

# E&MJ

## ENGINEERING AND MINING JOURNAL

A Mining Media International Publication

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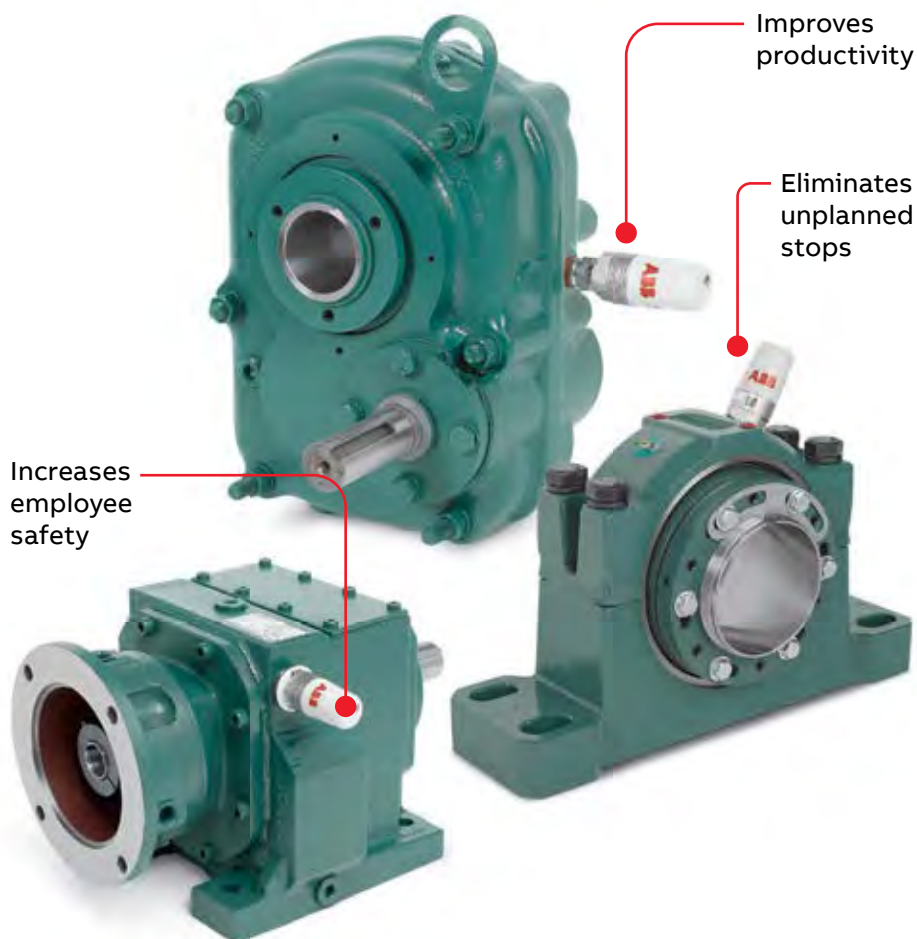
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## FEATURES

### Machines That Help Reduce Dilution

*The top narrow vein mining solutions on the market offer an increased power-to-weight ratio, lower ownership costs and higher productivity.....* **28**

### Mineral Processing Titans Merge

*Stephan Kirsch, president of Metso Outotec's new Minerals Business Area, discusses the next steps for the business and new opportunities.....* **34**

### Refining Gold Processing

*E&MJ looks at designs and technologies that are making gold flowsheets more efficient and economic .....* **36**

### Dealing With Data: Cybersecurity in the COVID-19 Era

*Working smarter and safer has become an industry creed for employee welfare. Companies should apply the same principles to data management.....* **52**

### Making the Right Call

*Idling production to improve mining conditions pays dividends .....* **58**

### Dewater, Derisk, Deliver

*Dewatering is a vital component of safe, productive mining operations, but its role and impact are often misunderstood .....* **60**

### Special Report: Mining in Peru

*The engine to rebuild an economy.....* **65**

## LEADING DEVELOPMENTS

Gold Field Greenlights Salares Norte .....	<b>4</b>
Rio Tinto Reveals Maiden Resource at Winu .....	<b>4</b>
Anglo American Maintains Production Despite COVID-19 .....	<b>4</b>
CEQ Issues Final Rule to Modernize NEPA Regulations.....	<b>5</b>
Barrick Serves Notice of Dispute Over Porgera Mine.....	<b>5</b>
Alamos Announces Phase III Expansion for Island Mine.....	<b>6</b>
OceanaGold Reports Positive PEA for Waihi District .....	<b>6</b>

## AROUND THE WORLD

<b>U.S. &amp; Canada:</b> Cameco to Restart Cigar Lake Mine .....	<b>8</b>
<b>Latin America:</b> Premier Gold Restarts Production at Mercedes Mine .....	<b>14</b>
<b>Australia/Oceania:</b> NQ Minerals Acquires Beaconsfield .....	<b>16</b>
<b>Africa:</b> Resolute Extends Mako's Life of Mine .....	<b>18</b>
<b>Europe:</b> Outokumpu Initiates EIA for Kemi Expansion .....	<b>20</b>
<b>Exploration Roundup:</b> Rio Tinto Begins Exploring Forum's Janice Lake Project....	<b>22</b>



*This month, E&MJ reports record gold prices and offers ideas on how miners can recover more gold from existing systems. On the cover, gold miners are using high-frequency vibrating screens to increase capacity, boost recovery and reduce overall water usage. (Photo: Derrick Corp.)*

## DEPARTMENTS

Calendar .....	<b>26</b>
Classified Advertisements.....	<b>94</b>
Equipment Gallery.....	<b>90</b>
From the Editor.....	<b>2</b>
Markets .....	<b>96</b>
Operating Strategies .....	<b>82</b>
People .....	<b>12</b>
Processing Solutions .....	<b>88</b>
Suppliers Report.....	<b>84</b>
This Month in Coal .....	<b>24</b>



**Steve Fiscor**  
Publisher & Editor-in-Chief

## EPA Moves Forward With Gold King Cleanup

They say gold loves misery and, so far, most would agree that 2020 has been a miserable year. Backing up that old adage, gold prices this month surged above \$2,000 per ounce (oz). On a percentage basis, the price of silver actually performed better than gold. The two usually rise and fall in tandem. Silver had been lagging, but it quickly caught up, rising more than 60% to nearly \$29/oz. Metal prices across the board have firmed (See Markets, p. 96). Look for an industry-wide revitalization to begin with precious metals.

As this edition was going to press, which would be the five-year anniversary of the Gold King mine blowout, the U.S. Environmental Protection Agency (EPA) and the state of Utah announced they had reached a settlement. On August 5, 2015, a contractor working for the EPA pierced the seal of a mine portal in southwest Colorado and released mine water laden with heavy metals. The catastrophic environmental incident created an orange plume that fouled the waterways from Silverton, Colorado, to Lake Powell in Utah and into Lake Mead in Nevada for weeks.

Pursuant to the agreement, Utah will dismiss its legal claims against the EPA and the United States, as well as EPA's contractors, and the EPA will strengthen Utah's involvement in the agency's work to address contamination at the Bonita Peak Mining District (BPMD) Superfund Site, which includes the Gold King mine and other abandoned mines. The EPA will also continue to partner with Utah on other environmental priorities, including the assessment of abandoned mine sites in Utah that may be impacting its waters as well as other projects to improve Utah's water quality.

EPA Administrator Andrew Wheeler positioned the agreement as a win-win for the EPA and Utah. "It will bring environmental benefits to Utah, avoid protracted litigation, and hopefully serve as a lesson for the future to avoid repeating the mistakes of the past," Wheeler said.

Utah Attorney General Sean Reyes was more direct. "After years of intense litigation and negotiations, we are very pleased that millions of dollars can now be spent toward mitigation, remediation and assuring water quality in Utah rather than years of more litigation, trial and appeals," Reyes said. "This is what cooperative federalism looks like — a true federal and state partnership. Protecting the people, public health and environment of [Utah] have always been the top priority in this case."

Reyes explained that they had two simple goals. First, get the federal government to clean up massive amounts of waste still lurking in many historic mining districts. Second, get the EPA to act on the Utah Department of Environmental Quality's application for millions of dollars in Clean Water Act funds for various projects. The EPA now expects to conduct and oversee the completion of more than \$220 million in work on abandoned mining sites with the potential to improve Utah's water quality. In late July, the EPA released for public comment a proposed plan for a centrally managed mine waste repository for the BPMD Superfund Site.

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# Gold Field Greenlights Salares Norte

Gold Fields has given Texas-based engineering firm Fluor notice to proceed with its Salares Norte open-pit gold mine in Chile. Fluor is providing comprehensive engineering, procurement and construction management services for the project located in the Atacama region of northern Chile situated approximately 4,267 meters above sea level.

Construction is scheduled to begin later this year and will be completed in early 2023. When fully operational, the mine will produce an estimated average of 400,000 ounces (oz) of gold per year over a 11.5-year mine life. The project will be managed by Fluor's Santiago, Chile, office.

Fluor has worked with Gold Fields since 2016 when it completed the pre-feasibility study for the project.

"This award is a tribute to the close working relationship that our team has developed with Gold Fields since first starting work on the prefeasibility study four years ago," Fluor Mining and Metals President Tony Morgan said. "Fluor's innovative engineering and construction approach has demonstrated how we have been able to provide solutions to the challenges this project has presented by its remote, arid and high-altitude location."

Fluor's scope of work includes the engineering, procurement of permanent plant material, tendering, award and post-award services for major construction and primary services contracts, as well as construction management and pre-commissioning support.

## Rio Tinto Reveals Maiden Resource at Winu

Rio Tinto has disclosed the maiden inferred mineral resource for its Winu copper-gold project and revealed the discovery of a new zone of gold-dominant mineralization approximately 2 kilometers (km) east of the Winu deposit in the Paterson province of Western Australia. The inferred mineral resource, reported at a 0.2% copper equivalent cutoff, is 503 million tons at 0.45% copper equivalent (CuEq). This includes a higher-grade component of 188 million tons at 0.68% CuEq at a cutoff grade of 0.45% CuEq.

To date, study work suggests the copper mineralization supports the devel-



Construction begins for on-site housing at Salares Norte in Chile.

opment of a relatively shallow open-pit mine, combined with industry-standard processing technology that is used at other Rio Tinto sites. Drilling continues to refine the overall geometry of the system and controls. The deposit remains open at depth as well as to the north and southeast. The Winu project team continues to work with local Nyangumarta and Martu traditional owners and regulators to progress the agreements and approvals required for any future development.

First production from Winu is targeted for 2023, subject to securing all necessary approvals.

The discovery of a new gold bearing zone, at a prospect called Ngapakarra, as well as a number of other encouraging drilling results in close proximity to the maiden Winu Resource, provides further encouragement about the potential for the development of multiple ore bodies within one system.

"We're taking a more agile and innovative approach at Winu, and are working on the studies for a small-scale, startup operation focused on Winu's higher-grade core as we take another step toward commercializing this deposit," Rio Tinto Group Executive of Growth and Innovation and Health, Safety and Environment (HSE) Stephen McIntosh said. "We are also assessing options for future expan-

sion in the Paterson region given the extent of mineralization identified to date and our large land package."

McIntosh said the exploration results support the company's position that the Paterson region has the potential to be developed into a large-scale operation over time.

## Anglo American Maintains Production Despite COVID-19

Anglo American said it continues to increase production and reached 90% of production capacity at the end of June. The company said it acted quickly to help safeguard the livelihoods of its workforce and host communities and those moves are paying dividends. "Anglo American has shown resilience in addressing the challenges posed by COVID-19," Anglo American CEO Mark Cutifani said. "Our comprehensive response supported the continuity of the majority of our operations during varying degrees of lockdown in different jurisdictions, albeit at reduced capacity in many cases."

In its recently released second-quarter production update, Anglo American reported that Minas-Rio in Brazil continued its strong operational performance, with 6.2 million metric tons (mt) of high-quality iron ore production. The Collahuasi mine in Chile increased copper produc-



tion by 38%. Metallurgical coal production suffered a 32% decrease to 4 million mt due to two incidents underground, at Moranbah and Grosvenor, as well as long-wall moves at Grosvenor and Grasstree. The COVID-19 lockdowns across southern Africa affected De Beers, Kumba, thermal coal operations, and platinum group metals (PGMs). Refined PGM output was also impacted by the repairs and ramp-up of the Amplats ACP plant.

Rough diamond production decreased by 54% to 3.5 million carats, primarily due to the COVID-19 lockdowns in southern Africa. Anglo said its production guidance remains unchanged at 25 million to 27 million carats, subject to continuous review based on the disruptions related to COVID-19 as well as the timing and scale of the recovery in demand.

Copper production increased by 5% to 166,800 mt due to continued strong plant performance at Collahuasi, partially offset by expected lower production at Los Bronces due to lower water availability resulting from the unprecedented drought conditions in central Chile. Production from Los Bronces decreased by 12%, to 80,700 mt. At Collahuasi, production increased by 38% to 75,700 mt, a historical record for the operation, driven by higher throughput (14 million mt vs. 12 million mt) and record copper recovery (92.0% vs. 87.3%), reflecting plant improvement projects implemented during 2019, as well as planned higher grades (1.31% vs. 1.21%).

The company said production guidance for the year remains unchanged at 620,000 mt to 670,000 mt, subject to water availability and the impact of the COVID-19 pandemic.

Platinum sales volumes decreased by 67% to 195,700 oz and palladium sales volumes decreased by 66% to 160,800 oz due to lower refined production in the period, which was partially offset by a drawdown in refined metal inventory to supplement sales. Production guidance is unchanged at 1.5 million to 1.7 million oz of platinum and 1 million oz to 1.2 million oz of palladium.

Kumba Iron Ore's total production decreased by 20% to 8.5 million mt. This reflects lower workforce levels in response to the COVID-19 lockdown, the subsequent reopening of operations with reduced workforce levels of 50% and the ramp-up in production to normal

run-rates in June. Sishen's production decreased by 21% to 5.8 million mt and Kolomela's production decreased by 17% to 2.7 million mt. Full-year guidance for iron ore remains unchanged: Kumba, 37 million to 39 million mt; and Minas-Rio, 22 million to 24 million mt.

## Barrick Serves Notice of Dispute Over Porgera Mine

Barrick Gold announced that its subsidiary, Barrick (PD) Australia Pty Ltd., an investor in the Porgera mine, has given

notice to Papua New Guinea (PNG) that a dispute has arisen under the Bilateral Investment Treaty (BIT) between PNG and Australia. Barrick PD said the dispute arose out of the PNG government's decision not to extend the Porgera Special Mining Lease (SML) in violation of the terms of the BIT and international law governing foreign investment.

Barrick PD is seeking to recover damages it has already suffered and damages it may suffer in the future since PNG refuses to grant an extension of the Porgera SML,

## CEQ Issues Final Rule to Modernize NEPA Regulations

On July 16, the U.S. Council on Environmental Quality (CEQ) announced its final rule to comprehensively update and modernize its National Environmental Policy Act (NEPA) regulations for the first time in more than 40 years. The announcement comes after a multiyear review of its NEPA regulations, and after receiving more than 1.1 million public comments.

"Through the rulemaking process, we heard from a variety of individuals, organizations, and job creators that the regulations were overly complex, led to unnecessary litigation, and delayed important infrastructure and other projects," CEQ Chairwoman Mary B. Neumayr said. "The final rule will make the NEPA process more efficient and effective, ensure consideration of environmental impacts of major projects and activities, and result in more timely decisions that support the development of modern, resilient infrastructure."

Currently, the average length of an environmental impact statement is more than 600 pages, and the average time for federal agencies to complete such NEPA reviews is 4.5 years. NEPA is also the most litigated area of environmental law. Delays due to lengthy reviews and lawsuits increase costs for project applicants, states, tribes, localities and taxpayers, according to the CEQ.

CEQ's final rule will modernize the NEPA regulations to facilitate more efficient, effective, and timely environmental reviews by simplifying and clarifying regulatory requirements, including a two-year goal for completing environmental reviews. The final rule codifies Supreme Court and other case law, updates the regulations to reflect current technologies and agency practices, eliminates obsolete

provisions, and improves the format and readability of the regulations.

The rule also exempts certain loan guarantee programs from the NEPA process, which will reduce unnecessary burdens on small businesses and family farms. Additionally, the rule will expand public participation and the involvement of tribal governments in the NEPA process. The modernized NEPA regulations will accelerate the environmental review and permitting process for development of modern, resilient infrastructure, management of our federal lands and waters, and restoration of the environment.

"NEPA reviews have become very costly and time-consuming, threatening the construction of important infrastructure projects and job creation across this country," EPA Administrator Andrew Wheeler said. "There is a direct link between a wealthier economy and a cleaner environment. EPA is confident this regulation can help both the U.S. economy grow faster and safeguard its environment for future generations."

"While a NEPA analysis has become 'standard operating procedure' for our members, it also has become increasingly more cumbersome, time consuming and expensive," American Exploration and Mining Association (AEMA) Executive Director Mark Compton said. "NEPA is no longer the planning and decision-making tool it was designed to be. Instead, it has become the tool used by obstructionist groups who oppose responsible and lawful mineral development on federal public lands."

He added, "[This] is a positive step toward a more effective permitting system while maintaining important environmental safeguards and ensuring meaningful public involvement and participation in the NEPA process."

the company said. If the dispute cannot be resolved through consultations and negotiations, Barrick PD has elected to refer the dispute to arbitration before the World Bank's International Centre for Settlement of Investment Disputes (ICSID).

Barrick Niugini Ltd., the joint venture between Barrick PD and a subsidiary of Zijin Mining Group Ltd., has also commenced conciliation proceedings against PNG before ICSID, Barrick said.

Barrick said it continues to advocate for a negotiated solution to an extension of the Porgera mining lease on terms that would be beneficial to all stakeholders.

### Alamos Announces Phase III Expansion for Island Mine

Alamos Gold reported results of the positive Phase III Expansion Study conducted on the Island gold mine, located in Ontario, Canada. Based on the results, it is proceeding with its Shaft Expansion project, which will increase production to 2,000 metric tons per day (mt/d) from 1,200 mt/d. A detailed evaluation of several scenarios demonstrated the shaft expansion as the best option to grow mineral reserves and resources, according to the company.

Upon completion, production from the Island gold mine should be able to average 236,000 ounces per year (oz/y) starting in 2025, a 72% increase. The company believes the move would lower average all-in sustaining costs to \$534/oz starting in 2025, a 30% decrease. It would double the current eight-year mineral reserve life, based on a mineable mineral resource of 9.6 million mt grading 10.45 g/mt of gold, which equates to 3.2 million oz.

