communities will help guide the development of the strategy to be released this fall.

In 2019, Ontario produced more than \$10 billion worth of minerals, accounting for 22% of Canada's total mineral production.

Ontario minerals are already part of a globally integrated supply chain and Ontario minerals are used in products worldwide.

In October 2020, the province announced funding to retool Ford of Canada's Oakville Assembly Complex, transforming Ontario into a global electric vehicle manufacturing hub.

Boliden Reports Production Disruptions

Citing COVID-19 related sick leave combined with production disruptions at both the Aitik mine in Sweden and the Tara mine in Ireland, Boliden said the operating profit in its mining segment would be negatively affected by close to SEK200 million (\$23.5 million) during the first quarter.

The company has not been able to maintain full production at the Aitik mine during the first quarter. In addition, hydraulic problems in one out of two primary mills in the concentrator plant have led to production disruptions. Production capacity has been reduced by a little more than 1 million metric tons (mt).

Increased absenteeism due to COVID-19 at Tara had a negative effect on production. In addition, a breakdown of the ore hoist occurred at the mine. The breakdown caused a halt in mining production, which was expected to last for a week.



A rope-shovel loads ore into a haul truck at Boliden's Aitik mine. (Photo: Lars deWall)



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South Dakota Mines Gets Public Funding for Mineral Industries Building



Gov. Kristi Noem signs off on funding for the South Dakota School of Mines.

South Dakota legislature and Gov. Kristi Noem recently approved \$19 million in public funding for the construction of a new state-of-the-art Mineral Industries Building on the South Dakota School of Mines and Technology campus. The new facility will advance the future of science, engineering, and technology while increasing environmental stewardship and catalyzing economic development in the region, according to the school.

The school said the modern research spaces and classrooms will lead to new discoveries, spur creation of new high-tech companies, and help attract new employers to the area while educating the next generation of innovators. A few examples of research under way include private partnerships being leveraged in a new multidisciplinary entity called the Mining Hub, which explores cutting-edge technology such as autonomous vehicles, artificial intelligence, robotic mining and a new era of environmentally sustainable mining practices. Faculty and students are tapping the massive well of geother-

mal heat deep inside the earth as part of a study at the Sanford Underground Research Facility (SURF) in Lead, South Dakota. New products and manufacturing methods are being created from mined and recycled minerals with innovative research funded by private industry, NASA, the Department of Defense and the National Science Foundation.

"Thanks to state leaders, we have an exciting opportunity in this new facility to produce a large return on investment for both the public and private sector," Mines President Jim Rankin said. "This facility will yield new research and spin-off companies alongside a new crop of science and engineering innovators in multiple fields."

State Sen. David Johnson authored the bill and served as the prime sponsor. Sen. Johnson is also an alumnus. "It was an honor to work on this legislation for my alma mater and for the state of South Dakota," Johnson said. "Mines faculty and administrators were key on bringing me up to speed on the critical issues related

to rare earth mining and its role in our own economic development and our nation's defense.

"This building will also help us retain high quality scientists and engineers right here in South Dakota."

The location of the building is between the O'Harra Building and the James E. Martin Paleontological Research Laboratory. The new building is expected to open in late 2023 or early 2024.

Caterpillar is supporting the creation of a new laboratory at the school to explore state-of-the-art mining technology, which includes the collaboration with Western Dakota Tech and local industry. A new agreement with Cat is also exploring transforming part of SURF into an underground robotic mining test facility.

Industry leaders from Nucor and a wide range of other companies are committing millions of dollars to this project.

Arizona Court Rules in Favor of Florence Copper Project

The Arizona Court of Appeals has confirmed all aspects of the Superior Court of Arizona's 2019 decision in favor of the Florence Copper project and rejected the arguments made by the town of Florence. The court upheld Florence Copper's right to mine its private property within the town and awarded \$1.7 million in legal fees and costs to Florence Copper.

"We are certainly happy with the appellate court decision, which draws to a close all outstanding litigation brought by the town," said Stuart McDonald, president of Taseko Mines Ltd., which owns Florence Copper. "While it is the outcome we expected, the closure this decision brings is important for not only for the company, but for all those who benefit from the social and economic contribution we are making to the region."

The legal challenges initiated by the town have now ended in Florence Copper's favor.

The project has received one of two key permits necessary for commercial operations to begin by the Arizona Department of Environmental Quality, and the

federal Environmental Protection Agency is taking the final steps required to issue the second key operating permit.

The success of the recent bond offering means capital requirements for commercial production are in hand, according to the company. Final design and engineering of the commercial in-situ production facility as well as procurement of certain critical components is under way.

Mine Closure Project Will Create Value for Barrick and Jobs for Montana

Montana Gov. Greg Gianforte and Barrick Gold Corp. President and CEO Mark Bristow met at the closed Golden Sunlight mine in Jefferson County to discuss an innovative project that is expected to create 75 or more jobs and tens of millions of dollars in tax revenue and benefits to the state over the next decade, while removing a source of potential water pollution from the mine site. The project involves the reprocessing of tailings in the Golden Sunlight mills. The focus will be on removing and concentrating the sulphur from iron pyrite that will then be sold to and used in gold production by Nevada Gold Mines, the largest gold producing complex in the world.

Barrick, which owns Golden Sunlight, is also the majority owner and operator of Nevada Gold Mines. The concentrated sulphur is not only a valuable byproduct of the process, but its removal will also eliminate a source of potential groundwater contamination. After reprocessing, the remaining benign material will be back-filled into the Mineral Hill pit.

"It's great to see Barrick's Golden Sunlight mine continue to invest in the community of southwest Montana," Gov. Gianforte said. "This is the type of investment that is possible when state agencies provide a stable, predictable regulatory process that companies can rely on — one that benefits the local environment, too."

Bristow said the groundbreaking project, which combined rehabilitation with value creation, would serve as a model for Barrick's future mine closures.

"It's very much in line with Barrick's commitment to sustainability as well as our philosophy of sharing the economic benefits generated by our mines with stakeholders," he said. "Everyone wins:



The Golden Sunlight mine produces more than 3 million oz of gold during its nearly 40 years of operation.

the local community gets jobs and cleaner water; the state of Montana gets taxes; and Barrick continues to get some revenue from an operation previously judged to be terminal."

The permitting process is expected to be complete in the fall and first concentrates could ship as early as the end of the year, Bristow said.

Public environmental scoping comments on the project closed on March 12 and the Montana Department of Environmental Quality is currently completing its environmental review.

The Golden Sunlight mine produced more than 3 million ounces (oz) of gold during its nearly 40 years of operation. The mine shut down in 2019 when gold production was no longer economically viable.

Newmont Will Buy Remaining Interest in GT Gold

Newmont Corp. and GT Gold Corp. have entered into a binding agreement where Newmont will acquire the remaining 85.1% of common shares of GT Gold not already owned by Newmont. Under the terms of the agreement, Newmont will acquire each GT Gold share at a price of C\$3.25, for cash consideration of approximately \$311 million (C\$393 million).

"We are excited to expand our world-class portfolio to include the Tatogga project in the Tahltan Territory located in the highly sought-after Golden Trian-

gle district of British Columbia, Canada," Newmont President and CEO Tom Palmer said. "Newmont recognizes that our relationships with indigenous, first nations and host communities are critical to the way we operate."

Palmer said the company is committed to continuing to build the relationship with the Tahltan Nation, including with the community of Iskut, which is near the project. "We understand and acknowledge that Tahltan consent is necessary for advancing the Tatogga project and we will partner with the Tahltan nation at all levels, and with the government of British Columbia to ensure a shared path forward," he added.

Tahltan Central Government (TCG) President Chad Norman Day said TCG understands the sensitivities of all mining projects and has communicated with Newmont that Tahltan consent is a requirement for the advancement of any project in Tahltan Territory.

The Tatogga project, including the primary Saddle North deposit, has the potential to contribute significant gold and copper annual production at attractive all-in sustaining costs over a long mine life. In addition to the known deposits at Saddle North, there are further exploration opportunities throughout the land package. The acquisition of the Tatogga project adds to Newmont's existing interest in the prospective Golden Triangle

through the company's 50% ownership in the Galore Creek project.

The transaction is expected to close in the second quarter of 2021, subject to meeting normal closing conditions.

Rio Tinto Will Build New Tellurium Plant at Kennecott

Rio Tinto will begin construction on a new plant that will recover tellurium, a critical mineral used in solar panels, from copper refining at its Kennecott mine near Salt Lake City, Utah. Rio Tinto is investing approximately \$2.9 million to establish the plant, which will recover tellurium as a byproduct of copper smelting, extracting the mineral from waste streams. The plant will have a capacity to produce approximately 20 metric tons (mt) of tellurium per year.

Rio Tinto expects to begin production of tellurium in the fourth quarter of 2021, creating a new North American supply chain for this critical mineral.

Tellurium is an essential component of cadmium telluride, a semiconductor used to manufacture thin film photovoltaic (PV) solar panels. Thin films made of this compound can efficiently convert sunlight into electricity. Tellurium can also be used as an additive to steel and copper to improve machinability, making these metals easier to cut. It can also be added to lead to increase resistance to sulphuric acid, vibration and fatigue.

"The minerals and metals we produce are essential to accelerate the transition to renewable energy," Rio Tinto Kennecott Managing Director Gaby Poirier said. "Adding tellurium to our product portfolio provides customers in North America with a secure and reliable source of tellurium produced at the highest environmental and labor standards with renewable energy."

"Rio Tinto is committed to using innovation to reduce waste in our production process and extract as much value as possible from the material that we mine and process."

Utah Gov. Spencer Cox said, "Rio Tinto's smelter at Kennecott is one of only two that is capable of producing copper and other critical minerals. The new tellurium plant is another valuable contribution to critical mineral independence and energy security in the U.S."

Along with producing almost 20% of U.S. copper, Kennecott's smelting process also recovers gold, silver, lead car-

bonate, platinum, palladium and selenium, while molybdenum is recovered from the Copperton concentrator. In total, nine products are currently recovered from the ore extracted at Kennecott.

Rio Tinto is a partner with the U.S. Department of Energy's Critical Materials Institute (CMI) and works closely with CMI experts to discover further ways to economically recover critical mineral by-products such as rhenium, tellurium and lithium. The company is also investing in new facilities to extract battery grade lithium from waste rock at its Boron, California, mine site and high-quality scandium oxide from waste streams at its metallurgical complex in Sorel-Tracy, Quebec.

Goderich Miners Ratify 5-Year CBA

Compass Minerals announced that its unionized miners at its Goderich salt mine in Ontario have ratified a new five-year collective bargaining agreement (CBA). The five-year term represents the longest CBA ever negotiated at the Goderich mine since it first opened in 1959.

"This agreement is a reflection of our shared commitment to treat each of our employees with fairness and respect as we partner together toward our common objective to operate safely and responsibly," said Peter Baker, vice president of operations at Compass Minerals' Goderich mine. "We strive to be an employer of choice and recognize our responsibilities as part of the Goderich community."

The CBA clarifies a number of operating protocols at the mine and codifies a competitive pay and benefits package for the term of the agreement.

Located 1,800 ft beneath Lake Huron, the Goderich mine is the largest underground salt mine in the world, producing about 8 million metric tons per year. The rock salt produced at the mine is shipped to hundreds of communities around the Great Lakes and along the St. Lawrence Seaway for de-icing purposes. Some of the salt is packaged for distribution and sale at retailers in North America. The salt is also sold in bulk to manufacturers that make plastics, detergents, disinfectants and other important products.

New Gold Will Invest in Harte Gold

New Gold Inc. has agreed to purchase nearly 155 million shares of Harte Gold

Corp. at a price of \$0.16 per share for total consideration of approximately \$24.8 million. New Gold will have a 14.9% strategic interest in Harte Gold's pro forma issued and outstanding common shares. Closing of the transaction was expected to occur on or about March 24.

In connection with the closing of the transaction, New Gold and Harte Gold will enter into an investor rights agreement where as long as New Gold holds not less than 10% of the issued and outstanding common shares of Harte Gold, have the right to participate in certain equity financings by Harte Gold in order to maintain its 14.9% interest in Harte Gold; and nominate one person to the board of directors of Harte Gold.

New Gold is a Canadian-focused intermediate mining company with a portfolio of two core producing assets in Canada, the Rainy River gold mine and the New Afton copper-gold mine. The company also holds an 8% gold stream on the Artemis Gold Blackwater project located in British Columbia and a 6% equity stake in Artemis. The company also operates the Cerro San Pedro Mine in Mexico (in reclamation).

MSHA Issues Stronger Mine Safety Guidance on Coronavirus

On March 10, the U.S. Department of Labor (DOL) released a worker safety guidance to help mine operators and mine workers implement a coronavirus protection program and better identify risks that could lead to exposure. The Mine Safety and Health Administration's (MSHA) "Protecting Miners: MSHA Guidance on Mitigating and Preventing the Spread of COVID-19" provides recommendations and outlines existing safety and health standards.

"The pandemic has cost too many Americans their lives or their well-being. Together, employers and workers have vital roles in making their workplaces as safe as possible to counter this terrible disease," said Senior Counselor to the Secretary of Labor M. Patricia Smith. "Mine operations face unique challenges, and the Mine Safety and Health Administration's updated guidance includes recommendations to help mining communities fight the virus, and

(Continued on p. 24)

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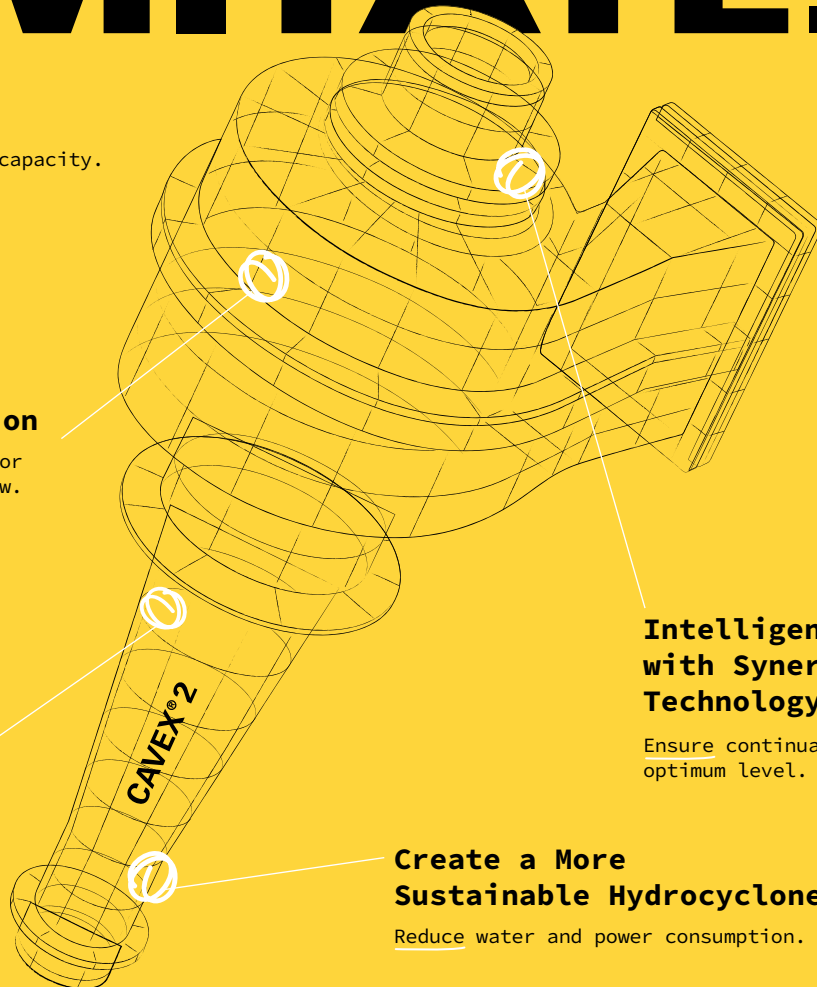
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David Klanecky

Piedmont Lithium Ltd. appointed **David Klanecky** as executive vice president and COO. Most recently, he was vice president of lithium operations for Albemarle Corp.

Argonaut Gold Inc. appointed **Lowe J. Billingsley** in the role of senior vice president, operations. He was previously the mine manager of the Stillwater East Mining Complex for Sibanye-Stillwater.



Lowe J. Billingsley



Regan Watts



Dr. George Puvvada

First Cobalt Corp. appointed **Regan Watts** as vice president, corporate affairs, and **Dr. George Puvvada** as its refinery technical manager. Watts has provided services to First Cobalt since 2019. Prior to working with First Cobalt, Watts was a member of IBM Canada's senior leadership group, heading the Innovation, Citizenship and Government Affairs team.

Great Panther Mining Ltd. announced that CFO **Jim Zadra** has left the company. The responsibilities of Zadra will be transitioned to the company's existing management team, including **Shawn Turkington**, vice president, finance, and **Sandra Daycock**, vice president, corporate finance and treasury, to support a smooth transition while the company conducts a formal search for a new CFO.



Phil S. Brumit Sr.



David Ogonowski

Josemaria Resources Inc. announced **Phil S. Brumit Sr.** and **David Ogonowski** have joined the Josemaria team. Brumit recently retired from Minera Candelaria, a subsidiary of Lundin Mining Corp., as president and managing director. Ogonowski retired from Freeport in 2013 as director of capital programs. During

2019, as general manager, he assessed and directed the execution of Glencore's developing copper projects in North and South America.

Nornickel appointed **Andrei Ambartsumyan**, previously head of the Department of Strategic Projects Management, vice president for investment project management, and **Stanislav Seleznev**, previously director of the Ecology Department, has been appointed vice president for ecology and industrial safety. The two top managers will report to **Sergey Dubovitsky**, senior vice president, head of Nornickel's Strategy and Strategic Project Management, Logistics, and Resource Support Unit.



John C. Galassini



Giulio T. Bonifacio

Arizona Gold Corp. announced that **John C. Galassini** has joined the company as executive vice president, COO. Galassini will direct all efforts associated with the current restart of operations at the Copperstone Gold mine. Galassini's previous senior roles include vice president, Ciner Resources. **Martin Kostuik** has stepped down from his position as president of Arizona Gold to pursue other business opportunities. **Giulio T. Bonifacio** will assume the role of president in addition to his chief executive role, which will further streamline the leadership team.

Artemis Gold Inc. appointed **Candice Alderson** as senior vice president of corporate affairs.

Aurion Resources Ltd. announced the resignation of **Mike Basha** as president, director and officer of the company for personal reasons. Basha has agreed to consult as a technical advisor on an ongoing basis.



Rex McLennan



Dan Dickson

Endeavour Silver Corp. announced that **Geoff Handley**, chair of Endeavour, plans to step down but will remain active as a director. **Rex McLennan** will become the lead independent director. **Bradford Cooke**, CEO and director, has been invited to assume the role of executive, and plans to step down as the CEO. **Dan Dickson**, CFO, has been nominated to assume the role of CEO of Endeavour, and **Christine West**, vice president controller, has been nominated to assume the role of CFO of Endeavour.



Christine West

St. James Gold Corp. announced **Dr. Stewart A. Jackson** as its vice president of exploration. During his career, Dr. Jackson was also the exploration manager for Houston Oil and Minerals during the discovery and development of the Borealis, South McCoy and Manhattan gold deposits in Nevada.



Dr. Stewart A. Jackson



Douglas T. Dietrich



Robert L. Clark

Minerals Technologies Inc. elected **Douglas T. Dietrich**, CEO and a member of the board since 2016, to serve in the additional position of chairman. Dietrich will succeed **Duane R. Dunham** who has been a director since 2002 and chairman since 2016. **Robert L. Clark** has been appointed to the newly created position of lead independent director, effective immediately. Clark, who has been a member of the MTI Board since 2009, is the provost and senior vice president for research at the University of Rochester.



Chris Leighton

Monument Mining Ltd. appointed **Chris Leighton** as interim CFO effective immediately while **Luther Nip** has resigned in the transition period. Mr. Leighton has been a financial executive over the past 20 years.

The *International Council on Mining and Metals (ICMM)* appointed **Rohitash Dhawan** as CEO, following a competitive global selection process, to succeed **Tom Butler**, who stepped down. Rohitash was managing director and head of the EMEA region at Eurasia Group, a geopolitical research and analysis firm.



Rohitash Dhawan



Marla Tremblay

Marla Tremblay has been hired as the new executive director of *MineConnect*, an industry association representing mine service and supply companies in Northern Ontario. Tremblay has run her own consulting company, Markey Consulting, for close to 10 years.

Superior Industries Inc. appointed **Jeff Gray** as its director of international sales. Gray comes to Superior after almost 25 years at Astec, most recently as the company's key accounts and systems director.



Jeff Gray



Dr. James Siddorn



Terry Braun

SRK Consulting announced **Dr. James Siddorn** as the new North America board chair and **Terry Braun** as the new North America president. After 24 years, **Andrew Barrett** stepped down, but will continue his tenure with SRK through project work and internal advisory roles. Siddorn has 25 years of experience in structural geology, 17 of which have been with SRK. Braun has three decades of experience working on mining and environmental projects, including more than 25 years with SRK.



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Minera Alamos Selects Contractor to Build Santana Gold Mine in Mexico

Minera Alamos Inc. selected Trigusa as the mining contractor for the Santana gold mine in Sonora, Mexico, based on its mining experience, which includes open-pit mining, crushing, tailings dam construction and heap-leach pads and ponds at projects in multiple Mexican states.

“Our Mexican operations team has a long and positive history with Trigusa dating back to their involvement with the construction and operations at the El Castillo mine,” Minera Alamos CEO Darren Koningen said. “Given the logistical challenges surrounding the construction of a new mine during the COVID-19 pandemic we have witnessed firsthand, and in the toughest of environments, the commitment and execution of Trigusa. We all look forward to a long-term relationship between the groups as Minera Alamos completes the transformation to a new and growing gold producer in Mexico.”

Trigusa’s team is currently active at the Santana gold project site and have recently completed all civil works related to the construction of the gold recovery (carbon) plant, solution ponds and heap-leach pad. The newly finalized contract will cover all mining activities for the project from drilling/blasting to the transport and loading of gold ore onto pads for leaching operations. The agreement also covers all required support services for mining activities excluding mine planning, which will be performed by the Minera engineering team.

The major construction activities related to the gold recovery (carbon) plant are now complete and preparations are under way for testing. Final electrical and piping work will be finished in parallel with other site activities leading up to the start of mining operations. The initial heap-leach pad area has also been completed and will continue to be expanded concurrently with the commencement of mining activities. Solution ponds are ready and available for the final testing of the pumping system that will be utilized for the circulation of gold leaching and recovery solutions.



The construction activities related to the gold recovery plant (above) are now complete.

Capstone Adds Cobalt Twist to Santo Domingo

Capstone Mining Corp. plans to vertically integrate cobalt production as it advances its Santo Domingo project in Chile toward construction by the end of the year. The company expects the production of battery-grade cobalt sulphate at Santo Domingo to add significant value to the copper-iron-gold project.

“Capstone has an incredible opportunity to produce ethically sourced battery-grade cobalt sulphate from Santo Domingo’s future copper-iron tailings stream,” President and CEO Darren Pylot said. “The process is a series of conventional steps, with below-zero costs given significant byproduct credits.”

By 2025, an estimated 140,000 metric tons (mt) of cobalt contained in cobalt sulphate will be required for lithium-ion (Li-ion) batteries. Capstone said Santo Domingo would be the only cobalt sulphate project in the Americas not dependent on third-party feed from the Democratic Republic of the Congo. Its cobalt processing capacity could supply enough battery-grade material for more than 500,000 electric vehicles (EVs) annually.

“A cobalt operation at Santo Domingo would unlock Chile’s vast potential for this critical metal and it is exciting that

Capstone is leading this vision,” Pylot said. “The selection of a strategic partner due later this year will accelerate this unique project to recover a future-facing, green metal from a waste stream, a plan that I’m set on making a reality.”

Capstone’s concept for cobalt recovery is based on its bond with pyrite, which is concentrated by preferential flotation on a tailings stream. Approximately 840,000 mt per year (mt/y) of pyrite containing 0.6% cobalt and 0.4% copper is expected to be recovered at this step. The concentrate is fed through a five-stage process consisting of roasting, leaching, copper precipitation, cobalt solvent extraction and crystallization to yield battery-grade cobalt sulfate heptahydrate. Recovery of cobalt from pyrite concentrate is expected to be approximately 90% at very low cost due to significant byproducts from increased copper recovery, sulfuric acid production and energy generation, the company said.

The Santo Domingo concentrator is expected to commence construction in late 2021, with first year of operation in 2024.

In related news, Capstone also announced it has entered into three separate agreements to advance the Santo Domingo project. It signed a \$290 million gold stream agreement with Wheaton Precious Metals. The company will use

\$120 million to purchase Korea Resources Corp.'s 30% ownership interest in the Santo Domingo project consolidating its ownership position to 100%.

Capstone has entered into a framework agreement with Puerto Abierto SA, a subsidiary of Puerto Ventanas SA (PVSA), where PVSA assumes responsibility for the design build, operation and financing of the port, which reduces initial capital expenditure at Santo Domingo by an estimated \$250 million, according to the company. Santo Domingo will guarantee a throughput commensurate with the economic recovery model for an agreed IRR and PVSA will have an option to purchase the facility outright subject to approval from environmental regulatory bodies.

Sierra Metals Receives Approval to Increase Production at Yauricocha

Sierra Metals Inc. has received an Informe Tecnico Sustentatorio (ITS) permit from the Peruvian Ministry of Environment through its agency SENACE. The ITS is a key permitting milestone and the second-to-last step for the company on receiving approval to increasing the permitted throughput of the Chumpe plant at the Yauricocha mine to 3,600 metric tons per day (mt/d).

"The company expects to receive the ITM permit in the second quarter of 2021," Sierra Metals CEO Luis Marchese said. "This permit would allow a 20% increase in throughput and assist the company in maintaining its annual production guidance."

Meanwhile, the company is also focusing on completing the prefeasibility studies at Yauricocha, which examines increasing throughput to 5,500 mt/d starting in 2024, as well as prefeasibility studies examining increases at the Bolivar and Cusi mines in Mexico to 10,000 mt/d and 2,400 mt/d, respectively. All three mines are polymetallic mines that produce some precious metals.