"Island Gold has been a tremendous acquisition," Alamos Gold President and CEO John A. McCluskey said. "We ac-

quired it in 2017 at a cost of \$600 million when it had 1.8 million oz of mineral reserves and resources. The deposit has more than doubled to 3.7 million oz and we expect further growth yet."

He added that the mine is one of the most profitable in Canada and the expansion will increase production and reduce costs, making it even more profitable.

The Phase III Expansion envisions the installation of a shaft, paste plant, and an expansion of the mill and tailings facility. Total capital expense for the project is estimated at \$514 million over five years. The operation will transition from trucking ore and waste to skipping ore and waste to surface through the new shaft infrastructure.

The total construction capital for the shaft installation including all supporting infrastructure is \$232 million. A 5-m-dia. concrete lined shaft will be constructed with a steel head frame. The shaft will house two 12-mt skips in dedicated compartments for ore and waste movement, and a double-deck service cage for the transport of personnel and materials. The shaft will be sunk to an initial depth of 1,373 m. The hoisting plant is designed for an ultimate depth of 2,000 m providing flexibility to accommodate future exploration success. At the initial depth of 1,373 m, the shaft has a capacity of 4,500 mt/d, more than sufficient to accommodate the peak mining rates of 3,300 mt/d (ore and waste).

The increased mining will be supported by a significantly smaller mobile fleet than required under ramp-mining scenarios. A total of five haul trucks will be required to support a mining rate of 2,000 mt/d. This compares to a peak of 18 haul trucks required to sustain ramp haulage at 1,200 mt/d. This also lowers

ventilation requirements, and electricity and diesel consumption.

The expansion will also include mill upgrades totaling \$40 million. Mill recoveries are expected to average 96.5% over the life of mine.

### OceanaGold Reports Positive PEA for Waihi District

OceanaGold has announced the results of a preliminary economic assessment (PEA) of development of four mining projects in the Waihi district on the North Island of New Zealand. The projects include Martha Underground (MUG), Wharekirauponga Underground (WKP), Martha Open Pit Phase 5 Cutback (MOP5) and Gladstone open pit.

WKP is located 10 kilometers (km) north of Waihi.

The forecast financial and operating metrics reflect the inclusion of the four projects as they progressively contribute to production, beginning with MUG in the second quarter of 2021. The PEA assumes an initial total of 2.2 million oz of gold produced, after application of metallurgical recoveries averaging 90%, over the life of the operations to 2036.

Oceana will continue to drill the Martha and WKP underground deposits with the aim of increasing the size of both resources.

The PEA assumes underground mining at MUG and WKP and conventional open-pit mining at MOP5 and Gladstone. MUG is expected to produce 35,000 ounces (oz) to 45,000 oz of gold in 2021, with production beginning in the second quarter utilizing modified Avoca and remnant mining methods. Annual gold production is forecast to range from 35,000 oz to 45,000 oz in 2021 to approximately 300,000 oz of gold in 2028.

Total capital investment to develop the four deposits is estimated at approximately \$447 million over eight years. The life of mine all-in sustaining costs are forecast at \$627/oz, while life-of-mine cash costs are forecast at \$557/oz, including estimated royalties.

"The critical path for success is expected to be resource consenting (permitting) of WKP and surface projects including the Martha Open Pit Phase 5 and additional tailings storage capacity," OceanaGold President and CEO Michael Holmes said.

Oceana expects to complete a feasibility study for MUG in the first quarter of 2021 and a prefeasibility study for WKP in the second half of 2021.



With shaft haulage, the Island gold mine will increase production and reduce the number of trucks needed to reach the goal.





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# Cameco to Restart Cigar Lake Mine



The restart at Cigar Lake will depend on the company's ability to establish safe and stable operating protocols.

Canada-based Cameco plans to restart its Cigar Lake uranium mine in northern Saskatchewan at the beginning of September. Initial production is expected to take about two weeks and the company said it will not be able to make up for lost production during the shutdown. The mine was put on care and maintenance on March 23 due to the threat posed by the coronavirus. If the company is able to restart and maintain production, it is targeting a production of 5.3 million lb for 2020.

The restart at Cigar Lake will depend on the company's ability to establish safe and stable operating protocols and the availability of the necessary workforce and how the COVID-19 pandemic is affecting northern Saskatchewan, the company said.

Cameco President and CEO Tim Gitzel said the current pandemic has disrupted global uranium production, but the risks to supply are greater than the risk to demand.

"Therefore, we think our plan to restart Cigar Lake at the beginning of September is prudent," Gitzel said. "While health and safety are the primary considerations for the timing of our Cigar Lake mine restart decision, there were also commercial considerations, including market-related factors and the impact on our cost structure."

The decision represents an "appropriate balance of the commercial considerations affecting our decision," he added.

The company has \$878 million in cash and short-term investments on its balance sheet and a \$1 billion undrawn credit facility, which it does not anticipate it will need to draw on this year.

Gitzel said the company believes risks have been reduced thanks to a unanimous decision by the Federal Court

of Appeal in the company's favor regarding its tax case with the Canada Revenue Agency (CRA) for the tax years 2003, 2005 and 2006. "Based on our belief that the principles in the decision apply to all tax years subsequent to 2006, we expect to recover the \$303 million in cash paid and \$482 million in letters of credit secured with the CRA in relation to this dispute," he added.

## Teck Delays Red Dog Concentrate Shipments

During early July, Teck Resources reported a failure of a loading arm on one of two shipping barges at the Red Dog Operations' port in Alaska. The company said it has completed testing of the loading arm on the second shipping barge at the port to ensure its integrity. It also confirmed there were no injuries or environmental impacts related to this incident.

As a result, the start of the Red Dog shipping season has been delayed. Teck currently expected to start shipping from Red Dog with one barge operational, and that repairs to the other barge will be completed in about a month. This will affect the timing of customer deliveries. Barring unforeseen severe weather conditions, Red Dog expects to ship all of its production during the shipping season, despite the mechanical incident.

## Generation Mining Initiates Marathon Feasibility Study

Generation Mining Ltd. has contracted with all of the major engineering companies that will participate in the feasibility study on its Marathon palladium-copper project in northwestern Ontario. The fea-

sibility study is expected to take approximately seven to eight months.

The feasibility study team consists of G-Mining Services, mine plan and mineral reserves, infrastructure scope of work and integration of the costs and economic analysis. Ausenco Engineering Canada Inc. is progressing the process facility layout and design based on the metallurgical testing that is currently under way at SGS-Lakefield. Knight-Piesold will design the tailings facility and open-pit geotechnical engineering; and in support of the feasibility study and environment impact interactions, Stantec and Ecometrix. P&E Mining Consultants Inc. will be responsible for the mineral resource estimate.

"I am confident that these firms will optimize the value of the Marathon-PGM property and will continue to de-risk the project," President and CEO of Gen Mining Jamie Levy said. "Our goal is to maximize the Net Present Value of the project while designing an operation that will minimize environmental impacts and provide economic benefits to the local communities."

He added that the project will be close to shovel-ready and well-timed to the buoyant palladium market.

At this early stage, the work on the feasibility study will consider an optimized processing and mine production rate that is more aggressive than what was outlined in the preliminary economic assessment (PEA) back in January. That PEA that contemplated starting at 5 million metric tons per year (mt/y) and expanding to 8 million mt/y after five years.

The Marathon deposit is the largest undeveloped platinum group metal Mineral Resource in North America. The Marathon property covers a land package of approximately 22,000 hectares. Generation Mining acquired a 51% interest in the Marathon property from Sibanye Stillwater on July 10, 2019, and can increase its interest to 80% by spending \$10 million over a period of four years.

## Alamos Completes Expansion at Young-Davidson Mine

Alamos Gold has completed the lower mine expansion at the Young-Davidson mine in Ontario, Canada, with the successful commissioning of the Northgate shaft. In



addition to the Northgate shaft, the underground crusher and conveyor system have also been successfully commissioned. Mining rates are expected to ramp up through the second half of the year to 7,500 metric tons per day (mt/d) by the end of 2020.

"This marks a significant milestone for Young-Davidson and a turning point for Alamos as we transition from a reinvestment phase to a period of strong free cash flow growth," President and CEO Alamos Gold John A. McCluskey.

## Kirkland Lake Extends Suspension at Holt Complex

Kirkland Lake Gold Ltd. announced the suspension of operations at the Holt Complex in Ontario will be extended until further notice. The company suspended business activities at the complex on April 2 as part of its COVID-19 protocols, and at the same time continued with a strategic review to assess a potential restart of the operations.

The Holt Complex, including the Holt, Taylor and Holloway mines and Holt Mill, was designated as non-core by the company on February 19, with the company planning to consider all options to maximize the value of the assets. The company said high cost structures, low grades, diminishing reserves and requirements for new investments have resulted in significant negative cash flows from these operations, and are key drivers of its decision to extend the suspension of business activities.

"When we transitioned Holt Complex to suspended operations in early April, our first step was to provide base wages to all affected workers for the first month," President and CEO of Kirkland Lake Gold Tony Makuch said. "We also began working to identify opportunities to reassign as many employees as possible from the complex to new roles at other sites within our Canadian operations."

To date, more than 220 employees at Holt Complex, from a total workforce of 475 people, have been reassigned to new positions, or have recently been offered new roles within the organization, Makuch said.

Moving forward, Makuch said the company will continue to review strategic options for the Holt Complex properties, including the potential for additional exploration activities in the area.

## Labrador Gold Gets Exploration Permit for Kingsway

Labrador Gold Corp. has received approval for mineral exploration on the Kingsway



## Safford Rescue Teams Help Stranded Kids

The Emergency Response Team from the Safford mine recently helped rescue a 14-year-old girl and 10-year-old boy who became trapped in a 30-ft-deep hole. The kids were enjoying natural waterslides in a creek that feeds into Frye Mesa Reservoir near Safford, Arizona, when they reached a spot too dangerous to slide through and could not escape.

Located 170 miles east of Phoenix, the Safford mine is a large open-pit mine operated by Freeport-McMoRan. Having trained with the local globe fire department and Graham County Search and Rescue teams, the Safford Emergency Response Team was the first on scene and assisted through the night and early morning to safely rescue the kids.



Hats off to the first responders, including Safford Health and Safety technicians and Rescue Team members: Ray Bejarano, Chance Norton, Louis Enriquez, Robert Olivar and Danny McEuen.

Property from the Department of Natural Resources, Newfoundland and Labrador. Receipt of the approval, which is good through July 22, 2021, means the company can now begin mobilizing field crews to Gander to kickstart its summer exploration program.

LabGold has planned a systematic exploration program that leverages its geochemical database to rapidly follow up known anomalies and generate drill targets. The results of the surveys, together with detailed geological mapping will be used to plan a first phase drill program currently scheduled for the fall.

"We are excited to get the go ahead to carry out our proposed program at Kingsway," President and CEO Roger Moss said. "Due to our database and our research over the last four months, we have a very good idea of where to focus our efforts to maximum effect to aggressively advance the Kingsway property to the drill stage. We anticipate an exciting field season exploring for Fosterville style gold mineralization in the Gander gold district."

Exploration to date in the Gander district has shown the effectiveness of soil sampling to detect gold mineralization. Most of the known gold occurrences were discovered by following up gold in soil anomalies.

## Marigold Produces 4 Millionth Gold Ounce

SSR Mining Inc.'s Marigold mine has achieved another major milestone with

the production of its 4 millionth ounce of gold on June 30. The Marigold mine has been in continuous operation for more than 30 years and produced a record 220,227 ounces (oz) of gold in 2019.

"Four million oz of gold from continuous production is a testament to the scale and quality of the Marigold deposits and the commitment of the Marigold team," President and CEO Paul Benson said. "Since the mine began operating in 1989, it has consistently replaced mineral reserves and mineral resources and today it has a longer mine life than when it opened.

"We are advancing several exploration targets across our Marigold, Valmy and Trenton Canyon land packages, which have the potential to increase mineral resources. With the recent promising sulphide ore intercepts at Trenton Canyon, the Marigold mine continues to demonstrate its exploration potential and longevity."

Additionally, SSR Mining is increasing its Marigold 2020 exploration expenditures to \$14 million, a \$2 million increase, to accelerate reverse circulation and diamond drilling at the Trenton Canyon sulphide gold discovery.

## Harte Gold Restarts Sugar Zone

Harte Gold Corp. has entered into a binding term sheet with Appian Capital Advisory LLP for up to \$30 million in financing, subject to receipt of approval from the

Toronto Stock Exchange. Proceeds of the financing was used to facilitate a restart of the Sugar Zone mining operation in July.

The financing package will provide the company with a funded solution for mine restart, a return to 800-ton-per-day (t/d) capacity and a pathway to 1,200-t/d capacity as well as enhanced exploration efforts.

"This proposed transaction represents the completion of our review process," Chair of the Board of Harte Gold and Chair of the Special Committee Joseph Conway said. "Given the company's current financial condition, the proposed transaction provides the best financing alternative available to the company, limiting up-front dilution, providing sufficient funding to cover cash flow and capital requirements on startup, and allowing for immediate capital to accelerate the restart of operations."

The proposed transaction will, subject to receipt of approval from the exchange and other closing and drawdown conditions, provide the company with the funds required to restart the Sugar Zone mine operation in mid-July and allow Harte Gold to carry out several initiatives that are already well under way.

All mine activities have commenced at the Sugar Zone mine. The company is ahead on all key mining metrics, supporting the planned mill startup scheduled for early August. Backfill, waste and ore development are meeting or exceeding expectations. Longhole blasting and ore haulage rates are improving daily. A significant stockpile has been built up to feed the mill on restart.

A phased restart approach has been established and will start with backfill and select mining operations. Mill operations would resume in late July once a sufficient stockpile is developed. The company believes approximately C\$35 million (approximately US\$25.7 million) is required to return the mine to 800 t/d. A detailed 18-month planning is now complete. The company is targeting 2020 production at 20,000 ounces (oz) to 24,000 oz. Production for 2021 is targeted at 60,000 oz to 65,000 oz. For 2021, the company would expect to see significant production growth over 2019 and 2020 production levels, resulting from entering into higher grade zones, higher mine production and improving mine development rates.



Rigs drill blastholes in the Mackey pit at the Marigold mine.



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Christine Ramon

*AngloGold Ashanti* announced that **Kelvin Dushnisky** will step down as CEO, effective September 1. Dushnisky will be available to assist the group with a smooth handover until February 28, 2021. **Christine Ramon**, currently CFO, has been appointed interim CEO, while the board embarks on a comprehensive recruitment process to find a new CEO. Ramon will assume the role on September 1.



Aoife McGrath



Leandro Sastre

*Barrick Gold Corp.* appointed geologists **Aoife McGrath** and **Leandro Sastre** in the newly created positions of vice president of exploration for Africa and Middle East, and Latin America and Asia Pacific, respectively. McGrath has worked with and led exploration teams in Africa, North and South America and Europe and her experience spans the full spectrum of company size and exploration stages. Sastre was previously mine operations and technical manager at the Veladero gold mine.



Leandro Garcia

*Compañía de Minas Buenaventura SAA* announced that **Victor Gobitz** has resigned as the CEO, effective August 31, to pursue another professional opportunity. The board appointed **Leandro Garcia**, CFO, to assume the role of CEO, effective September 1.

*Outokumpu* President of the Business Area for Europe **Maciej Gwozdz** has decided to resign to take a new position in another company. He will continue to work in Outokumpu in his current position until the end of September. His successor will be appointed in due course.

*Pretivm Resources Inc.* announced that **Patrick Godin** will be joining the company as vice president and COO. Most recently, Godin was president, CEO and director of Stornoway Diamond Corp.



Patrick Godin



Anne Noonan

*Summit Materials Inc.* announced that **Thomas W. Hill** plans to step down from his role as president and CEO and as a member of the board effective September 1. At that time, **Anne Noonan** will be appointed president and CEO and as a member of the board. Hill will serve as a senior advisor through the end of the year and then transition into a consulting role through July 2023.



Andrey Bougrov

*Normickel* announced several changes. **Andrey Bougrov**, previously appointed as senior vice president for environmental protection, will focus on stakeholder relations on sustainable development issues and the support of the Board of Directors Environmental Task Team. **Larisa Zelkova** is returning to the company to become senior vice president for human resources, social policy and public relations. **Alexey Zakharov**, vice president for financial markets, is appointed vice president for innovations.



André van Niekerk

*Nevada Copper Corp.* appointed **André van Niekerk** as CFO. He was previously CFO of Golden Star Resources.



Nathan Bullock

*PolyMet Mining Corp.* appointed Glencore executive **Nathan Bullock** to the board of directors, replacing **Hilmar Rode**, who stepped down. His is one of three Glencore seats on the seven-member board.



Stephen Enders

**M. Stephen Enders** is the new head of the Mining Engineering Department at the *Colorado School of Mines*. A Mines alumnus, Enders joined the Mines faculty in 2009 and previously served as head of the Geology and Geological Engineering Department from 2016 to 2019.



Doug Reddy

*Equinox Gold Corp.* announced that **Doug Reddy** will transition to the role of COO at the start of September upon retirement of the current COO **Attie Roux**. Reddy has been executive vice president of technical services for Equinox Gold since March 2020 following the merger with Leagold Mining Corp., and was Leagold executive vice president of technical services from the company's formation in 2016. Roux will remain available in an advisory capacity as needed.



Paolo Toscano



Tim Williams

*Marathon Gold Corp.* appointed **Paolo Toscano** as vice president, projects, effective September 1. Since March 2016, Toscano has been employed by Alamos Gold Inc. as director of projects. It also appointed **Tim Williams** as COO. Most recently, Williams served as executive vice president and COO for Rio2 Ltd. responsible for the development of the Fenix Gold Project in Chile.

*Minera Alamos Inc.* hired **Chris Sharpe** as vice president of project development, effective September 1. Since February 2015, Sharpe had worked for Centerra Gold as a senior mining engineer and more recently as director, projects and technical services.



Carmen Amezcua

*Amerigo Resources Ltd.* appointed **Carmen Amezcua** as CFO.



Peter Critikos

*USA Rare Earth LLC* announced that **Peter Critikos** has joined the management team as director of engineering and development. Most recently, he was senior project manager with Samuel Engineering.