"[This is] an exciting time for [Sierra Metals] as we continue with organic growth plans, including significant brownfield and greenfield exploration programs to support future mineral resource and production growth," he said. "Management also continues to focus on improving and modernizing our mine operations, increasing operating efficiencies to improve productivity and reduce costs."

Sierra Metals said it recently had several new key discoveries and still has many more exciting brownfield exploration opportunities at all three mines.

Electricity Reforms Spark Controversy in Mexico

The controversial electricity reforms of the Mexican government's electricity law include changes to power sector rules to favor state-run utility CFE, sidelining private producers and renewables projects.

The changes allow Mexican authorities to unilaterally cancel or modify self-supply permits that enable private players to purchase cheaper and cleaner energy directly from private producers.

While the reform has been suspended by a federal court pending a series of appeals, the issue will likely be decided by the supreme court.

Fresnillo — Mexico's top gold and silver producer — confirmed it is planning legal action to defend its right to source cleaner and cheaper electricity for its operations, amid plans to meet 75% of its power needs from renewables.

Now Newmont has outlined concerns over political challenges standing in the way of its carbon reduction goals.

"As we move to net zero... we are going to rely upon energy coming from renewables," Newmont CEO Tom said.

"We are already seeing examples in some of the jurisdictions in which we operate where governments are supporting state-owned enterprises, which aren't the most energy efficient sources of [power] and preventing renewables coming into the system."

While the CEO did not mention Mexico, the country's reforms are aimed at supporting state-owned CFE, while re-

stricting access to the grid for renewable energy projects.

The company plans to use its political clout to push for changes, Palmer added.

"That's going to require us to engage with these governments, to collaborate with these governments and to support the move to renewables," he said.

Canada's small business, export promotion and international trade minister Mary Ng warned the reforms could have a negative impact on Canadian investments, particularly in mining.

The reforms establish a hierarchy of dispatch placing CFE generation at the top, rewrite the rules for clean energy licenses and for self-supply contracts and remove legacy "basic supply" contracts, among other changes.

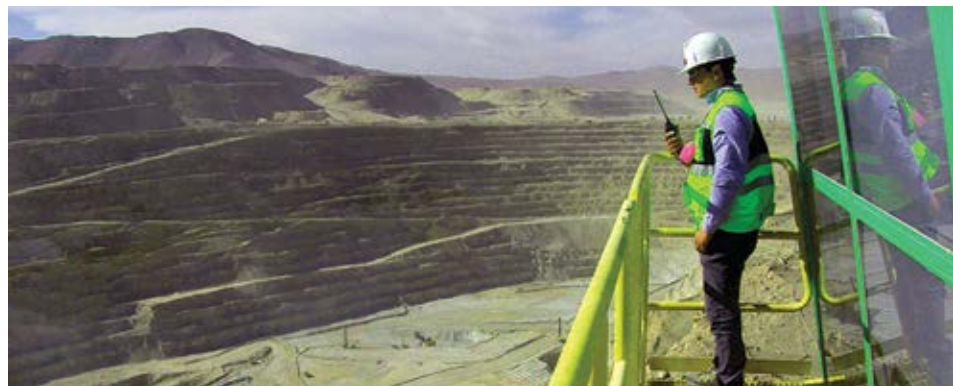
The reforms are also facing challenges by electricity industry players and Mexican opposition senators.

Radomiro Tomic Detonates Codelco's Largest Blast

To further improve efficiency at Codelco's Radomiro Tomic (RT) copper mine in Chile, the mine team conducted the largest blast in its history, which moved 3.2 million tons of ore.

RT superintendent of drilling, blasting and crushing, Angelina Picon, said, "We have to be efficient and we started to blast more than a million tons with each blast; later, a million and a half; then two million and now we have achieved the goal of 3.2 million tons."

Picon said previously they were blasting up to two or three times in the same day, but now they are aiming for a maximum of three massive blasts per week. "We are moving more material with less interruptions for the day-to-day mining activities," Picon said.



The blast, the largest in Radomiro Tomic's history, moved 3.2 million tons of copper ore.

St. Barbara Selects Macmahon to Provide Underground Services at Gwalia



The Gwalia mine (above) is one of Australia's oldest gold mines.

Macmahon Holdings Ltd. has been selected by St. Barbara Ltd. to provide all underground mining services to the Gwalia underground gold project in Western Australia from May 2021. The Gwalia mine is one of Australia's oldest underground gold mines, with St. Barbara having operated this flagship asset for the past 15 years. The mine was originally established in 1897 by Herbert Hoover.

The scope of work for Macmahon will involve a whole of mine service including mine development, ground support, production drilling and blasting, loading and trucking, shotcreting and paste fill reticulation.

The initial contract term will be for five years, with St. Barbara having an option to extend for a further three-year period. Macmahon estimated the contract will generate approximately \$500 million in revenue over the initial five-year term, which will require capital expenditure of circa \$40 million over fiscal year 2021 and fiscal year 2022.

Macmahon and St. Barbara are working to finalize the mining services agreement, and signing was expected in March. Macmahon will commence early works on site in April, before full mobilization in May.

Macmahon Managing Director and CEO Michael Finnegan said, "We will work very closely with our new client to ensure continuity of operations during the transition period."

St. Barbara Managing Director and CEO Craig Jetson said he sees the appointment of Macmahon as the underground mining contractor at Gwalia unlocking the potential of the mine and instilling a performance-led culture.

Macarthur Picks Up 10 Prospecting Leases in Western Australia

Macarthur Minerals Ltd. has entered into an exclusive agreement with Zanil Pty Ltd. to undertake due diligence on 10 tenements in and around the Leonora Goldfields region in Western Australia. The agreement is intended to strengthen the value proposition for a potential future repositioning of Macarthur's non-iron ore assets, the company said. Macarthur said it will undertake a legal review of these tenements alongside a geological assessment and ultimately, the completion of an independent valuation on behalf of Zanil. The purpose of this due diligence is to assess the value implication of amalgamating these historic gold/copper mining ten-

ements into a transaction to spin out these areas alongside the company's Pilbara gold, lithium and copper tenements. The exclusivity period under the agreement allows Macarthur a period of 90 days to complete its due diligence review.

Zanil either directly holds rights over, or is duly authorized on behalf of the relevant tenement holders, to enter into the agreement with Macarthur in respect of these tenement areas: the Leonora tenements located in the Central Goldfields region of Western Australia, approximately 237 kilometers (km) north of the city of Kalgoorlie within the proximity of active gold mines such as Agnew gold mine, Gwalia gold mine and Sunrise Dam gold mine.

The tenement portfolio consists of two mining leases and eight prospecting licenses, with nine of the areas located on historic gold workings. The other tenement, Barlow's Gully, has no established mine workings, but has been subject to surface gold extraction for more than 100 years.

Key tenements are Garden Well, Camel Lease, Great Northern, Barlow's Gully and Coppermine.

The past production reported from these areas are not treated as current or historical mineral resources and further exploration is required to understand the potential for gold or copper mineralization.

Alan Joe Phillips, managing director of Macarthur Minerals, commented, "The main focus for the company is 'first and foremost' the ongoing development of the Lake Giles Iron Ore assets. The entering into of the due diligence agreement with Zanil is designed to all for an exclusive low-cost review of the Central Goldfields assets to augment the company's Pilbara gold, copper and lithium tenement portfolio.

"If these tenements demonstrate value, Macarthur will consider spinning out this portfolio as part of a wider Pilbara/Central Goldfields transaction. The objective is to create value for shareholders by exploiting these tenements without detracting or distracting Macarthur from delivering on its substantial Lake Giles Iron Project."



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Resolute Reaffirms Guidance



Resolute's Syama mine (above) in Mali is expected to produce 155,000 to 170,000 oz of gold from sulphide ore.

Resolute Mining Ltd. reaffirmed its 2021 production, cost and capital expenditure guidance and confirmed that robust operating cash flow generation is expected to support the accelerated repayment of debt on or before the required due dates. The company offered the announcement in response to speculation regarding its ability to meet debt repayments following the announcement of receipt of a letter from the Ghanaian Minerals Commission advising that the mining lease for the Bibiani Gold Mine (Bibiani) remains terminated.

Based on total 2021 gold production from Resolute's Syama gold mine in Mali and Mako gold mine in Senegal, together with operating cost and capital expenditure guidance, Resolute expects to generate sufficient operating cash flows to support debt repayments of \$50 million in 2021. This includes the early repayment of \$25 million over and above the minimum debt repayment obligations of \$25 million, which are due in September 2021.

Proceeds from completion of the sale of Bibiani to Chifeng Jilong Gold Mining Co. Ltd. for \$105 million in cash were to be taken as an opportunity to rapidly accelerate Resolute's debt repayments. However, these proceeds are not required to meet Resolute's minimum debt repayment obligations which can be satisfied through operating cashflow generation from Syama and Mako.

Resolute continues to work through all options in relation to resolving its position with the Ghanaian Government regarding

the termination of the Bibiani Mining Lease with the objective of reaching an amicable solution to restore the Mining Lease and enable the sale process with Chifeng to continue.

Resolute is forecasting total gold production for 2021 of 350,000 ounces (oz) to 375,000 oz at an all-In sustaining cost (AISC) of \$1,200/oz to \$1,275/oz. Syama sulphide production is forecast to increase by more than 25% to between 155,000 oz and 170,000 oz with a resulting decrease in AISC to between \$1,200/oz and \$1,275/oz. A planned 36-day shutdown of the sulphide processing circuit has been scheduled during September and October 2021. Syama oxide production of 80,000 oz to 85,000 oz is forecast at an AISC between \$1,050/oz and \$1,090/oz from the Cashew and Tabakoronni satellite operations.

The Mako mine is expected to produce 115,000 oz to 120,000 oz at an AISC between \$1,175/oz and \$1,225/oz.

In addition to cash and bullion balances of \$106 million at the end of 2020, operating cash flows in 2021 are expected to be sufficient to support the repayment of \$50 million in debt during 2021. This is not contingent on completion of the sale of Bibiani. Resolute established a new low-cost senior debt facility in March 2020 comprising a three-year \$150 million Revolving Credit Facility (RCF) and a four-year \$150 million Syndicated Loan Facility (SLF). The company's SLF begins to amortize in September 2021 with re-

payments due under this facility of \$25 million every six months.

NERSA Approves South Deep Solar Plant

Gold Fields Ltd. welcomed the electricity generation license approved by the National Energy Regulator of South Africa (NERSA) for the construction of a 40-megawatt (MW) solar power plant at its South Deep mine.

The acting CEO of NERSA now has to authorize the license, a decision that should be forthcoming over the next two weeks. All the regulatory approvals to proceed with the project are in place.

Gold Fields will update its definitive costings and finalize all the required internal processes to commence the project as soon as possible. The solar plant has the potential to provide around 20% of South Deep's average electricity consumption.

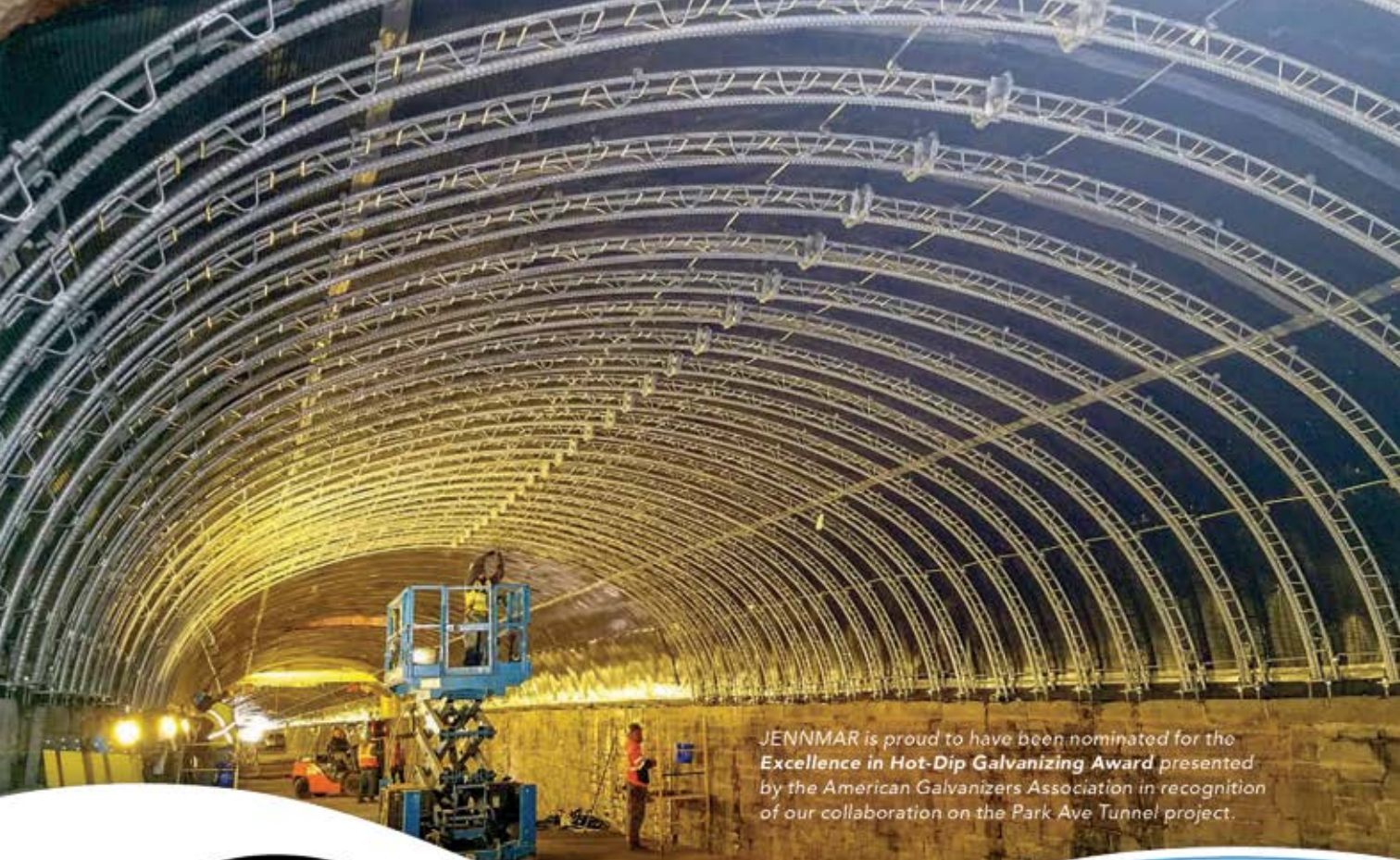
Gold Fields CEO Nick Holland said, "The solar power plant will increase the reliability and affordability of power supply to South Deep, ultimately enhancing the long-term sustainability of the mine.

"The approval of this license sends a strong, positive message to mining companies and their investors, potentially leading to decisions being taken to sustain and grow mining operations in the country, especially in deep-level, underground, marginal mines. Enabling companies to generate their own power also gives Eskom room to address operational issues at its power plants."

Gold Fields' energy objectives are based on four pillars — energy must be reliable, available, cost-effective and clean — which promote a shift to self-generation using renewable energy sources. "We are fully committed to making our contribution toward net-zero emissions," Holland said.

During 2020, Gold Fields successfully implemented solar and wind power plants, backed by battery storage, at two of its Australian mines, Agnew and Granny Smith, and committed to renewables at its other Australian mines, Gruyere and Saint Ives, as well as the Salares Norte project in Chile when it starts operations

(Continued on p. 24)



JENNMAR is proud to have been nominated for the **Excellence in Hot-Dip Galvanizing Award** presented by the American Galvanizers Association in recognition of our collaboration on the Park Ave Tunnel project.



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Turquoise Hill's Oyu Tolgoi Declares Force Majeure on Chinese Contracts



The Mongolian copper mine is forced to rebuild one of its shafts. (Photo: Turquoise Hill)

Turquoise Hill Resources Ltd.'s Oyu Tolgoi LLC in Mongolia has declared force majeure on some customer contracts for concentrate after shipments to China were suspended due to COVID-19 safety precautions at the Chinese-Mongolian border. It said it will continue to support the government of Mongolia's efforts to work with Chinese officials to resume the shipments as soon as possible.

The miner also confirmed two cases of COVID-19 at the site, which it said were managed in compliance with public health guidelines. It has also completed 9,726 PCR (polymerase chain reaction) tests at site that have all been confirmed negative.

The open-pit mine, concentrator plant and bagging plant continue to operate uninterrupted, however, underground work was halted while testing was under way to ensure the safety of employees on site.

There are ongoing travel restrictions for people coming from Ulaanbaatar to the site and Oyu Tolgoi said it is developing contingency plans to mitigate any associated risks.

The problems do not end there. A new claim was filed in the ongoing lawsuit against Rio Tinto and Turquoise Hill Resources and its management of the expansion project at Oyu Tolgoi, which is led by the largest and most-outspoken minority shareholder, Pentwater Capital Management. Rio Tinto has been accused of concealing the real cause of the delays and cost increase for the expansion

project. Pentwater Capital Management claimed senior executives at Rio Tinto and Turquoise Hill Resources knew the \$6.75 billion expansion of the copper mine was in trouble months before the problems were disclosed to investors. The 163-page complaint said the delays and cost overruns of the project were due to defective steel, deficient engineering, and poor procurement and construction that forced the majority of one of the mine's shafts to be rebuilt, as opposed to the given reason of geotechnical problems.

Despite setbacks, the claim alleged that Rio Tinto and Turquoise continued to tell investors that the project was on track. It was not until July 2019 that Rio Tinto announced a 30-month delay in the timeline for the project and increased the cost estimate to \$6.75 billion from \$5.3 billion. In December 2020, it announced an updated timeline with the underground project reaching sustainable production by October 2022.

Investors are not the only one with concerns. Turquoise Hill is scheduled to meet with the government of Mongolia over a new financing agreement for the project. The government has threatened to pull the plug on the project. It was concerned the development costs of the Oyu Tolgoi project have "eroded the economic benefits it anticipated to receive."

At peak production, the project will be one of the world's biggest copper mines, producing almost 500,000 metric tons

per year. Rio Tinto owns a 51% stake in Turquoise Hill Resources, which in turn owns 66% of Oyu Tolgoi and the rest is owned by the government of Mongolia.

India's Vedanta Proposes New Copper Smelter After Closure; Adani Group Plans Copper Foray

By Ajoy K. Das

Three years after the closure of Vedanta's Sterlite Copper, India is turning from a net exporter to net importer of copper. Meanwhile, Anil Agarwal-led Vedanta Ltd. is back with a bid to construct a green-field coastal copper smelter entailing an investment of \$1.37 billion.

Tapping into opportunities presented by the closure of Sterlite Copper and a domestic shortage of copper, Adani Group has also thrown its hat into the investment ring proposing to construct a 1-million-metric-ton-per-year (mt/y) copper refinery in the western state of Gujarat.

Vedanta Ltd., a subsidiary of the U.K. headquartered Vedanta Resources, has floated a notice seeking expression of interest (EoI) from various Indian state governments in coastal regions for partnership to construct the copper smelter and seeking land of around 1,000 acres and access to a port with capacity to handle around 5 million mt of raw material freight.

The Adani Group, has floated a subsidiary christened Kutch Copper Ltd. proposing to construct a "copper complex" in Gujarat with 900,000 mt of primary copper smelting capacity, 100,000 mt/y in copper scrap melting capacity and a project report has been submitted for federal government's Ministry for Environment, Forests and Climate Change (MoEFCC) for necessary mandatory approvals, a company official said.

Editor's note: In 2018, Vedanta-owned Sterlite Copper's smelter, located in the southern state of Tamil Nadu, was forced to close down by local government authorities for alleged breach of pollution control laws and protests, which led to the killing of 12 people and the loss 400,000 mt/y of copper.

Hall of Fame Names 2021 Inductees

The National Mining Hall of Fame and Museum (NMHFM), which is located in Leadville, Colorado, USA, recently announced its 2021. They are being honored for setting new and uniform standards and improving existing processes for feasibility studies and resource/reserve estimation, executive contributions and proactive leadership in safety and diversity, innovative practical application of geostatistics, and lifetime contributions to the education of many of the world's leading mining industry professionals.

The Prazen Living Legend of Mining Award will also be presented at an induction ceremony currently scheduled for October 23. This award recognizes an individual or organization for significant and sustained commitment to educating the public about the relationship of mining to our everyday lives through educational materials, programming and outreach.

2021 National Mining Hall of Fame Inductees:

Dr. Richard L. (Dick) Bullock

(1929-2020) was one of mining's greatest experts on valuation, operations, and research and development. After earning a bachelor's degree in mining engineering in 1951 and then time in the army, he worked in the research department at St. Joe Lead in Missouri. There, he developed the Bullock Burn Cut that would become the worldwide standard for blasting development drifts. Bullock continued to work in the mining industry for St. Joe and Exxon Minerals for the next 31 years while completing a master's and doctorate degrees in mining engineering. He became an expert on managing mineral property feasibility evaluations, mine development and projects, ongoing mining operations, mining research, and multidisciplinary engineering design groups. He became a professor at his alma mater, Missouri University of Science and Technology, where he taught for 21 years. He developed and mentored young engineers and published some of the most important reference books in the mining.



Gary J. Goldberg (1959-) became president and CEO of Newmont Mining Corp. in 2013. He turned the company's overall performance around through a disciplined focus on safety, technical fundamentals, and value over volume. This enabled Newmont to execute acquisitions, including Goldcorp in 2019, the largest transaction in the history of gold mining. That same year, Goldberg was instrumental in creating the Nevada Gold Mines joint venture with Barrick. Goldberg has bachelor's degree in mining engineering from the University of Wisconsin-Platteville and an MBA from the University of Utah. Prior to joining Newmont, he had leadership roles with Rio Tinto companies around the world.



Harry M. Parker (1946-2019) was best known for his leadership in establishing clear and defensible methods for classifying mineral resources and reserves in the global mining sector.



He was a leading expert in geology, geostatistics, and resource and reserve evaluations. He completed a valuation of St. Joe Minerals' domestic assets, which he described as "\$500 million in five days." Parker served on the Committee for Mineral Reserves International Reporting Standards from 2007 to 2018, including as deputy chairman, chairman and past chairman. He was instrumental in establishing the registered member category of the Society for Mining, Metallurgy and Engineering, in which members can serve as qualified or competent persons. Between 2007, when the category was created, and 2019, he chaired SME's Registered Member Committee, co-chaired its Resources and Reserves Committee, chaired its Ethics Committee, and was a vital member of its Valuation Committee.

Raja V. (Raj) Ramani (1938-) has devoted most of his career to educating mining industry leaders through his affiliation of more than 50 years with The Pennsylvania State University. Ramani earned his bachelor's degree in mining engineering

with honors in 1962 at the Indian School of Mines. He joined Bengal Coal Co. before immigrating to the U.S. to earn his master's and doctorate degrees at Penn State. Ramani joined the faculty and has spent the remainder of his career there. After obtaining his professional engineering (P.E.) license in 1971, he developed a short course to prepare mining engineers for taking the P.E. exam. The course was taken over by the Society for Mining, Metallurgy and Engineering and continues to prepare exam takers even today. By 1978, he became a full professor. He served as chairman of the Mineral Engineering Management Section and head of the Department of Mineral Engineering and was appointed to the first endowed chair in the College of Earth and Mineral Sciences.



2021 Prazen Living Legend of Mining Award:

Elizabeth J. B. (Liz) Arnold

(Liz) Arnold comes from a logging and farming background and married a miner. Growing up in the mountains in the West, she watched special interest groups politically assaulting the livelihoods of miners, loggers, ranchers and farmers in the media. In 1993, she joined a small grassroots group to fight back — People for the West! (later called People for the USA! — PFUSA). She rose from "member" to Nevada state chairman with 13 chapters across Nevada. When PFUSA's Board of Directors decided their next chairman of the board should be a grassroots person, she was elected and re-elected for three terms. The group grew to more than 30,000 members during her years of service. All her PFUSA work was uncompensated and volunteered.



Due to the COVID-19 pandemic, the decision about whether the ceremony will be in-person or broadcast will be made at a later date. Visit www.MiningHallOfFame.org for updates. Sponsorships are available; contact Landry Harris, events manager, at Landry@MiningHallOfFame.org for details.

Union Miners Reject Tentative Agreement With Warrior Met



Warrior Met Coal operates three longwalls and a prep plant near Tuscaloosa, Alabama, USA.

More than 1,000 miners at Warrior Met Coal Inc., which includes the No. 4 mine, No. 5 preparation plant, No. 7 mine and its Central Shop, walked off the job on April 1 at 11:30 p.m. The United Mine Workers of America (UMWA) was renegotiating a contract with Warrior Met that expired on April 1. The UMWA reached a tentative agreement with the company on April 6, but rank-and-file members rejected it on April 9. The members remained on strike as this edition was going to press.

The terms of the agreement were not disclosed. Warrior Met Coal said it has been working in good faith to reach an agreement.

"Throughout negotiations, our sight has remained on the future — to provide our employees with a competitive package while protecting jobs and the longevity of the company and its workforce," the company said.

It said it will continue to work with the UMWA to find a package that their employees will appreciate.

"While we are disappointed that the UMWA has taken this extreme step to declare a strike while we continue to negotiate in good faith, we have continuity plans in place to continue meeting the demands of our key customers," the company added.

Mechel Launches New Longwall at Southern Kuzbass

During mid-March, Mechel PAO, one of Russia's leading mining and steel companies, commissioned a new longwall at Southern Kuzbass Coal Co.'s V.I. Lenina mine. Investment totaled approximately 470 million rubles (\$6.1 million).

The new longwall panel's reserves are estimated at 435,000 metric tons (mt). The average seam height is 1.8 meters (m), with the longwall nearly 200-m long with an extraction panel of 720 meters.

The longwall is equipped with 134 powered roof supports and is compliant with modern industrial and labor safety requirements.

"V.I. Lenina's reserves consist of coking coal with excellent quality characteristics, which is high in demand. Southern Kuzbass Coal Co. will be working this new longwall for eight months. The coking coal we will produce from it will be marketed both domestically and internationally," Mechel Mining Management CEO Igor Khafizov said.

CIL Approves 32 Projects By Ajoy K. Das

In one of its most aggressive expansion moves, India's state-run Coal India Ltd. (CIL) has approved 32 new coal projects, representing an estimated capital expenditure of \$6.57 billion.

The expansion program that includes 24 brownfield and eight greenfield projects aim to drive annual coal production of 1 billion metric tons (mt) by 2023-2024, up from 650 million mt by end of 2020-2021 and reduce imports. During April-January 2020-2021, Indian coal imports were pegged at 181 million mt.

More significantly, the Indian government's push to ramp up CIL's coal production comes parallel to its increase in renewable energy generation target to 175 gigawatts (GW) by 2022 and 440 GW by 2030, up from 90 GW at present.

A CIL official said even with the government's ambitious plans on renewables, coal will continue to dominate the Indian energy sector and account for 50% of domestic energy generation capacity, even with 440 GW of renewable power generation capacity achieved by 2030.

He said the combined incremental peak rated capacity of the 32 projects approved would be 193 million mt. Of this total, 85% or about 167 million mt would be accounted for by brownfield and greenfield projects to be implemented by three of CILs' wholly owned operational subsidiaries — South Eastern Coalfields Ltd. (SECL), Central Coalfields Ltd. (CCL) and Mahanadi Coalfields Ltd. (MCL).

Apart from the \$6.57 billion investments on new projects, CIL has set up a war chest for expansion of mining infrastructure and allied ancillary investments up to 2023-2024. Of this, an estimated \$8 billion on infrastructure development at existing mines and \$4.72 billion on augmenting coal evacuation infrastructure including mechanized coal handling and transportation conveyor systems and rail links to mine heads and another \$3.26 billion on clean coal technologies.

According to the CIL official, the basket of projects approved by the miner was the result of re-strategizing and nixing some projects conceived earlier which were labor intensive and it was imperative to renew focus on productivity levels against backdrop of opening up of coal mining to private miners.



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(Regional News-U.S. & Canada - from p. 10)

eventually end its devastating health and economic consequences.”

MSHA said implementing a coronavirus protection program is the most effective way to reduce the spread of the virus. MSHA drew upon guidelines from the Centers for Disease Control as well as from programs already in place at mine operations around the country. MSHA recommends conducting a hazard assessment; identifying control measures to limit the spread of the virus; adopt policies for miners who are absent that does not punish them as a way to encourage potentially infected miners to remain home; ensure communication of coronavirus policies and procedures to English and non-English speaking workers; and implement protections from retaliation for miners who raise coronavirus-related concerns.

Principal Deputy Assistant Secretary for Mine Safety and Health Jeannette Galanis said operations should identify a mine coordinator who will be responsible

for COVID-19 issues. “Communication is key to this whole thing,” Galanis said.

In addition, Galanis said it is important to educate and encourage miners to do health checks on their own. Although, she pointed out, some companies have also implemented their own health checks at the mine site, which is a good addition to self-checks. “This is a very aggressive position to take and we appreciate that,” she said.

The guidance details key measures for limiting the coronavirus’s spread, including ensuring infected or potentially infected miners are not in the workplace, implementing and following physical distancing protocols and using surgical masks or cloth face coverings. It also provides guidance on use of personal protective equipment, improving ventilation, good hygiene and routine cleaning.

“Generally the key things to remember are the things we’ve been hearing for the last year,” Galanis said. This includes wearing a mask, practicing social distancing when able, washing hands, using hand sanitizer and staying home when sick.

The guidance is not a regulation, thus is not enforceable. However, MSHA encouraged operations to adopt these practices and continue to report work-related COVID cases. Just as before, contact tracing will be conducted by state and local agencies.

For these recommendations to become enforceable, the DOL would have to implement an emergency temporary standard (ETS), which is issued when the danger to miners is so grave that immediate action is necessary. Back in June 2020, the United States Court of Appeals for the District of Columbia Circuit (the Court) denied a petition for a writ of mandamus for the MSHA to issue an ETS to protect miners’ safety and health from COVID-19.

According to Galanis, the agency meets regularly about the possibility of issuing an ETS with her counterpart at the Occupational Safety and Health Administration and other agencies. “I suspect a conclusion in the next couple of weeks,” she added. However, she said, there is no time frame.

(Regional News-Africa - from p. 18)

in 2023. All its other mines are also reviewing renewable energy options.

Since full commissioning of the Agnew microgrid, renewable electricity averages more than 55% of total supply at the mine. During 2020, renewable electricity averaged 8% for the Australia region and 3% of total group electricity. Once the South Deep project is commissioned, renewable’s contribution to the group total will rise to approximately 11%.

“We expect our investment in renewable and low-carbon energy sources to

contribute significantly to our carbon emission reductions over the next few years,” Holland said. “Power from the South Deep solar plant will partially replace coal-fired electricity from Eskom, enabling us to significantly reduce our Scope 2 carbon emissions.”

ZCCM Shareholders Approve Mopani Acquisition

Shareholders of ZCCM Investment Holdings approved the agreement announced in January to acquire Mopani Copper Mines (MCM) from Glencore. The company will now transition from an invest-

ment company to owning and operating a multibillion-dollar mining asset in Zambia. MCM operates underground mines, a concentrator, a smelter and a refinery at the Mufulira complex, as well as open pits, a concentrator and a cobalt plant at the Nkana complex.

In January, Glencore announced its subsidiary Carlisa Investments Corp. signed an agreement to sell its remaining 90% interest in MCM to ZCCM for \$1 and in exchange ZCCM agreed to assume nearly \$1.5 billion in debt.

The transaction debt will be capitalized for the first three years after completion, and then will be payable quarterly at LIBOR plus 3% (subject to a switch to an equivalent interest rate based on SOFR). Principal will be repayable under a dual mechanism where Glencore receives 3% of gross revenue for MCM from 2021-2023, and 10-17.5% of gross revenue of the MCM thereafter; and 33.3% of EBITDA less tax, changes in working capital, capital expenditure, royalty payments and interest and principal.

After completion of the sale, Glencore will retain offtake rights in respect of Mopani’s copper production until the transaction debt has been repaid in full.

NEWS - CALENDAR OF EVENTS

MAY 4-6, 2021: Canadian Institute for Mining (CIM), Montreal, Quebec, Canada. Contact: Web: convention.cim.org.

MAY 25-27, 2021: Austmine 2021 Exhibition and Conference, Perth, Western Australia. Contact: Web: <https://austmineconference.com.au/>.

JUNE 1-3, 2021: Euro Mine Expo (Virtual), Kraft Center, Skelleftea, Sweden. Contact: Web: www.eurominexpo.com.

JUNE 7-11, 2021: Elko Mining, Elko, Nevada, USA. Contact: Web: www.ExploreElko.com.

SEPTEMBER 13-15, 2021: MINExpo INTERNATIONAL, Las Vegas, Nevada, USA. Contact: Web: www.minexpo.com.

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The Future is Boring

Boring solutions have been breaking records, improving safety, gaining acceptance, and ultimately changing the suppliers that offer them

By Jesse Morton, Technical Writer

Boring is faster and safer. A couple of smashed records that date back to when life was cheaper, and at least one recent successful shaft-sinking project, stand as evidence.

Beyond the speed and safety offered, the newest boring solutions require com-

paratively fewer personnel. They improve project feasibility at a time when miners are launching expansion projects. And increasingly, they are field proven.

The testimony, the headlines, the project milestones, the corporate literature, and the social media posts all point

to a future where boring machines transform worksites and processes, cut costs, improve safety records, make previously unobtainable ore obtainable, and even increase production.

Experts say the hype is substantiated. They also say it will require more than favorable anecdotal evidence to convince customers. A combination of timely, convincing case studies and a subtle shift in priorities may be required to tip the scales.

“Boring machines have been utilized in hard rock with raisebore machines, but the application of drilling larger-diameter blind holes for use as shafts and blind raises are a change in methodology,” said Bracken Spencer, principal engineer, Alpine Consulting and Mining Engineering. “With increasing demand for higher efficiency solutions, which also limit or altogether remove the miners’ exposure to risk, shaft boring will be recognized as a viable option. As successful case studies come out, the general acceptance of shaft boring within the underground hard rock mining industry will not only increase but could conceivably become a preferred method.”

Several miners have recently adopted boring as a preferred method. According to the supplier partners, they have been, or will be, richly rewarded for it.

South African Mine Adopts Disruptive System

Master Drilling reported its new Shaft Boring System (SBS) was adopted by a South African mine for a possibly 1,000-m shaft. The miner adopted the innovative system for the efficiency and safety gains it offered, the company said.

SBS is described as an integrated shaft-sinking system. “It is more than just a machine,” said Koos Jordaan, executive director, Master Drilling. “It includes indirect associated equipment such as the headgear, winders, winches and conveyances, as well as processes such as pre-sink, cementation, station breakaways and equipping.”



The two shafts at Nezhinsky mine in Belarus are more than 700 m deep and 8 m in diameter. Herrenknecht Shaft Boring Roadheaders do the boring while Redpath manages the project. It is completed fast and with a perfect safety record. (Photo: Redpath Deilmann)



Master Drilling's new Shaft Boring System covers boring, mucking, reinforcing and lining. After a successful field trial, it is recently adopted for a mine in South Africa. (Photo: Master Drilling)

The system covers boring, mucking, reinforcing and lining, and has been hailed as disruptive to the shaft-sinking industry.

The offered benefits include reduced costs and improved productivity. SBS also dramatically drops the number of personnel in the work area. "There have been shaft-sinking projects using conventional methods with 350 personnel working. More common right now is between 80 to 180 persons," Jordaan said. "We believe that this number could be reduced to as low as 20 personnel."

The miner adopted an SBS design for a 4- to 5-m-diameter, 500- to 1,000-m-deep shaft. The miner saw the advantage in SBS limiting the scope of work and the amount of personnel in the work area. Currently, the project is in the approval phase.

Upon completion of the shaft, the offering is expected to see wider adoption, Jordaan said. "The concept is scalable," he said. "The real value for clients is this solution on larger scale projects."

The sale follows a successful field trial of an SBS design for 4- to 11.5-m-diameter shafts with depths of up to 2,000 m. The design uses "a pilot and ream configuration in the front part of the machine," Jordaan said. "This allows for a smaller volume of rock to be lifted from the shaft bottom at a smaller diameter and the enlargement at a larger diameter to be done by reaming a larger-diameter shaft."

The larger-reamed volume of rock is removed by gravity, while the smaller pilot-face rock is removed by "a more complex method," he said. "This significantly reduces the complexity, weight, power and cost of the machine that is within the shaft barrel."

The configuration proved viable during the first stage of a multistage project that was otherwise using conventional methods in 300-MPa norite.

"We were following a staged approach to deal with risk, and had completed Stage 1 with a very good performance of just under 1 m/h instantaneous advance rate," Jordaan said. The opportunity presented to test out the SBS design. "We reviewed various designs before we concluded on the W-head design that is a novel and registered feature," Jordaan said. "We then did a successful experimental sink 10 m deep at 4 m diameter."

By offering improvements in productivity and safety, SBS speaks to the needs of aging mines to pursue new orebodies in more challenging geologies and in sensitive and remote locations, he said.

"This offering will provide much value to the industry through higher project feasibilities and performance for our clients," Jordaan said. "Master Drilling has a diversified and sustainable solution for modernizing shaft sinking in hard rock."

The release of SBS capped an evolutionary process that redefined the supplier over many years.

Master Drilling started as a raise boring service company. As it increasingly took on projects located in remote or harsh environments, it became more of a solution-based service company.

"We soon realized the benefits of boring shafts versus conventional methods during our raise bore operations," Jordaan said. "Some shafts do not have bottom access, are too deep, too large in diameter or have geological instability,



Herrenknecht's SBR is proven at Nezhinsky mine, where it broke records for speed. Above, the team that built the first unit for factory acceptance testing in 2018. (Photo: Herrenknecht AG)



On October 2020, the last Herrenknecht SBR is hoisted out of Shaft 1. (Photo: Redpath Deilmann)

and need to be constructed by shaft sinking methodology.”

Over the years, the costs, safety record and productivity numbers of conventional methods prompted the supplier to innovate in boring solutions, he said. “So, we set upon a journey to build capability at shaft sinking by rock boring in hard rock in the hope that in the future we will be able to offer clients value in better safety and project financial performance.”

That journey seems a natural progression for a company with a deep history in raise boring. Like the new SBS, the raise boring services offered by Master Drilling add value by prioritizing accuracy, safety, sustainability and efficiency, said Izak Bredenkamp, manager, new business development, Master Drilling.

“We offer a safe and efficient method of mechanically excavating between two levels or from surface to underground,” he said. “Compared to conventional methods of excavation, raise boring is safer, does less damage to surrounding rocks, involves greater automation, and is more cost-effective.”

Those benefits arise from the company’s blast-free approach. “Hence, this is all mechanical excavation. The no-blast is safer, quicker and has less impact on the environment,” Bredenkamp said.

“In addition, Master Drilling has released a new user interface with the machines, enabling some autonomous functions up to full remote control of operations,” he said. “We therefore reduce the head count at the machine to ensure

that there is less risk and more commercial viability.”

The supplier is currently developing a large raise boring machine for the excavation of large and deep-diameter shafts. It will best the capacity offered by predecessor competition, Bredenkamp said.

“We have a business model that allows for research and development and to ensure we can respond quickly and give a solution for requirements that are increasingly becoming more challenging and complex,” he said. “We are pushing the envelope of disruptive technologies to ensure that previous projects that may not have been feasible are now feasible.”

For example, as part of a sustainability focus, the supplier is developing ways to reduce power consumption and recycle the water used, Bredenkamp said.

Targeting improved efficiency, machine monitoring capabilities are offered, he said. “Our onboard machine technology allows for an interface with the client’s management system, and the machine metrics enable real-time analyzes and decision making to optimize production.”

That supports “horizontal and vertical elevation that is quicker and safer than conventional methods,” he said.

In 2020, Master Drilling completed a 1,377-m pilot hole for raise boring at Northam Platinum’s Zondereinde mine. “Our team used ground-breaking directional drilling technology and also our flagship RD8 machine,” Bredenkamp said.

“Our skilled operators ensured that we achieved the level of accuracy required in order to create a shaft that can be equipped for both man and material hoisting,” he said. Reaming is currently under way.

That level of accuracy stems from superior equipment, methods and teamwork, Bredenkamp said. “It’s a partnership between the client and the contractors to ensure success,” he said. “We are eager to partner with clients to unlock more value.”

Shaft Borers Break Records in Belarus

In July 2020, one of two Shaft Boring Roadheaders (SBRs) reached the final target depth at Nezhinsky mine in Lyuban, Belarus. The development was the climax of a project that quickly became a major success story.

It has since been trumpeted by both the shaft-sinking solutions suppliers involved for proving the viability of boring machines

in soft-rock shaft-sinking projects. Redpath, which ran the project, described it as precedent setting. Herrenknecht, which supplied the SBRs, described it as a top performance with a perfect safety record.

Project milestones included a month that saw a combined total of more than 280 m of advance. Ultimately, the shafts were completed in half the time it would have taken were conventional methods used, Herrenknecht reported.

"In April 2020, both shafts broke Redpath Deilmann's company records from 1938, which was achieved at the time thanks to practically nonexistent safety regulations," it said.

Jochen Greinacher, managing director of Redpath Deilmann, said he considered the project a game changer. "The combination of reliable and proven SBRs, the newly developed and patented Redpath DH hydraulic curb ring, the adapted hoisting systems all played significant roles in the success of these shafts," he said.

"To anyone involved, it is clear that the most critical aspect of the overall success was the knowledgeable and experienced team," Greinacher said. "The team executed at an average advance rate of 3 m of finished shaft per day, with peak performance of more than 7 m per day and, admittedly, in favorable rock conditions, advancing each shaft more than 140 m in one month, thus taking the burden from future clients to rely on a prototype rather than a proven system."

For perspective, that performance should be compared to the average rate for traditional shaft-sinking methods of roughly 2.4 m per day, Kevin Melong, vice president, shafts and technical services, Redpath, said.

Herrenknecht's SBR is based on its Vertical Shaft-sinking Machine. The roadheader is telescopic. "The method has now been modified for mining with a hydraulically driven rotating cutting drum and an adapted backup area," Herrenknecht reported.

The SBR cuts the ground and pneumatically loads material into the bucket for hoisting to surface, Melong said.

Redpath shaft-sinking specialists worked closely with Herrenknecht engineers "to ensure the SBRs not only had capabilities to efficiently and safely cut and move the broken ground, but ensured all aspects of the sinking cycle were incorporated in the design of the machines," Redpath said in a statement.

The SBRs and processes were developed as the shafts progressed. "With the help of a data acquisition system, the advance rates were recorded, processes precisely analyzed, and initial weaknesses rectified," Herrenknecht reported. Improvements led to significant time savings.

Other project deliverables managed by Redpath included the installation of the shaft lining elements, temporary and permanent shaft furnishings and services, and installation of the ventilation system.

Both suppliers said the safety record of the project reflected the capabilities of the SBRs.

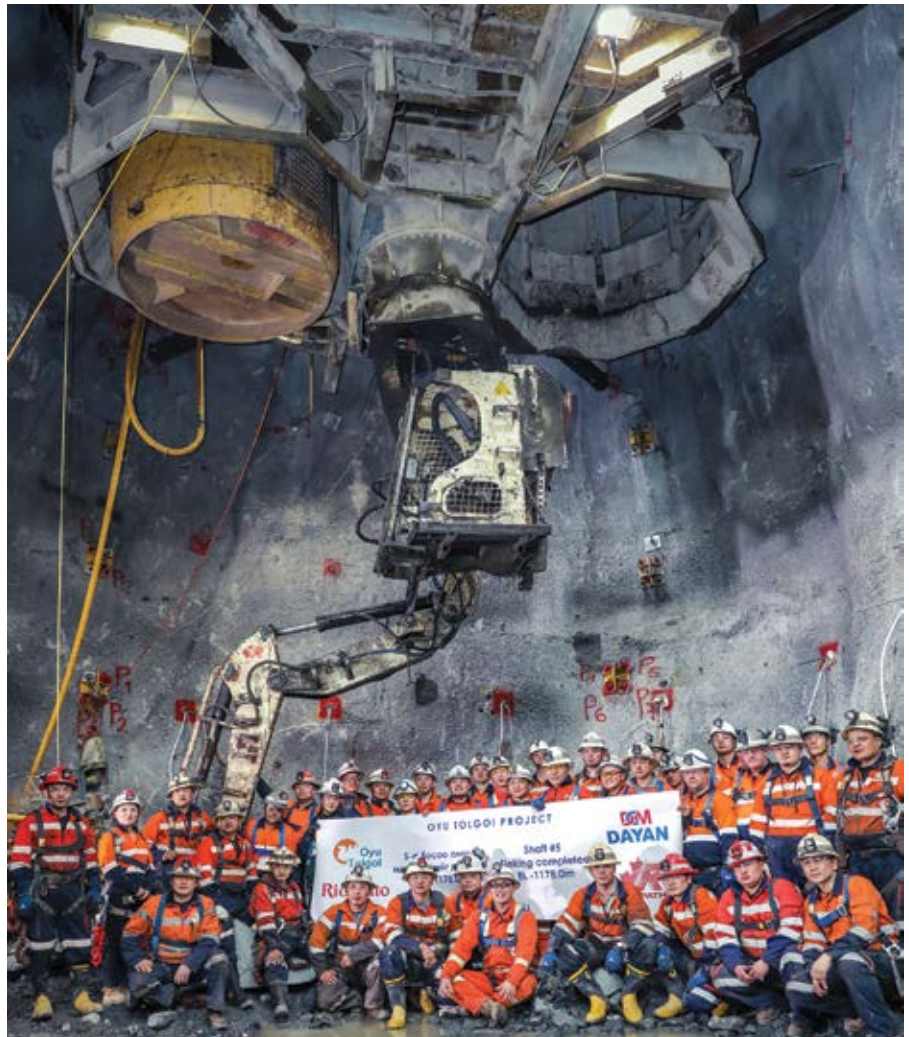
"No people at the face means less exposure of our crew to potential hazards," Redpath reported. "Redpath Deilmann is very proud of not a single lost-time incident during sinking, including construction of the stations and the loading pockets."

The noteworthy challenges faced included drilling through an aquifer. "Due to a water-bearing layer of earth, the ground was frozen to a depth of 165 m," Herrenknecht reported. "A breach with a water ingress at the end of the freezing depth was the greatest challenge in the project."

The measure did not prevent the shaft from being completed in record time. Upon completion, the two shafts were 750 and 697 m deep and 8 m in diameter.

Nezhinsky, owned by IOCO Slavkalyi, is a 2-million-metric-ton-per-year (mt/y) potassium salt mine.

During the course of the project, Redpath identified many areas of potential incremental improvements. They will be applied on future projects and in the development of Herrenknecht's Shaft Boring Cutterhead for hard rock shaft sinking, Redpath reported.



Redpath will soon test its fourth-generation stage-mounted hydraulic mucker, which is a 'complete rethink' of the earlier models. One is pictured here in Oyu Tolgoi in Mongolia. (Photo: Redpath Deilmann)

SHAFT SINKING



Redpath sells six Redbore raise drills to a customer in Chile. The sale shows the pickup in demand for boring solutions as expansion projects gain steam amid rising metals prices.

“On the heels of the success with the Herrenknecht SBR program, the teams are busy developing a prototype hard-rock sinking machine, capable of handling much harder rock formations, in the range of 200 mpa,” Redpath reported. “The approach requires disk cutting as opposed to the use of road header picks, and has progressed to the trial stage later in the year.”

Other innovations from Redpath include a hydraulic curb ring for securing the bottom of the concrete liner pour versus traditional scribing, and a hydraulic key door for opening and closing of the shaft forms, adding to the overall safety and efficiency in the concrete cycle.

Typical curb rings are used with scribing pins that run from the curb out to the excavated wall, with sheeting laid on top to act as the floor for the concrete pour, Melong said. “The hydraulic curb does not require any of that extensive scribing work, and closes that gap with a proprietary design, which takes a fraction of the time of the manual scribing or false floor work.”

The main forms or shutters have a key door running the length of the sections to allow the release of the forms from the previous concrete pour, he said. “The door is normally a mechanical bolted design with the requirement to pry open, and force shut the key door within the ring of form panels when in the next position,” Melong said. “The hydraulic key doors remove this challenging task from the cycle without any manual work, in a fraction of the time required.”

Separately, Redpath will launch its fourth-generation stage-mounted hydrau-

lic excavator shaft-mucking unit, currently nearing testing. “With a complete rethink of the original hydraulic mucker, which was successfully used on shafts in Canada and Mongolia, engineers have come up with a unit that will allow for concurrent tasks in the sinking cycle to be executed,” Redpath reported.

The unit can be lowered from the main galloway, and operated remotely, with no workers below the galloway. “Not only will the overall sinking cycle be reduced drastically by allowing safer concurrent work, but the customary concerns around the availability of skilled operators on traditional shaft-mucking units will be eliminated,” Redpath reported.

With the mucking unit detached, the ability to be lowered independent of the galloway position, and the ability to operate without workers below, the mucker “offers the potential to conduct concrete pouring concurrent with shaft bottom mucking, the two lengthiest tasks in the complete sinking cycle,” Melong said.

Redpath has also developed a high-speed shaft signaling system network that supports smart stages in shaft construction, and can be used to monitor

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MODULAR MINING

shaft conditions and mitigate risks in real time.

“Redpath has developed its own collection of technologies, equipment and in-house designs that have been tested or adapted for the unique and harsh environments related to mineshaft construction,” Melong said. “Assembling the right collection of technologies and protocols for each unique construction project enables the Redpath Shaft Control System to reliably and instantly collect and distribute information from sensors, controllers, cameras, computers, phones and virtually any type of electronic device available on the market.”

Upon completion of the shaft, the networks have been used by the clients in the routine shaft operations. “Of particular interest has been the application of real-time shaft-guide alignment monitoring, which trends multi-axis acceleration and vibration of the conveyances running on the complete length of the guide string,” Redpath reported. “The sensing unit is mounted to each conveyance and sends data immediately to surface where it is combined with other winder parameters and shaft sensors to provide a comprehensive account of system conditions throughout the shaft.”

The data can be referenced by maintenance teams as needed to assess guide string conditions over time and detect potential problem areas before they become critical, the supplier reported.

More recently, Redpath made headlines for the sale of six Redbore raise drills to a customer in Chile. Among the machines was a Redbore 60 UR, designed specifically for the Chilean market. It has a capacity range of up to 2 m in diameter.

The order reflects growing demand resulting from the ongoing revival of new mine projects around the globe. Many of those projects will require shafts that go below traditional depths, Redpath reported.

In response, the supplier will seize on the opportunities available to offer state-of-the-art boring solutions. However, “we recognize that there will continue to be the majority of shafts sunk using conventional drill and blast techniques for some time,” Redpath reported. “We are therefore also focused on making the traditional methods safer and more productive.”

Game-changing Raise Borer Smashes Records

In August 2020, Byrnegut's Raising Australia raise bored two 0.75-m-diameter box-

holes for a total of 50.88 m in 24 hours at Paddy's Flat gold mine using a Rhino 100 raise borer made by TRB-Raise Borers and sold by Sandvik. The feat included setup, drilling and demobilization. The mining contractor dubbed it a “fantastic achievement.” Sandvik said it was a possible world record.

The next month, underground mining services supplier Barminco announced that in about a year, one Rhino 100 had drilled a total of 3,843 m at four Goldfields mines. To cap the winning spree,

the supplier had just purchased another rig for use at a Regis Resources mine.

These results and others outright prove the raise borer is nothing short of a game changer for underground production drilling, according to Jarko Salo, managing director, TRB-Raise Borers.

That's no misprint. The raise boring rig takes production drilling to the next level, he said.

For example, after Fazenda Brasileiro commissioned a Rhino 100 in Q3 2018



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Nimble and manageable by one operator, the Rhino 100 inspires a revolution in thinking about production drilling. With record-breaking speed, it can raise bore slot raises to serve as void spaces for blasting for improved fragmentation and the many downstream benefits. (Photo: Sandvik)

to drill slot raises, it reported a gain of a whopping 6.6% in ore recovery. The rig is credited with allowing the recovery of ore that was previously considered out of play, Sandvik reported.

Previously, raise boring as part of production drilling was considered out of play too, for good reason. “Historically, the prevailing opinion has been lack of mobility makes raise boring an unattractive alternative for drilling slot raises in production drilling applications,” Salo said.