*55 North Mining Inc.* announced that **Brien Sirola** has resigned as a director for personal reasons.

*Golden Tag Resources Ltd.* resigned **James Levy** as a director.



Hayden Locke

*Marimaca Copper Corp.* appointed **Hayden Locke** as president. Prior to that, he worked in investment banking with JP Morgan and mining private equity with Barclays Natural Resource Investments. Since early 2018, Locke has been CEO of Emmerson Plc.



Thomas Line

*Taruga Minerals Ltd.* appointed **Thomas Line** as CEO. Line has been working as the project manager for Taruga.



Kent J. Lang

*Bowman Consulting Group* announced that **Kent J. Lang** joined the firm as principal, mining group leader. Lang is the former group leader of U.S. Mine Water and Environment for Golder Associates based in Tucson.

*Asante Gold Corp.* announced the passing of **Florian Riedl-Riedenstein** on July 7. A resident of Vienna, Austria, he was a retired investment banker working in both New York and Austria with more than 30 years' corporate experience as a director and officer of Canadian-listed companies. He successfully introduced Canadian resource companies to European investors. He was a co-founder of Asante Gold Corp. and active in Ghana gold exploration for more than 20 years.

*Galiano Gold Inc.* announced the passing of the company's COO, **Josephat Zvaipa**, as a result of complications associated with a COVID-19 infection. Zvaipa joined the group in 2014 and had been the managing director of Asanko Gold Ghana Ltd. from 2015 to mid-2019 during the time that the Asanko Gold Mine was financed, built and commissioned.





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# Premier Gold Restarts Production at Mercedes Mine



Production at the Mercedes mine has been consolidated from five headings to one.

Premier Gold Mines has recently restarted processing at its Mercedes mine in Mexico that is aligned with a new mining plan that includes limited mining and development activities at Lupita, including the Lupita Extension, and Diluvio zones. The mine was put into care and maintenance during late March due to government restrictions related to the COVID-19 pandemic.

Production has been consolidated to one heading from five. The mining rate was reduced to 1,200 metric tons per day (mt/d) from 2,000 mt/d. The processing plant began operating in early July on a “campaign basis,” in alignment with the new mine plan and crew rotations. This realignment will optimize Mercedes’ production to its current reserve base rather than its processing capacity, the company said.

This restructuring has resulted in a 40% reduction of employees required to operate the mine and 75% of mining-related contractors. The plan focuses on enhancing underground operating efficiencies and supervision to minimize dilution and improve ore quality, the company said. It added that the success of future exploration and delineation drill programs will allow the production rate to increase toward nameplate capacity over time.

“A new vision for success was required to ensure the mine’s long-term viability,” Premier COO Peter van Alphen said. “Our team has developed a focused and achievable plan that will lead to future growth of production at Mercedes.

“We do not take lightly our decision to reduce the number of employees at the mine and must acknowledge the hard

work, dedication, and support of our Mercedes employees and nearby communities impacted.”

## El Teniente Suspends Construction of New Level

Chile’s national copper company Codelco said it will temporarily suspend construction activities at the new mine level (Nuevo Nivel Mina) at the El Teniente mine, due to COVID-19 concerns.

The temporary demobilization, which affects the Andes Norte, Diamante, Andesita and Recursos Norte projects, was initiated and reduced the number of people on-site by 4,500 people and lowered the possibilities for contagion, the company explained. During this shutdown period, Codelco will be preparing the restart of associated projects, whose peak of activity is scheduled for the years 2021 and 2022.

In the meantime, the mining operations at El Teniente will continue under a 14 × 14 shift basis, which means 14 days of work and 14 days off. This new shift system is intended to significantly reduce manpower exposure in common areas.

## Lundin Gold Restarts Operations at Fruta Del Norte

Operations at Lundin Gold’s Fruta del Norte gold mine in Ecuador have restarted. The company said it anticipates resuming regular shipping of concentrate to the port within the next few days. The mill is currently processing stockpiled ore and the mine at a rate of approximately 2,800 metric tons per day (mt/d) and is expected to ramp up to 3,500 mt/d over the next two months.

The mine has resumed producing ore, and production is planned to ramp up over the next three months. The company’s activities include strict coronavirus (COVID-19) protocols intended to minimize risks to the health and safety of all personnel, contractors and local communities.

“I want to thank all of our staff for their efforts and dedication during these challenging times, especially the team who has been at site since operations were suspended in March,” President and CEO Ron Hochstein said. “Their work and dedication, which included the planning and implementation of new COVID-19 protocols and changes in procedures at site, were critical to ensuring a safe restart of operations.”

Work on the completion of the South Ventilation Raise (SVR) is also well advanced, the company said. The SVR has been filled with concrete due to localized ground fall. Once the concrete cures, the company will grout the raise prior to the start of raise boring. Work on the SVR is anticipated to be completed in the fourth quarter. The timing of this work does not impact planned production in 2020.

Gold production at Fruta del Norte for the second half of 2020 is estimated to be in the range of 150,000 ounces (oz) to 170,000 oz of gold. Together with actual production achieved prior to the onset of the temporary suspension, total 2020 gold production is estimated to be between 200,000 oz and 220,000 oz. Average mill production in the second half of 2020 is projected at 3,200 mt/d at an estimated average head grade of 10 g/mt. Average gold recovery is anticipated to be approximately 85% during this time and is expected to reach design levels of 92% in late Q4 2020.

All-in-Sustaining-Costs (AISC) for the second half of 2020 is expected to range between \$770/oz and \$850/oz of gold sold. AISC for the second half of 2020 reflects additional COVID-19 costs and \$10.4 million in sustaining capital that includes costs for the tailings dam raise, the purchase of surface mobile equipment and other efficiency improvement projects.





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# NQ Minerals Acquires Beaconsfield



The Hellyer plant (above) upgrade exercise has been successfully completed six months ahead of expectation.

NQ Minerals Plc purchased the historic Beaconsfield gold mine in Tasmania, Australia. The mine has historic recorded production of 1.8 million ounces (oz) of gold averaging 15 grams per metric ton (g/mt) and was closed in 2012 due to the low gold price at that time, the company said. The gold price has since increased substantially and the company said it plans to reopen the mine as soon as practicably possible.

NQ has started the recommissioning the gold processing plant, which was under care and maintenance. At the same time, they are reopening the mine by developing a new decline accessing the Beaconsfield mine from the surface to reconnect into the existing mine workings at the lower section of the orebody.

NQ is currently increasing production at its flagship Hellyer gold mine in Tasmania, Australia, by 44% to more than 1.3 million mt/y, compared to 2019's full-year plant production numbers. The new production rate of 150 mt/ is now being achieved after a June plant upgrade and circuit optimization exercise. This new rate compares to 2019 Hellyer Full Year plant throughput totaling 835,877 mt (average 103 mt/h at 92% plant availability).

Process optimization works are now under way to ensure the plant achieves maximum recoveries and concentrate specifications at these new higher production rates. Engineering assessments will continue to plan for further production rate increases later in the year, should higher production rates be required.

Chairman of NQ Minerals Plc David Lenigas said, "This Hellyer plant upgrade exercise has been successfully brought in some six months ahead of expectation. The increase in saleable mine product will have a very positive affect on the company's top and bottom line revenues going forward, and will assist NQ greatly with its ability to service ongoing debt obligations and strongly position the mine for increased profitability as commodity prices improve with the world emerging from the COVID-19 pandemic."

The world-class Hellyer underground mine, on the West Coast of Tasmania, in Australia, began production in 1989 under the ownership of Aberfoyle Ltd. The Hellyer deposit had a published pre-mining mineral resource of 16.9 million mt grading 13.8% zinc, 7.2% lead, 0.4% copper, 167 g/mt silver and 2.5g/mt gold.

## Horizon Minerals Pours First Gold From Boorara Gold Mine

Horizon Minerals Ltd. announced first gold production from the first stage of the Boorara gold mine, 10 kilometers (km) east of Kalgoorlie-Boulder in the gold-fields of Western Australia. The company said mining continues ahead of schedule at the Boorara gold mine. The first ore processing campaign commenced on July 17 with first gold poured on July 23 for shipment and gold revenue commencing before the end of July.

Mining commenced at Boorara on May 5 with first ore mining shortly thereafter from the Regal East pit. The Regal East

and Regal West pits will be mined concurrently to enable efficient cycling of mining production and drill and blast activities, Horizon Minerals said. Mining of the Crown Jewel pit has now commenced to provide an alternative dig location as the Regal pits advance. To date, a total movement of 376,000 BCM has been mined with approximately 90,000 metric tons (mt) of oxide and transitional ore mined at a fully diluted grade of 1.5 grams per mt, in line with reserve model estimates for the upper areas of the pits.

The first milling campaign is scheduled for completion in late July with first mine to mill reconciliations shortly thereafter. Dore bullion is shipped to the Perth Mint for refining and sale with first revenue expected in coming weeks. Ore treatment campaigns will continue on a monthly basis through to January 2021.

## PFS Supports Block Caving at Carrapateena

OZ Minerals has reported positive results from a prefeasibility study (PFS) of developing block cave mining operations in the lower half of the orebody at its Carrapateena copper-gold mine in South Australia. Based on the PFS results, the company has initiated a feasibility study of block cave development.

Carrapateena is located 160 kilometers (km) north of Port Augusta, South Australia. The upper half of the orebody is currently being mined by sublevel caving methods. The mine produced its first copper-gold concentrate in December 2019. The operation is now ramping up to an expected 4.25-million-metric-ton-per-year (mt/y) run rate by the end of 2020 and targeted rates of 4.7 million to 5 million mt/y from 2023.

The block cave PFS considers increasing plant throughput to 12 million mt/y from 2029 at a lower operational cost and cut-off grade than the sublevel cave. The block cave would also bring forward the ability to mine higher-grade ore at the bottom of the orebody. This ore would have been otherwise mined closer to the end of the mine life, using the sublevel cave mining method.

In conjunction with its release of the PFS results, OZ also reported the results (Continued on p. 26)





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# Resolute Extends Mako's Life of Mine



Mako's gold production over the next five years will average 140,000 oz/y.

Resolute Mining Ltd. announced that successful extension exploration drilling programs, mine design improvements, and optimization of mine scheduling work undertaken at the Mako gold mine in Senegal (Mako) has resulted in material improvements to an updated life of mine plan (LOM).

The updated LOM has generated a 39% increase in total gold production and a mine life extension of two further years of production. The original mine plan at Mako at the time of its development consisted of a seven-year mine life expected to produce 890,000 ounces (oz) of gold.

Mako is now expected to have a total mine life of nine years and produce a total of 1.24 million oz of gold. Production over the next five years will average 140,000 oz of gold per year. Expected average LOM All-in-Sustaining Cost (AISC) has been updated to \$848/oz.

Including 2020, Resolute now expects to mine a further 900,000 oz of gold from Mako until early 2027 at an expected average AISC over this period of \$900/oz.

Managing Director and CEO John Welborn said, "This initial extension of the mine life at Mako will be further reinforced by our investment in the significant untested exploration potential of the region. Today's announcement is a great result for Resolute shareholders and for our principal partner at Mako, the Senegalese Government. We are delighted to increase total mine production and extend the mine life at Mako, which will

expand the economic benefits the mine provides to the local communities and broader population of Senegal."

Mako is located in eastern Senegal. Following initial discovery of gold in 2011, first production was achieved in January 2018 and commercial production commenced in March 2018.

## Endeavour Expands Houndé Gold Operations

The Burkina Faso government has granted Endeavour Mining a mining permit extension covering the full Kari Area at Endeavour's Houndé open-pit gold operations. The Kari Area hosts the previously announced Kari Pump, Kari West, and Kari Center discoveries, in addition to the recently discovered Kari Gap and Kari South targets. Mining has begun on the Kari Pump deposit about 7 kilometers (km) west the Houndé plant.

The Burkina Faso government has permitted the Kari Area as an extension of the main Houndé mining permit, allowing the area to benefit from Burkina Faso's 2003 Mining Code, which includes a corporate income tax rate of 17.5%, a 10% free-carried state interest, and a royalty based on a 3% to 5% sliding scale linked to prevailing gold prices.

Endeavour completed more than 60,000 meters (m) of grade-control drilling in the Kari Area during the second quarter of 2020 in anticipation of receipt of the mining permit. Mining activities have com-

menced and are expected to increase the second-half 2020 average feed grade to the Houndé plant, positioning the mine to achieve the upper end of its production guidance of 230,000 oz to 250,000 oz.

Endeavour CEO Sébastien de Montessus said, "We are pleased to have received consent to start mining in the Kari Area, beginning with the Kari Pump deposit, and we are grateful to the Burkina Faso government for its extraordinary efforts to finalize this permit in spite of the unusual challenges resulting from the ongoing COVID-19 crisis.

"Endeavour has been keenly focused on creating value through the drill bit. Our success in moving Kari Pump from discovery to production in under three years underscores our aggressive exploration strategy and the value of our strong established government partnerships in West Africa.

"Getting the Kari Area permit was a key 2020 milestone and will position us to achieve the upper end of our production target at Houndé as we benefit from mining higher-grade ore at Kari Pump. The Kari Area continues to hold exciting upside potential, and we will be providing an updated resource estimate for the entire area in the coming weeks."

A 2020 exploration program of up to \$11 million, totaling approximately 94,000 m of drilling, has been planned at the Houndé mine permit, including the Kari Area, with the aim of delineating additional resources. As of early July, more than 400 holes representing more than 50,000 m had been drilled since the start of the year in the Kari area, in addition to grade-control drilling.

On July 22, Endeavour announced that measured and indicated resources at the Houndé mine had increased by 554,000 oz to 4.5 million oz based on further resource delineation at the Kari Area. The Kari Area now accounts for 57% of Houndé measured and indicated resources, with 2.5 million oz of indicated resources discovered over the past three years.

The Houndé mine is located 250 km southwest of Ouagadougou, the capital city of Burkina Faso. Ownership is 90% Endeavour, 10% government of Burkina Faso. The mine produced 223,000 oz of gold in 2019 at all-in sustaining costs of \$878/oz.



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# Outokumpu Initiates EIA for Kemi Expansion

Outokumpu has launched an Environmental Impact Assessment (EIA) process for its expansion plans for the Kemi chromite mine in Finland. The company is investigating the planned changes to the operations and underground mining methods and its impact on the rock surface, soil, water systems, the environment as well as air and climate. The planned changes to the operations of the mine include expanding the mining concession area and mine within the limitations of the current allowed area.

It also includes increasing volumes of ore mining and chrome production, revising underground mining methods, processing and using the resulting tailings and building a new tailings pond.

A decision to expand the mine has not yet been made.

The assessment is part of the mine's long-term development plan to optimize the use of the existing resource. Outokumpu is not currently planning to increase its ferrochrome production as the production volumes of the mine and the concentrating plant have been optimized according to the amount of raw material required by Outokumpu's ferrochrome plant in Tornio.

The EIA procedure will not affect the progress of the ongoing DeepMine project at the Kemi mine. The environmental impact of the Kemi mine was previously assessed in 2009. Completion of the current assessment is planned for 2021.

## Rio Tinto Files Complaint Over ISAL Smelter

Rio Tinto has submitted a formal complaint to the Icelandic Competition Authority (ICA) alleging abuse of market dominance by Landsvirkjun, the energy supplier to Rio Tinto's ISAL aluminum smelter in Iceland.

The company's complaint alleges that pricing terms of the power agreement with Landsvirkjun are discriminatory, abuse its market dominant position and cannot be justified. Landsvirkjun's supply contracts bind customers to long-duration terms, rendering it impossible for alterna-



Completion of the EIA for the Kemi mine (above) is planned for 2021.

tive energy suppliers to either enter the Icelandic market or expand operations, the company said.

If Landsvirkjun does not address its abusive conduct, Rio Tinto said it will have no choice but to consider terminating its energy contract and plan for the closure of the smelter.

## Management of Talnakh Concentrator is Dismissed

Nornickel, the world's largest producer of palladium and high-grade nickel and a major producer of platinum and copper, announced that the internal investigation regarding the discharge of recycled water from Talnakh Concentrator's technical water sump on June 28, has been completed.

The investigation discovered two instances of unauthorized industrial water discharge from a recycled water sump, part of Talnakh Concentrator's tailings dam system, into an adjacent area using flexible pipes and floating pumps.

The water samples taken from Talnakh Concentrator's technical water sump on June 28 indicated that the water discharge should not have any material impact on the environment and, most importantly, on the Kharaelakh River. An inspection

survey conducted jointly with the Center of Laboratory Analysis and Technical Measurements, part of the Environment Supervision Agency, confirmed there was no impact on the Norilskaya River.

Nevertheless, the company said no recycled water discharge is allowed beyond the boundaries of Talnakh Concentrator's tailings dam. Although the company has no evidence that similar violations have been committed previously, it said it could not completely rule them out.

"Any violations of industrial safety or environmental protection should be completely eradicated," Nornickel First Vice President and COO Sergey Dyachenko said. "Nornickel announces zero tolerance toward environmental violations and will take harsh disciplinary actions whenever such violations take place."

Upon completion of the internal investigation, director, chief engineer and deputy chief engineer, operations and industrial and environmental safety of hydraulic structures, of Talnakh Concentrator have been dismissed due to gross misconduct. A new department is being set up to focus solely on technical support and instrumental supervision of hydraulic structures of the Polar Division.





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# Rio Tinto Begins Exploring Forum's Janice Lake Project

Forum Energy Metals reported in late June that Rio Tinto Exploration Canada has initiated exploration at Forum's Janice Lake sedimentary copper/silver project in northern Saskatchewan. Forum President and CEO Rick Mazur said, "I look forward to this summer's program, with a regional focus on uncovering the full extent of copper and silver mineralization at Janice Lake. We have barely scratched the surface on exploring this sedimentary basin, which stretches for over 50 kilometers (km). Rio Tinto's focus will not only be on finding higher-grade and thicker open-pit strata-bound horizons but also high-grade structurally controlled mineralization."

Copper showings and structural, geophysical, geochemical, and boulder train targets developed by the mapping and prospecting program will be drilled using a rotary air blast (RAB) drill rig to test bedrock in areas of overburden for hidden copper/silver mineralization. Drilling permit applications for this work and a proposed future diamond drilling program were expected to be granted by mid-July.

An eight-person prospecting and mapping team has started systematic traverses on 2-km-wide spacings on the 52-km extent of the property. Detailed follow-up mapping and prospecting will be completed on prospective areas for strata-bound and structural copper/silver targets and mineralized areas discovered on the property.