“These are rigs traditionally associated with terms like ‘bulky’ and ‘extremely heavy.’ The opinions come from experience: Hauling all this equipment is a cumbersome project, underground even more so, with careful scheduling included,” he said. “Making it a daily or even weekly chore? No, thanks!”

The Rhino 100 changes all that because it is nimbler, easier to operate and safer than conventional solutions, Salo said.

“It pushes the envelope: No more concrete pads, 15-minute setup times and safer operation,” he said.

The rig “allows larger holes and shafts to be drilled quickly, easily, cheaply,” he said. “This was previously unheard of. Still today many conservative miners do not believe me when I tell them about the rig. It is true, a raise borer can be a production drilling rig.”

Several capabilities allow the rig to shatter norms. Compared to competing solutions, it is highly mobile and can be set up and shut down quickly, Salo said. The controls allow for it to be managed by a single operator, without additional resources or other dedicated equipment.

“This means all the necessary tools are carried with the rig to simplify underground logistics,” he said.

Improved mobility supports a “revolution in thinking” about production drilling using a boring solution, he said.

Byrne cut saw the possibilities offered. More importantly, it was able to get its ducks in a row to act on those possibilities, Salo said. The stars aligned, and then the rig accomplished the truly remarkable as if it were just another day at work.



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“The real story behind their achievement is the fact that the drill sites were available, the mining plan was calling for drilling, they were using the Rhino, and the operators were probably paid a per-meter salary,” Salo said. “It was really just another day at the office: Nothing special except everything was ready for them to perform.”

Similar unexceptional days at the office have occurred at several other mine sites using a Rhino. For example, in September 2018, an Agnico Eagle Kittilä operator did 29.4 m of downreaming in one shift. To any other site, that would be a major flex. For Kittilä, it was just another day using the Rhino, Salo said.

“We have seen customers achieve more than 400 m per month regularly. Agnico Eagle Kittilä mine is one of the pioneers in fast-track underground benching,” Salo said. “Their record month of drilling is nearly 500 m in 18 slot raises, yet for a lion’s share of that month, the rig was idle.”

Similarly, Byrnescut boring records included 365 m for the third month after commissioning, and 410 m for the next month. That with the rig sitting “idle at times because the mine had troubles providing drill sites,” Salo said.

As mine, company, and other records for m/shift and m/month fall, so tumble production records.

Raise-bored slot raises provide void space for blasting, which translates to improved fragmentation. It also translates to lower production costs with fewer blasting holes, smaller and cheaper blasts, lowered ventilation requirements, improved blast control in poor rock conditions, and quicker stope turnaround time, Salo said.

“The slots are straight and predictable,” he said. That creates the opportunity to maximize long hole rig efficiency and minimize rework.

“The high-capacity Rhino 100 allows drilling of two (round 0.66/0.75-m-diameter) slot raises in a stope to ensure blasting success, if there were any doubts,” Salo said. “Slots can be developed well in advance, making planning easier and more flexible. Safety is improved by eliminating re-drilling of blast holes.”

Productivity increases of a mind-boggling 60% are attainable, he said. Operating costs per meter can be reduced by as much as 30%. The mining cycle for each stope can be shortened by up to 14 days.

“Raise boring will facilitate the process and turn other rigs working in the

same ore more efficient and productive,” Salo said. “Rework, rescheduling, and hang-ups are not on the agenda as they were in the past.”

“As a result, we engage mining operations differently. We can be discussing their production capacities and targets rather than single rigs,” Salo said. “We can point out bottlenecks and improve rig utilization.”

The rig is capable of supporting teleoperation, which is gaining interest, he said.

“Another one is the plug-and-drill concept, where one rig can use optimized drilling technology in both directions of drilling with a number of benefits,” Salo said, “including higher reliability, lower maintenance requirements, and versatility in drilling diameters and applications.”

Further, the safety, productivity and efficiency gains have “many people very interested,” Salo said. “Just one rig can bring a huge change in underground mining operation.”

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Fleet Management for Today and Tomorrow

E&MJ explores the integration of fleet management, health and safety systems and how new technologies are paving the way for smarter, more efficient practices

By Carly Leonida, European editor



Truck-shovel haulage forms the backbone of many open-pit mining operations.

Over the past 10 years, mining equipment has become increasingly complex. Smart technologies, sophisticated arrays of on-board sensors, and enhanced communications capabilities have moved the needle for the systems tasked with managing the actions of mobile fleets.

While haul cycle automation remains a mainstay for any fleet management system (FMS), mine operators' expectations have grown infinitely. Today's miners expect their FMS providers to not only leverage the advancements taking place within the mining sector, but to also take advantage of the innovations in automotive design, robotics, artificial intelligence, and many other non-mining-related industries.

To better understand how FMSs and mine networks have progressed, *E&MJ* spoke to Neil Ferreira, Associate Director Product Strategy at Modular Mining about the company's DISPATCH FMS.

"DISPATCH was built on the visionary concept that the backbone of every open-pit mine — the haulage cycle — could be made more accurate, efficient, and reliable, through computerized, automated dispatching," he explained. "The DISPATCH system changed the game in 1979 when it was brought to market and introduced the concept of optimization to the mining industry.

"More than four decades later, optimization is still the cornerstone of the DISPATCH FMS and the Modular Mining brand. Our proprietary optimization algorithm continues to drive the real-time truck assignments that enable haulage cycle efficiency and increased productivity at open-pit mines around the world."

Advancements in wireless communications, multi-constellation Global Navigation Satellite System (GNSS) positioning, and onboard computer processing power, have contributed to the ongoing evolution of DISPATCH. And, on a broader scope, Modular Mining is working on new ways to harness the powers of data analytics, the IoT, and process digitization.

"By integrating these and other aspects of mainstream technology into our development processes, the DISPATCH system has the ability to help mines mitigate oft-seen challenges, such as wasted time during shift change, unreliable payload metrics, inaccurate material blending, and more," said Ferreira. "By expanding our perspective, we can help our customers achieve maximum productivity, efficiency, and safety, across the entire mining value chain."

An Integrated Approach to Fleet Management

Modular Mining, like many other FMS providers, has been working hard to bring greater interoperability into its product suite over the past 24 months. While this capability brings numerous benefits in fleet automation, it's also key to the integration of different asset health monitoring and safety technologies.

"There is no shortage of offerings designed to address individual segments of the operational big-picture," Ferreira said. "Often, these third-party systems generate vast amounts of valuable data. Unfortunately, the external applications rarely have native compatibility with other systems, which leads to redundant hardware, additional infrastructure and siloed functionality.

"For mines to experience seamless operation, the discrete technologies must communicate, exchange data and work together in a unified manner. Integration is the key component that will enable third-party systems, aftermarket OEM sensors, and FMSs to work synergistically and help mines achieve their goals of increased safety, efficiency and productivity.

"In keeping with our corporate vision — sustainable mining powered by open technology solutions — we embarked upon a mission to increase our integration, interoperability and communication with relevant third-party systems. One outcome of this effort is the Modular Mining API (application programming interface) program."

In accordance with its goals of increased openness and mine-wide optimization, and to satisfy customers' need for connectivity between third-party applications, and the DISPATCH FMS and ProVision Machine Guidance Systems, Modular Mining released a series of APIs in May 2020.

Based on internet-standard communications protocols, such as WebSockets and REST, the APIs facilitate bidirectional data exchange with the third-party applications, thus enhancing functionality at both ends.

The APIs target the key areas of supervisory control, payload management, crusher management, mine planning and aftermarket systems integration. Through them, the Modular Mining ecosystem gains access to previously unavailable information, to supplement real-time decision-making algorithms, automate tasks, and avoid duplication among systems.

The APIs enhance third-party systems by providing real-time, read-only access to various endpoints including equipment positioning data, equipment status changes, and equipment cycle state changes. They also provide write-access to various entry points, including location status, equipment status, road state and material management.

“The Modular Mining APIs are based on industry standards, including OpenAPI and AsyncAPI technical specifications and employ both REST with JSON for request/response patterns and Web-Sockets for publish/subscribe patterns,” Ferreira said. “We have deployed the APIs globally at multiple tier-one mines and have received increasingly positive feedback from those customers.”

The APIs were developed within a framework designed to be expanded upon as needs change and opportunities arise.

“We initially focused on challenges that our customers face on a regular, sometimes daily basis,” explained Ferreira. “For example, difficulty adhering to the mine plan, frequent inaccuracies in recorded payload volumes, traffic bottlenecks at the crusher, incomplete feedback loops between the mine management and enterprise systems, and the lack of communication between the equipment’s onboard OEM sensors and the FMS.

“Going forward, we will closely monitor and evaluate the needs of our customers and the demands of the industry, and take a strategic, value-centric approach to augment the API program, accordingly.”

Ecosystems Create New Possibilities

While the mining industry is moving toward greater connectivity and interoperability, and more comprehensive mine management systems, this doesn’t mean that FMSs will be tasked with running the gamut of functionality needed throughout the mine.

According to Modular Mining, FMS providers will instead need to step up their efforts to facilitate real-time interoperability with an ever-expanding range of third-party applications, systems and aftermarket sensors. In the connected mine, each component will do what it was designed to do — be it 3D visualization, fragmentation analysis or weather tracking. And then, through integration, interoperability and bidirectional data exchange, the mining technology ecosystem will become more robust, as a whole.

Another FMS provider looking to leverage technology ecosystems is Hexagon’s Mining division. The company’s MineOperate suite includes FMSs for both open-pit and underground operations, which integrate seamlessly with its safety, assistance and slope monitoring systems to provide autonomous capabilities. Hexagon refers to these as “Autonomous Connected Ecosystems” (ACEs).

MineProtect portfolio manager, Marcos Bayuelo, and MineOperate portfolio manager, Larry Estep, shared their thoughts on future fleet management systems with *E&MJ*.

“Over the past decade, we’ve seen a shift from data collection tools that provide information for mine operators’ decision-making, to tools that automate the decision-making process within fleet management and safety solutions,” Estep said. “This has helped to optimize productive material movement in real time without human intervention.

“Today, the interoperability trend in solutions for safety, mine design and automation across multiple technology providers makes it possible to automate machines and processes based

on real-time decisions. This allows users to take the right action to optimize productivity and improve safety.”

The evolution of technologies used to develop FMS solutions, the administration behind decision-making processes plus the quantity of data these systems generate have made it more challenging for mine operators to distill the necessary information. This has led to the development of data visualization and analysis tools that, from a single source of truth, provide the right information, in the right format over the life-of-mine.

“For example, using information on the health of your machines, such as current engine status or hydraulic errors, and information on how to act, mines can make the right decision to optimize asset availability and reliability,” Estep said. “This in turn allows supervisors to optimally meet productivity goals while fully exploiting asset value in real time using the vehicles’ automated decision-making.”

Better integration between FMS and health and safety solutions delivers numerous benefits, including reduced costs through minimizing the number of vehicles required for the same production goals, improved productivity by adding extra available time per vehicle by optimizing reliability and, reduced costs and improved productivity through reduced downtime and, better cycle times through driver awareness and accident prevention.

Bayuelo added: “Increased computing power, wireless data transmission, onboard data volume transfer, peer-to-peer and other IoT technologies have also enabled fewer hardware components to be used for deploying most production and safety solutions. Solving productivity and safety challenges now requires fewer costs, and less maintenance, training and adoption time.”

More connected devices and solutions with reliable data mean better decision-making inputs, and new ways to solve challenges, such as a single way to provide positioning for all onboard solutions making data more reliable.

A single user interface for vehicle drivers improves adoption and declutters the cabin and vehicle handrail (no more multiple GPS antennas or screens in the cab). Increased computing power also enables powerful computer vision and video processing solutions to run hand-in-hand with other safety and productivity solutions, like fatigue management systems, displaying an external awareness video feed with the FMS on a single interface.

The advent of faster, more widespread network infrastructure has also allowed the connection of back-end data with onboard de-



Modular Mining’s DISPATCH FMS has been a mainstay in mining since its launch in 1979. (Photo: Modular Mining)



Interoperability is key to the integration of FMSs with different asset health monitoring and safety technologies.

vides for real-time, on-the-edge decisions and notifications, such as the connection of drill and blast and slope-monitoring solutions with fleet management and safety devices. This provides direct feedback to vehicle drivers on zones that are forbidden due to blasting, or a redirection to a new shovel to improve the cycle time.

Harnessing Smart Devices

The HxGN MineOperate OP Pro LP system, which will soon see the release of version 3.0, gives mines greater visibility by combining hardware and software to automate workflows, optimize haulage and blending, and deliver situational awareness. By integrating data, and automating production cycles and operations workflows, OP Pro LP helps mines to better use their equipment, improve their workflows, reduce costs and improve productivity.

MineOperate OP Pro provides real-time decision actions to autonomous solutions using standardized onboard data sharing APIs or software development kits (SDKs), such as Mission Manager. It has improved and unified UI/UX interoperability, which Estep said has added significant value for end-users, as it dramatically improves usability and adoption.

Using these features and capabilities, Hexagon is now working toward creating integrated “smart device ecosystems” or SDEs for short, for fleet optimization.

Estep explained in more detail: “Hexagon is driving its technology toward ACEs utilizing the data from multiple sensors and modularizing the solutions we provide in a simple hardware architecture that we call the Smart Device Ecosystem (SDE). It contains the same components to deliver the solutions to the specific challenges mines face. Mines can scale these solutions as needed via the same SDE already installed on vehicles and other infrastructure.

“For example, in the same antenna, computing box and display, you could deploy: MineOperate OP Pro along with Reverse Assist; or OP Pro and our Asset Health module; or OP Pro with the HxGN MineProtect Collision Avoidance System (CAS) and Operator Alertness System (OAS).”

The idea is to allow mines not only to scale up solutions across their mobile fleets but to scaleup around their overall life of mine. For example, the creation of an ecosystem allows Hexagon’s IDS GeoRadar slope deformation system to send alerts in real time to all CAS-equipped vehicles. The MinePlan engineering suite will automatically synchronize the time and date of blast patterns with OP Pro to prevent vehicles from entering

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the vicinity, and to provide information in real time on whether vehicles are occupied or not.

“Seeing connected devices from the same hardware creates great opportunities for efficiencies and cost-savings,” Bayuelo said. “The SDE will be made available in stages, so customers can adopt solutions as needed, and build incrementally according to their requirements.”

Estep added: “In EMEA, we are currently deploying a SDE solution comprising OP Pro, OAS, Asset Health and Reverse Assist and, in Europe, we are deploying a SDE which includes OP Pro, CAS, Asset Health and Reverse Assist.

“Customers are excited to see Hexagon’s life-of-mine vision being realized, and users have given us great feedback on how easy the solutions are to use and how modern they look.”

A Healthy Fleet is a Productive Fleet

Predictive analytics have also brought a new level of capability and insight into the fleet management space over the past decade. From helping determine how many trucks will be needed at each location and when, to deciding the most efficient haul routes and predicting machine failures... providing the data quality and quantity are sufficient to train the models, the possibilities in fleet optimization are almost endless.

Colin Donnelly, vice president of product engineering at predictive maintenance specialist Dingo, said, “Predictive analytics in any space can help you make better educated, smarter decisions over time. From our angle, we see predictive analytics as key to asset availability and uptime. The output from our system feeds into the mine FMS, which routes the machines to where they need be, so our system is complimentary to optimization. It’s up to the mine to determine how they use the equipment, and their FMS may have analytics behind the scenes to help do some of that too.”

By bringing predictive analytics into the asset health space, mines are now able to be more efficient and proactive in their maintenance schedules, extending planned intervals where possible and pre-empting failures before they happen; the aim of the game is to be more cost effective and use often limited resources more efficiently.

“Preventative maintenance activities are performed on schedule,” Donnelly said. “Things like oil changes are performed when a vehicle or engine reaches a certain mileage or number of operating hours. Most operations will work in that realm for a



Hexagon will soon release version 3.0 of its MineOperate OP Pro LP fleet management system. (Photo: Hexagon Mining)

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lot of their maintenance activities. It's easy and cheap to implement, and you know exactly what your costs look like.

"With predictive analytics, you're actually collecting data and using it to determine when you next do maintenance, rather than working entirely to scheduled intervals."

Some tasks have to be done on a set schedule, for example, oil and filter changes, but there are also plenty of activities that can be performed based on machine or component condition. Donnelly said that many mines tend to over maintain their equipment.

"We try and push them to let the data determine when to do certain tasks," he said. "If you don't have to do maintenance, don't do it."

With preventative maintenance, if a problem comes up after the machine has been serviced, then it will likely be another 250 or 500 hours before technicians get a chance to see it, and there's a good chance a failure would occur beforehand. But, if that mine is collecting information through sensors, regular oil samples and other condition monitoring data, then there is an opportunity to be more proactive in the maintenance of that vehicle.

Donnelly described the use of analytics in mine fleet health as "emerging."

"There's a wide spectrum," he said. "We have some customers who had never looked at predictive maintenance before but had heard about the benefits. Then we have others who are really trying to push the limits and are using it to predict component failures."

"For those customers, we've built some remaining useful life models that use anonymized data to identify that we've had a specific engine model fail with a particular failure type 10 times

in the past. Can we use that information to predict when it's going to happen? We're working with approximately half a dozen customers on that type of approach to help them with logistics and planning.

"We can also provide, what I would consider to be a virtual assistant, where we use data feeds to make recommendations using machine learning and statistics on when to do corrective maintenance — change the oil, filters, or do a borescope inspection — those types of things."


Dingo has a data science team based in Brisbane that works closely with Queensland University of Technology and various subject matter experts to develop and train its models and algorithms.

"I think all mines would take advantage of predictive analytics if they were readily available to them," said Donnelly, honestly. "But it's not a plug-and-play technology. People often sell it that way, but when it comes to implementation, it's not quite that simple."

"If you want to predict a certain type of issue, then you have to collect the right data. It needs to be high-quality data with the accompanying history. A lot of mines are starting to realize that now."



Hexagon is driving its technology towards Autonomous Connected Ecosystems harnessing data, sensors and solutions in a simple hardware architecture that it calls the 'Smart Device Ecosystem.' (Photo: Hexagon Mining)



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I'd say over the next two or three years, data collection and quality will improve, and we'll really see a big uptake of this technology."

Getting the Most From Analytics

So, where should mines start when looking to implement predictive analytics?

"Don't try to build the ocean up front," Donnelly said. "Focus on what your problems are whether that's equipment health or haulage optimization. Figure out what data you need to capture if you're not already capturing it, so that you have the right information to help predict the problem before it happens.

"Some mines have machines that are really sensitive, but they don't have the infrastructure to get the data off the machine quickly and back into a centralized office to make decisions based on it, so check your communications and data transfer systems too. That might be what's holding you back.

"Look at how you could digitize your inspections. A lot of mines are still doing inspections on paper or using excel spreadsheets. We've had a lot of success with moving customers on to a mobile inspection app, which syncs customer's inspection data into our system. Within five minutes of logging the data, a subject-matter expert, who could be on the other side of the world, can see that information with photos and provide support.

"Also, make sure you have a solid maintenance strategy in place; you need to know what to do when you run into abnormal conditions. If you're struggling with the basics, and you throw more data at it, you're just going to have a bigger problem. Get the fundamentals right first."

For mines that are already using predictive analytics and want to take their applications to the next level, Donnelly recommended looking outside of the operation, even outside of mining, to see what other industries are doing. There might be opportunities for improvement.

And again, make sure historical data is well classified, because models that run on badly classified, incorrect data, can only provide poor outputs.

"You could have the best models in the world, but if they're running on bad data, they're not going to give you the outputs you're looking for," he added.

Dingo's Trakka cloud-based predictive maintenance software system provides mines with tools, insights and decision-support to run a best-in-class asset health program. Trakka can be integrated with existing asset health systems at an operation or run in parallel.

"We've recently added the Inspect inspection app (mentioned earlier), which allows customers to collect data on equipment structural integrity," Donnelly said. "Things like temperature and vibration measurements can be logged, and customers can collect digital images of frame cracks, etc. It's designed to help mines digitize their inspections so previously static information can now be ingested and analyzed with other condition data to get the complete picture.

"We're also working on a business intelligence reporting tool that will be released in Q2. This new capability empowers customers to connect directly to our database to do their own custom analytics and reporting.

"We'll also be giving customers direct access to our Power BI client, so that they can consume and share information in ways that they haven't been able to in the past. We want to ensure that the insights and intelligence from Trakka is accessible and relevant whether you're in the C-suite or on the shop floor."

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Chilean Copper Miners Recover

Despite temporary suspensions, production for 2020 remained on track and projects are now moving forward again

By Steve Fiscor, Editor-in-Chief

Chile is the leading copper producing country. A year ago, back in March 2020, all copper miners, including Corporación Nacional del Cobre de Chile (Codelco), the world's largest, were facing a 1-2 punch: the uncertainty of operating in a COVID-19 pandemic with copper prices briefly falling below \$2/lb. Even if they could find a way to safely operate, there were no guarantees copper prices would improve.

Immediately, most mining companies idled or slowed development projects. Some temporarily suspended production and laid off workers, while others persevered. Copper prices rebounded relatively quickly and then some. Today, copper is trading around \$4/lb and construction activities on expansion projects have resumed.

The tightening of the copper market speaks volumes about the recovering world economy. Chile's copper sector depends heavily on Chinese consumption and China's economy grew by less than 3% in 2020, the slowest level in more than 30 years. But, the Chinese economy grew. While the pandemic didn't disrupt the demand for copper consumed in manufacturing and construction, it did affect the supply side of the equation, and that drove prices higher. Somehow, many of the mines in Chile found a way to still meet production guidances despite these headwinds.

Codelco Puts Plan in Place, It Pays Dividends

Headquartered in Santiago, Chile, Codelco is the world's largest copper producer. The company operates seven mining divisions: Chuquicamata, Ministro Hales, Radomiro Tomic, Gabriela Mistral, Salvador, Andina, El Teniente, as well as the Ventanas smelter and refinery. In 2020, Codelco produced 1,727,355 metric tons (mt) of fine copper. That figure, which includes the company's share of the production from the El Abra (49% owned) and the Anglo American Sur operations (20% owned), was an increase of 21,342 mt, that is, 1.3% more than the total production of 2019 (1,706,013 mt) during the COVID-19 pandemic.



Octavio Araneda Osés, executive chairman, Codelco, and his team prepare to head underground at Chuquicamata.

How did they keep production on track when the rest of the world was coming to grips with the global pandemic? Codelco's executives quickly realized this was an exceptional situation and became proactive, putting the health and well-being of all first. The company consulted with a team of medical experts and they developed a plan for continued operations and communicated with everyone about it.

"[Last year] was very challenging. Facing the coronavirus and its adversities represented an extremely complex task for all companies, and Codelco was no exception," said Juan Benavides Feliú, chairman of the Codelco board. "The commitment that we observed throughout the year, however, even in the worst months of COVID-19, allowed us to confirm that the entire company fully understood the responsibility of safeguarding operational continuity."

With its people informed, protected and engaged, and many of the engineers and specialists working remotely, Codelco was able to protect not only the personal health and peace of mind of families, but also the operational and financial health of the company.

Like many companies, they endured months of uncertainty. In some instances, they reduced staff. Some projects were temporarily suspended. Miners and plant

workers became accustomed to physical distancing and tight shifts. This did not lead to a drop in Codelco's production, however, quite the opposite, Benavides explained.

Operating With COVID-19

Codelco put procedures, controls and management in place to mitigate infections, in addition to continuing to support communities in managing COVID-19. "We finally achieved a new normal, ensuring permanent changes," said Octavio Araneda Osés, executive chairman, Codelco. "For this, we gradually resumed suspended projects and operations. We consolidated the most efficient work practices in all areas and began to capture the savings in contracts with third parties. We focused on exceeding production objectives with lower costs." Thanks to these changes, Araneda said Codelco generated a surplus of \$2.1 billion, 55% more than 2019.

More importantly, Araneda said productivity in 2020 rose to 54.5 mt fine copper per person, a figure that was 11% higher than 2019. Codelco now plans to increase its surpluses in 2021 by \$1 billion.

"Collaborative work will be an essential condition to transform Codelco into a competitive company for the future," Araneda said. "We are building structural projects to extend the life of the depos-

its for another 40 to 50 years, raising our standards, and increasing our productivity to maintain the current levels of 1.7 million mt of fine copper annually.”

Codelco is currently completing the Traspaso Andina (the Andina or Andean Transfer), which will be launched later this year. At the same time, the El Teniente Project Portfolio continues, which will allow the division's operations to be extended for 50 years and start the development of the El Teniente 9 level. In 2020, the Andes Norte NNM advanced 65%, the early Diamante works advanced 55% and Andesita advanced 65%.

During 2020, Codelco made important progress on the Rajo Inca (Inca Pit) project that could extend the operation of the Salvador Division for 47 years. It's an important project, given the depletion of the resources currently in operation. Approval of the project was obtained from the Environmental Assessment Commission in February 2020 and early works were completed in March.

Codelco is developing a prefeasibility study for Radomiro Tomic (RT) II Sulphides and reviewing the RT division's future development strategy. They are also considering a desalination plant for the Northern District, which would likely be engineered and operated by a third party. Feasibility studies are also under way to extend the processing of oxidized minerals until 2027 and to expand the dump and the phase IX secondary waste leaching process. Both could begin in 2022.

The Traspaso Andina project will relocate the existing primary crusher to allow the expansion of the open-pit mine. To do this, Codelco is building a new crushing plant and the necessary infrastructure to support it in the sector called Node 3,500. It will connect to the existing concentrator through a tunnel and a 4.8-km conveyor. The project was temporarily suspended during April to deal with COVID-19. Despite these restrictions, the project reached a global progress of 93% in 2020 and its startup is projected for the first half of 2021.

BHP Maintains Production at Escondida

BHP's Chilean assets, which includes Escondida and Pampa Norte, operated with a workforce reduced by approximately 30% as a result of the plan the company implemented for COVID-19.

During the second half of 2020, Escondida's copper production decreased by 5% to 572,000 mt with record concentrator throughput of 386,000 mt/d. As a result of the reduced operational workforce and the need to balance mine development and production requirements, BHP prioritized concentrator throughput over cathode production. That had an approximately 30,000-mt impact on cathode volumes for the second half of 2020. BHP has narrowed its FY 2021 guidance for Escondida to between 970,000 mt and 1,030,000 mt from between 940,000 mt and 1,030,000 mt. Production is also likely to be affected in FY2022 by reduced material movement in FY2021.