A program of geophysical and geochemical orientation surveys has commenced over the known mineralization at the Janice target that was drilled in summer 2019. Exploration techniques such as induced polarization, electromagnetic, vegetation and soil surveys will be conducted over the deposit to identify signatures that may identify other deposits on the property.

Downhole logging of the 2019 holes will be completed this summer, and a regional AMT transect across the full 11.6-km width of the basin will be conducted to understand basin architecture.

Crews have begun construction of a 50-person camp on the property at Bur-

bidge Lake. This camp will provide improved, proximal access for proposed future diamond drilling.

([forumenergymetals.com](http://forumenergymetals.com))

## Exploration Briefs

**Antipa Minerals** has entered into an A\$30 million farm-in agreement with **IGO Ltd.** in respect of 1,563 km<sup>2</sup> of tenements that are part of the Antipa's 100% owned ground in the Paterson Province of Western Australia. The farm-in area is to be called the Paterson project.

IGO has committed to sole fund a minimum of A\$4 million expenditure on the farm-in area within two and a half years of commencement of the farm-in agreement, with no less than 75% of this amount directed toward "in-ground" activities.

Provided IGO has not withdrawn, IGO may sole fund a further A\$26 million expenditure within 6.5 years from commencement of the agreement to earn a 70% joint-venture interest in the farm-in area. Upon joint-venture formation, IGO shall free-carry Antipa to the completion of a feasibility study.

Antipa will manage operations during the initial two and a half year period and will receive a management fee of 10% on all eligible expenditure incurred in that period.

([www.antipaminerals.com.au](http://www.antipaminerals.com.au))

**Group Eleven Resources** has intersected 10.3 meters (m) of 14.6% zinc, 5% lead, and 43 grams per metric ton (g/mt) silver from drilling on its 100% owned PG West project in the Republic of Ireland. The intersection includes a high-grade zone of massive sulphides containing 6.6 m of 21.5% zinc, 7% lead, and 59 g/mt silver, starting at 60 m downhole.

Mineralization is shallow, open along strike, and represents not only the best mineralization ever encountered at the Carrickittle prospect but also the best mineralization Group Eleven has drilled since inception of the company in early 2015.

The Carrickittle prospect is located in the Limerick basin in southwest Ireland. The prospect lies within the Pallas Green

Corridor, a 25 km-long trend of mineralization defined by the Pallas Green deposit in the north and Group Eleven's Carrickittle, Ballywire and Denison prospects to the south.

Group Eleven CEO Bart Jaworski said, "The thickness of massive sulphides and associated grades of zinc and lead was a much better result than expected. This intercept represents a breakthrough in our understanding of how mineralization is oriented at Carrickittle and offers a compelling hypothesis as to why historic drilling missed or seemingly only skimmed along areas of mineralization.

"Finding such high-grade mineralization at shallow depths is a very rare occurrence these days in the industry, and it is highly encouraging for Group Eleven. Carrickittle is a prospect that lay largely dormant for over 54 years after it was labelled as 'sub-economic' in 1966. The prospect, however, now clearly appears under-drilled and under-conceptualized — and requires immediate follow-up."

([www.groupelevenresources.com](http://www.groupelevenresources.com))

**Discovery Metals** has announced results from recent drilling at its flagship Cordero project in Chihuahua state, Mexico, where a Phase 1 diamond core drilling program was initiated in September 2019. The program was recently expanded from 35,000 m to 55,000 m and has a goal of defining a large-scale, high-margin project with excellent leverage to rising silver prices.

Discovery added a second drill rig to the project during the first week of July and plans to add additional rigs when it is confident health and safety risks related to COVID-19 can be managed effectively.

Drilling will be focused on two key areas: 1) targeting of broad zones of breccia-hosted mineralization in the east and northeast of both of the project's mineralized corridors and 2) testing of the width, grade, and continuity of extensive high-grade vein systems identified in and adjacent to historical artisanal underground workings during the early history of the project.

([dsvmetals.com](http://dsvmetals.com))





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# Adani Begins Overburden Removal at Australia's Carmichael Mine



A shovel breaks ground at the Carmichael mine as overburden removal operations begin.

Adani Mining's excavator and mine trucks have begun work at the Carmichael open-cut mine in Queensland's Galilee Basin to remove overburden and expose coal seams. Adani Mining CEO David Boshoff said the box-cut was a significant milestone to mark off on the construction schedule.

"We are on track to export first coal in 2021," Boshoff said. "It's great to see our big new gear, the Liebherr R 996B excavator and the Cat 796 haul trucks, hard at work. In time, they will reach the coal seam, then we will be excavating coal as we need to remove around 4 m<sup>3</sup> of rock for every ton of coal we mine."

Boshoff said there are more than 700 people working on the mine and rail project construction and numbers continue to increase as contractors arrive to build the coal handling plant and work on the railway.

"The expansion of our mine accommodation to 400 beds is complete to cater for the additional workforce and we will soon be able to accommodate another 1,200 people in our temporary rail accommodation villages," Boshoff said. "We remain on track to deliver 1,500 direct and 6,750 indirect jobs."

The mine's first five mining trucks and excavator have arrived on site and are operational. The assembly of the second excavator will commence in the coming weeks.

Adani will add more than a dozen mining trucks to its fleet over the coming months. The trucks will be assembled in Mackay, with each taking a team of about 40 men and women up to 10 weeks to put together before they are transported more than 300 km to site.

The Carmichael Mine will produce 10 million metric tons per year (mtpy) of high-quality thermal coal, which will be used to generate electricity for communities in India and southeast Asia.

## CONSOL Will Lay Off 233 at Enlow Fork

CONSOL Energy filed a Worker Adjustment and Retaining Notification Act notice saying it will lay off 233 Enlow Fork mine workers on August 31. The mine was idled in mid-April.

About 600 people work at the Enlow Fork mine during full production.

"In these unprecedented times, it is extremely difficult to predict when our production at Enlow Fork mine will return to normal capacity, as it is always our intent to run our operations based on market conditions," the company said.

"In the interest of keeping our employees informed and meeting all legal requirements, we issued the WARN notice to a portion of employees who will not be

recalled from furlough at this time. Situations can certainly change and we will continue to monitor daily," the company said in a statement.

Enlow Fork is one of three mines that make up the Pennsylvania Mining Complex, which also includes the Bailey mine and Harvey mine.

## Wyoming DEQ Approves Brook Mine

The Wyoming Department of Environmental Quality (DEQ) awarded Ramaco Carbon approval to mine coal at the Brook mine, located in a traditional mining area outside Sheridan. This will create Wyoming's first new mine in almost four decades. The purpose of the mine is to develop alternative uses for coal beyond burning it, and potentially revitalizing a key facet of both the state and the national economy, according to Ramaco Carbon.

This also constitutes a permit of one of the largest private coal/carbon ore reserves in the country. The company said pre-mine development work would begin shortly, and it intends to employ local Wyoming miners affected by the industry's downturn. The initial opening of the mine is anticipated to employ 30 to 40 direct mining jobs.

"By awarding this permit, the state has acknowledged our efforts to be good stewards of this area's high quality of life and environment," Chairman and CEO Randall Atkins said. "It has also recognized our investment in the Sheridan area since 2011 and in the future of this state."

The privately funded Brook mine will provide carbon resources for Ramaco's research and manufacturing efforts, as part of the nation's first vertically integrated carbon tech platform. This platform also includes the iCAM (Innovation Carbon Advanced Material Center) and research park campus now in final stages of construction, as well as the future iPark mine-mouth coal to product manufacturing facilities. The iCAM facility will house carbon research for advanced carbon products and materials, such as carbon fiber, carbon building products and graphene.



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*(Regional News-Australia/Oceania - from p. 16)*

of a Carrapateena “Life of Province Scoping Study,” which considers the future potential of resource extensions, satellite deposits, and exploration targets in the Carrapateena district.

Capital investment for block cave development of about A\$1.2 billion to A\$1.3 billion is weighted toward 2025 to 2027.

OZ Minerals CEO Andrew Cole said, “The prefeasibility study analyzed the whole Carrapateena Province and determined that replacing the lower half of the current sublevel cave with a block cave and expanding the expected annual throughput rate from the 4.7 million mt/y to 5 million mt/y currently planned from 2023 to 12 million mt/y has the potential to create significantly more value than the sublevel cave alone. The block cave would leverage existing underground infrastructure, supported by expanded surface processing capability.

“The study work showed the conversion to a block cave creates significant additional value from the Carrapateena resource and the province more broadly as it potentially enables a series of future add-on block caves, which have been considered in the Life of Province Scoping Study.

“A block cave conversion in the lower portion of the Carrapateena resource has the potential to almost double average production to approximately 110,000 mt/y to 120,000 mt/y of copper and 110,000 oz/y to 120,000 oz/y of gold from 2026, with life-of-mine all-in sustaining costs of approximately US\$0.75 to 0.85/lb of copper.

“An incremental, three-phased approach to capital investment in the project provides optionality at various stages, including a decision on whether to proceed to stage one decline development in



Gold Fields installs natural gas to support the Agnew gold mine's renewable energy microgrid.

2022 and then, at a later date, a decision as to whether to proceed with the block cave itself. How best to expand the process plant can be considered later, again based on available technology and the plant capacity at the time.

“The potential for the block cave to progressively unlock the province more broadly via a controlled and incremental approach is particularly attractive as it manages risk and capital expenditure while enhancing value upside for our stakeholders.

### Gold Fields Installs Natural Gas Power Generation

A set of gas generators have been installed to provide power for EDL Energy's hybrid renewable energy microgrid, which supports Gold Fields' Agnew gold mine in Western Australia. The 56-megawatt (MW) Agnew hybrid renewable microgrid system — Australia's largest — consists of a new off-grid 23-MW power station incorporating gas, photovoltaic solar and diesel power generation, and 18-MW

wind generation, a 13-MW battery and an advanced microgrid control system.

To meet the crucial requirement of continuous and reliable power at temperatures up to 45°C, Gold Fields used nine Cummins QSV91G gas generators. The QSV91G generators can operate in high ambient conditions and provide high impact step loads and fast ramp rates while maintaining power quality, according to the company. Cummins also installed two QSK60 diesel generator sets to provide additional power during peak periods of demand, in addition to providing the ability to black start the power station in the event of a power outage. A Cummins digital master control (DMC8000) was also installed to communicate with EDL's microgrid controller to balance the power demand from the mine.

Gold Fields wanted to create an innovative hybrid renewable energy solution at the site, which has operated for more than 30 years, with an annual gold production of approximately 220,000 ounces.

## NEWS - CALENDAR OF EVENTS

**SEPTEMBER 8-11, 2020: UGOL & Russia, Novokuznetsk, Russia.** Contact: Web: [www.ugol-rossii.com](http://www.ugol-rossii.com).

**OCTOBER 20-22, 2020: MiningWorld Russia, Crocus Exhibition Center, Moscow.** Contact: Web: <https://miningworld.ru/>.

**NOVEMBER 30-DECEMBER 4, 2020: The annual meeting of the American Exploration & Mining Association, Nugget Casino Resort, Sparks, Nevada, USA.** Contact: Web: [www.miningamerica.org](http://www.miningamerica.org).

**FEBRUARY 1-4, 2021: Investing in African Mining Indaba, Cape Town, South Africa.** Contact: Web: [www.miningindaba.com](http://www.miningindaba.com).

**FEBRUARY 7-10, 2021: 47th Annual Conference on Explosives and Blasting Technique, Orlando, FL, USA.** Contact: Web: [www.ISEE.org](http://www.ISEE.org).

**FEBRUARY 28-MARCH 3, 2021: SME Annual Conference & Exposition, Colorado Convention Center, Denver, CO, USA.** Contact: Web: [www.smenet.org](http://www.smenet.org).

**MARCH 7-10, 2020: The annual meeting of the Prospectors & Developers Association of Canada, Toronto Convention Center, Toronto, Canada.** Contact: Web: [www.pdac.ca](http://www.pdac.ca).

**MARCH 14-17, 2021: Haulage & Loading 2021, Hilton El Conquistador Resort, Tucson, Arizona.** Contact: Web: [www.haulageandloading.com](http://www.haulageandloading.com).

**SEPTEMBER 2021: MINExpo INTERNATIONAL, Las Vegas, Nevada.** Contact: Web: [www.minexpo.com](http://www.minexpo.com).



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# Machines That Help Reduce Dilution

*The top narrow vein mining solutions on the market offer an increased power-to-weight ratio, lower ownership costs and higher productivity*

By Jesse Morton, Technical Writer



The DL2711 is a fully mechanized top-hammer longhole production rig capable of drilling vertical and inclined fans, single or parallel, 64- to 89-mm-diameter longholes, up to 38 m in length, using T38, T45 and T51 MF-rods or 65-mm tube rods. (Photo: Sandvik)

Hecla's San Sebastian silver mine used a handful of techniques to reduce dilution. They used controlled blasting techniques, trench sampling, and relied heavily on geologists in the pit to visually assess the muck and face and pinpoint cutoff grade. "Through the whole project, through to the end, we didn't exceed 10% on dilution," Alberto Ramos, senior project engineer, Hecla Mining, said. "It ranged between 3% and 7%."

When it launched underground operations in 2018, it planned on cut-and-fill stoping, with ore extracted by rubber-tired equipment. It tested longhole mining, which proved successful, and it refined its blasting plan. "We designed everything at 2 m. Then we did some stope optimizations and reduced that to 1.5 m," Ramos said. "We ended up managing to mine at 1.5 m, longhole stopes, at 15-m sublevels."

In its late stages, the mine is now a success story in part because the company prioritized continuous improvement as part of the mining process.

Some of the headlining solutions in the underground narrow vein mining space speak to that discipline. They are dynamic and versatile, safety-centric, and

designed for operations looking for ways to mine more ore and less waste.

## Compact Long Hole Production Drills

Sandvik released the DL2711 and DL2721 long hole production drills, which complete the 2711 narrow vein drill class. The electro-hydraulic drill rigs were developed through close working relationships with customers, ensuring designs specific to the applications, the company reported. The resulting exemplary performance should speak to the highest priorities of the company, Damien Tang, product manager, underground drilling, Sandvik, said.

"We are focused on real end-user requirements, not only from the development of a new product perspective, but adding value and benefits at the mining process level," he said. "The DL2711 and DL2721 have been developed and fueled by Sandvik's desire to meet or exceed customer needs, producing real benefits to their mining operations."

Customers around the globe provided feedback, data and information that was used in development. The benefits include increased production. "In China,

the drill rigs were used to drill a series of 89-mm-diameter by 25-m-long production holes," Tang said. "They were able to do this highly efficiently and effectively, achieving an average production rate of 200 m drilled per shift."

The rigs averaged more than 100,000 drilled meters per year. "Similar results have been reported from Russia, South Africa and Peru," Tang said.

The drills are described as fully mechanized top-hammer rock drills, designed for underground mining in 3.2- x 3.2-m or larger production drifts. They are capable of drilling vertical and inclined fans, single or parallel, 64- to 89-mm-diameter long holes, up to 38 m in length, using T38, T45 and T51 MF-rods or 65-mm tube rods.

The listed features include: a robust design and proven components; a HL710S hydraulic rock drill; 360° drilling module rotation; wide boom swing and tilt angles; and a long hole drilling module with carousel equipped with a strong anchoring system. The DL2711 is more compact and allows the drill module to be closer to the face. The DL2721 has an FOPS canopy.

Tang said the machines offer high drilling capacity, safely and ergonomically, in a compact machine format with high levels of mobility. "Furthermore, as mining operations are tough on man and machine, they have a robust design and hard wearing components to provide the highest levels of mechanical availability."

Top benefits include lowered operating and maintenance costs, he said. "All key components were designed with commonality across the entire Sandvik underground equipment offering," Tang said.

Most importantly, the drills save money by reducing dilution. "Dilution of mined ore with waste from drilling operations is now considered to be the biggest challenge facing miners in order to deliver efficient and productive drilling and hence mining," Tang said.



"The narrow platform of the new drills enables miners to excavate smaller tunnels and production drifts, and the strong anchoring system of the machine with its precise boom positioning enable excellent hole accuracy," he said, "thus reducing any dilution of waste into the ore, thereby providing a solution to this major problem."

The drills should help dispel the long-held misconception that miners and contractors should primarily focus on drilling and blasting for ore extraction. The drills help prove long hole drilling in many cases is a viable alternative, Tang said. "Sandvik has over the years been tasked to deliver purpose-designed solutions for specific applications, encompassing various mining and excavation methods," he said. "Sandvik has been able to do this successfully due to our extensive and wide offering which has been able to provide customer-focused solutions for virtually all requirements."

While purpose-designed for narrow vein operations, the new drills are "suited to a wide spectrum of applications," Tang said. "This means that whether the drill will be working in the diamond mines of South Africa, the permafrost gold mines in Siberia, or at high altitude (up to 4,600 m above sea level) in the Andean countries or the Himalayan Plateau in China, it will perform to specification, meeting or exceeding customer requirements."

The new drill class was announced in mid-November 2019. The company reported drills in the class would come with



The PFL 8 LHD has a 0.8 m<sup>3</sup> bucket, a payload capacity of 1.5 mt, breakout force of up to 40 kN, an operating weight of 6.3 mt, and engine power of 69 kW. (Photo: Paus)

its fleet data monitoring systems for optimal performance and management. The first two models in the class, the DD2711 development drill and the DS2711 mechanized bolter, were described as "ideal solutions for underground mines and drilling contractors looking for smarter control of ore dilution and increasing selective process in mining."

Tang said the two new long hole drills, released in July, are "part of an ever-growing story that reinforces the message of Sandvik's experience and expertise in underground drilling, satisfying or exceeding the requirements of the mining industry, and dealing with and overcoming issues and trends, such as narrow vein applications."

## Powerful Rockdrills for Compact Carriers

J.H. Fletcher & Co. reported the field-proven HVL-38 and HV-32 hydraulic percussive rockdrills are designed for efficiency and sized to fit low-profile rigs for narrow vein mining.

The (hydraulic valve-less) HVL-38 is a high-performance, low-operating-cost percussive rockdrill that provides an impact frequency of 97 Hz, an impact energy of 196 Nm, and output power of 19 kW, Steve Nye, western district manager, metal and non-metal division, J.H. Fletcher, said.

"All that at around 190 kg," he said. "The rockdrill does not require the maintenance of accumulators, therefore there is no requirement to charge accumulators with nitrogen and replace damaged diaphragms."