During the second half of 2020, copper production at BHP's Pampa Norte division, which includes the Spence and Cerro Colorado mines, decreased 22% to 97,000 mt, largely due to planned maintenance at Spence and a reduced workforce. The Spence Growth Option achieved first production in December 2020.

BHP's guidance for Pampa Norte for FY2021 remains unchanged at between 240,000 mt and 270,000 mt of copper, reflecting the reduced workforce, the startup of the Spence Growth Option and expected grade decline of 5%. BHP's guidance of an average of 1.2 million mt/y of copper production from its Chilean operations over the next five years, however, remains unchanged.

Collahuasi Posts Record Results

Anglo American reported copper production of 647,400 mt from its mines in Chile for 2020, an increase of 9,400 mt over 2019. Record production at Collahuasi and a strong operational performance at Los Bronces offset the headwinds related to COVID-19 restrictions and expected lower water availability.

At Los Bronces, production decreased by 3% to 324,700 mt, compared to 335,000 mt in 2019, due to expected lower water availability and planned lower grades (0.81% vs. 0.83%). At Collahuasi

Chile's Major Copper Mines (metric tons of copper)				2020	2019
Escondida	BHP 57.5%, Rio Tinto 30%, JECO 12.5%	OP	1,155,700	1,157,000	
Collahuasi	Anglo 44%, Glencore 44%**	OP	630,000	565,000	
El Teniente	Codelco	UG	443,220	459,744	
Chuquibambilla	Codelco	UG	400,720	385,309	
Los Pelambres	Antofagasta plc	OP	359,600	363,200	
Los Bronces	Anglo American Sur	OP	325,000	335,000	
Radomiro Tomic	Codelco	OP	260,653	266,415	
Centinela	Antofagasta plc	OP	246,800	276,700	
Pampa Norte* (est.)	BHP	OP	215,400	243,000	
Andina	Codelco	OP	184,437	170,274	
Ministro Hales	Codelco	OP	170,606	151,838	
Sierra Gorda	KGHM 55%	OP	148,700	108,200	
Candalaria	Lundin 80%, SMM 20%	OP/UG	126,700	146,300	
Caserones (est.)	JX Nippon Mining & Metals	OP	119,400	145,500	
Gabriela-Mistral	Codelco	OP	102,080	104,087	
Antocoya	Antofagasta plc	OP	79,300	71,370	
Lomas Bayas	Glencore	OP	74,100	78,900	
El Abra	FCX 51%, Codelco 49%	OP	71,900	81,520	
Carmen de Andacollo	Teck 90%, ENAMI 10%	OP	58,000	54,000	
Salvador	Codelco	OP	56,302	50,561	
Zaldivar	Antofagasta plc	OP	48,200	48,200	
El Saldado	Anglo American Sur	OP	45,800	54,200	
Mantos Blancos (est.)	Mantos Copper	OP	42,300	45,400	
Mantoverde (est.)	Mantos Copper	OP	36,600	47,800	
Quebrada Blanca	Teck 60%, SMM 30%, ENAMI 10%	OP	13,400	21,100	
Total			5,416,938	5,432,637	

* Includes Spence Growth Option; ** Anglo 44%, Glencore 44%* and Japan Collahuasi 12%
 Note: UG=Underground mining; OP=open-pit mining; FCX=Freeport-McMoRan;
 ENAMI=Empresa Nacional de Minería; SMM=Sumitomo Metal Mining

si, Anglo American's attributable share of copper production increased by 11% to 276,900 mt, compared to 248,800 mt in 2019. This was a record for the operation, driven by strong plant performance, reflecting the plant improvement projects implemented during 2019, as well as planned higher grades (1.24% vs. 1.19%). C1 unit costs decreased by 38% to \$0.62/lb from \$1/lb in 2019, another record, reflecting the solid production performance.

Production at El Soldado decreased by 15% to 45,800 mt compared to 54,200 in 2019, due to planned lower grades (0.84% vs. 0.93%) and water restrictions.

QB2 Remains on Track

Teck Resources produces copper from the Quebrada Blanca and Carmen de Andacollo operations. Last year, Carmen de Andacollo's production was 58,000 mt compared to 54,000 mt in 2019. For 2021, production is expected to be lower, in the range of 46,000 mt to 51,000 mt of copper due to lower copper grades.

Quebrada Blanca produced 13,400 mt of copper cathode in 2020, compared to 21,100 mt in 2019. Mining operations at Quebrada Blanca ceased in the fourth quarter of 2018, and mining equipment and personnel have been redeployed to the Quebrada Blanca Phase 2 (QB2) project. The operation now extracts secondary copper from previous leach piles.

During Q4 2020, QB2 continued its staged ramp up of the construction workforce to pre-COVID-19 levels in line with the plans developed in Q2 2020. Teck said the project achieved its overall progress goal of 40% by year-end 2020. First

production is expected in the second half of 2022, but that is dependent on the operation's continued ability to successfully manage through the impacts of COVID-19, among other things.

FCX Mulls Major El Abra Investment

During 2021, Freeport-McMoRan (FCX) plans to increase operating rates at the El Abra mine (51% FCX, 49% Codelco) to pre-COVID-19 levels, subject to ongoing monitoring of public health conditions. Incremental copper production associated with increasing El Abra's stacking rates from 65,000 mt/d of ore to more than 100,000 mt/d of ore, could generate 70 million lb/y of copper beginning in 2022.

FCX continues to evaluate a large-scale expansion at El Abra to process additional sulphide material and to achieve higher recoveries. They believe that El Abra's large sulphide resource could potentially support a major mill project similar to facilities constructed at Cerro Verde in Peru. Technical and economic studies continue to be advanced to determine the optimal scope and timing of the project in parallel with extending the life of the current leaching operation.

Antofagasta Switches to Renewable Energy

During 2020, Antofagasta plc produced 733,900 mt of copper and its net cash costs were \$1.14/lb. This reflects the company's agility in changing operating conditions, said Antofagasta plc CEO Iván Arriagada.

"Last year was challenging, but we have successfully kept our people safe and healthy, achieved our production and

exceeded our cost targets..." Arriagada said. "I am proud of how everyone at Antofagasta has worked together and adjusted to overcome the year's challenges."

Antofagasta now expects to power all of its mines in Chile with renewable energy. Over the past few years, its Chilean mining operations have renegotiated their power purchase agreements, switching from conventional sources — principally coal — to renewables. In July 2020, Zaldívar became the first of the group's mining operations to use 100% renewable energy and by the end of 2020, 19.4% of the mining division's energy came from renewable sources.

Zaldívar will be followed by Antucoya, Centinela and Los Pelambres, and during 2022, the company expects that its mining division's electricity consumption will be supplied entirely from renewable sources.

As a result of the COVID-19 pandemic, the Los Pelambres Expansion project was temporarily suspended from March to August. Work resumed with approximately 75% of the original planned workforce on-site and it is assumed that these manpower levels will continue throughout 2021.

The Los Pelambres Expansion project is divided into two phases. Phase 1 is designed to optimize throughput within the limits of the existing operating, environmental and water extraction permits.

During 2020, the decision was made to change the scope of the project and double the planned capacity of the desalination plant that is part of Phase 1 of the project, from 400 liters per second (l/s) to 800 l/s. The amount of work that can be done on the expansion of the desalination plant during Phase 1 is limited by what is allowed under the permits that have already been issued.

Following the change of scope and the delays due to COVID-19, the project reached 45% overall project completion by the end of the year and is now expected to be completed in the second half of 2022.

As mining progresses at Los Pelambres, ore hardness will increase. The expansion is designed to compensate for this, increasing plant throughput from the current capacity of 175,000 mt/d of ore to an average of 190,000 m/d of ore. The plant expansion includes not only the desalination plant and pumping infrastructure, but also an additional SAG mill, ball mill and six additional cells in the flotation circuit. Copper production will be increased by an average of 60,000 mt/y over 15 years.



Construction activities resume, such as the trunnions for the grinding line at the QB2 project (above).

The 400-l/s desalination plant includes a 62-km pipeline from the coast to the Mauro tailings storage facility, where it will connect with the existing recycling circuit that returns water to the Los Pelambres concentrator plant. To complete the expansion of the desalination plant to 800 l/s, additional permits will be required.

The capital cost of the project was revised to \$1.7 billion during the year to include the direct costs related to COVID-19 and the delay caused by it, and the investment in enabling the future expansion of the desalination plant.

Phase 2 of the expansion requires two separate Environmental Impact Assessment (EIA) applications, one for the desalination plant expansion and one for mine life extension.

In addition to the desalination plant expansion, Antofagasta Minerals will have to construct a new water pipeline from the Mauro tailings storage facility to the concentrator plant. This EIA will be submitted in the first half of 2021 and is expected to be approved in approximately two years with the project being completed by 2025. The desalination plant will be able to supply Los Pelambres with more than 95% of its water needs.

The current mine life of Los Pelambres is 14 years and is limited by the capacity of the Mauro tailings storage facility. The scope of the second EIA will include increasing the capacity of the tailings storage facility and the mine waste dumps. This will extend the mine's life by a minimum of 15 years, accessing a larger portion of Los Pelambres's 6 billion mt of mineral resources. The EIA will also include the option to increase throughput to 205,000 mt/d of ore, increasing copper production by 35,000 mt/y. This EIA will likely be submitted in 2022.

Esperanza Sur is 4 km south of the Esperanza pit and near Centinela's concentrator. The deposit contains 1.4 billion mt of reserves with a grade of 0.4% copper, 0.13 g/mt of gold and 0.012% of molybdenum.

Stripping was expected to start in early 2020, but was rescheduled in response to COVID-19 to the third quarter, and is now expected to be completed in the first half of 2022 at an unchanged capital cost of \$175 million. The stripping cost is being capitalized and is being carried out by a contractor. Once it is completed, autonomous trucks operated by Centinela will be used to mine the deposit.



Zaldívar's ore stacking system now runs on renewable energy.

Opening the Esperanza Sur pit will improve Centinela's flexibility to supply its concentrator and, over the initial years, the higher-grade material from the pit will increase production by some 10–15,000 mt/y of copper, compared to how much would be produced if material was solely supplied from the Esperanza pit. This greater flexibility will allow Centinela to smooth and optimize its year-on-year production profile, which has in the past been variable.

Antofagasta is currently evaluating the construction of a second concentrator and tailings deposit about 7 km from the existing concentrator in two phases.

Phase 1 would have a capacity of approximately 90,000 mt/d of copper ore, producing copper, and gold and molybdenum as byproducts, with an annual production of approximately 180,000 mt of copper equivalent. Once Phase 1 has been completed and is operating successfully, a further expansion (Phase 2) is possible and would involve increasing the capacity of the concentrator to 150,000 mt/d of ore with annual production increasing to 250,000 mt of copper equivalent, maximizing the potential of Centinela's large resource base.

Ore for the second concentrator would be sourced initially from the Esperanza Sur deposit and later from Encuentro Sulphides. The latter lies under the Encuentro Oxides reserves, which are expected to be depleted by 2026.

The EIA for both phases of the project was approved in 2016 and the initial feasibility study for Phase 1 was completed during 2020 with further detailed and supplier engineering progressing during 2021.

In late 2020, a tender process was started to invite third parties to provide water for Centinela's current operations, by acquiring the existing water supply system, and building the new water pipeline. This process is expected to be completed during 2021.

Zaldívar's Chloride Leach project was rescheduled in response to COVID-19 in the third quarter of 2020 and completion is now expected in the first half of 2022. The project is expected to increase copper recoveries by approximately 10% with further upside in recoveries possible, depending on the type of ore being processed. This will increase copper production at Zaldívar by approximately 10,000 to 15,000 mt/y over the remaining life of the mine. The project requires an upgrade of the solvent extraction (SX) plant, new reagents facilities and the construction of additional washing ponds for controlling the chlorine levels, at an estimated capital cost of \$190 million.

The current disposition in the Chilean copper market is positive. Copper demand is expected to recover the volumes lost in 2020, and to grow further. While there is some uncertainty about the pace of the Chinese economy, the economic recovery expected in the USA, Europe and elsewhere, supported by fiscal stimulus packages, will have a positive impact.

Chilean copper production is expected to grow as several projects are completed, but the COVID-19 risks are still present and could affect production, maintenance and construction activities. In general, the copper market is expected to remain tight for a few years as several of these large projects are completed.

Perfecting the Performance of Secondary Crushers

E&MJ asks eight industry experts how best to optimize the operation and throughput of secondary crushing circuits

By Carly Leonida, European Editor



Cone crushing often provides the most economic and reliable method for secondary crushing in mineral processing applications. (Photo: thyssenkrupp)

The role of the secondary crushing circuit, like every other stage in mineral processing flowsheets, is to prepare the feed material for the next stage of the process. The equipment selected depends on the characteristics of the ore and the desired end-product. However, in most mineral processing applications, the ore is relatively abrasive, and this lends itself to breakage via compression.

Cone crushing often provides the lowest operating cost and the most reliable method of production, although some operations with softer or less abrasive ores can use secondary sizers, horizontal shaft impactors, hammer mills, or other machines, each of which have varying benefits and drawbacks.

Cone crushers are fed with pre-screened material from the primary crusher (usually a jaw crusher or primary gyratory), and the secondary crusher should

always, if possible, have a scalped feed. Ideally, the deck on the scalping screen should have a cut point equal to the closed side setting (CSS) of the crusher.

The feed size to a secondary crusher is typically in the range of 50 mm to 250 mm (up to 300 mm). If the capacity is higher, the acceptable feed size gets larger. After crushing, the product is in the range of 0-60 mm (75 mm) diameter.

For mineral processing, secondary crushing can be used to prepare feed for downstream processes or to go directly to leaching. Downstream processes typically include tertiary crushing or primary grinding, with the tertiary crushers often being cone crushers or high-pressure grinding rolls (HPGRs), and the primary grinding mills being autogenous (AG) semiautogenous (SAG), or even rod or ball mills.

In most applications, the secondary crusher has a primary target of maximizing

the reduction ratio and reducing the top size and F80 for the downstream equipment. However, in some applications, the target can be also to avoid over-crushing in heap leaching applications, for example.

In primary-secondary HPGR circuits, the secondary circuit can be closed with a screen to provide a consistent top size and gradation for optimizing HPGR performance. Closed circuited secondary crushing can also bring benefits if cones are used in tertiary crushing, too. However, the cost of the additional equipment is not always welcome.

Frank Drescher, head of the crushing technologies product line at thyssenkrupp Mining Technologies, explained: "A typical aim [for secondary crushing] in mining applications is to reach a grain size distribution with 100% of the material smaller than a defined maximum size. In some applications an additional requirement is to produce a minimum number of fines. A crusher is not able to directly produce a specific grain size, so the discharge always contains a wide range from fines up to a maximum size, plus oversize. The solution is a crushing circuit with an arrangement of a crusher, a subsequent screen and a conveyor to return the oversize to the crusher.

"For example: If the following process requires 100% less than 80 mm without a high quantity of fines, the crusher can produce 90% less than 80 mm. After screening out the 0-80 mm fraction, the oversize that is more than 80 mm material is rejected to the crusher and crushed again. To crush the feed directly to 100% less than 80 mm would require a bigger machine, more energy and the amount of fines would significantly increase."

Taking a Holistic View on Optimization

The configuration of the secondary crushers is usually specified at the project phase based on a set of design criteria.

Tero Onnela, director for engineering and RTD in the Crusher Wears business line for Metso Outotec's Consumables business area, explained: "It's common that these conditions are not realized at the start of plant operation, if ever. Since the feed and ore properties will naturally fluctuate over time, it's best to analyze and optimize the crushing chamber designs, operating setpoints, and equipment configuration regularly as the feed properties change over time."

Jeremy Polcyn, product sales support manager, in Metso Outotec's Services business area, added: "Careful attention should be paid to the required product size, most commonly the P80, and the incoming feed size. The online grading analysis technology available today, for example, Metso Outotec's VisioRock can monitor these conditions and make changes to crusher parameters with the assistance of artificial intelligence."

When it comes to throughput, crushing circuits should always be assessed holistically, as changes to the operating parameters and throughput in one area will naturally affect the next. Trying to operate in a consistent manner can help to pinpoint where tweaks can be made most effectively and can indicate where higher profile liner upgrades may be utilized.

Drescher said: "On the one hand, you have to consider which machine represents a bottleneck and thus limits the flow of the production line. But it also makes sense to look at a line as a whole. If the entire crushing process is distributed over several machines arranged in sequence, then it's possible to change the influence of individual crushers on the entire process by altering their settings. This then has an influence on the wear of the individual crushers and the particle size distribution in the final product."

For example, in a simple arrangement, if the primary crusher produces a high quantity of fines, then more material is screened out and less material is fed to the secondary crusher, thus reducing wear. Various factors can influence the process, for example, the feed material might change due to natural fluctuations in crushability, hardness or moisture content. The product of individual crushing stages can also change due to wear of the crushing tools. In order to react to this, it's important to regularly check the wear

level of individual crushing stages as well as throughout the entire process.

Ekkhart Matthies, global applications director at Weir Minerals, said: "The most important thing to remember when assessing a crusher is — think about the bigger picture. No crusher works in a vacuum. Changes to one crusher often impact the equipment working alongside it and the stages that follow it."

While it's important to routinely check on and evaluate critical pieces of machinery, refinements should be made with an application-wide view of the process or in partnership with application specialists.

"Due to the arrival of Industrial Internet of Things (IIOT) and remote monitoring, it has never been easier to regularly check a crusher's performance," Matthies added. "Today, operators can monitor and analyze multiple pieces of equipment in real-time from the comfort of their desk. This may tempt users to become focused on machine-by-machine improvements.

However, emphasis should always be placed upon holistic, site-wide optimization. Our Synertrex IIOT platform offers users the ability to monitor the performance and health of Weir process equipment across their flowsheet — providing valuable insight to inform their wider optimization initiatives."

Bill Malone, global product director for crushers at FLSmidth, agreed: "It's very important to monitor the settings and output from each crusher. And with modern control systems, this is possible. This ensures that a constant, or at least more normal product, is presented to the screens, which ensures stability in the system and therefore more consistent process results.

"Normally, the frequency of monitoring will depend on the wear characteristics of the material and how often corrections have to be made to compensate for this. So, for a high-wear material, possibly once or twice per shift and, for a low-wear material, perhaps once or twice per week. If you have modern control systems installed, they will take care of this function automatically."

Anticipating the Need for Change

When a complete circuit is running in a consistent manner, varying output results are the most obvious indicator for when change is necessary. Secondary applications are dependent on the primary crusher to provide a targeted feed size, so fluctuations in the run-of-mine (ROM) ore can contribute considerably.

Changes in gradation (i.e., feed getting coarser or finer), hardness, moisture or, if the work index increases or decreases



Trio crushers in an aggregate application. (Photo: Weir Minerals)



Experts examine crusher wear parts as part of a chamber optimization program. (Photo: Metso Outotec)

es, can trigger adjustments in screen panels as well as potentially crusher mantles, bowls and concaves to compensate.

“Mine planning and preparation can be a good indicator to prepare for change,” explained Lucas Steiner, vice president for Metso Outotec’s Mining Crusher Products business line. “If it’s known that ore hardness or abrasiveness is going to change, preparations can be made and watched for in an effort to combat and maintain circuit performance.”

There are also key indicators that change may be necessary in both the secondary crusher and in downstream tertiary crushers. These include symptoms such as sporadic or continuous force or power overloads, poor efficiency or utilization of available crushing work, short crushing chamber life, or performance inconsistency during the life of the crushing chamber.

“When downstream (tertiary) crushers are bottlenecking, it’s good to remember that it can be helped by secondary crusher performance,” Onnela said. “All crushing stages influence one another.”

If circuit loads become too high, the process and settings should also be reviewed.

“Changes to major operational figures such as tonnage, power usage and the life of wear parts are indications that there may have been a change to the crusher’s operating conditions,” Matthies said. “Monitoring a crusher’s tonnages is the quickest and most noticeable sign your crusher is not performing optimally. Is your crusher discharge in line with your expectations?

“By power usage we refer to how much electrical energy is being drawn from the motor, which is a subtler indication than tonnages. The motor’s amp reading can indicate if your crusher is suffering from lack of power, or if other factors are forcing your crusher to work harder to achieve its expected results.”

Wear parts can also reveal a lot about a crusher’s condition. If wear patterns appear to have worn unusually or the life of the part has shortened, these suggest there are opportunities to alter the crusher’s settings and further improve its performance.

Focusing on Individual Machines

To optimize the performance of individual machines, the best course of action is to maintain operation of the crusher within three critical controlled variables: volumetric capacity, power draw and crushing force.

“Keeping the machine within these parameters will lead to the most holistic machine performance with regards to production and reliability,” Steiner said.

One of the best places to start on the optimization of individual machines is with manipulated variables like the CSS or speed. Sometimes controlled variables such as power draw can be used to manipulate crusher CSS and, lately online product gradation analyzers have been used to control crushers, aiming to stabilize their performance. There are also additional disturbance variables like crushing chamber wear and feed size.

“To a certain extent, these disturbances can be compensated by manipulated

variables when a sophisticated feedback control system is used,” Onnela said. “It can find the best operating parameters for the crusher and crushing chamber. Further step changes can be achieved by designing an application-specific crushing chamber with the aim of giving the best performance throughout its life within the limits the crusher sets.”

In specific cases, it’s also possible to change the crusher stroke by exchanging the eccentric throw arrangement.

A basic prerequisite for an analysis is to know the particle size distribution and the mass flow rates of the crusher feed and discharge. By monitoring these parameters, the crushing process can be influenced by adjusting crushing gaps, speed, etc.

“Timely replacement of crushing tools is also an important point to ensure the efficiency of the crushing process as it reduces downtime and assembly costs,” Richter said. “The shape of the crushing tools has an influence on the product, crushing forces, energy consumption and wear, as well as utilization rate and service life. They can therefore contribute significantly to the optimization of the crushing process.”

Wear Parts Play Key Role

Wear parts and crusher upgrades play a highly critical role in crusher optimization, and the materials used have the potential to increase the service life and thus the time during which a machine operates optimally.

Steiner explained: “Optimization of both crushing chamber profiles and wear-part materials can have a tremendous impact on machine performance, including the throughput capacity, reduction ratio, performance consistency and availability by improving the liner life. Also, crusher energy efficiency can be maximized by designing an application-specific crushing chamber. In some cases, reducing energy requirements by tens of percent.”

Matthies agreed: “Wear parts are, in my opinion, one of the most important factors when optimizing a crusher. Using the correct liner configuration, operators can increase the tonnage and quality of end-product delivered by their equipment. Every feed curve has an optimum liner configuration. The design of a crusher’s wear liners hugely impacts the performance of the crusher and its uptime.”

Operators should also regularly check the crusher's feed curve and the correlation between the motor power, chamber pressure and the tonnage. If the tonnage, motor power or crushing pressure is not what you would expect, there is room to optimize your crusher performance and the lifetime of its wear parts.

High-quality wear parts not only help crushers perform, but they can also offer exceptional wear life, reducing downtime and contributing to an overall reduction in the site's cost per ton.

The quality of wear part plays an integral role in optimization. However, wear part quality should not be confused with the percentage of manganese contained within the part.

Manganese has been used in crushers for decades because of its work-hardening properties. As rocks meet the outer layer of the manganese particles, their exterior layer toughens. This results in a material that is harder to wear down during operation and can handle higher impact blows compared to other alloys.

"It's a common misconception that more manganese increases the robustness of the wear part," Matthies explained. "A manganese alloy will typically contain carbon, chrome and manganese elements. An increase in any of these ingredients will require adjustments to the wider recipe. Without considering the application and the wider formula, increases in manganese can result in weaker or less reliable parts.

"Due to the importance of wear parts to the overall success of the project, I recommend that operators always source their parts from experienced suppliers and subject matter experts."

Matthies said his team worked with an iron-ore mine in Russia supplying custom-engineered ESCO crusher liners, manufactured using premium alloys and an improved wear profile designed for that specific application. After the first set of ESCO liners were installed in the Trio TP600 crusher, the customer benefited from four more days of wear life, a 16% increase in the bowl liner and a 20% increase in mantle utilization.

Sven Hoerschkes, head of GPLM, construction and feeders at FLSmidth, reported similar with his own customers: "In some cases, we've delivered 10% extra capacity and 30%-40% longer liner lifetimes by optimizing their profiles and the material composition," he said.

"It's important to also check the screen performance too as this will affect the crusher significantly."

Upgrades and, in extreme cases, machine replacements also provide the opportunity to reach new levels of safety, efficiency and performance.

Steiner explained: "There are numerous cases across different crusher

models where we have optimized equipment and/or provided upgrades to get the most out of the machine and in cases secondary crushers. From MP1000 to MP1250 upgrades that have seen a 25% increase in throughput, to upgrades of Symons crushers that can decrease downtime and increase availability by as much as 25%."

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In 2020, Weir Minerals replaced a competitor cone crusher within an iron-ore mine in China with a Trio TP900. The incumbent cone crusher was suffering from lack of availability and excessive downtime.

“From commissioning, the customer has benefitted from a 10% increase in availability and a 50% reduction in service frequency, considerably boosting the site’s uptime,” Matthies added.

From Machines to Circuits

Circuit optimization should start with identifying the deficiencies and knowing the goals surrounding throughput/tonnage, material reduction, resource consumption (energy, water, etc.), machine reliability, machine availability and total cost of ownership. Identifying this gives information about where adjustments need to be made and, on what scale, from minor setting tweaks to larger scale upgrades.

Drescher explained: “It’s necessary to know and understand all the parameters (feed material, feed granulation, product granulation, mass flows), and the crushers must be adjusted so that circuit loads help improve the product and overall performance, not reduce the output.

“For example, the primary crusher product size needs to be adjusted to the secondary crusher feed size or the AG/SAG feed size, and also the secondary unit product size needs to be adjusted to the

mill or HPGR feed size, which needs to be adjusted according to concentrator specifications. The same logic needs to be applied for throughput and feed rates. Inaccurate adjustments usually lead to overall reduced plant techno-economic efficiency, especially if it’s an integrated plant.”