The drill uses female striker bars, eliminating one threaded coupler and decreasing overall feed length. "A shorter feed length reduces weight, decreases boom wear, and improves equipment mobility," Nye said.

The supplier has around 115 machines successfully operating in the field with the HVL-38.

The company's automated mechanized rock bolters use the (hydraulic valve) HV-32 rockdrill, which is described as the shortest hydraulic percussive drill in its class.

"A J.H. Fletcher module length of 2.55 m can accommodate a 1.8-m rock bolt," Nye said. "This low-profile rockdrill allows J.H. Fletcher the ability to offer the shortest mechanized remote or automated roof bolt modules in the market."

With a height of 0.5 m, it has an impact frequency of 75 Hz and an output power of 9 kW.



The HVL-38 offers an impact energy of 196 Nm, uses female striker bars, features a shorter feed length for reduced weight and improved mobility, and can be retrofitted on existing carriers. (Photo: J.H. Fletcher & Co.)

HV-32 mechanized remote modules can accommodate a variety of rock bolt lengths and types.

"These modules are available to be retrofitted on your existing carriers," Nye said. "The carriers can be powered with battery, diesel, electric cable or a combination of power options," he said. "J.H. Fletcher offers rubber tire with steer axles, articulated steering, and rail mounted machines; and FOPS/ROPS enclosed cabs or canopies are available."

Historically, the rockdrills have been used in platinum, nickel, copper, coal, limestone and salt mines.

The drills were originally developed with other mechanized solutions for operations using jacklegs for roof and rib bolting, Nye said. The desired end was "improved safety level as well as efficiency, thus improving the bottom line cost," he said. "J.H. Fletcher & Co. operates with a singular vision: to work with a vigilant focus on finding ways to improve mining processes and reducing risk for the people who work there."

## Specialized Machines Lower Ownership Costs

PAUS reported its narrow vein mining applications equipment offer an excellent

total cost of ownership, which is the focus of product development at the company.

Beyond that focus, the PFL 8 LHD offers ease of use, high load capacity, operator safety, optimal visibility and an "excellent payload-to-weight ratio," Helmut Jaspersen, marketing manager, said.

The loader has a 0.8 m<sup>3</sup> bucket, a payload capacity of 1.5 metric tons (mt), breakout force of up to 40 kN, an operating weight of 6.3 mt, and engine power of 69 kW.

"With our LHD Loaders product range, we offer our customers the right solutions for their individual tasks," Jaspersen said. "Repeat customers prove the viability of the loader."

The Scaler 853 S8 was designed with ergonomics and safety in mind. "The spacious cab with a comfortable driver's seat and functionally arranged instrument cockpit offers one of the best all-round views in this scaler class," the company reported. The cab is ROPS/FOPS certified.

With articulated steering and swivel boom, the scaler offers "unmatched maneuverability," the company reported. With an operating weight of 8.8 mt, and a max speed of 20 km/h, the scaler comes equipped with a NPK hammer with a rated weight of 300 kg.

The Universa 40 platform vehicle is offered as a workshop or passenger vehicle. With a 7 mt payload and an engine rated at 93 kW, it comes equipped with the PAUS Power Flow variable pumps that regulate oil supply; and features a hydrostatic drive, an ROPS/FOPS-certified cab, and optimized hydraulic lines. "The advantages are fuel savings, lower oil temperatures" and component longevity, the company reported.

The offerings speak to the company's mission to be "the people who care," Jaspersen said. "We are known as a specialist for individual adaptations and we continue building where series manufacturers stop."

## Narrow LHD Gets Charging Stations

Aramine reported that its Mobile Charging Stations for the miniLoader L140B are being tested in two underground settings with the hope the solution can be released later this year.

One of the stations is deployed to a wet underground mine with humid and corrosive conditions. Another is deployed to a civil engineering work site "with less difficult conditions," but where it is "moved very frequently," the company reported.

Aramine told *E&MJ* the testing so far has prompted no major design changes but has revealed some potential best practices for users. "Thus far, we noted that in the mine a stationary version of the station would be much more economical," Marc Melkonian, president, Aramine said.

The tests are expected to continue and the solution will advance beyond development once the company is content with the customer feedback, the versatility of the solution and the ease of manufacturing, the company reported.

"Today, battery technology is still in its beginning stages and we need to prove ease of use," Melkonian said. "That is why Aramine created the Mobile Charging Station, which can ease and speed the changing of batteries," he said. "This helps the user in his transition to a battery-powered machine."

Beyond the charging station, the company is developing other technologies key to long-term use of battery-powered machines, Sylvain Reynier, director, research and development, Aramine, said.

"Our R&D department is currently studying our next battery powered machine, the miniLoader L350B, which



With a 0.7-m<sup>3</sup> bucket, the battery-powered L140B has a tramping capacity of 1,300 kg, tilt breakout force of 32 kN and lift breakout force of 35 kN. (Photo: Aramine)





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The LF-3 has an operating weight of 11 mt, a standard bucket capacity of 1.5 m<sup>3</sup>, and a payload capacity of 3.5 mt. (Photo: GHH)

will be much bigger than the miniLoader L140B, and plans to use the same Mobile Charging Station,” Reynier said. “For this, we are making sure that the weight of the energy modules to be replaced on the L350B is compatible with the Mobile Charging Station.”

The station is equipped with a crane, connects to a mine’s electrical system, and is piloted by remote control. It will provide charging and changeout scenario optionality beyond the current methods, which include plugging the LHD directly into an outlet or quickly switching the drained battery out with a pre-charged one.

A full recharge from a socket could take from 2 to 5 hours, the company reported.

The Quick Replacement System takes about 10 minutes and mandates a designated space in the mine for charging and stowing standby batteries. The system is ideal for a miner seeking to operate only one machine, and is available for adoption as an aftermarket kit.

A fully charged battery allows for up to 4 hours of mucking, Melkonian said.

Released in 2016, the L140B comes standard with a lithium battery, a Can-bus-type electrical system for diagnostics and programming, and “intuitive and ergonomic controls,” the company reported.

Benefits beyond negligible emissions include a lower heat and noise signature. The unit has as much or more breakout force than the diesel competition, Reynier said.

The L140B has a tramming capacity of 1,300 kg, tilt breakout force of 32 kN and lift breakout force of 35 kN. It has a 0.7-m<sup>3</sup> bucket and can move fully loaded at up to 7 km/h.

Aramine describes the unit as “extremely narrow,” and ideal for narrow vein mines. It is 5.3 m long, 2 m high, and 1 m wide.

It was developed for miners that want to “limit the size of their galleries, increase production, and limit dilution,” Melkonian said.

The Mobile Charging Station is calendared for commercial release prior to the end of 2020. The battery-powered L350B is scheduled to debut at MINExpo 2021.

## Narrow Loader Lowers Costs

GHH reported customers say the compact LF-3 loader “produces well” with “low downtime.”

Released in Q2 2018, the loader is the culmination of years of research and development on narrow vein mining solutions, Ingo Rath, product line manager, loaders, GHH said. “The team took all the learning of developing previous low-profile machines and translated this into designing a robust, durable and reliable machine that is extremely maneuverable,” he said. “The LF-3 is only 1.5 m wide with excellent power-to-weight ratio.”

Units have been deployed to Australia, Brazil, Turkey, and Peru; and soon to Zimbabwe.

Feedback from Ölmez Maden kur un çinko i letmesi, a cut-and-fill lead and zinc mine in Turkey, states the loader is “working extremely well,” Rath said.

“The customer is extremely satisfied with the loader and says it’s the best loader in their fleet,” he said. “They say its breakout force and speed is far better than others.”

Because of its dimensions, it “can be operated almost anywhere in the mine,” Rath said.

“Additionally, they mention that while operating the LF-3, there is less exhaust and smoke, which they love,” he said. “It is safer and more environmentally friendly.”

In Peru, the company partnered with Overprime to sell the LF-3 and other loaders that complement it to make a total narrow vein solution, GHH reported.

The loader is roughly 7.1 m long, 1.5 m wide, and 1.9 m high, with a 3.1 m max inner turning radius and a 5.3 m max outer turning radius.

It has an operating weight of 11 mt, a standard bucket capacity of 1.5 m<sup>3</sup>, and a payload capacity of 3.5 mt. Customized buckets are offered.

The loader comes with either an EPA Tier 2, EU Stage II, air-cooled, Deutz 72-kW diesel engine, or a Tier 3, Stage IIIA, water-cooled, Cummins 67-kW diesel engine.

“The engine packages allow for deep-level gold and nickel mining, as well as high-altitude mining above 4,000 m, like in Peru,” Rath said.

It has a max tramming speed of 17 km/h.

Drive train options are a Dana Series C 270 single-stage torque converter, or a three-gear Dana Series RT 20,000 power-shift transmission.

The canopy is ROPS/FOPS certified.

Options include a collision avoidance system, a diesel particulate filter, and a corrosion protection kit.

Top tier benefits include low operating costs and “great operator comfort with excellent cab ergonomics and all-around visibility,” Rath said.

“The LF-3 is extremely cost-effective to run and easy to maintain,” he said. “It also has a very large and comfortable operator’s compartment, considering the size of the machine.”

The loader is purpose-designed for narrow vein applications, Rath said. “It provides a solution to miners in a way that they can keep their haulage sizes as small as possible according to the vein and make sure to minimize dilution and maximize productivity and ultimately profitability.”

The unit is part of a line that will include the LF-7 at the end of 2020. The LF-7 will be the largest narrow vein loader the company offers, Rath said. “We now have a complete narrow vein offering from small to large loaders.”





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# Mineral Processing Titans Merge

*Stephan Kirsch, president of Metso Outotec's new Minerals Business Area, discusses the next steps for the business and new opportunities*

By Carly Leonida, European Editor

On June 30, nearly a year after the deal was first announced, the combination of mineral processing firms, Metso and Outotec, was completed. Mining is now Metso Outotec's largest market ahead of aggregates and metals recycling, accounting for 61% of its illustrative combined sales of EUR 4.19 billion (\$4.95 billion) in 2019. CEO Pekka Vauramo and CFO Eeva Sipilä formally presented the combined company and its management team to investors and global media on July 1.

Stephan Kirsch, former Head of Mining Equipment at Metso, has stepped up to lead the new Minerals Business Area (one of six across the company; metals has its own dedicated unit) and he outlined plans for the division, both short and long term. "I feel humbled to be selected for the role," he said. "At Metso Outotec, we are fortunate to have a very knowledgeable, powerful and highly experienced team of mineral processing experts. With this team, we will support the industry with engineering, equipment and aftermarket services, from run-of-mine ore to production of metal. This is quite a comprehensive scope and I am proud that we can deliver this to the industry."

"The main benefit for our customers is that single-sourced key processing equipment within the mineral processing plant

can be balanced to ensure the highest recovery rates and the most economic and efficient operation of the plant."

"The comprehensive line offering will also provide our customers with much stronger development support, competitive supply packages and drive for our innovations."

## Cutting-edge Innovation

Kirsch mentioned that, as a leading player in the mineral processing sector, Metso Outotec is aiming high with its plans (and budget) for R&D.

In his presentation on July 1, Vauramo announced that, in its first year, Metso Outotec would allocate EUR 100 million (\$118 million) — approximately 2.5% of its sales — to R&D, adding that he would not hesitate to increase that number to 3% if the right opportunities presented themselves.

*E&MJ* asked how the budget of €100 million will be split across the six business units and how much funding will be dedicated to the Minerals division?

"It is a significant R&D budget, and we committed to this because we want to ensure that we meet our aim to be the industry leader for innovation," Kirsch said. "And you have to spend money to achieve that objective."



Stephan Kirsch, president of Metso Outotec's new Minerals Business Area.

"Now that we have brought both companies together, we committed to keeping both R&D budgets stemming from Metso and Outotec. The combined number — EUR 100 million — makes us, on the spending side, a front runner in R&D."

Kirsch was keen to point out though that it's one thing to spend money, it's another thing to achieve results.

"This is something we have to be very mindful of," he said. "That's why with our R&D, we are not working with a centralized R&D department. Each of the business areas has its own R&D function that is very specific to its capital equipment."

"The idea behind this is that we own our R&D projects, and that the bringing to market strategy will work. We are not doing R&D for the sake of doing R&D, but for the sake of developing something that will be applied and operated."

"We will analyze product lines and spend our money wisely wherever we see it can be applied most economically for the benefit of our customers, but also, for ourselves. Obviously, when you spend R&D money, you're also looking at return on investment. For now, the main focus is on product innovations, digitalization and sustainability."

In the Minerals business area, R&D activities are broken down into product groups like crushing and screening, and flotation rather than by commodity.

Kirsch explained: "The reason for that is quite simply because when you look at a crusher or a mill, the challenges for R&D are in the design of the products."



The new combined company — Metso Outotec — was presented to investors and the press on July 1, 2020.





Metso Outotec now has an extended reach across the mining value chain from orebody to metal.

The same crusher, for instance, can be used across gold, copper, iron ore, or base metal applications. It's only further downstream that the technologies become more ore specific.

"In the Metals business area, they are more focused on commodities; the old Outotec had R&D facilities dedicated to iron ore or copper for example. So, that's where we differentiate by commodity."

### More Services, More Equipment

Announcing the combination of two leading companies is, of course, exciting. But before the teams can properly get down to business, there are discussions to be had and plans to be advanced.

Up until July 1, Metso and Outotec were officially competitors and, while the companies were able to plan for the integration to some extent via external consultants, according to the antitrust process, the teams were not allowed to communicate directly.

"There is no textbook for the merger of two industry heavyweights," Kirsch said. "We are writing that textbook and every day we learn new things. Obviously, there are challenges, but I think they are outweighed by the opportunities. There are a lot of synergies where we can bring locations and people together, which will benefit everyone. It will benefit the company, our customers and also our employees."

Speaking of opportunities, Metso Outotec now has an extended reach across the mining value chain from orebody to metal. This puts the company in a unique

position to help customers that are looking to optimize their processes holistically in line with megatrends such as circularity, decarbonization and zero emissions.

"I see significant opportunities, particularly in the provision of our services," Kirsch said. "Metso has got a very strong service background. When I talked to customers and they often said 'this is great, Outotec has got such a good high level of processing technology. And if we add to this the really superior Metso services, then it's a powerful combination.'"

It is worth noting that services accounted for 56% of Metso Outotec's illustrative combined sales during 2019 — more than capital equipment — and around a third of the company's workforce (5,000 people) will be engaged in services going forward at 140 service locations worldwide.

A larger installed base requires a larger service team, but with that comes the opportunity for increased learning and access to knowledge. Customers will be able to benefit from increased sales and support capabilities, particularly, on the data analytics side of things. And they now have access to both companies' subject-matter experts.

"As individual companies, but also as the new combined company, we are well represented in all major mining markets," Kirsch said. "I see further growth potential in all of those markets because of the new full line offering and our combined technical expertise.

"But particularly, I see Africa and Southeast Asia as regions that have good growth potential."

### Moving Forward as One

During his presentation, Vauramo also explained a little about Metso Outotec's branding strategy.

In essence, existing Metso product lines will continue to keep the Metso name, existing Outotec lines will keep the Outotec name, and new jointly developed products as well as services and consumables will carry the combined name.

"It is important for us to ensure continuity for our customers and, as such, we will keep the brand names as they were established over decades," Kirsch explained further. "But, obviously, when it comes to new products generated from Metso Outotec, from the new company, then we will look into this case by case and see whether they should actually be branded as Metso Outotec. It is likely to happen like this, but those are one of these detailed areas where we need to dive deep and see how we do it in the future."

The scope of Metso Outotec's capability going forward is not just exciting for customers; from an employee perspective, it must be amazing to join forces with one of your biggest competitors and gain access to their experts and technologies.

Together, the possibilities must be almost limitless?

"The whole process is very exciting, I must say," enthused Kirsch. "To bring two companies like this together... you don't do that often in your lifetime.

"I've been in this industry for around 30 years. I've gotten to know many members of the Outotec team in that time, and it's good that we are now part of one family."

# Refining Gold Processing

*E&MJ looks at designs and technologies that are making gold flowsheets more efficient and economic*

By Carly Leonida, European Editor



Operation of high-frequency screens for fine carbon capture in California. (Photo: Derrick)

Gold processing is one area of mining where the old adage 'if it ain't broke, don't fix it' really rings true.

If you took a gold miner from the 1990s and put them into an operation today, they would probably be familiar with every piece of equipment and circuit in front of them. Sure, there would be incremental changes, mainly technological, in the control systems, there's a greater focus on carbon management now, energy efficiency, the addition of pre-leach thickeners etc. And there are more plants dealing with refractory ores. But, on the whole, not a lot has changed.

"We're still using the same basic processes and equipment that we were 20 or 30 years ago," Ben Murphy, Global Key Account Manager and Key Industry Director for Gold at FLSmidth, told *E&MJ*.

"But people are tweaking certain areas...for example, there has been a lot of work into alternative lixivants for gold leaching, but to date there hasn't been widespread implementation. When it comes down to it, the old cyanide leach plan is pretty efficient at getting gold out."

"We've now got the international cyanide code. People are a lot more conscious of cyanide and the environment than they were 30 years ago. That is a good thing. There are various strategies... Different separation methods, preconcentration to minimize material that comes into contact with the cyanide, and detox to reduce the concentration in tailings.

"It is a lot more common now to see a flotation circuit in gold plants, because they need to capture the gold that may be associated with sulphides.

"Interest in fine-grinding is also increasing because, for some refractories, they simply require grinding down to a size that allows the gold to be exposed for leaching. Once again we are still using the same basic technologies, albeit it more efficiently. I don't see that changing any time soon."

## Gradual Progress

Jan Van Niekerk, Director of Gold Process Solutions at Metso Outotec, agreed: "20 or 30 years ago, cyanide was already established, even the use of carbon had been established. And, yes, the process is fairly much still the same.

"But there have definitely been incremental improvements. For example, ore sorting; that's certainly been gaining more market acceptance. A lot of that is to do with the technology and the instrumentation that's available.

"But something like the gravity circuits, if you think of 20 years ago, for the most part the gravity circuit was an afterthought or add-on, that wasn't really well designed and engineered for most plants. Whereas now it's an essential part of the plant design.

"The principles of milling are still very much the same, but the controls have been fine tuned. Things like mill optimizers that create benefits in power saving and managing the throughput of your mill...

"Even on flotation, the instrumentation has advanced significantly. It does give you that step change in ability to control the plant and get better recoveries. Again, we are getting more variable ores, and you can't just set a plant and leave it to run for a long time; you have to constantly monitor and adjust."

Process modeling programs have also contributed to the optimization of plant designs.

"Modeling has certainly made a difference. And, in gold, it's been under-



utilized for the most part,” Van Niekerk said. “But we’ve seen, especially with more complex orebodies where you’re starting to get copper in and there’s a copper circuit attached, or those with high variability, then a process modeling program is a really powerful tool to have.

“Mining models are normally built around the gold and sometimes a sulphur model or maybe an arsenic model. But, with geometallurgy and variable orebodies, you can almost get to the point where you’re building an operating envelope model to determine what the recovery is in certain areas of the plant and for certain areas of the orebody. That’s going to change more and more over the next few years.”

Geometallurgy and process modeling coupled with instrumentation and process control will become even more important in the coming years. Especially as we see mines and concentrators developed in more remote locations; it’s not easy to get highly skilled people permanently stationed on remote sites, and there is a growing requirement to control plants remotely.

We’re also starting to see a shift in design philosophy, partly driven by higher gold prices and partly by mining companies’ attitudes toward risk.

“A few years ago, the focus was really on building the cheapest plant possible because the orebodies were fairly simple,” explained Van Niekerk. “Whereas, with more complex orebodies in more remote locations, there’s a requirement to build a slightly more expensive plant, but you get better reliability, lower power consumption and better water management.

“There’s more a philosophy of investing in and designing a plant for life, rather than just seeing it as an upfront capital cost. That’s a big change that I hope it’s going to continue.”

## Orebody Complexity

Increased ore complexity is one of two over-arching themes that are driving innovation in gold processing.

The ideal orebody would be one where the gold is located at shallow depth, is well liberated at a coarse size and can be recovered using simple gravity techniques. Next would be a free milling oxide orebody where a cyanidation and

gold recovery circuit would be required. Transition material with a mixture of oxides with increasing amounts of sulphides would then be the next hardest to treat with the flowsheet having to possibly incorporate ultrafine grinding and partial oxidation technology.

Finally, there are fully refractory orebodies where the gold is locked within sulphides, and the flowsheet becomes more complex with the addition of an oxidative treatment method such as pressure oxidation (POX), roasting or bacterial oxidation (bio-oxidation).

The presence of carbon in the ore can result in the orebody being classified as double refractory and this may require additional process steps again.

To clarify: refractory gold ores are generally defined as those ores that do not give economic recoveries in conventional cyanide circuits where the ore has been ground to around 53-75 microns. There are several reasons as to why an ore may be refractory. The two most common are:

- 1) The gold is locked in refractory sulphide minerals such as pyrite, arsenopyrite or pyrrhotite and occurs in both the chemically bonded state and as micro or nano-size grains of metallic gold.
  - 2) Or the gold is locked in silica.
- Other reasons for an ore not responding to conventional cyanidation include:
- 1) Preg-robbing due to the presence of carbonaceous material;
  - 2) Other minerals reacting with cyanide;
  - 3) The presence of lead, copper, or antimony minerals; and
  - 4) Interference and passivation from the decomposition products of pyritic and other minerals.

The rise in the processing of refractory ores is mainly because most of the shallow, free milling, oxide orebodies across the globe have been exhausted. Elevated gold prices mean that attentions are now turning to mixed orebodies or refractory ones where the gold is harder to liberate and recover, and this of course puts additional pressure on the project economics.

“Evaluation of refractories has become a lot more common,” Murphy said. “We’ve seen a massive uptick. Last year FLSmidth acquired Barrick’s technical research arm, AuTec. Not only for its expertise in complex gold

processing, but for their expertise in POX piloting.

“We brought the pilot plant down from Vancouver to our lab in Salt Lake City. It was commissioned in September 2019 and it’s been running, pretty much, 24/7 since, doing test work on different orebodies.”

## The Environment and Economics

The second major theme revolves around environmental responsibility. Over the past 10 years, every mining company, large or small, has turned their attention to more sustainable mining practices.

In gold processing, this translates into using technologies and processes that are more energy efficient, for example, next-generation ultrafine grinding mills or high-pressure grinding rolls (HPGRs). Technologies with smaller footprints, or those that consume less water and cyanide are also growing in popularity and, there is a growing focus on total cost of ownership.

“One thing that’s becoming more and more important is water balance and the management of water around the mine,” said Van Niekerk. “There is increasing legislation around the use of water and discharge requirements. And that links to the environmental permitting which, in itself, is becoming more complex. Community relations and all those aspects that need to be taken into consideration too.

“Also, sites in more remote locations aren’t always easy to access, and that carries certain requirements from a design and selection of technologies point of view.”

Underpinning these two themes are gold prices and the commodity super cycle. Prices are, as of July 30, at an all-time high. It’s been a bullish couple of years and, during July, geopolitical uncertainty and global financial instability fueled by COVID-19 saw gold prices surge toward \$2,000/oz. As a result, mines, engineers and OEMs alike are mostly working flat out right now.

“Everyone is trying to make hay while the sun shines,” Murphy said. “That provides the opportunity to go back to basics. There are a lot of old gold plants out there that haven’t seen love for a number of years because of the price.

“So, yes, we’re seeing a lot of activity, and a lot of enquiries.”

Van Niekerk reported similar: “In general, we are seeing increased interest, particularly in plant audits and optimization services. A lot of that has to do with the gold price - there’s pressure to maximize recovery. But also, with a higher gold price there’s actually some cash available to spend on R&D and process optimization. Whereas when the gold price is low, that money isn’t always there.”

## Test, Test and Test Again

Every expert interviewed for this article agreed that, the more complex the mineralogy, the more important it is to get test work and characterization right at the start, and to continue sampling throughout the life of the facility.

“With traditional geometallurgical test work, you do your test, you get some results, A plus B equals C... Great. But if you have some unseen complexity there, you may be in trouble,” Murphy said.

“Whereas, if you do in-depth test work, using a lab like our one in Salt Lake City, Utah, we have the mineralogy team working side-by-side with the process people. They do the test work, and they’ve got a more holistic view of what’s happening and why. They’re also, brilliant for troubleshooting, especially in the early stages.”

*E&MJ* has spoken to multiple mining companies over the years that have picked up projects rejected by others due to orebody complexity or geometallurgical complications that were missed at the pre-feasibility stage. This is just one reason for the cost overruns that seem to have become almost endemic in the gold industry.

Steve Flatman, General Manager at UK-based engineering specialist, Maelgwyn Mineral Services, told *E&MJ*: “Unfortunately the metallurgy is often an afterthought. There’s often little metallurgical representation on the boards of mining juniors. They start off with a conceptual study, and management just assumes that they’re going to recover 100% of whatever gold’s there.

“Only later on when they’ve actually done some metallurgical test work, do they realize that it’s not quite as simple as that. And it’s difficult to talk the

share price up after that. So, they tend to sell the project on to somebody else. That’s why you see some of these more difficult deposits bandied about. Because yes, the capital required for technologies like POX is not insignificant.”

*E&MJ* asked if we should be doing more test work early on in the scoping process to help circumvent this issue?

“Yes,” said Flatman unequivocally. “The geometallurgy must be an integral part of the whole program. You don’t have to wait until the definitive feasibility study — the last stage of the project — to start doing the metallurgical and pilot test work, which we quite often see. At that stage you’re almost too far down the line in terms of environmental permitting. For instance, if it comes up that you need higher cyanide additions, then that could affect your environmental permitting and put the project back again. That’s why it’s important.”

Van Niekerk added: “The biggest issue when you’ve got a highly variable orebody is the testing requirements for various ore zones. It makes the whole process of developing the project so much more complex.

“It’s not as simple as selecting a sample and then doing work on it. Often the mining model is developed over time, so you’re always changing the blend that’s going into the plant. If you’ve got a uniform orebody it doesn’t matter that much. But when you get variability it becomes difficult. It means that you’ve tested one zone, but suddenly you’re not going to treat that on its own, you’re going to mix it with something else and you have to do another test program on that.

“Often some of the tests are done at one laboratory and the next set of tests at another and in between the origins of the samples get lost or diluted or there’s different test procedures. Most companies do a lot of test work, but often the management or the planning around that is not coherent over the whole development of the project and management of the data isn’t always that good.

“Again, that’s where modeling programs are coming to the fore; where you can have a set of standard tests on the different ore zones and the software can then integrate that into an overall model based on your feed parameters.”

“Getting back to the point about cost overruns; we’ve certainly seen under-performance on some projects because there was never a proper understanding of the orebody.”

## Optimization Opportunities

*E&MJ* asked Murphy where he sees the greatest opportunities for optimization improvements in gold circuits at present.

“Preconcentration works really well on certain orebodies. I think it’s something that we need to look at more, but the economics are very orebody dependent,” he said.

“In the gold sector, I’m really an advocate of going back to basics. We’ve got a fantastic gold price right now, but as we all know the industry is cyclic. Sooner, or later, that gold price is going to drop and tough times will return. Driving your operating costs down as low as possible will not only improve profitability for now but will secure your future when the downturn comes.

“There is some very low-hanging fruit, for example pump optimization. Getting the pump matched to the duty can save you in maintenance costs but also can reduce energy consumption. When you multiply this by the number of pumps that run in a plant, it adds up quite quickly. There are many pumps on plants that were installed when the plant started and have never been changed despite the duty changing. In the last 20 to 30 years there has been a lot of progress in wear materials and understanding of slurry pumps which can now be applied to the benefit of the operator. A quick review can lead to major savings.

“Another area is sampling. A lot of gold mines, especially older ones, don’t have the best sampling equipment. It’s so critical when you’re trying to control the process; if you’re striving to get the lowest cost per ounce, you really need a good understanding of that process.

“It sounds cliché, but it’s true: if you can’t measure it, you can’t manage it. And the first step in measuring that is getting a good sample. Yes, downstream, where you’re sampling liquids, it’s a lot easier, making sure you have really good slurry samples is



also important. The samples need to be collected in the right places and ensuring they are representative of the process.

"I see a lot of shortcuts in existing plants. Having good sampling makes life easier from a control perspective, and also from an accounting perspective. If you've got better sampling, you've got a better idea of the inventories in the process. So, at month-end, you're not searching around for 'missing ounces' which, I'm sure, keeps a number of CEOs up at night.

"It's important to remember that there are two ways of changing the mining cost per ounce: you can either produce more ounces or you can reduce costs. Never rule out the first one. If you can produce more efficiently by having better process control that is a big win for the site."

### Gravity Concentration

"As I said, for existing plants, it's very much getting the basics right," added

Murphy. "For design, going forward, we're likely to see a more holistic approach with greater focus on total cost of ownership. But there are also some new, exciting technologies coming."

Gravity concentration has been an area of focus for the team at FLSmidth of late. Murphy explained their progress to *E&MJ*...

"A number of years ago, we acquired the Knelson batch centrifugal concentrator (BCC), which was and still is the industry leader in gravity technology," he said. "The Knelson is typically installed in the grinding circuit and pulls out free gold. It captures the gravity gold upfront which reduces the chance of that gold getting lost to tails and gives you a quicker return.

"Most gold mines, in this day and age, will do testing at the start of the project to see if the gold is gravity amenable and is able to be recovered by a BCC.

"What we've been developing over the last few years is a Continuous

Knelson. It uses a similar concept to the BCC but has some important differences. A batch Knelson has a low mass pull. It can pick up gold associated with other minerals, such as sulphides but generally, it is most efficient at targeting free gold due to the high density difference."

As the name suggest the Continuous Knelson is designed to be run in continuous mode and doesn't need to be installed in a circulating load to maximize recovery efficiency. In addition, because of the way it's set up, it can target a wider density range for efficient separation.

"We've been doing a lot of lab work," said Murphy. "And we've got a few clients who have bought pilot units from us and done their own test work on concentrating gold that is associated with sulphide minerals. This work has culminated in a number of Continuous Knelson applications, typically installed on the cyclone overflow stream.



A BIOX bio-oxidation plant at Metals Ex's Runruno gold mine in the Philippines. (Photo: Metso Outotec)

"I can't mention who or where yet, but let's just say these machines are very different beasts. They're separating out the sulphides with gold, in much the same way that a float circuit would."

"In one case, the client didn't want to put in a float circuit because of logistical challenges. They've done all their test work and due diligence, which resulted in them installing production units. Feedback from the site is that they are working really well."

"A key limitation of the batch Knelson is that it only has a mass pull of around 0.1% of the feed. The Continuous Knelson can pull 5% to 30% quite easily, depending on the ore characteristics. So, it's a much more flexible machine. These units can handle up to about 300 nominal tons per hour. Obviously, it depends on the exact site and the feed conditions. It's a different way of doing things, there are no reagents and a very small footprint."

"We also have some exciting developments that will improve our batch Knelson coming out soon. We have done a lot of optimization and computational fluid dynamics (CFD) work. Based on these results and improved understanding we have changed a few things around the design. Early 2021, we will be releasing a new modification that can be retrofitted to existing models. Early results with this redesigned unit show a marked improvement in gold recovery in certain size ranges which we are getting pretty excited about."

## Harnessing Screening

Another incredibly efficient and time-tested way to separate and classify materials in gold concentrators — one that is often overlooked as an optimization tool — is screening. New designs and capabilities mean that screens can now be used to replace some of the more traditional elements of flowsheets.

"Anywhere that a particle separation takes place, a screen is the most efficient device," explained David E. Perkins, Mining & Industrial Commercial Manager and Director of Precious Metal Applications at US-based manufacturer Derrick. "Often in gold circuits, screens are used to capture very fine carbon and boost gold recovery. Also, models like the Derrick Stack Sizer are capable of



Maelgwyn's Aachen Reactors in a Leachox application. (Photo: Maelgwyn Mineral Services)

replacing hydrocyclones in the grinding circuit, resulting in increased recovery as well as reducing the power consumption per ton and increasing the capacity of the grinding circuit."

Derrick's approach is to tackle the applications that are the most difficult. Its line of machines with high flux rates and non-blinding panel technology allows the company to provide a machine that is a fraction of the size of traditional screen units and capable

of consistent capacities through the life cycle.

"The Derrick solution might be a 4x8, whereas the alternative is 8x16," said Perkins. "Being capable of processing the same volume of material in a much smaller plant footprint can be a big advantage to gold operations."

Screens are used in a variety of applications in gold concentrators. Removing preg-robbing trash, separating slurry from loaded carbon, sizing of



# OPTIMIZATION



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carbon, dewatering of carbon and, as a safety device to prevent loaded carbon from going to tails, are just a few examples.

"I have experienced operations that have large screens that are shaking the foundations and, after replacing them with a Derrick, operators have difficulty in knowing if the machine is operating due to the very low transmitted forces and low sound levels," said Perkins. "I had a client that was losing productivity by having to wait several hours to de-

cant the feed hopper to their kiln and, after replacing the dewatering screen with a Derrick, there was no longer a wait required."

By replacing 50+ year-old cyclone technology with high-frequency vibrating screens like the Derrick Stack Sizer or SuperStack, some mines can increase their plant capacity by 20%-50% and boost recovery by up to 10%. Aside from reducing the plant footprint, this also has the added benefit of reducing overall water and cyanide con-

sumption, resulting in a much 'greener' approach to recovering gold and other minerals as well.

In early 2020, Derrick launched the G-Vault urethane-surfaced interstage screen for use in carbon-in-pulp and carbon-in-leach (CIP/CIL) circuits; an alternative to traditional stainless-steel wedge wire screens. The enhanced durability and anti-blinding technology mean that the G-Vault has shown substantial reductions in maintenance and downtime. Compared to the alternative of



Clean Mining's reagent test plant in Menzies, Western Australia. (Photo: Clean Mining)





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Start-up of CIP safety screens at a gold mine in Suriname. (Photo: Derrick)

multiple, weekly shutdowns with existing wedge wire screens, the G-Vault can run beyond eighteen months with no cleaning required; a boon in remote locations where access to site is tricky.

The G-Vault features independent screen sections retained in a stainless-steel cage. Their interchangeable nature reduces maintenance costs by permitting replacement of only a heavily worn section, rather than an entire screen.

Alex Nicosia, Global Precious Metals Manager for Derrick's New Business Development Division, told *E&MJ* that the company has seen strong interest in the G-Vault from its client base, and field testing has now been conducted in six countries across North and South America, as well as Asia.

## Bio-oxidation

June 2020 also saw the launch of Outotec's MesoTHERM BIOX process, an enhancement to the well-known mesophile BIOX process that combines bio-oxidation technology with a higher-temperature thermophile oxidative stage to enable more effective overall sulfide oxidation.

"The MesoTHERM process has been in development for quite a while," Van

Niekerk said. "We're getting significant savings in cyanide — up to 50%. The higher temperature thermophile bacteria give a more benign product following bio-oxidation that then consumes less cyanide in the downstream processing.

"BIOX or the mesophile technology has been around for over 30 years. And even the thermophile technology has been around for a long time. It's just nobody has really commercialized it. And we've gone through a very long-gated process to develop this, but it's now being commercially operated at the Fairview BIOX plant in South Africa."

Van Niekerk said the company has also had multiple enquiries from mines looking to upgrade the BIOX process they currently have. Upgrading to MesoTHERM is a relatively simple process that involves reconfiguring the circuit with the addition of Outotec's High Rate Thickeners for interstage thickening and OKTOP Atmospheric Reactors for the thermophile step.

"Most of the newer projects immediately ask if we're testing MesoTHERM as part of their project development," he said. "The Fosterville mine has already expressed an interest to test this too.

"We're primarily targeting mines with higher-grade sulfide orebodies. That's something that normally results in high cyanide consumption when you're treating the ore using the normal mesophiles. So that's where this will really add benefit."

## Partial Oxidation

In terms of flowsheet design, refractory sulphides are normally treated through a flotation route. The gold-rich sulfide concentrate is then treated further using roasting, POX or bio-oxidation. These are all aimed at breaking down the sulphide matrix to liberate gold. Ultra-fine grinding performs the same function particularly where gold is locked in silicates or other minerals. Many of these processes are well developed and can yield very high gold recoveries — more than 90% or even higher for POX — but all tend to have inherent issues.

Roasting although historically used is an environmentally unfriendly process and presents permitting issues in many countries. POX requires a fairly high degree of operator skill and control, not to mention often exotic materials of construction. Bacteria used in bio-oxidation, whether heap or tank leaching, are susceptible to changes in environmental conditions and require careful control.