This task should be performed at the early stages of a project because, once the steel or civil works are finished and equipment is installed, the available space sets up clear limitations for new or additional equipment installations. Arrangement changes can also carry extraordinary costs.

Circuit performance should be monitored throughout the life of the plant, and mines should conduct a full range of lab tests and run a complete plant simulation when looking to make significant changes. Every person interviewed for this article recommended engaging an expert at this stage.

“I understand that some operations may have their own process engineers. However, I would always recommend that original equipment suppliers and associated process specialists are consulted when approaching any optimization project,” Matthies said.

“It’s important that the team optimizing the process fully understands the ROM characteristics, the desired end-product and their influence on the machine’s settings and wider circuit.”

ROM characteristics provide operators with information on the product hardness, feed curve, abrasiveness — essentially predicting the flow sheet, equipment selection and possible equipment changes over time.

Because of this, circuit optimization requires a macro viewpoint of all equipment and targets within a flowsheet, along with a micro-view of crushers and other equipment on an individual basis. This can be hard for a mining company to achieve alone, and the utilization of experts at this stage can provide objective analysis and recommendations.

“When it comes to detailed specifics on the crushers themselves, the highest level of support comes from people who are knowledgeable in the design and operation of the equipment along with wider experiences,” Onnela said. “In our Chamber Optimization Program, Metso Outotec uses in-house developed simulation tools and laboratory equipment to study detailed parameters and understand the crushing circuit, and how changes also influence the other equipment.”

Crushing in the Digital Age

Improvements require measurements, and the capability to detect improvement potential from the measured data. Applying the latest digital technologies is adding an exciting new dimension to bettering the performance and lifetime of critical equipment such as crushers, and the ability to process big data is enabling valuable new performance and health-related services.

Onnela explained: “Measuring inherent variable crushing conditions requires longer-term data to make high-quality conclusions and profitable decisions. In this work, digital technologies are a key enabler.

“The ability to connect to crushers remotely allows access to huge amounts of accurate factual data. Supporting this, sensor development is also close to the level where we can talk about creating online digital twins of crushers, allowing scenario simulations and clear value-added action proposals based on data collected.

“Sensor technology also diminishes the need for sampling data manually in conditions where people can face health and safety risks. Online sensing also gives a better overall view of the crusher perfor-



A Metso Outotec Nordberg GP330 cone crusher in operation. (Photo: Metso Outotec)

mance condition compared to a sporadic sampling campaign.”

Digital technologies are essentially bridging the data gap between end-users and experts, allowing issues to be identified before they arise and preventative measures to be taken where necessary. With the rapid expansion of data collection and storage, many OEMs are now being asked to upgrade existing equipment so that performance data can be collected, quickly analyzed and reviewed regularly, leading to better performance and reliability.

Having full equipment data insights is particularly important for the mining and aggregates industries given that equipment is typically dispersed over large areas. Being digitally connected enables operators and maintenance staff to monitor the performance and health of their equipment quickly from the safety of their office.

“With the array of sensors and optical devices now available, real-time monitoring and, more importantly, instantaneous reaction to the results obtained, allows us to operate the crusher under its most



The team at Weir recently supplies custom-engineered ESCO crusher liners to an iron-ore mine in Russia. The customer gains four more days of wear life with a 16% increase in the bowl liner life and a 20% increase in mantle utilization. (Photo: Weir Minerals)

efficient conditions,” Malone concluded. “We also now have a better understanding of the predictability of component life, which allows us to proactively plan

maintenance and changeout schedules and prevent major time loss due to failure. This all leads to a quicker and safer way to work with a lot less downtime.”

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Pumps and Valves: Ready for Prime Time

Heavy-duty pumping systems are the norm in mining, but newer equipment designs and materials are aimed at lightening the load – in terms of weight, opex, mechanical complexity and service requirements

By Russell A. Carter, Contributing Editor



Gold producer Nordgold recently increases the processing capacity of its Taborny mine in Russia from 5 million to 7.5 million mt/y. Included in the expansion project is a new pumping station at the mine's heap leaching site comprising four Sulzer pumps, each with a capacity of 400 m³/h.

The number of pump types used at any large-scale metal mining operation might only be surpassed by the range of sizes, body materials, power demands and maintenance requirements associated with them. Pumping tasks can differ greatly — pit dewatering vs. mill discharge, slurry vs. sludge, for example — and like the human workforce that installs, inspects and services them, some pumps are generalists capable of handling a variety of jobs, while others are specialists, designed to handle dedicated pumping tasks.

They're among the oldest and most tradition-bound equipment types used in mining. As Harvinder Bhabra, head of the fertilizers, metals, mining and chemical process business segment at Swiss pump builder Sulzer, pointed out in a white paper last year, pumps have been used to transfer fluids for centuries, progressing

from early Egyptian shadoofs — basically a pole and a bucket — to the Greek Archimedean screw and on to the highly engineered designs available now.

They're also a major part of the picture in any future vision of Industry 4.0. Bhabra noted that over time, as industry processes became increasingly sophisticated, specifications for various pump types demanded innovative manufacturing techniques to keep pace. Some of these include hydraulic profiling, CAD/CAM, computational fluid dynamics, finite element analysis and 3D printing. Most recent developments link to the advent of the Internet of Things (IoT) and the collection of pump operating data and condition monitoring. Real-time visibility of a pump's performance provides a reduced risk of unplanned downtime caused by a failure. Mine-site pumps

also may be required to operate long after mining activity ceases, for care and maintenance purposes; reliability and remote monitoring capabilities are critical factors in those applications.

Next-generation models will likely not just transfer media more efficiently but will also be capable of sending performance and machine health data at unprecedented levels to a variety of digital platforms and devices, as mining companies continue to shift from capex to opex-based models that demand constant and comprehensive data flows for maximum effectiveness. Increasingly, companies are regarding pumps and the piping, valving and control networks they're part of as an integrated fluids management system that can be used innovatively to help resolve broad industry issues of water usage and energy consumption, along with specific ongoing concerns about life cycle costs, leakage and repair frequencies.

Design innovations that support this approach are proliferating rapidly, encompassing features ranging from easier access for inspection and adjustments to quicker changeout of wear-prone components.

Integrate for Efficiency

Mine and plant pumping requirements can span a range of demands that vary from simple and straightforward to multi-dimensional, and obvious system choices aren't always the complete answer to a pumping problem: For example, the favorable economics offered by a properly sized, efficiently powered and well maintained pump can be degraded by a piping setup that causes severe water hammer incidents resulting in leakage or pump damage; or a crucial heavy-duty valve may be so large that it requires extra vertical clearance to install and operate — and a crew of workers to safely maintain it; or perhaps a failing critical pipe section that was assumed to be protected against cor-

rosion by its fusion bonded epoxy (FBE) lining should have been roto-lined instead for better performance.

These are all reasons why an integrated approach to pump-system design usually pays off. (As an example, see the accompanying sidebar describing how one pump supplier's methodology solved multiple system demands at a Mexican gold mine.) All major pump manufacturers offer various levels of needs analysis, design consultation and on-site support both before and after system startup. And, as we'll see further along, third-party participants such as electrical and engineering contractors, pump component suppliers and others can provide significant value to customers through

advice and services related to pumping facility location and layout, monitoring and maintenance.

Recent pump models coming through the product pipeline offer end users a constantly expanding range of options for pump-system flexibility. Tsurumi, for example, has been particularly active during the past year, adding to its LH series heavy-duty submersible pumps for mining applications and introducing the GPN 837 heavy sand pump.

The new LH-D-series features two-pole, 110/185 kW motors and a double-suction impeller to deliver reliable performance in high-volume, high-head applications. The company said the pumps, with a maximum capacity of 14 m³/min and a max-

imum head of 92 m, meet the needs of open-pit and underground mining, heap leaching and large-scale tunnelling work.

According to Tsurumi, an important feature of the new LH-D series is the ability to draw large volumes of water from both the upper and lower sides of the double suction impeller, thus reducing thrust load, extending bearing service life and increasing the stability of pumping operations. The pumps have a flow-through design that actively cools the motor during extended operation at low water levels and a useful inspection window at the bottom of the stuffing box.

The top-of-the-line GPN 837 heavy sand pump is rated at almost 2,400 gallons per minute (gpm) and is designed

Designing a System to Meet Multiple Challenges

An open-pit gold mine in Sonora, Mexico, planned to expand after discovering additional mineral deposits. To support increased production, the mine needed an efficient water management solution that would boost the pumping capacity for the mine's process water and dewatering systems while ensuring the operation had a minimal impact on the local environment.

Xylem along with Bombas y Suministros del Norte, the local Xylem distributor, were tasked with a twofold challenge. The first goal was to develop a process water-pumping solution capable of feeding the high-pressure pumps that irrigated the extracted mineral to leach the gold from the ore. The second goal was to avoid contaminating the recovery pools with cyanide.

Working closely with the customer, the team engineered a system incorporating three products from Xylem's portfolio: Goulds Water Technology vertical turbine pumps and Flygt submersible dewatering pumps, paired with Aquavar IPC variable-speed controllers.

Twelve Goulds Water Technology turbine pumps were installed on four custom-built raft units, three pumps per raft, floating on reservoirs containing process recovery water and well water. The pumps feed high-pressure pumps to irrigate the extracted mineral ore.

They were paired with Aquavar IPCs, which are specifically designed for submersible and groundwater applications and enable the pumps to respond smoothly and efficiently to fluctuations in demand, minimizing wear and improving pump life. In this application, they control pumps speed based on water demand, energy savings and efficiency.

Two 60-hp Flygt NS3202.180 submersible pumps were also installed, as part of the dewatering system. These units come into play when the site has heavy rainfall, pumping water from one recovery pool when it fills to a second recovery pool. The Aquavar IPC ensures that all pumps operate as efficiently and consistently as possible, pumping 6,000 gpm.

Jessy Parmar, business development manager, Xylem Industrial Solutions, said, "We recommend a holistic approach to mine water management, examining all aspects of the system to maximize productivity, reliability and sustainability. An op-

timized system includes built-in protection against downtime caused by equipment failure. The first line of defense is effective monitoring and maintenance.

"However, the most critical equipment requires contingency planning and emergency backup. In this case, two CD150 Godwin diesel automatic self-priming pumps were installed as a backup for the Flygt submersible dewatering pumps. This provided peace of mind that, in the unlikely event of a pump failure, a solution was on hand to ensure the safety of the surrounding environment."

Since being installed, the process water and dewatering pumping solutions have operated reliably and efficiently. Having efficient and powerful pumps in place, suitable to this specific application and optimized by Aquavar IPCs, has ensured hassle-free operation.

Parmar continued, "Our mining customers take their environmental responsibilities seriously. As well as securing the safety of the surrounding ecosystem by ensuring the cyanide used to extract mineral ore did not leach into the recovery pools, our solution enhanced the productivity of the operation. Smart mine water management makes sense on many levels."



Three Goulds Water Technology turbine pumps on a Xylem custom-built raft unit are a key part of the process water solution. These turbine pumps feed high pressure pumps that irrigate the extracted mineral ore.

for use whenever large amounts of solid matter are involved, Tsurumi said, noting that the unit can pass up to 30-mm rocks. The 1,800-lb (815-kg), 39-in.-tall (1-m) pump is powered by a 50-hp (37-kW) motor and features an oil filter that uses centrifugal force to lubricate in any position. The GPN 837 pumps vertically up to 78 ft (24 m) and when submerged is pressure-resistant down to 30 m.

Tsurumi recently began to promote its Tandem Kit, a pumping innovation developed for high-head applications where the need for strong output — and thus, larger pumps — collides with a lack of installation space, a situation not uncommon in underground mining.

As a solution, Tsurumi developed the Tandem Kit, which is attached to the casing of the LH and LH-W series pumps and enables two pumps of the same model to be easily connected in series, providing twice the total head of a single pump at a fixed flow rate. The operating principle of this method is the same as that of a multistage pump, according to the company, which has six 4- to 40-hp (3- to 30-kW) pump models that are compatible with the kit, with most featuring a dual impeller design. The standard kit, which can be easily attached to the pumps at the work site, provides a maximum 833-ft (254-m) head, and a 400-m head is achievable with optional equipment.

Weir Minerals has launched several new products, including the VL axial pump, horizontal process pump and vertical high-pressure molten salt pump, all in the company's Lewis line. In addition, it introduced the mobile Multiflo LF pump range, available in different configurations to meet varied demands including applications where liquids may contain high percentages of solids or acidic conditions with low pH values. Mounted on either a trailer or a skid, the pumps are available with Tier 3 or 4 diesel power or an electric motor.

Weir said the pumps' impeller design and larger-diameter pump shaft enables efficient handling of large solids while reducing operational and maintenance costs. This is achieved through an advanced, high-efficiency pump-end that requires less energy to process fluids.

The MultiFlo LF offers flow rates ranging from 100 m³/h to 3,200 m³/h, and discharge heads of 10 m to 210 m. The line's robust bearing frame and pump shafts have been proven to result in fewer seal failures and shaft breakages under extreme conditions, according to the company.

Vertiflo announced the Series 1600 horizontal close-coupled, vortex end-suction pump line, offering capacity up to 1,600 gpm, heads of up to 170 ft, and capabilities for handling temperatures of up to 250°F. The pumps, offered in cast iron, stainless steel or alloy construction,

feature a convenient, cost-saving back pull-out feature for easy inspection or maintenance, and an impeller design that facilitates better passage of solids, reduces axial loading, and prevents dirt from entering the sealing area.

Innovation Leads to Optimization

Innovative applications of existing technologies and improved material properties are also contributing to pump performance and reliability. Sulzer recently reported that, by using bearing manufacturer SKF's fiber-optic sensing system to validate new pump designs, it can confirm product performance using actual measurement data previously unavailable. Sulzer said it used the SKF system to verify the design of a new centrifugal process pump.

The sensing system measures loads directly in the bearing, which gives a deeper insight into a pump's actual operating conditions. "Design verification, using real load data, is enabling Sulzer to further improve its pump designs, and enable product design verification with real-time data rather than calculated scenarios. It improves physical test confidence and reduces time to market" said Daniel Perreng, sales and market champion, fiber optic sensing at SKF.

The system uses load-sensing bearings with fiber optic sensors, fitting the most commonly used bearing sizes used in heavy-duty process pumps. Only minor modifications are needed to install the sensors in the bearing housing, according to SKF, which explained that it measures bearing loads, and changes in loads and directions, accurately and repeatably. The system can also determine housing and impeller qualities and alignment.

It was tested and validated on a Sulzer mechanical test rig. SKF said that while Sulzer used the system in a research capacity, an end user can also use it to collect detailed data in the field. SKF will offer global support for setting up the system and training of Sulzer staff at their R&D sites as well as provide data analysis.

Gorman-Rupp recently developed a new integrally mounted diaphragm priming assembly as an option on select 4-through 12-in. (100–300 mm) Prime Aire and Prime Aire Plus pump models. Offered as an alternative to the venturi/compressor priming system on Gorman-Rupp's priming-assisted pump models, the diaphragm primer delivers up to 60 cfm (1,700 lpm),



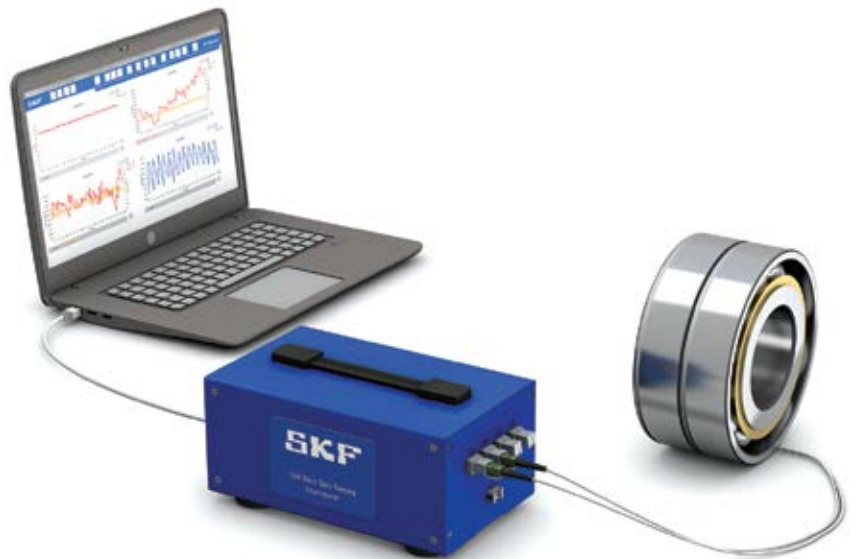
Weir Minerals says its latest MultiFlo pump model features an enclosed impeller design and larger diameter pump-shafts, allowing the unit to efficiently handle large solids at lower operating cost.

a vacuum to 30 ft (9.1 m) and is rated for temperatures as low as 15°F (-9.4°C).

The company said the new primer assembly, with fewer components, offers reliability and increased efficiency, as well as higher lifts. Reversed air flow and thinner valves help any liquids entering the primer to escape easily. The new primer's single-bearing housing has fewer leak paths and alignment issues compared with dual-bearing housing alternatives.

New synthetic-based products such as SealRyt Corp.'s Style 2017 stuffing box packing and South Africa-based Vesconite Bearings' Hitemp 160 can provide better performance in tough mine pumping applications, according to both suppliers. Style 2017 packing consists of pre-twisted high-carbon yarn with monolithic polyester filament that is interbraided with an asymmetric matrix. According to SealRyt, Style 2017 exhibits very high tensile strength, is "shaft friendly" and resists picking and fraying wear, along with offering significant heat dissipation properties. Its pre-twisted configuration allows all beneficial material characteristics to be present throughout the entire product matrix.

Earlier this year, Vesconite reported that a pump containing three sleeve bearings



A major pump manufacturer used SKF's new fiber-optic sensing system to validate its design of a new centrifugal process pump. The system can measure bearing loads and also can determine housing and impeller qualities and alignment, according to the company.

made from its new bearing material, Hitemp 160, which can operate at temperatures up to 160°C (320°F) and is resistant to abrasion, was tested and received South African Bureau of Standards (SABS) certification.

The pump tested, according to the company, is part of a range of large ver-

tical spindle suction pumps that will be primarily used in mining. "The pump manufacturer tested and included our proprietary Hitemp 160 material, which has excellent abrasive properties, negligible water swell and allows the pump to run dry periodically," said Phillip de Villiers, Vesconite pump applications specialist.

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Ehouses offer an economical, easily relocatable and flexible solution for mines that need to house and protect pump controls and other low- to medium-voltage equipment in remote areas. (Photo: Morrison-Maierle)

“Having a material that could aid in the pump’s need to run dry occasionally for short periods of time was a priority, and our material could serve that need in this specific application,” noting that the new material fills a gap in the market for high-temperature bearings that are able to operate in immersed conditions.

Ehouses Enter the Picture

Project owner reluctance to construct permanent structures at remote mine-site locations is converging with the industry’s attraction to digital solutions and modular design to drive increasing interest in Ehouses and similar movable enclosures for pump power, control and protection. As *E&MJ* reported in the November 2020 issue (see *3 Takes on Tailings Technology*, pp. 54–56), Weir now offers a skid-mounted pumphouse that features towable relocation capability, adjustable leveling, an internal gantry crane, pump component lifting jigs and multiple access points for ease of maintenance. One of these mobile systems, recently delivered to a client, incorporates an integral gland water supply system and a three-point pump base-mounting system, which allows the base and skid to act independently, minimizing the risk of pump and motor shaft misalignment during operation and the relocation process.

Ehouses — transportable prefabricated electrical equipment structures containing medium- and low-voltage switchgear and motor control electronics — are gaining popularity, in part because the reduced size of this gear due to digitalization allows more of it to be packaged efficiently in smaller spaces. *E&MJ* asked Brian C. Literski, elec-

trical engineer with engineering and professional services group Morrison-Maierle, to describe some of the advantages Ehouses can provide in pumping applications.

Literski, who has designed a number of Ehouses for Morrison-Maierle clients over the past 8-10 years, said project scheduling benefits are the primary driving factor for Ehouse orders from mining clients. “Mines identify a project, get it funded through their process, and then hurry to get the project installed within the fiscal period. The Ehouse approach enables the owner to procure long lead-time items — medium-voltage VFDs, for example — and have them shipped to the Ehouse manufacturer. The Ehouse manufacturer concurrently works on the building structure and once they receive the equipment they can install, test and wire most of the components in a matter of two to three weeks.

“Another plus for Ehouses is that once the design is bid and priced, we have seen very few change orders on them. Pricing is firm except for shipping rates, which are usually determined in the last few weeks before delivery,” Literski explained. Quality control and labor costs also enter into the equation: “Having qualified trades people working [on an Ehouse] in a manufacturing facility helps with quality control of the installations, and labor costs are lower” because project owners may avoid having to pay on-site workers overtime or per diem, he noted, particularly when conditions at the installation site can result in schedule disruptions. And, he continued: “The systems contained in the Ehouse are also more ‘plug and play.’ The entire unit arrives ready to be set in

place and have external wiring connected. The internal wiring is already completed with equipment mounted and tested.”

Ehouse sizes vary, Literski said, with typical dimensions in the range of 12 ft wide x 40 ft long x 12 ft high or less, which makes shipping logistics easier. He also designed a unit that measured 14 ft 2 in. wide x 46 ft long x 13 ft high, weighing about 90,000 lb with equipment installed. “I’ve also seen two structures bolted together to make a wider Ehouse with pass-through doors to access each side. And when the pumping station only uses low voltage (480 volts or below), we can use a Conex style — 8 ft wide, with varying lengths — to house the equipment.”

These enclosures can easily meet the industry’s need for expanded instrumentation, data collection and security, said Literski. “We’ve included control panels and communications equipment in every Ehouse we’ve designed. The data links we provide to these units have enough bandwidth for process control data delivery as well as security cameras. And Ehouses are not just limited to pumping stations; any remote location that requires electrical power, data acquisition, or a combination of both are good candidates.”

Valves: Less is More

Valves may not be the largest cost-per-unit item in a piping system, and their selection may not be at the top of project engineering focus, but the wrong choice — either from cost considerations or misapplication — can have a disproportionate effect on process efficiency and facility safety. Lack of corrosion resistance, inappropriate pressure ratings and pressure loss throughout the system, or unnecessary system weight and stress are all problems that can contribute to poor piping-system performance.

Weir Minerals, for example, unveiled the Isogate WR knife-gate valve line, which the company said is designed to provide higher reliability at considerably less weight than equivalent mining valves.

“We’ve optimized the Isogate WR knife gate valve’s body design, by reinforcing the areas subjected to the harshest wear and pressure. At the same time, we’ve reduced the weight elsewhere to produce a robust, long-lasting mining valve that’s significantly lighter than comparable products,” said John Abbott, global product manager, valves and tailings. “The weight reduction can be especially significant in situations

where a number of valves are used on a specific installation, such as in a hydrocyclone cluster, or where lightweight piping systems are used."

The gate has also been redesigned, with stronger materials resulting in a thinner gate that can still withstand the pressure of mining slurries. This combines with a unique gate guide that reduces deflection by ensuring smooth gate movement and less stress on the sleeve elastomer during blade transition.

The Isogate WR knife gate valve features the IsoGate WSL sleeve, which, according to the company, uses proprietary Linard HD 60 silica-reinforced natural rubber to solve three common problems with sleeved knife gate valves: leakage during cycling, tearing and load distribution ring (LDR) failure due to corrosion and erosion. The Isogate WSL sleeve fully encloses the LDR to prevent corrosion. By allowing the rubber to move as the blade cycles, the design reduces the chance of tearing while reducing slurry discharge by up to 75%. The sleeve, according to Weir, also can also be used in existing Isogate WS knife gate valves, improving wear life and decreasing discharge on cycling.

"When designing the Isogate WR knife gate valve, we focused on features that improve the everyday experience of working with our valves. This includes important things like improved grease distribution and improved body flushing when used on high solids concentration applications. In-depth finite element analysis (FEA) enables us to ensure the product's integrity, while making it lightweight. There are also a lot of smaller features to make life easier, such as a larger grease reservoir, ISO mount standardization and an external visual indicator for the valve's status," Abbott said.

Last year, Flowrox introduced a major design change for its larger (>DN 900) slurry knife gate valves. The traditional valve-actuator tower design, according to Flowrox, usually works well with this range of valve sizes, but also results in extremely tall units. Flowrox's new design eliminates the cylinder tower and repositions the actuator cylinders to the side, significantly reducing valve height.

As an example, a DN 1200 valve with the traditional tower design could be as tall as 5.6 m (18 ft) in open position, making the valve more difficult to handle, less stable during assembly and harder to access for maintenance. The new Flow-

rox design for valves from DN 900 to DN 1500 has actuator cylinders on each side of the valve. Compared to the conventional design, a Flowrox DN 1200 knife gate valve is only 3.6 m (12 ft) tall in a fully open position. All maintenance access points are located less than 2 m from the ground, making them easily accessible.

Another change affects the valve body, which in conventional designs comprises two pieces that are bolted together, increasing the possibility of leakage and requiring tedious unbolting/bolting during maintenance. The new Flowrox valve body is cast in one piece, reducing the risk of leakage

and containing fewer parts, for savings in spare part inventory and maintenance time.

Red Valve's long-established and popular Series DX slurry knife gate valve was designed to be durable and user-friendly for difficult slurry applications, according to the company. The fully elastomer-lined DX prevents slurry buildup or dewatering by eliminating the seat cavity. Reinforced elastomer sleeves seal against each other, providing a 100% full-port opening, minimizing turbulence and wear when the valve is open. Seats isolate and protect metal parts from contacting process media. When closed, the sleeve provides a drop-tight seal in both directions.

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Iron Ore Miner Fortescue Expands Fleet Mobility



Four Ford Rangers were retrofitted with an on-board vehicle automation system to support a driverless equipment transfer service.

Fortescue Metals Group recently reported that it's taken two steps to advance mine fleet mobility and emissions reduction, starting with the successful operational deployment of autonomous light vehicles (ALVs) at the company's operations in the Chichester Hub, comprising the Cloudbreak and Christmas Creek mines in Western Australia's Pilbara iron ore district. The company also said it is working with an engineering company to advance the concept of battery power for electric mining trucks.

Developed by Fortescue's Technology and Autonomy team as a solution to improve the efficiency of the Christmas Creek mobile maintenance team, the company said ALVs remove the need for fitters to make an estimated 12,000 28-km round trips annually to collect equipment and parts.

With the assistance of Ford Australia, four Ford Ranger pickup trucks were retrofitted with an onboard vehicle automation system to support the driverless equipment transfer service, which will improve efficiency and safety by enabling team members to spend more time on maintaining assets.

The company said the system features an integrated LiDAR/Radar perception system that facilitates obstacle detec-

tion and dynamic obstacle avoidance, a comprehensive independent safety management and fail-safe braking system and extensive built-in system monitoring and fault response capability. Successful deployment of ALVs at Christmas Creek will provide the opportunity to implement a similar system at other operational sites to improve safety, productivity and efficiency, according to Fortescue.

Fortescue CEO Elizabeth Gaines said, "With the flexibility to introduce similar systems into other mobile assets, this project is fundamental to our future mobile equipment automation projects."

Fortescue also announced an agreement with Williams Advanced Engineering (WAE) to design, build, test and integrate a battery system to power an electric mining haul truck. The project will involve the design and construction of a bespoke battery electric power train with the ability to regenerate power as the truck travels downhill. The battery will be built at WAE's facility in Grove, Oxfordshire, U.K., before being shipped to Perth, Australia, for integration into a 240-ton prototype haul truck for performance testing at Fortescue's mining operations.

To support the full implementation of a battery-electric haulage fleet, the project will also involve the development of a fast charging unit that will harness renewable energy from Fortescue's Pilbara Energy Connect network.

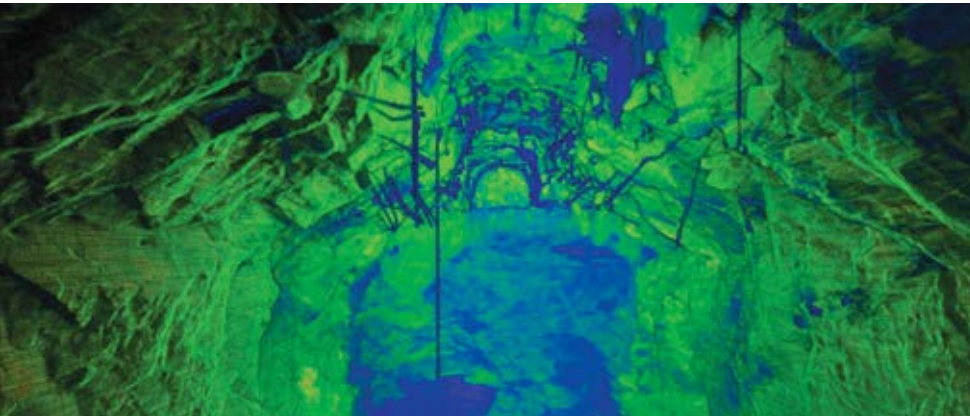
Gaines said: "Climate change is one of the most pressing issues facing the planet and Fortescue is committed to tackling this challenge head on through our industry leading target to achieve net-zero operational emissions by 2040. This includes a 26% reduction in Scope 1 and 2 emissions from existing operations from 2020 levels by 2030. With around a quarter of these emissions attributed to our mobile haul fleet, this represents a significant opportunity to drive our pathway to being diesel free."

Olympic Dam Finds New Uses for Underground Drone Tech

A recently released white paper from high-tech drone technology provider Emesent details how BHP's adoption of mobile LiDAR technologies, such as its Hovermap, at the company's Olympic Dam mine in South Australia has delivered numerous benefits. The paper, available at Emesent's website, indicates drone usage is helping to de-risk the transition of mining activity from the older and well-understood Northern Mining Area (NMA) to the newer Southern Mining Area (SMA) by providing unprecedented insights into the new rock mass.

Hovermap is a smart mobile scanning unit, which can be handheld or mounted to a variety of equipment types to provide autonomous mapping in risky or inaccessible areas. Its quick-release mechanism makes it easy to switch from drone to handheld use, enabling the collection of critical data both in the air and on the ground, with the ability to automatically merge the results. Weighing just 1.8 kg, it is portable and compatible with smaller drones such as the DJI M210.

Being able to safely scan previously inaccessible voids, stopes, drawpoints and orepasses allows BHP's survey, geology, engineering and geotechnical teams to validate and improve modelling, opti-



As shown in this stope scan image, Hovermap's rotating LiDAR provides a wide field of view, ensuring 3D data is collected in all directions.

mize stope design and predict stope behavior more accurately.

Emesent said Olympic Dam has continued to find additional use cases for the Hovermap system and the LiDAR data it captures. For example, it is now used across the mine to map the ore handling system and other vertical infrastructure and identify convergence and other deformation.

Training and regular use of the system in situ means operators are able to capture data confidently and competently via a range of methods — vehicle, tether, handheld and drone. End-users' ability to analyze and utilize the LiDAR data has also increased significantly over time.

In addition, the multidisciplinary approach to deploying Hovermap and sharing data has encouraged collaboration across technical teams at the site and led to the development of efficient new workflows. And, according to Emesent, Hovermap is helping BHP optimize revenue at the site. Based on production output published by BHP in 2020 and LME commodity prices for that year, Emesent estimates average revenue (EBITDA) per stope of \$20 million. The insights gained from data captured by Hovermap help BHP to improve confidence in the drivers of stope stability, and to develop informed responses to issues.

This potentially saves the company millions of dollars each year.

Anglo American Conducts Feasibility Study for South Africa's Hydrogen Valley

Anglo American announced a collaboration agreement to complete a feasibility study to develop a "hydrogen valley" anchored in the platinum group metals-rich Bushveld geological area in South Africa.

Spearheaded by South Africa's Department of Science and Innovation (DSI), the collaboration agreement also includes energy and services company ENGIE, the South African National Development Institute (SANEDI) and clean energy solutions provider Bambili Energy (Bambili).

The proposed hydrogen valley will stretch approximately 835 kilometers from Anglo American's Mogalakwena platinum group metals (PGMs) mine near Mokopane in Limpopo province in the north of South Africa, along the industrial and commercial corridor to Johannesburg and to the south coast at Durban.

This collaboration follows the launch in 2020 of the South African Hydrogen Society Roadmap, aimed at integrating hydrogen into the economy by capitalizing on the country's PGMs resources and renewable energy potential to revitalize and decarbonize key industrial sectors. The study will be conducted by ENGIE Impact and will identify tangible opportunities to build hydrogen hubs and explore the potential for green hydrogen production and supply at scale.

"The transition to a low carbon world is an opportunity to drive the development of cleaner technologies, create new industries and employment, and improve people's lives," said Natascha Viljoen, CEO of Anglo American's PGMs business. "Anglo American was an early supporter of the global potential for a hydrogen economy, recognizing its role in enabling the shift to greener energy and cleaner transport. Our integrated approach includes investing in new technologies, supporting entrepreneurial projects and advocating for policy frameworks that enable a supportive long-term investment environment for hydrogen to deliver that potential."

The regional PGMs industry will be central to such a hydrogen valley, with PGMs playing an important role both in Polymer Electrolyte Membrane (PEM) electrolysis used to produce hydrogen at scale and in fuel cells themselves.

Anglo American is already investing in renewable hydrogen production technology at its Mogalakwena PGMs mine and in the development of hydrogen-powered fuel cell mine haul trucks — the world's largest to run on hydrogen.

"The department's hydrogen valley partnership with Anglo American, Bambili Energy and ENGIE is an example of leveraging investments made in the Hydrogen South Africa Programme to create mechanisms for the uptake of publicly financed intellectual property," Dr. Phil Mjwara, DSI director-general, said. "The hydrogen valley is among the projects that will be implemented in partnership with the private sector to support the Platinum Valley Initiative, which is aimed at supporting small, medium and micro enterprises (SMME) to take advantage of opportunities in the green economy in support of a just transition."

The public-private partnership is aligned to the Government's Economic Reconstruction and Recovery Plans for South Africa, with science, technology and innovation playing a key role in supporting the country's plans to revitalise its economy.

Sebastien Arbola, ENGIE executive vice president in charge of thermal generation and energy supply activities, said, "ENGIE is delighted to be part of the hydrogen valley study. We are keen to share our knowledge and expertise encompassing the entire hydrogen value chain to accelerate hydrogen solutions' deployment in South Africa and beyond. We already have a demonstration project under way to supply the hydrogen for the world's first hydrogen mining truck being developed by Anglo American at the Mogalakwena PGMs mine.

Zanele Mavuso Mbatha, CEO Bambili Energy, said, "The initiative to develop the South African hydrogen valley and the collaboration between Bambili, Anglo American, ENGIE and the South African government is significant as it will build material public awareness, confidence and support for the hydrogen economy. This collaboration is illustrative of Bambili's view that a public-private partnership is critical in the development of this industry in the South African economy."

FLSmidth Opens Kazakh Facility for Regional Customers



FLSmidth opens its 5,200-m² Supercenter, which will focus on supplying solutions that extend asset lifecycle. (Photo: FLSmidth)

FLSmidth opened its 5,200-m² Service Supercenter in Karagandy, Kazakhstan. The center, which includes a 2,500-m² warehouse and a 1,200-m² workshop, will focus on the efficient delivery of mining equipment, component maintenance, and service and support.

The Supercenter holds a range of inventory, lab equipment, and spare and wear parts. It has a primary emphasis on supplying solutions that extend an asset's lifecycle. It supports repairs and rebuilds, equipment and component upgrades, parts and consumables strategic stocking programs, technical assistance, and customized service packages.

FLSmidth said the Supercenter will help it better support customers in Kazakhstan and Central Asia. It will enable the supply of "the best solutions, fast access to spare and wear parts, and, of course, local knowhow and expertise," Mikko Keto, president, mining, FLSmidth, said. "This move supports FLSmidth's ever-growing focus on customer service and aftermarket."

SIEMAG TECBERG Sells Hoists to Kazakh Mine

TNC Kazchrome JSC contracted SIEMAG TECBERG for the delivery of shaft hoisting systems for the Donskoy mine in the

Aktobe region of midwestern Kazakhstan. The order is for a shaft construction project expected to help triple chrome ore mining production.

The scope of the project includes two four-rope Koepe hoists with slide bearings and in tower arrangement, with electric drive power, hydraulic brakes, automation, and signaling technology; eight deflection sheaves; and related equipment and spare parts.

SIEMAG TECBERG said the order was indicative of the viability of its heavy machinery line. "We have once again prevailed against global competitors and especially against emerging manufacturers from China and Russia," Jürgen Peschke,

managing partner, SIEMAG TECBERG Group, said. "The continuous development of product innovations combined with the system integration of mechanics, hydraulics, automation, drive and signaling technology under the same roof is the unique selling point of SIEMAG TECBERG and this has led to the leading market position."

Kazchrome is owned by the Eurasian Resources Group, based in Luxembourg.

Donskoy is the second-largest chrome mine in the world by reserves. The operation employs 7,500 people.

ABB Installs Asset Vista in Chinese Coal

ABB installed ABB Ability Asset Vista Condition Monitoring at the Shanyang coal mine in Heyang near Weinan City in China's Shaanxi province. The digital mine solution was selected to streamline maintenance, minimize costs and optimize capacity.

Equipment at the mine includes a production hoist, two service hoists and one main ventilation system. The hoists are equipped with ABB brake systems installed previously by ABB China. The solution that ABB offered included a data acquisition system, five workstations, network devices and ABB Ability Asset Vista to monitor the hoists and the main ventilation system.

The supplier's track record at the mine and elsewhere helped it win the contract, the mine reported. "ABB's local technical competence and the adaptation and



ABB installs five work stations to support Asset Vista at Shanyang coal mine in China. (Photo: ABB)

scalability of ABB Ability Asset Vista were additional key factors in awarding this contract,” Chongyun Zhang, Shaanxi Chenghe Shanyang Coal Mine Co. Ltd., said.

ABB said Asset Vista has been installed at 18 sites worldwide since 2015, and the commissioning at Shanyang Coal Mine is the first for ABB in China.

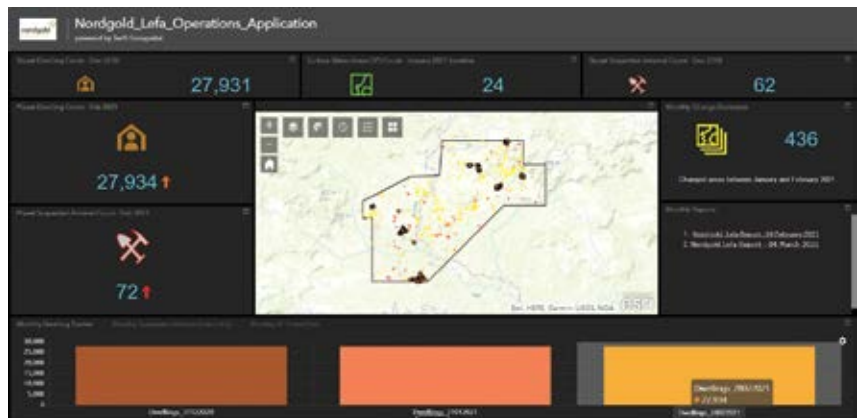
Salares Norte Buys Wenco FMS, More

Gold Fields selected Wenco International Mining Systems for a fleet management system (FMS) and supplementary solutions for Salares Norte mine in the Atacama Desert of Chile.

Wenco will supply its FMS and Benchmanager, a high-precision machine guidance system, to manage the site’s excavators, drills and dozers. The solutions, which use LTE technology, will gather real-time data to support rapid decision-making and to help increase productivity.

Salares Norte also bought Wenco’s ReadyLine asset health management system to help reduce unplanned downtime and extend equipment longevity.

Wenco said the supplier developed rapport with the miner while working together on the St. Ives project in Australia. “The successes we’ve had throughout Latin America, from Mexico to Argentina, really shows the expansion of Wenco’s capabilities in the region in just the past



A satellite-based monitoring system is adopted for use in monitoring Nord Gold’s 1,100-km² Lefa mine in Guinea. (Photo: Nord Gold)

few years,” said José Eugenio Saravia, regional manager, Latin America, Wenco.

Satellites Used to Monitor Lefa Mine

Nord Gold deployed a satellite-based monitoring system by Swift Geospatial Solutions at the Lefa mine in Guinea. The system uses imagery processing algorithms to proactively identify risks at the mine’s tailings storage facilities.

The system serves other purposes. It is used to monitor “community welfare by tracking community dynamics, including house building,” Nord Gold reported. It is also used to monitor artisanal mining activities near the 1,100-km² mine.

The system uses artificial intelligence, gives regular updates, and presents deliverables on a web-based dashboard.

Nord Gold said it is pleased with the system. “It will help us to receive timely and relevant information about the condition of Lefa’s critical environmental infrastructure and the mine’s immediate surroundings,” Evgeny Tulubensky, chief legal officer, Nord Gold, said. “Using this rich data, our aim is to continue reducing our impact on the natural environment and ensuring sustainable development of local communities.”

Normet Greenlights Multipurpose Facility for India

Normet’s board of directors approved the investment proposal for a new and expanded multipurpose facility in India. The facility will support equipment manufacturing, service operations, training, and research and development.

Normet said the move supports the company’s strategic-growth and customer-support ambitions. “We anticipate significant demand for our new equipment offering and this new facility will play a key role in fulfilling that demand,” said Kari Hämäläinen, senior vice president, equipment. “India is an optimal location for a manufacturing and R&D operations facility serving global markets.”

BME Primed to Partner for US Market

BME reported that it seeks partnerships, joint ventures and distribution agreements in the U.S. The company has an office in Denver, Colorado, and explosive magazines in Utah, and is primed to ser-



Gold Fields taps Wenco for its FMS and for Benchmanager for excavators, drills and dozers at Salares Norte (above). (Photo: Wenco)



With its popular electronic initiation offering, AXXIS, in demand BME is seeking partnerships to expand its footprint in the U.S. market. (Photo: BME)

vice and supply miners across the country, the company said.

The supplier can offer a full range of initiation systems for surface and underground applications, BME said.

"In addition to BME's AXXIS electronic initiation line, our private label arrangement with a major explosive manufacturer gives BME a complete product line in the USA," Joe Keenan, managing director, BME, said. "We are confident that BME's world-class, proven technologies will excite the U.S. market, especially those large U.S. drill and blast companies looking for a better deal and specialist service from their explosive supplier."

Partnership for AR Digital Twins

Arvizio partnered with Sight Power to deliver augmented reality (AR) digital twins to the mining industry. The partnership will enable Sight Power's Digital Mine platform to seamlessly share mining data, 3D models and LiDAR scans with Arvizio's Immerse 3D AR solution.

The resulting digital twins will help customers reduce costs, improve efficiencies, increase productivity and enhance safety, Sight Power said.

"Our work with leading mining companies using Digital Mine, demonstrated that combining operational technology, monitoring systems, devices and spatial datasets into a single workflow system, streamlines mining operations at every phase," CEO Sergey Reznichenko said. "We are delighted to team with Arvizio to integrate Immerse 3D AR visualization

into our workflows and use augmented reality to empower stakeholders around the world for a more efficient exchange of information, problem solving, verification of key operations and safety systems in their mining projects."

ESCO Taps Kinaxis for Supply Chain Optimization

ESCO contracted Kinaxis for its Rapid-Response and a planning technique that will transform its global supply chain. Kinaxis reported the solution will support global sales and operations.

RapidResponse will offer ESCO full connectivity and visibility across its sup-

ply chain. It will make available to everyone in the supply chain network a consolidated and timely company-wide view of data for analysis and in support of rapid decision making, Kinaxis said.

"Using Kinaxis, ESCO will gain the best balance of ready-to-configure applications and a flexible platform that can grow and evolve with the company," Kinaxis CEO John Sicard said.

ESCO is a division of The Weir Group.

Allseas Taps Strohm for Jumper

Allseas adopted a composite jumper by Strohm for use in recovering polymetallic nodules from seabeds at depths of 4,000 meters (m) to 6,500 m. Strohm will provide a spoolable thermoplastic composite pipe (TCP) jumper to connect the seabed vehicle to the vertical transport system.

TCP is 80% lighter in weight compared to its metallic equivalents, reducing the need for buoyancy. It provides good collapse resistance while maintaining sufficient flexibility, Strohm reported.

The solution's versatility and suitability compared to steel-reinforced alternatives made it appealing to Allseas, Strohm said. "TCP was first implemented by the oil and gas sector in 2007, and we have enjoyed zero failures to date making it an extremely reliable technology," Strohm CEO Oliver Kassam said. "It is also completely recyclable."



Allseas adopts Strohm's spoolable jumper for use in mining at depths of up to 6,500 ft. (Photo: Strohm)

Master Drilling Buys Big Stake in AVA

Master Drilling Group announced it acquired a 40% stake in AVA Solutions, a specialist in data-driven mining fleet management solutions. Currently, AVA's digital platform analyzes and tracks more than 1,800 load and haul vehicles across 28 different sites in five African countries.

Master Drilling said the move is part of the supplier's mission to prioritize innovation that helps customers lower costs, optimize operations and increase safety. "Our investment in AVA is aligned with our strategy to diversify our services and invest in opportunities in our existing target markets with low capital requirements and short return cycles," CEO Danie Pretorius said. "We believe that AVA has great growth potential, and we look forward to supporting them through our existing client base and networks internationally."

Bentley Systems to Acquire Seequent

Bentley Systems entered a definitive agreement with investors to acquire geology software maker Seequent for \$900 million and three million shares of stock. Upon closing, Seequent will operate as a stand-alone Bentley subsidiary with a new CEO.

Seequent employs 430 in 16 locations and has customers in more than 100 countries. Bentley's footprint in China will accelerate Seequent's expansion in new markets, Bentley said.

Seequent said customers should expect "business as usual" with "many product and commercial synergies eventually forthcoming."

The transaction is calendared to close in Q2 and is subject to customary closing conditions and regulatory approvals.

Kal Tire Commissions Reactor at Recycling Facility

Kal Tire reported the commissioning of one of two thermal conversion reactors at the supplier's new off-the-road tire recycling facility in Antofagasta, Chile. The reactor is undergoing full load tests.

As of March 15, the commissioning of the facility's second reactor was near completion, the company reported.

The facility was conceptualized in 2015. The recycling process uses heat and friction to cause a reaction that breaks the tires down into their basic elements.



The thermal conversion reactors at Kal Tire's OTR tire recycling facility in Antofagasta, Chile, uses heat and friction to help reduce tires to their component elements. (Photo: Kal Tire)

The impending opening of the facility will cap an effort that involved the national government, miners, and rubber producers, Kal Tire said. "There have been many learnings to get to this stage," Dan Allan, senior vice president, mining tires, Kal Tire, said. "We wanted to ensure we were building a recycling facility to the highest standards in every aspect of design, safety and environmental considerations."

Maptek Turns 40

Maptek celebrated its 40th anniversary. It was founded in 1981 as a computing solution supplier for geologists. The company founder got his start in computerizing coal seam drafting.

Initially, Maptek specialized in computerizing the plotting of boreholes and mapping coal deposits. It evolved over the years to become pioneer and a major player in ushering in the era of the digital mine.

In commemorating the anniversary, the company hailed how over the years it has helped democratize data. "We want to make sure our customers get the most of their data, sharing it across the organization in such a way that everyone benefits," CEO Eduardo Coloma said. "We give our customers the freedom to dream and ask for solutions to their real world problems."

JLT Joins Ivanti Validation Program

JLT Mobile Computers joined the Ivanti Wavelink Device Validation Solutions Pro-

gram. The program helps rapidly validate products for the Ivanti Wavelink software platform, which facilitates device and wireless infrastructure management.

Ivanti Wavelink said customers will benefit from easy access to mobile-enablement solutions that boost supply chain efficiency, productivity and security in the warehouse and across the supply chain.

"The aim is to create a formal ecosystem through which our partners can offer their customers pre-validated hardware and software solutions that eliminate the risks enterprises face when migrating applications to multiple modern hardware devices, software solutions and host applications to enhance efficiency," Kelly Unga, vice president, alliances and channels, Ivanti Wavelink, said.

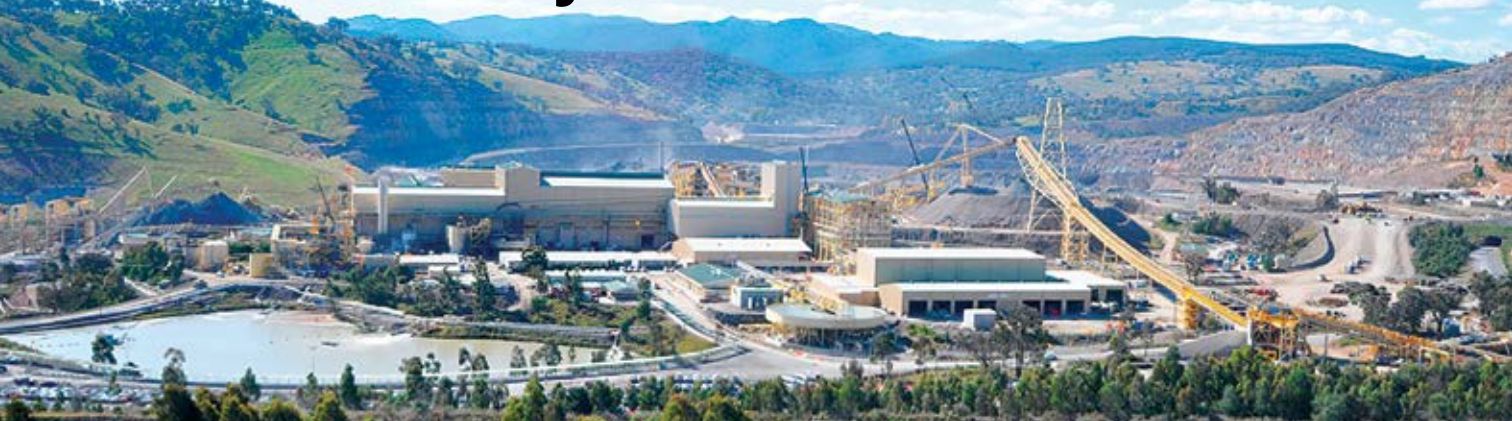
RPMGlobal Certified for SAP-Integration

RPMGlobal received SAP-integration certification for its enterprise product offerings. It means RPM's solutions can integrate with SAP S/4HANA and SAP S/4HANA Cloud-Extended Edition using standard integration technologies.

For the certification, separately deployable components were trialed in qualification procedures in a development lab setting.

The SAP certification is a significant indication of the technical alignment and interoperability capabilities between the solutions, RPMGlobal reported.

Newcrest Uses Eriez Separators at Cadia Valley



Newcrest Mining's Cadia Valley Operations (above) is the first to commercially apply HydroFloat coarse particle flotation for sulphides and will also be the first to use the coarse-particle flotation technology in a tail scavenging application.

Eriez Flotation said it will supply four HydroFloat Separators to Newcrest Mining for utilization in Stage 2 of Newcrest's Cadia Valley Operations expansion project in New South Wales, Australia. The announcement follows the delivery, commissioning and ramp up of four Eriez CrossFlow Separators and two HydroFloats as part of the Cadia Coarse Particle Flotation demonstration plant in 2018.

Eriez Flotation Global Managing Director Eric Wasmund said, "When Stage 2 of the Cadia Expansion Project is complete, 100% of the Concentrator No. 1 tailings will be retreated, significantly improving overall plant recovery for a coarser primary grind."

Eriez said the HydroFloat Separator is an aerated fluidized-bed (or teeter-bed) separator in which the synergistic effect of combining flotation with gravity concentration results in an outcome that cannot be achieved by either approach alone. Air bubbles are dispersed by the fluidization system, percolate through the hindered-setting zone and attach to the hydrophobic component, altering its density and rendering it sufficiently buoyant to float and be recovered.

The use of the dense-phase fluidized bed eliminates axial mixing, increases coarse particle residence time and improves the flotation rate through enhanced bubble-particle interactions. As a result, the rate of recovery is high for both fully- and semi-liberated particles. Eriez said Newcrest Mining is the first mining

company to commercialize HydroFloat coarse particle flotation for sulphides and the first in a tail scavenging application.

Cadia Valley's Stage 2 gold mine expansion will include plant upgrades designed to increase capacity from 33 million metric tons per year (mt/y) to 35 million mt/y while improving life of mine gold and copper recoveries by 3.5% and 2.7%, respectively.