"For large high-grade deposits, POX is generally used as these deposits can justify the high CAPEX and OPEX," explained Maelgwyn's Flatman. "For smaller deposits, partial oxidation processes such as Maelgwyn's Leachox can be used. Although the recovery is lower at around 80%-90%, the costs can be an order of magnitude lower."

Central to Leachox is the Maelgwyn Aachen Shear Reactor — a proprietary low-pressure high shear mass transfer device — which has been available for many years now.

"The majority of our Aachen Reactor applications are in preoxygenation, and Aachen assisted leaching which improves the kinetics of gold leaching, increases gold recovery and reduces cyanide consumption," Flatman explained. "We use them on oxide ores and also on mixed orebodies and refractories. As you start to get more sulfides present and cyanide consumption starts to increase, then we use the



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Aachen aerators to add additional oxygen into the leach, but with the shear to keep the mineral surface clean so you're continually chasing that mineral reaction. Then, as you move further into refractory type of materials, the best way to process them is normally through flotation and that's because you can concentrate the gold into a smaller mass, so your process plant size is smaller.

"Again, we use the Aachen Reactors there, but in a much more intensive manner. Typically for pre-oxygenation roles, we would pass the concentrate once or twice through the Aachen Reactor, but in the Leachox role, we're doing partial oxidation so we may pass the slurry 30 to 40 times through the Reactor."

Leachox uses simple ultra-fine grinding equipment combined with

the Aachen Reactor to partially oxidize the sulfides. When combined with the liberation of gold by the ultra-fine grinding of concentrates it results in acceptable but, more importantly economic gold recoveries. The use of the Reactor accelerates the leach kinetics allowing for higher throughputs through the CIL/CIP plant and reduces cyanide consumption by initiating efficient oxidation of cyanicides in the pulp that react with cyanide in preference to gold and reduces the leaching effect. In parallel, the Aachen Reactor removes passivating layers on the mineral surface that can otherwise impair the leach reaction.

Where graphitic carbon is present leading to preg-robbing the Leachox circuit can be enhanced by using Maelgwyn's patented G-Cell to remove the carbon.

Aachen reactors can also be used for cyanide destruction at the end of the process as well, so they're a pretty flexible piece of kit.

"We've got around 70 reactors running at different sites now," said Flatman. "We commissioned a large facility with one of the eight reactors in South Africa last year at Evander Mines' Elikhulu tailings operation."

Barrick's flagship Kibali mine in the DRC is another fan. The Kibali process circuit consists of eight ultrafine grinding mills which mill the flotation concentrate to approximately 80% minus 18 microns. It is then subjected to two-stage pre-oxidation at pH 10 utilizing Aachen Shear Reactors before cyanidation.

Flatman spoke honestly: "If you've got a multi-million-dollar project — over a million-ounce gold project — and it's



Petropavlovsk's POX Hub is one of only two POX facilities in Russia. (Photo: Petropavlovsk)





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high grade, I would put in POX rather than our leach operation. And the reason for that is that POX gives a very high recovery, often as high as 98%.

"The problem is it's the most expensive option in terms of CAPEX and OPEX. Straight away you're talking high pressures, titanium vessels, you need skilled operators and instrument technicians. And if you're in a remote location, that can be expensive.

"Up until 30 years ago, roasting would have been used, but that's fallen out of favor due to environmental considerations. In roasting you can create gaseous emissions of sulphur dioxide, sulphur trioxide and if there's any arsenopyrite present, there can be arsenic emissions. Which can obviously cause major problems.

"Now, you can trap that through gas cleaning equipment. But again, it adds to the cost. So, POX has become the go-to process, like cyanide.

"Bio-oxidation became popular approximately 20 years ago. Although it's cheaper than POX, it's only really suitable for smaller deposits because of the time involved. Bacteria by nature are not instantaneous, you can be talking residence times of four to five days in some of the vessels, rather than four to five hours for the cyanide leaching. And if you don't have the technical people on site to understand how the bacteria work, you can kill them.

"So, that leaves a gap in the market for partial oxidation processes such as Leachox. And in our process, we don't get as high a recovery as POX or bio-ox-

idation, but the process is an order of magnitude cheaper. For smaller deposits, where you don't want to put in huge amounts of infrastructure, then Leachox is a good option."

It's also fairly straightforward to operate; basically, a pump sends material through the Aachen Reactor, which contains no moving parts.

"The slurry is accelerated up to 10-12 liters per second, deliberately to create the shear," explained Flatman. "In creating that shear, a significant amount of abrasion takes place and the Reactors have to be maintained; you can't just put them in leave them forever. So, we usually lease them. That has a two-fold advantage. Firstly, we ensure that it works — it helps to de-risk the project for the client — because the maintenance is included as part of the lease contract. Secondly, the operators themselves have the opportunity to believe in the process. Because if it doesn't work, then they can just stop it. It's very easy to prove it's working."

## Ultrafine Grinding

To date, the primary focus for Aachen Reactors has been gold ores. However, Maelgwyn recently commissioned its first application on a silver orebody at Gumustas Mining's Nigde-Bolkar gold-silver operation in Turkey with excellent results, including a recovery increase of 8% and a 30% reduction in cyanide consumption.

"We do see potential for silver," said Flatman. "One of the problems with sil-

ver is that the leaching is much slower, you tend to get a lot more passivation taking place. So, if the gold ore leaches in 24 hours it might take 76 hours for a silver ore to leach. The Aachen Reactor thins the boundary layer and speeds up the leach process. We are talking to a couple of silver operations at the moment, so watch this space."

To complement the Aachen Reactor in the Leachox process, Maelgwyn is also developing its own ultra-fine grinding mill — the Ro-Star mill.

"We've been developing it for the last two years," Flatman told *E&MJ*. "To date, we've had to rely on buying in mills from elsewhere. Although the mills have improved in quality, they tend to be very expensive. So, that increases the overall capital cost of the Leachox process. Our aim with the Ro-Star is basically to produce a better 'mouse trap' for want of a better term and drive down the cost of Leachox even further."

## Pressure Oxidation

Which leads us nicely to the gold standard for refractory processing: POX.

Although POX does carry significant CAPEX and OPEX costs, it can be harnessed to create significant value. One such example is Russian gold producer, Petropavlovsk. The company's POX Hub in Russia's Far Eastern Federal District is a world-class facility and a strategic asset.

Approximately 15%-30% of Russian gold reserves are classed as refractory, while nearly 6 million oz of the company's own reserves are also refractory.

## Alternative Lixiviants

While cyanide is still the go-to reagent for gold leaching, there are operations where, for environmental, social or logistical reasons, it cannot be used. And, in these instances, it's good to have alternative options.

Clean Mining, part of the Clean Earth Technologies Group, offers a non-toxic, non-flammable, reusable and water-soluble reagent based on an inorganic compound that can be used as an alternative to cyanide.

The technology, originally developed by CSIRO, is particularly aimed junior producers that don't want the compliance and rehabilitation costs associated with cyanide. Clean Mining offers a mobile/transportable and scalable plant design that it said is suited to both large and small high-grade deposits.

The front-end milling circuit is the same as a cyanide-based plant — so the new technology applies only from

the leaching to gold recovery phases. This makes for an easier transition, and there is also an option for a dewatering process to produce dry tailings.

"The plant itself is very similar to a cyanide plant with our technology fitting into the process specific to leaching and dewatering," Kevin Fell, Group CEO, told *E&MJ*. "The solution is scalable from artisanal operations all the way through to major operations in gold processing.

"We have been overwhelmed with enquiries on a global basis. Our test plant in Menzies, Western Australia, validated the process, and a variation of our solution was provided by CSIRO, to Barrick Gold in Nevada in 2014 prior to us obtaining the IP. We currently have in testing several opportunities globally and will be rolling out several plants in the not too distant future."



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costs. It also means it can leverage stranded refractory ore deposits, which cannot be mined and processed in an economical and environmentally sound manner without a POX plant.

of open pit and underground, with 15 million metric ton per year (mt/y) ore processing capacity in addition to the 500,000 mt/y potential of the POX Hub.

The POX Hub is located at the site of the company's first and now depleted mine, Pokrovskiy, where it benefits from existing milling facilities, road and rail infrastructure, low-cost renewable power (hydro-electric) as well as a nearby limestone deposit — a key ingredient in the POX process.

The processing of refractory gold ores begins with crushing and grinding, followed by flotation at the mine site which reduces the volume of material down to between 2.8% and 4.2% of the original mass by selectively enriching gold mineralization. The resulting concentrate is then transported to the POX Hub by road and/or rail for further processing and gold recovery.

The POX Hub is designed to operate at a pressure of 3,500 kPa and a temperature of 225°C which is higher than most other POX plants and enables the efficient processing of a variety of refractory feeds, including double-refractory concentrates.

What makes this POX plant unique is that there are four separate autoclave vessels that provide flexibility, allowing concentrates from different sources, and with varying characteristics and grades to be treated optimally, either individually or as blends, in separate autoclaves. It also means that scheduled maintenance can be undertaken by shutting down only one autoclave at a time. Each individual autoclave is expected to operate for 7,500 hours per year once at full capacity. The layout has been designed to accommodate a fifth and sixth autoclave in the future, something which is being considered and would increase capacity by around 50% compared to the existing level.

Throughput rates are determined by the specific characteristic of the concentrate and particularly the level of sulphur, with high sulfur concentrates taking longer to process given the additional time required to oxidize sulphur in the autoclaves. As a result, the capacity of the plant varies on an annual basis according to the material it is processing.

The group's first 3.6 million mt/y flotation plant was successfully commis-



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sioned at Malomir in 2018. Concentrate grades vary between 21 and 32 grams per mt (g/mt) of gold with a sulphur content ranging from 21% to 29%. The ore at Malomir is double refractory and requires special measures to neutralize the carbon so that gold recoveries are not negatively impacted. These include strict control over chlorine ion levels and the relatively high pressure and temperature of the autoclaves. As a result, the average recovery of gold in the POX circuit is expected to be between 93% to 96%.

The construction of a second 3.6 million mt/y flotation plant began in H2 2019 at Pioneer. Once operating at full capacity, Pioneer's flotation plant will double Petropavlovsk's flotation capacity of its own ore to 7.2 million mt/y. Construction is well under way and the new plant is expected to be fully operational later this year. Once commissioned, Pioneer concentrate grades are anticipated to vary between 20 and 33 g/mt of gold, with an average gold grade of 24.2 g/mt and average sulfur grade of 21.0%. Gold recovery in the POX circuit is expected to be around 93%, although the company's engineers believe 98% is achievable.

Subject to board approval, Petropavlovsk is also planning to expand Malomir's flotation plant, potentially beginning construction in late 2020. This would increase the capacity from 3.6 to 5.4 million mt/y of concentrate. Longer-term, a flotation plant at Albyn is envisaged for 2028 to process refractory ores at the Elginskoye and Unglichikanskoye deposits. The grade of these concentrates is expected to vary between 20 and 40 g/mt, and the average sulfur grade will be around 15%.

"The smooth ramp-up of the POX Hub stands as a record for the industry. It reflects more than a decade of R&D and is testament to the strength of the company's scientific and engineering capabilities. At the onset, POX processed our own refractory ore but since July 2019 we have been treating third-party concentrates from several sources, quickly achieving the design recovery rate," said Pavel Maslovskiy, co-founder of Petropavlovsk.

Technological improvements are constantly being made to the POX Hub. Current projects include: working to isolate and recover antimony as

a by-product; reducing the amount of organic carbon in concentrates; and suppressing the sorption activity of a carbonaceous substance through heat treatment of concentrates which have passed through the autoclaves and low- and high-temperature POX.

In the future, Petropavlovsk said it might be able to process some very

complex refractory materials, at the Hub including:

- Pyrrhotite-bearing concentrates;
- Cuprous and antimony gold-bearing concentrates;
- Triple-carbon concentrates;
- Concentrates from the tailings of existing mines; and
- Bio-cake.

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# Dealing With Data: Cybersecurity in the COVID-19 Era

*Working smarter and safer has become an industry creed for employee welfare. Companies should apply the same principles to data management.*

By Russell A. Carter, Contributing Editor



The mining industry's growing appetite for real-time data collection and analysis brings with it an equally robust need for wider use of mobile devices and broader sensor networks — all of which can also heighten an operation's vulnerability to cyberattacks when its data security and management practices can't meet the challenge.

"Data" might be the most imprecise word in the language of business, both in terms of meaning and value. For mineral producers, a data item could be anything from a momentary, routine signal from a remote sensor, to a single cell in a vast financial spreadsheet. As for value, how is it measured? Is a gigabyte of drill hole data worth more than a gigabyte sent from a pipeline pressure sensor?

Sometimes the actual value of data can only be determined when it's misused or missing. The cost of ignoring or misinterpreting data from a haul truck temperature sensor might be reflected in the price of an engine overhaul, and the eventual financial impact ensuing from theft of sensitive spreadsheet information could provide a quick indication of how much that data was worth — both to the company that owned it and the hacker who stole it.

One indication of how valuable a company's data can be was presented in a recent article on the Forbes.com website that pointed out that several large companies in other industrial sectors (airlines, retail, etc.), stressed by pandemic-related economic factors, had certain data assets appraised in order to qualify these assets as collateral to secure large business loans. The appraisal results, according to the ar-

ticle, suggested the value of the data was two to three times more than the actual market value of the companies themselves.

Data management and data security can be viewed as two sides of the same coin. Data that isn't well-managed probably isn't secure, and security measures won't be optimally effective without prior determination of which types of business data are most valuable and potentially vulnerable. Management and security practices covering the full range of mining activity from exploration to port delivery need to be capable of protecting vital information from misuse, theft and corruption, because the threat level to the mining industry is growing.

IBM's Security business group released a study of the financial impact of data breaches on organizations that showed the cost of these incidents has risen 12% over the past five years to \$3.92 million each on average. The rising costs, according to IBM, are representative of the multiyear financial impact of breaches, increased regulation and the complex process of resolving criminal attacks. And, breach costs aren't short-lived: For the first time, the report examined the long-term financial impact, finding that the effects of a data breach are felt for years. While an average of 67% of data breach costs were realized

within the first year, 22% accrued in the second year and another 11% accumulated more than two years after a breach.

Given the scope of possible consequences caused by cyber intrusion, the mining industry has flashed mixed signals in response; showing signs of casualness about the matter in some cases, while in other instances, it has moved forward positively to meet the challenges. Two examples:

The Australian survey organization State of Play, after interviewing and analyzing information from several large Australian mining and service companies, remarked that comments from high-level mining executives indicated that 98% of them expected a catastrophic event would be necessary to drive an industry response to cybersecurity, at least in that country.

In contrast, following the 2017 Prospectors and Developers Association of Canada (PDAC) trade show, six mining companies formed a group focused on the cybersecurity needs of the mining industry. The Mining and Metals Information Sharing and Analysis Center (MM-ISAC), as it is known, was established to protect members against incidents that could impact safety, environmental sustainability or operational productivity by sharing threat and vulnerability information, managing industry contingency planning, and providing opportunities for training security staff and incident response teams.

## Moving Beyond Legacy Limits

In a recent blog post on the State of Play website, an organization spokesperson explained that the industry's dependence on legacy systems, coupled with disinclination to adopt new software platforms, is further complicated by exponential growth in connected devices on mining networks due to investments in automation and monitoring technologies.

These legacy systems are often Industrial Control Systems (ICS), comprising



the SCADAs, DCSs and PLCs that control process equipment. ICSs, in general, were never intended or designed to be connected to other systems, but with the advent of industry digitalization and the growth of IIoT applications, now they are — not just to other ICSs, but to company-wide communications systems and other platforms, thus expanding potential avenues for intrusion.

Apala Ray, global cybersecurity manager, Industrial Automation, Process Industries at ABB, told *E&MJ* that as recently as a decade ago, cyberattacks targeting industrial control systems were rarely heard of. The emergence of Stuxnet, the first computer malware to target control systems found in industrial plants, and its role in the now-infamous attack on nuclear infrastructure in Iran in 2010 — followed by two high-profile attacks on a German steel mill and Ukraine's power grid — changed all that.

"Stuxnet was a wake-up call that operational technology (OT) and not just information technology (IT) could be targeted by cyberattacks, as well as ransomware like WannaCry and NotPetya, not targeted for OT can create huge impact," Ray said. "The estimated recovery cost from the 2017 NotPetya ransomware attack to Maersk, for example, may run to \$300 million.

"In the past, many industrial operators, including those in the mining sector, believed that because their OT and IT systems were not connected, they were not vulnerable. With digital and automation solutions now offering increased visualization and interconnectedness, this is no longer the case."

Mining cyberattacks typically take the form of espionage campaigns that target intellectual property and proprietary information, or phishing, whereby a user is tricked into divulging confidential data. Studies by US Homeland Security show that such attacks can be mitigated by up to 98% if industrial operators have put basic digital hygiene and process controls in place.

These fundamental safeguards constitute the first stage in ABB's three-layered approach to cybersecurity. "Our advice to clients is to make sure they apply the latest updated security patches and anti-virus definition procedures," Ray explained. "Use the concept of network segmentation and make sure you have a clearly defined back-up and recovery process in place. The latter is crucial in allowing a mine, for example, to contin-



New solutions to maximize the usefulness — and thus the value — of data are being offered to producers at a steady clip. The key to maximum effectiveness is to find the solution that fits the user's specific needs and resources for data utilization, storage and management.

ue to operate and avoid costly production downtime following a cyberattack.

"It is also important to have password policies and an asset inventory. These may be basic processes and controls, but they can eliminate most of the attacks on industrial automation control systems.

"Cybersecurity is a balance between risk, usability and cost. Our second layer of protection involves providing services to our clients, and the third encompasses a more mature OT monitoring solution."

ABB's Cyber Security Fingerprint service, for example, identifies critical control system vulnerabilities at mining facilities by focusing on three areas: procedures and protocols; group security policies; and server and workstation settings. The solution combines information from an ABB control system along with insights gained from interviews with working personnel.

"It is important to remember that cybersecurity is not a standalone solution: it is about people, processes and technology," said Ray. "We recently worked at a mine in Sweden that had employed ABB's Control System, called ABB Ability System 800xA, in the processing plant for some time. Using the ABB Ability Cyber Security Fingerprint the mine's cybersecurity policies and how they are implemented day by day were assessed."