Vale Advances Tailings Filtration, Block Plant Projects

Vale announced recently it has started operations at a tailings filtration plant located at the Vargem Grande Complex — the first of four filtration plants to be installed at Vale's sites in Minas Gerais, totaling \$2.3 billion in investments between 2020 and 2024. In addition to reducing the company's dependence on tailings dams, the startup is expected to facilitate an improvement in the average quality of Vale's product portfolio with the use of wet processing on the site.

Vale said the second filtration plant at the Itabira Complex and the first at the Brucutu site will begin operations in 2022. The four tailings filtration plants will serve beneficiation plants that can process 64 million mt/y of iron ore.

The company said the startup of tailings filtration operations in Vargem Grande is another step in stabilizing its iron ore production and reaching a targeted 400 million mt/y of production capacity by the end of 2022.

Last year, Vale reported it started the Pico Block plant, a pilot project to fabricate construction products made from tailings. The company said the plant at the Pico mine, in Itabirito, Minas Gerais, is designed to foster the circular economy within local iron ore processing activities. After an initial test period, Vale estimated that annually 30,000 mt of tailings that would be otherwise disposed of in dams or piles will be transformed into millions of pre-molded products with a variety of applications in the civil construction industry.

Vale, which said it had been studying options for reusing and recycling tailings since 2014, also noted that tailings use in civil construction in place of natural sand is a "green" solution, citing a 2019 United Nations report that said sand is the world's second-most heavily exploited resource after water, as it can be scarce and subject to illegal and predatory extraction. "Vale's sandy tailings resulting from ore processing activities have a high silica content and a very low iron content, in addition to a high degree of chemical homogeneity and optimum grain-size uniformity," said Rodrigo Dutra, executive manager for environmental licensing.

The company will invest approximately \$4.5 million in technological research and development in the first two years of operation of the Pico Block plant, which will receive technical support from the Federal Center for Technological Education of Minas Gerais (CEFET-MG). No products will be sold during the R&D phase.

“The main advantage of being in a plant inside a mining unit is the ability to study the application of various wastes and validate the technology developed in the laboratory in the production environment, on an industrial scale. This model will enable the transfer of technology in a more efficient way, in an environment that drives innovation,” explained Augusto Bezerra, lead researcher of the project and professor at CEFET-MG.

Vale plans to replicate the block plant in other units in Minas Gerais once the R&D phase at the Pico mine is completed. The company also combines efforts with more than 30 organizations, including universities, research centers and Brazilian and foreign companies to develop solutions for reusing mining tailings in different industrial sectors.

China’s First Commercial SART Plant Begins Production

BQE Water, a British Columbia, Canada-based provider of mining and metallurgical waste stream management solutions, has advanced the SART (sulfidization, acidification, recycling and thickening) plant it designed for a gold metallurgical facility owned by Shandong Zhongkuang Group to full production. Located in the Shandong Province in eastern China, the plant is operating under the technical supervision of BQE Water.

BQE Water said the SART plant eliminates the need for cyanide destruction, re-

covers copper and zinc as separate sulphide concentrates, and recycles free cyanide recovered by the plant to gold leaching.

The Zhongkuang SART plant, according to the company, also represents several firsts:

- It is the first application of SART globally where the cyanide competing base metals, copper and zinc, are recovered simultaneously from the leach solution as two separate high-grade concentrates that can be sold to generate incremental revenues.
- It is the first commercial-scale application of SART in China.
- It is the first SART plant where lime is used to control gas emissions to reduce operating costs and control the build-up of salts in the process water.
- It is the first SART plant to be integrated into a complex metallurgical flow-sheet that combines mineral flotation with cyanidation and SART in a Zero Liquid Discharge (ZLD) metallurgical facility with complete water recycle.

Study Shows Rare Earth Influence on Giant Ore Deposits

A study by scientists at an Australian university has found that a rare earth affects the fate of a key reaction with copper, gold, silver and uranium mineralization.

The work, conducted at Monash University in Victoria, is part of an “Olympic Dam in a test tube” project, where researchers tried in the laboratory to reproduce the

processes that resulted in the concentration of more than a trillion dollars’ worth of metals at one of the world’s best-known giant ore deposits: BHP’s Olympic Dam polymetallic operation in South Australia. The study, published in *Nature Communications*, found that cerium, a rare-earth element, speeds up important reactions and plays other significant roles.

“Previous thinking was that cerium just came along for the ride, that is, the ore fluids picked up some cerium on their way to Olympic Dam,” said study author Joël Brugger, professor in the Monash School of Earth, Atmosphere and Environment. “But our results place cerium in the driver’s seat, as the presence of cerium affects the fate of one of the key reactions associated with copper, gold, silver and uranium mineralization at Olympic Dam,” he said.

“The study establishes the fact that trace elements can have an important, yet difficult to predict, effect on the coupling between fluid flow, creation of porosity, and mineral dissolution and precipitation, that controls large-scale element mobility and rheology in the Earth’s crust.”

The university’s announcement pointed out that giant ore deposits represent an important part of Australia’s wealth and are key for resourcing a carbon-free economy. “In order to discover new giant deposits and efficiently mine existing ones, we need a mechanistic understanding of the processes that form — and transform — the minerals that host valuable metals,” Brugger said.

The research team discovered that cerium plays an active role during the replacement of magnetite by hematite: it acts as a catalyst that speeds up the reaction; provides space for the precipitation of the value minerals; and promotes a positive feedback between reaction and fluid-flow, which contributes to increasing the metal endowment of the deposit.

The study, according to the university, potentially has wide implications for the materials sector and industry. “Although more recycling is an important part of raw materials’ future, we need more metals than the sum of those mined to date to resource the transition to a carbon-free economy,” Brugger said. “Giant deposits are attractive because they can produce for decades, providing long-term security of supply and justifying large investment to ensure sustainable mining.”



A view inside Shandong Zhongkuang Group’s SART (sulfidization, acidification, recycling and thickening) plant in eastern China. Use of the SART technology at the gold plant, according to BQE Water, allows copper and zinc to be recovered simultaneously from the leach solution as separate high-grade concentrates.

New 600-mt-class Excavator Builds on Strong Success Record



Liebherr launched the R 9600 hydraulic excavator after a year of field experience in iron ore and coal in Australia. It is the successor to the popular R996B, and is based on the successful R9800 800-metric-ton (mt) unit.

The excavator is equipped with two QSK50 Cummins engines with advanced combustion technologies. A U.S. Environmental Protection Agency (EPA) Tier 4f- and EU Stage V-compliant version with the latest SCR after-treatment technology is available.

The management systems for the engines and hydraulic system reduce fuel consumption without impacting productivity, Liebherr reported. An electric drive version will be available soon.

In standard backhoe configuration with a heavy-duty wear package, the R 9600 comes with a 37.5-m³ bucket. It loads 190-mt trucks in three passes, T 264 240-mt trucks in four passes, T 274 300-mt trucks in five passes and T 284 375-mt trucks in six passes.

The excavator is also available in face shovel configuration with a 37-m³ shovel.

Liebherr described the cab as a first-class, state-of-the-art 14-m³ working space. The unit is equipped with the Liebherr Assistance Systems that provide analytics and actionable insights from live data.

Development of the excavator was customer-centric, Liebherr reported. Improvements over predecessor technology target ease of maintenance and heightened safety.

The R9600 will enter serial production by the end of 2021. Eight units will be operating in Australia by then.

www.liebherr.com

Battery-electric Top-hammer Longhole Drill

Sandvik introduced the fully automated DL422iE top-hammer longhole drill with an electric driveline system. It is the company's second battery-driven underground drill.

The DL422iE is designed for mass mining in 4-m by 4-m or larger production drifts. It is capable of continuous unmanned operation, automation and telereporting, and comprehensive data collection.

The rig can drill vertical and inclined fans with single or parallel 89-mm to 127-mm longholes up to 54 m in depth using ST58 and ST68 tube rods. It is equipped with the powerful 33-kW HF1560ST longhole rock drill, based on a proven concept, the company reported.

With an impact frequency of 40-45 Hz and optimized percussion dynamics, the unit delivers optimal bit-to-rock contact for improved energy transfer, Sandvik reported. This translates to decreased stress on the rock tools, lower tempera-





tures, and extended service life for the shank adaptor and tube.

Separately, Sandvik released a new dual-controls package for the DD422i and DD422iE face drills. The controls are designed to improve fleet optimization, versatility and performance, and to address a range of needs.

The package combines better drilling intelligence with readiness for sustained rough, multi-task usage, Sandvik reported. The controls better enable the drills to be used for multiple and different applications. Benefits include reduced noise levels, improved visibility, commonality of parts, improved performance, and reduced costs of drilling consumables.

The package was co-developed with mining contractor Byrnegut.

Sandvik also introduced the Power-Carbide SH69 for down-the-hole drilling applications. Offering a unique combination of strength, hardness, toughness and wear resistance, it can increase the service life of drill bits by up to 45%.

The SH69 is suited for hard and abrasive ground. Benefits include increased productivity, profitability and safety.

More recently, Sandvik introduced the Top Hammer XL for large-hole-size drilling. It offers a faster, more fuel-efficient, more cost-effective way to drill holes from 140 to 178 mm in diameter, the company said.

The Top Hammer XL is designed for use on the DP1600i drill rig, and with the new RD1840C rock drill and LT90 rock tools.

The rig is the newest member in the Pantera Dpi series. Sandvik reported it offers high penetration rates, advanced

automation options and drilling performance optimization.

www.rocktechnology.sandvik

World's First Face Drill With Internal Hydraulics

Epiroc reported the new Boomer M20 is the world's first face drill rig with internal hydraulics. The unit is designed and built to minimize unplanned stops and to maximize uptime and performance in demanding operations, the company reported.

The rig features a heavy-duty hoseless design that reduces the need for

hose repairs. On-board automation features, teleremote capabilities, and the ability to accommodate digital drill plans allow the unit to offer higher reliability, precision, performance and quality, the company reported.

The rig comes with a battery-electric driveline option, which offers savings on safety, maintenance, ventilation and cooling.

The Boomer M20 is perfect for miners and contractors that want to out-drill the competition through innovation, Epiroc said.

www.epiroc.com

Battery-powered Drill Rig

Mine Master released the battery-powered Roof Master 1.8KE drill rig for testing underground at the KGHM underground copper mine in Lubin, Poland.

The rig is for galleries from 3 to 5 m in height. It has a 1.8-m mechanized bolt mast for 9 bolts. The sodium-nickel battery is 120 kWh, and can recharge on the mine's existing network.

The battery charger is built on to the chassis. The battery will recharge when the rig goes downhill. The rig also features a closed, air-conditioned cabin.

The rig is the lowest in its class with a transport height of 1.65 m, the company reported. It is designed for a room-and-pillar system with slopes of 15°. It can





drill blast holes between 41 mm and 76 mm in diameter to a length of 3.2 m at heights above 1.7 m.

The rig is designed for easy maintenance, the company reported.
www.minemaster.eu

Containerized Compressed Air Solutions

Atlas Copco introduced AIRCUBE, containerized compressed air facilities. The sea containers house plug-and-play compressed air equipment, and help customers with space limitations to ramp up output quickly.

For example, the AIRCUBE can be equipped with fixed-speed or energy-efficient variable-speed drive compressors with sizes ranging from 11.2 kw to 82 kw. The compressor can then be matched with dryers, air receivers, filters and other add-ons. Atlas Copco will then assemble the solution in a 6.1-m or 12.2-m ISO-certified sea container.

AIRCUBE comes with ventilation, internal power distribution, certification and lighting. Options include environmental add-ons, smart connectivity and

control features, ISO 8573 filtration class options, and safety add-ons.
www.atlascopco.com

Smart Dryer for Conveyors, Plant Equipment

Donaldson Co. introduced the Ultrapack Smart dryer, which removes condensate and dries compressed air streams. It provides clean, dry, compressed air at critical point of use, and can be used to help extend equipment life and provide a safe and productive work environment, the company reported.

With a modular design, three versions are offered.

The filter elements and desiccant cartridge are easy to access and replace, the company reported. The solution uses Donaldson's UltraPleat filtration technology to separate liquid particles, improve the adsorption capacity of water vapor, decrease pressure loss, and save compressed air energy. UltraSilencer technology reduces the noise level.

The Ultrapack Smart dryer features a touchscreen display. It's remote on/off

signal can be linked to a plant's central control unit or machine controller.
DonaldsonProcessFilters.com

Rugged Tire for Trucks, Loaders, Dozers

BKT announced the EARTHMAX SR 412 for articulated trucks, loaders and dozers. The tire offers excellent stability and resistance to damage, the company reported.

Robust casing and all-steel belts help the tire avoid tears and punctures. The thread has a unique design with an E-4 depth, guaranteeing exceptional traction and high heat resistance, enabling greater vehicle control and maneuverability, BKT reported.

EARTHMAX SR 412 is available in 29.5 R 25 and 750/65 R 25.

The development follows the announcement of the prototype EARTHMAX SR 468, the biggest tire ever made by BKT.
www.bkt-tires.com



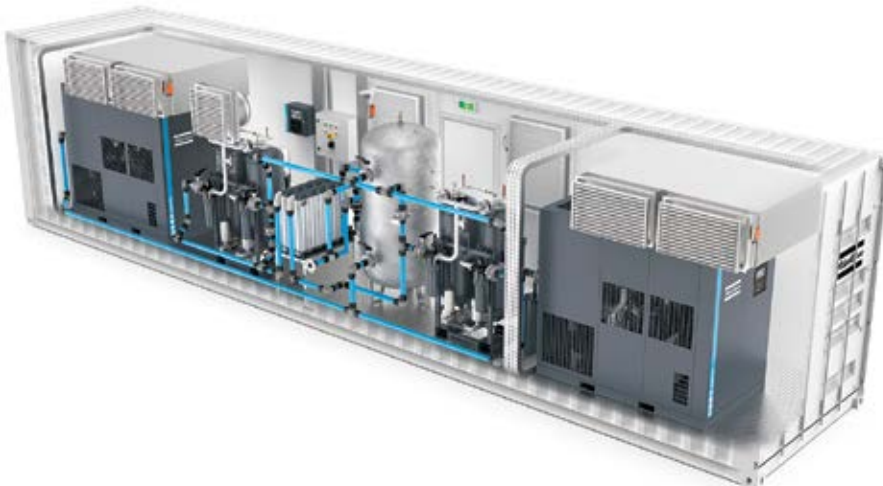
7-mt Loader for Narrow Vein Mines

GHH reported the articulated LF-7 loader carries a 7-mt, 3.6-m³ payload.

For large narrow vein or small mass mining operations, the LF-7 is 8.9 m long, 2.2 m wide at the bucket, and 2.2 m high. It weighs 18 mt, and is powered by a 164-kW Cummings diesel that complies with Tier 3 and 4 and Stage 5 emissions standards.

The loader has a four-gear Dana transmission. It can handle grades of 28% and offers a max speed of 27 km/h. It comes standard with a ROPS/FOPS-certified cab with a t-back seat.

The loader offers very low operating costs, GHH reported. Other benefits in-





clude ground-level maintenance, machine monitoring capabilities, and proximity detection. It is ideally matched with the MK-A20 truck.

www.ghmm.co.za

High-temp Load-indicating Fastener

Valley Forge & Bolt announced the new High Temp Maxbolt, which is able to operate in temperatures of up to 340°C (650°F).

The unit features a built-in analog gauge that indicates when the proper load is reached. With an accuracy of roughly 95%, it enables proactive maintenance, the company reported.

The High Temp Maxbolt helps reduce downtime, premature wear, and catastrophic joint failures. It is available in all the standard diameters and grades as the original Maxbolt.

www.vfbolts.com



Firefighting Foam With Increased Safety Factor

ANSUL showcased the NFF 3x3 UL201 non-fluorinated, alcohol-resistant firefighting foam concentrate for Class B firefighting. It offers class-leading, cross-functional performance for fire

knockdown and control and extended post-extinguishment burn-back resistance and vapor suppression.

The foam offers effective control and suppression on hydrocarbon fuel fires when used with standard, non-aspirated nozzles and hand lines. It has a viscosity similar to quality 3 x 3 AR-AFFF. It can be mixed using fresh, brackish or salt water. The minimum application rate is 6.5 lpm/m².

The foam passed with independent third-party witness the UL162 Type III test protocol for an AFFF, demonstrating an increased safety factor.

www.ansul.com

Automated Mineralogical Analysis

TESCAN ORSAY HOLDING announced TESCAN TIMA for automated mineralogical analysis. It delivers rapid access to actionable data, the company reported.

TESCAN TIMA handles high-throughput mineral processing with minimal need for operator intervention. Four energy-dispersive, X-ray spectroscopy detectors increase throughput speed for sample processing. A high-sensitivity spectral summing algorithm assures accurate and reproducible quantification for low-abundance elements, the company reported.

TESCAN TIMA automates mineral phase identification, measurement, and texture data interpretation, and then produces process mineralogy reports. It delivers reliable and reproducible quantitative data to improve processes, the company reported.

www.tescan.com

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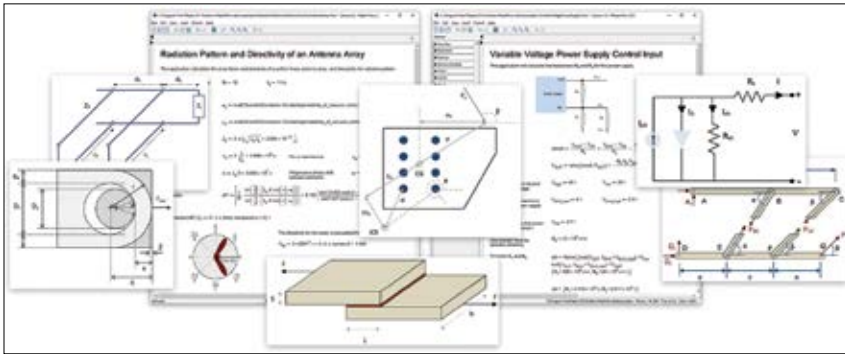
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Engineering Mathematics Software

Maplesoft released Maple Flow, a mathematics tool that provides a virtual, whiteboard-style environment that keeps calculations live as users refine, reposition and develop their calculations. The software provides an interface and workflow tailored to design engineers.

The company also released Maple, comprehensive math software. Maple is a general-purpose tool that supports advanced mathematical analysis and algorithm development done by research engineers.

www.maplesoft.com

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Magnetic Filter for Lithium Powders

Eriez showcased a white paper positing the Dry Vibrating Magnetic Filter is highly effective at removing very fine iron-bearing contaminants from hard-to-flow powders, such as lithium, to produce higher-quality end products. The paper reported the solution is ideal for both lithium producers and users.

DVMF uses a high-intensity electromagnetic and flux-converging matrix. The matrix amplifies a magnetic field to create a collection site for iron-bearing contaminants. The material being filtered is also vibrated, helping it flow evenly through the collection area.

DVMF reduces iron-bearing contaminants by an order of magnitude, with breakthrough results, Eriez reported.

www.eriez.com



Carbon-neutral Lubricants

Shell Lubricants announced a carbon-neutral portfolio for the industry sector. Products within the portfolio include Shell Tellus, Shell Gadus, Shell Naturelle, Shell Rhodina, Shell Omala, Shell Morlina, Shell Mysella and Shell Turbo.

Separately, the company reported Shell Rotella 16 Full Synthetic and Shell Rotella T5 Synthetic Blend for heavy-duty engines will also be carbon neutral.

The developments are part of a greater effort by the company to curb emissions. Shell reported it aspires to be a net-zero-emissions energy business by 2050 or sooner.

Shell.com

Metal Accounting System With Data Analytics

CASPEO announced the availability of data analytics tools in its metallurgical accounting solution, INVENTEO. The embedded algorithm gives consistent material balances from the raw data, the company reported.

The algorithm offers heightened accuracy by use of a statistical distribution of measurement errors based on probability. It also allows data quality checking.

The software solution, which originally was designed to help plant management switch from spreadsheets or databases to an efficient metal account-

ing system, ensures traceability and workflow in compliance with the AMIRA code.

Data reconciliation includes tolerances based on acceptable imbalances. INVENTEO also allows the user to set a range of expected values and generate a warning when out of it.

www.caspeo.net

Anti-fog, Comfortable Protective Glasses

Brass Knuckle reported Spectrum protective eyewear prevents fogging and offers optimal safety and comfort.

The glasses feature N-FOG anti-fog lens protection that won't wear or wash off. The protection exceeds European EN 166/168, the company reported.

Spectrum also features bowed, super-flex rubber temples that ratchet for custom fit. They touch the wearer only behind the ears, eliminating all pressure points. The face-hugging design inspires compliance, the company reported.

The second-generation PivotEase nose piece slides up and down, and pivots on a hinge for added secure fit. The



glasses also are anti-scratch, anti-static and offer UV protection.

They are available with a clear, smoke or amber lens.

www.brassknuckleprotection.com

Custom Polymer Seals

Oz Seals reported it offers custom seals made from Oz Super Polymer, with same-day machining and shipping available.

Oz Super Polymer is a triple-lubricated polyurethane offering maximum elasticity and effectiveness in fast operating cycles, the supplier reported. Super polymers have excellent temperature characteristics and longevity, Oz Super Polymer said.

www.ozseals.com

Lube With Metal Conditioner

Fuel Ox introduced Fuel Ox Infinity Lube Enhanced, described as a breakthrough



solution to maximize equipment performance and sustainability.

The line of lubricants is formulated with HDI-2500, a metal conditioner that helps improve the performance and longevity of engines and other machinery, the company reported. The conditioning reduces friction, lowers operating temperatures, and substantially decreases wear and tear.

Infinity Lube series products are non-toxic and were tested for 20 years prior to commercial launch.

www.fuelox.com

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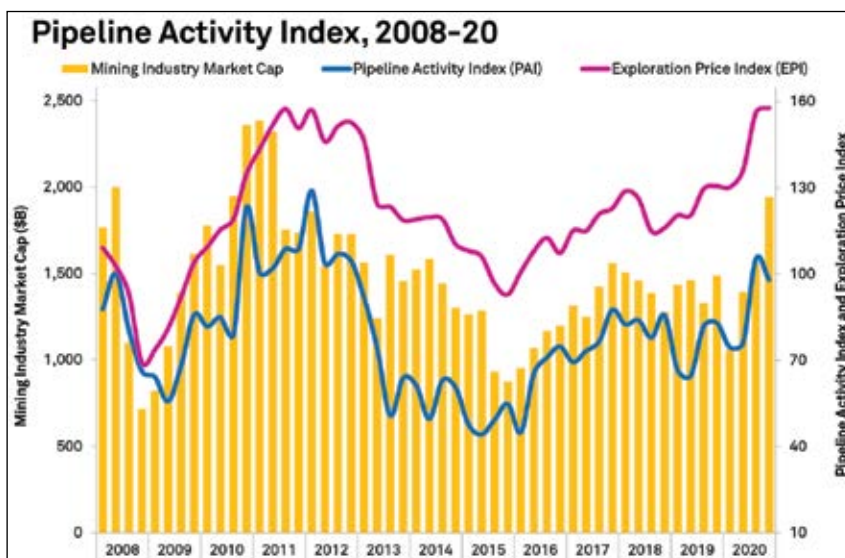
MINING media EUROPE

Exploration Budgets Should Recover in 2021

The global budget for nonferrous metals exploration decreased 11% to an estimated \$8.7 billion in 2020 from \$9.8 billion in 2019, according to the annual *World Exploration Trends Report* from S&P Global Market Intelligence, released in conjunction with the 2021 Prospectors & Developers Association of Canada (PDAC) International Convention.

Exploration budgets decreased modestly in 2020, due primarily to travel restrictions and lockdowns in response to the COVID-19 pandemic. An acute decrease in metal prices in March 2020, stemming from expectations of reduced demand, further hindered exploration planning and efforts, particularly in the first half. S&P Global Market Intelligence's survey of 2,500 exploring companies in 2020 revealed that the global aggregate nonferrous budget decreased 10% to \$8.3 billion year over year.

"The mining industry managed to navigate through market complexities and capitalize on rebounding prices and easing restrictions as 2020 progressed. The decline in the 2020 exploration budget was far less steep than initially anticipated at the end of the March quarter, when the global spread of COVID-19 was surging," said Mark Ferguson, research director at S&P Global Market Intelligence. "Although uncertainty remains, we are optimistic that exploration in 2021 will at a minimum reverse the pandemic-induced losses in 2020. Should



Source: S&P Global Market Intelligence's 2020 *World Exploration Trends Report*.

metal prices continue to remain strong over the next several months, it is likely that the 2021 exploration budget will be even stronger, rising by 15%-20% year over year."

Among the commodities covered by the report, only gold and silver posted modest increases in exploration budgets year over year, while budgets declined for the industrial metals, led by copper, zinc, lithium and cobalt. The relatively flat gold budget year over year and the quick recovery in metals prices cushioned the exploration sector from the severe declines seen during the global financial crisis in 2008.

The report also highlighted the industry's trend away from early-stage exploration to advanced- and near-mine exploration became more pronounced in 2020 due to travel restrictions, which made large-scale field programs more difficult to execute.

"In the medium term, explorers may continue to opt for exploration programs focused on less risky brownfields assets, yet such efforts will only serve to exacerbate production pipeline challenges for various commodities," added Kevin Murphy, principal analyst at S&P Global Market Intelligence.

E&MJ PRICES INDEX

(April 1, 2021)

Precious Metals (\$/oz)		Base Metals (\$/mt)		Minor Metals (\$/mt)		Exchange Rates (U.S.\$ Equivalent)	
Gold	\$1,730.30	Aluminum	\$2,212.50	Molybdenum	\$24,500	Euro (€)	1.177
Silver	\$27.92	Copper	\$8,768.00	Cobalt	\$50,105	U.K. (£)	1.382
Platinum	\$1,204.00	Lead	\$1,942.50			Canada (\$)	0.796
Palladium	\$2,648.00	Nickel	\$16,001.00	Iron Ore (\$/dmt)		Australia (\$)	0.760
Rhodium	\$27,100.00	Tin	\$27,369.00	Fe CFR China	\$163.68	South Africa (Rand)	0.068
Ruthenium	\$400.00	Zinc	\$2,765.50			China (¥)	0.152

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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