The solution generates a detailed report on gaps in the enterprise's existing cybersecurity measures and uses an analytics tool to compare the results with recognized industry standards.

"Having then assessed whether the correct procedures and policies are in place, the Cyber Security Fingerprint tool finally produces a report that contains detailed recommendations on how the cli-

ent can reduce vulnerabilities, and implement a focused and sustainable security strategy," explained Ray.

However, outdated or poorly managed enterprise resource planning (ERP) systems also carry additional risk factors.

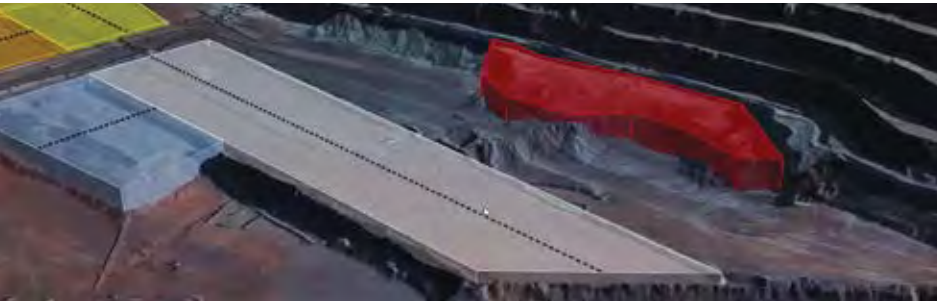
Deloitte noted in its *Tech Trends 2019* report, "Core modernization seeks to solve the riddle of how companies with significant investments in legacy systems can extract more value from these systems by making them a foundation for new disruptive innovations. As major ERP providers roll out next-generation platforms designed to enable real-time transactional processing and data analysis," the report's authors wrote, "mining companies are facing an imminent need to update their ERP systems and make choices on whether to host their data on premises or in the cloud."

Whether pursuing enterprise-wide transformation or making incremental improvements, mining companies need to consider the "five R's" when contemplating core modernization, according to Deloitte:

**Replatform** — Upgrade platforms through technical upgrades, software updates, and migration to modern operating environments (such as cloud platforms, in-memory databases, and virtualized environments).

**Revitalize** — Layer on new capabilities to enhance stable underlying core processes and data. This could include enhancing usability with digital solutions that improve employee engagement, adopting visualization suites to fuel data analysis, or introducing cognitive techniques to strengthen reporting and support predictive and prescriptive analytics.

**Remediate** — Address internal complexities of existing core implementations. This could involve reconciling master data



Modular Mining's recently released Application Programming Interface (API) is intended to enable enhanced integration and increased openness through bidirectional data sharing among third-party technologies, such as RPM Global's XECUTE planning software (shown here), and elements of Modular's IntelliMine portfolio.

to simplify business processes and introduce single views of key data, integrating disparate systems to streamline data sharing with external partners, or rationalizing custom extensions and bespoke solutions to simplify system maintenance.

**Replace** – Introduce new systems for parts of the core. This may mean adopting new products from existing vendors or revisiting build vs. buy decisions as new entrants roll out new solutions. Ideally, organizations will use these pivots to revisit their needs and build new capabilities rather than replicating the work habits associated with their old systems.

**Retrench** – Do nothing, which can be strategic as long as it's an intentional choice.

The State of Play blog also predicted that “things will get worse” until appropriate security processes and protocols are put in place. Things actually *have* gotten worse – the COVID-19 pandemic has added complexity to an already daunting technological puzzle by forcing companies to expand remote-worker assignments for health and safety reasons. As explained by Microsoft's Threat Protection group, “The increasing pervasiveness of cloud services in today's work environments, accelerated by a crisis that forced companies around the globe to shift to remote work, is significantly changing how defenders must monitor and protect organizations. Corporate data is spread across multiple applications — on-premises and in the cloud — and accessed by users from anywhere using any device. With traditional surfaces expanding and network perimeters disappearing, novel attack scenarios and techniques are introduced.”

A sobering assessment of the elevated risk of data loss or corruption from work-at-home or other remote locations was provided recently in a report from data security company Tessian. The report, titled *The*

*State of Data Loss Prevention 2020*, notes that despite a high level of confidence expressed by corporate IT leaders — 91% say they trust their employees to follow security best practice while out of the office — nearly half (48%) of employees admit they're less likely to.

Tessian said its latest research shows these key findings:

- 50% of employees say they're less likely to follow safe data practices when working from home because they're not working on their usual devices.
- 48% of employees say they're less likely to follow safe data practices when working from home because they feel as though they're not being watched by their IT teams.
- 47% of employees say they're less likely to follow safe data practices when working from home because they're distracted.

In the same vein, writing for the Global Mining Guidelines Group – a Quebec-based organization promoting collaboration and innovation across the mining sector – Sherry Jacobs, senior manager at Accenture Security - Resource (Energy), listed several important issues that companies need to consider when responding to cybersecurity threats posed by the pandemic:

- The pandemic has created social engineering opportunities, including phishing campaigns; phishing awareness is key, as cyberespionage and cybercriminal groups will take advantage of this condition while it remains active.
- Business Continuity Plans (BCPs), travel restrictions and remote work policies challenge enterprise monitoring, especially for companies that have not previously executed BCPs. Companies should advise work-from-home employees on home-based router and IoT protection and VPN best practices.

- Companies need advice on how to stratify, prioritize and outsource information security operations, and manage infrastructure and operational maintenance and growth. In-house security groups may be subject to increased demand to maintain or increase coverage under tighter budgetary constraints.
- Companies should be prepared to execute monthslong BCPs, including information security monitoring and response, while operating under quarantine conditions.

## New Problems, New Solutions

The “new normal” — the anticipated industry transformation of technologies, workflows and processes powered by digitalization and boosted into overdrive by pandemic-related business concerns – will depend on large-volume data capture from an ever-expanding universe of sources. One estimate predicts the number of IoT connections to rise to 83 billion by 2024, with the industrial sector accounting for around 70% of those connections. In addition to the expansion of IoT/IIoT connections, vendors are increasingly collaborating to improve software connections via interactive data sharing between various products and platforms. For example:

RPMGlobal and Modular Mining recently extended a partnership agreement to deliver a new industry standard Application Program Interface (API) that will allow enhanced interaction between the companies' products – in this case, RPM Global's XECUTE ultra short-term mining planning software and Modular's ProVision High-Precision Machine Guidance system. The API is a critical part of a solution which allows information to automatically flow between systems. The new industry standard allows applications and systems to communicate using a language that is universally understandable.

RPMGlobal chief technology officer Paul Beesley explained how the process will work: “The short-term plan, including the dig polygons, is published from XECUTE to ProVision. Then equipment status and bucket positions are sent back to the planning tool to ensure the plan is being executed. Those bucket positions can then also be used to automatically update the face positions and the schedule.”

Meanwhile, Symboticware and Uptake announced a partnership to provide mining companies with an integrated AI and data science tool to increase the produc-



tivity of mobile mining equipment. Symbotware specializes in real-time data management solutions, and Uptake is an industrial AI developer. The joint solution combines Symbotware's SymBot onboard device, which provides comprehensive data capture from mining fleets, with Uptake's Asset IO Asset Performance Management (APM) to apply AI to harvest predictive insights from data. Among the benefits attributed to the combination of these two products is greater visibility into assets, offering an ability to collect data from sensors, store time-stamped values in an internal database and seamlessly transmit data for AI analysis.

More recently, Uptake and conveyor-products supplier Flexco announced that they had formed a partnership to launch Flexco Elevate Belt Conveyor Intelligence, a real-time belt cleaner monitoring system that uses predictive data analytics to optimize belt conveyor productivity. Flexco said Elevate allows for the remote monitoring of belt cleaners via a wireless platform.

According to Flexco, the solution requires installation of a device to the end of each Flexco belt cleaner. Analytics are immediately aggregated and processed by

Uptake. The information is then wirelessly transferred to the Flexco Elevate Dashboard.

On a broader scale, vendors in virtually every sector of digital technology are introducing new concepts and updated features on an almost weekly basis. The challenge for producers is to find the right combination of products, services and support to fit their specific new-normal business plans and environments. Here are a few examples of what's recently become available, starting with basics such as a new device access security platform, and extending along the full spectrum of industry activity from exploration to tailings storage.

#### *Device Access Control*

Xage Security, a US company that provides blockchain-protected cybersecurity solutions for industrial operations, recently introduced a universal Multiple-Factor Authentication (MFA) offering intended to enable industrial organizations to protect a variety of assets, even those that lack basic device password protection. Built to support OT/IoT use cases, Xage's MFA solution is claimed to eliminate operational dependencies to ensure that industries can protect their assets from attacks, in-

cluding the growing wave of cyberattacks that exploit remote access vulnerabilities.

The company points out that many industrial operations include machines with no password protection, or basic lock/unlock features that lack secure access control. In the last two years alone, digital attacks targeting industrial control systems (ICS) and operational technology increased by over 2,000%. Xage says its solution enables MFA for any device and application, so companies can enforce authentication with multiple factors (passwords, one-time token, biometric, etc.) across their entire system. Operators can add MFA to all of their assets and enforce universal multifactor, identity-based, low-latency access on remote assets, even over intermittent networks.

According to Xage, authentication and enforcement are delivered at the edge and continue to operate even if connectivity to the center is lost — ensuring universal tamperproofing without additional dependencies. As a result, Xage's MFA solution is said to be capable of mitigating many common cyberattacks, including password spraying attacks, password or identity theft and phishing to plant malware on target devices.

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*Drill Data in the Cloud*

Recognizing that COVID-19 prevention measures can disrupt conventional geo-technical studies and exploration drilling activity, several software developers in this sector announced accelerated development and other changes to their cloud-based solutions in an effort to offer smarter, more efficient data management in the current business environment.

Geoscience software company Seequent said it is speeding-up development of its cloud-based solution Seequent Central, aimed at enabling organizations to continue work on critical, large-scale projects in the COVID-19 impacted environment.

The company said Central works alongside Seequent's other geoscience analysis, modelling and collaborative technologies to contribute understanding to subsurface geoscience and engineering design solutions. The cloud-based solution allows users in any location to visualize, track and manage geological models created for infrastructure and critical services projects, in a centralized, auditable environment. Users can readily access up-to-date information to manage risk and make better environmental and investment decisions.

Seequent said one early adopter of the platform, a Canadian junior focused on silver production in Mexico, is using its products effectively. The company, First Majestic Silver, owns and operates the San Dimas, Santa Elena and La Encantada mines and is pursuing development of its existing mineral property assets.

Seequent said First Majestic uses its Leapfrog Geo to develop a realistic presentation of the geology at each site (complex silver deposits with multiple veins), and Leapfrog Edge to aid resource estimation – and when geologic models are changed resource estimates also change dynamically. Seequent Central allows the company to publish models and resource estimates that are immediately available in real time.

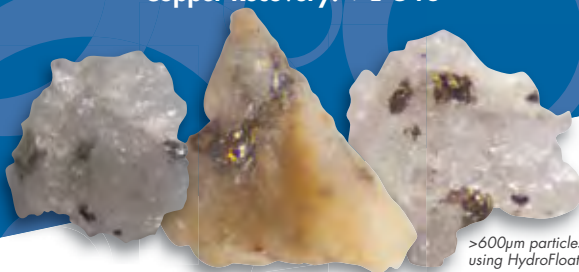
IMDEX, a Western Australia-based mining technology company, recently pointed out that drilling contractors and resource companies impacted by COVID-19 restrictions can continue to operate by using cloud-connected sensors that deliver and analyze critical data. Despite restrictions disrupting travel and work, IMDEX said clients can still make time-critical decisions backed by accurate data presented in real time.

The company reported that a majority of its clients intend to keep operating while working within government-imposed restrictions and with the priority of keeping their workers safe. IMDEX said existing clients already have access to IMDEX-HUB-IQ, a secure, cloud-based portal for validating field data transmitted from drill rigs, and recommended that clients use the current environment to access, review and analyze data by using IMDEXHUB-IQ to achieve efficient drillhole and sample data management from daily reporting and QA requirements to structural logging, survey and geochemical analysis.

IMDEXHUB-IQ Global Product Manager Tara Bennett-Connell said that while IMDEX HUB-IQ was available free to clients already using IMDEX tools, some were still opting to transfer data via email and USBs. "More secure, efficient and reliable methods are available, and when you can't get access to the data through those old methods, it's time to it's time to change," she noted.

IMDEX said its system has been certified for ISO/IEC 27001:2013, an international information security standard recognized in 161 countries.

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### Managing and Monitoring TSFs

Inmarsat, a provider of satellite-enabled managed connectivity services for land-based organizations, is now offering two versions of a Software-as-a-Service (SaaS) solution for mining companies, aimed primarily at operators that currently have tailings storage facilities (TSFs) where connectivity infrastructure and instrumentation is in place, but lack a critical component required for compliance.

The first of its two offerings, Tailings Insight Cloud, is a SaaS application claimed to be designed for interoperability, easy integration and compatibility with many sensors and IoT devices that make it capable of compiling tailings data from a broad array of sources. That data is then made visible via a single dashboard view in real time, accessible from anywhere. It also provides various ways of visualizing sensor data, while advanced alarm functionality helps notify key stakeholders of important changes in real time.

The system keeps users informed of sensor health via regular reporting, while also offering a full audit log, historical data comparison and journaling capabilities, plus it enables operators to standardize their tailings management globally, regardless of sensor type and other instrumentation.

Tailings Insight Plus, built around the cloud application core, is Inmarsat's fully managed service. As part of the solution, Inmarsat provides global satellite connectivity, sensor integration, edge connectivity in form of LoRaWAN — a point-to-multipoint networking protocol — as well as ongoing service monitoring and management. It monitors and manages all of the infrastructure (aside from the client's sensors) on an ongoing, end-to-end basis, with a service level agreement (SLA) tailored to client data collection needs.

### Mapping the Path

As technology continues to make it progressively easier for mining companies to collect and transfer vast volumes of data, the probability of extracting greater value from that data will be matched by the likelihood that it could put an enterprise at greater risk when misused, corrupted or stolen. Companies that plan to map their own routes to cybersecurity will be looking for guidelines; here's a set of recommendations from Accenture, a professional services company, aimed at helping organizations become "cyber resilient" to manage complex risk decisions.

**Update organizational threat models.** Make it a point to revisit what's important in the organization by understanding what assets are required to deliver the business outcome, the relevant threats and vulnerabilities for the industry and regions, and what security controls are in place.

**Build a strong foundation.** Gain visibility over IT and OT systems/assets, understand their criticality, and recognize threats the company may be exposed to. Identify high-value assets and harden them. Prioritize legacy systems. Prepare for the worst.

**Pressure test resilience like an attacker.** Enhance both red attack and blue defense teams with player-coaches that use threat intelligence and communicate closely to provide analysis on where improvements need to be made.

**Employ breakthrough technologies.** Automate defenses. Use automated orchestration capabilities and advanced behavioral analytics.

**Be proactive, go threat hunting.** Develop strategic and tactical threat intelligence. Monitor for anomalous and suspicious activity. Consolidate all threat information in the organization, then develop the support structures to effectively manage it.



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# Making the Right Call

*Idling production to improve mining conditions pays dividends*

By Mike Walsh

The underground manager, my boss, who was simply known by his initials, AJ, was planning to be away from the mine for a few days, and he needed someone to manage the mine while he was gone. “Hey Mike,” he called to me “You’ve got a First Class ticket don’t you?”

“Yes. I just got it a few weeks ago,” I said.

“Great. I’ll be away for a few days so you can look after the mine for me while I’m away,” he said.

This might not be so significant in other countries, but it was critical in Western Australia. Mining was governed by the Mines Safety and Inspection Act which specifically said that a mine had to be under the control of a Certificated Underground Manager, and “An underground manager for a mine employing 25 or more persons underground ... must be the holder of a First Class Mine Manager’s Certificate of Competency ... . Penalty: In the case of a corporation \$25,000 and in the case of an individual \$5,000.”

Our site was a remote, Fly-In-Fly-Out operation so the manager could not just leave the site on a whim. It always took

some planning and preparation, so it was enormously beneficial to have a back-up person on site who had a First Class ticket. And, I was that person.

We had about 50 to 60 people underground and they were producing about 8,000 ounces (oz) of gold per month so if an Underground Manager had no backup person who had a First Class Manager’s ticket, he simply could not leave without shutting the mine down. It was a major constraint. First Class ticket holders were valuable assets.

Before AJ departed he told me of the most important jobs, in addition to the projects that I was working on already and knew about.

“We are three quarters through the month and we are behind on gold production so you need to keep the pressure on,” AJ said. “We’ve produced about 5,000 oz so far but we should be up to about 6,000 oz by now. The most critical job is the 425 South drift. It’s long but it’s got the widest reef and the highest grades. It’s the one that’s keeping our noses above water right now. We need to keep that heading going.”

He left the mine at about 11 am to catch the 1 pm flight to Perth.

## Ventilation Concerns

I had been heavily involved in the mine since the day we fired the first cut three years earlier, so I knew all the drifts and all the headings. I knew it better than anybody. I was also the statutory Ventilation Officer, appointed by the Department of Mines, and I knew the state of ventilation in every part of the mine too and I knew that the ventilation in the 425 South was poor. My responsibilities under the Mines Safety Act were to report any deficiencies to the Manager whose responsibility it was to fix them. And, I had told AJ about the 425 South a few times over the past three weeks. But he had not had it fixed.

The 425 South’s main problem was that it was about 180 meters (m) long and it was at the limit of the ventilation bag. It was narrow so we couldn’t fit a larger bag in. The 22-kW fan simply did not have enough power to push any more air along it. On top of that, the vent bag had been nicked and caught by the loaders and the jumbo going in and out, and it was full of little rips and tears. It was literally dying a death by a thousand cuts.

Now I had a different problem. Before that day I had completely fulfilled my duty under the law by making sure the Underground Manager, AJ, knew about the problems. It was his problem not mine, and if he ignored them, he was the one breaking the law, not me. But now, suddenly, he had left for a few days and I inherited the legal responsibility for all the problems that he had let slide.

The most critical of all problems was the 425 South. It was the worst ventilated heading in the mine and it contained more gold per meter than any other. We needed the 425 South so that we would meet our monthly production target, which was not just a number on a piece of paper — we needed revenue from gold sales to pay our workers and our bills.

I went underground with my anemometer and smoke tubes to look at the



Keeping fresh air on the face improves working conditions and productivity. (Photo: Turnstone Industrial Solutions)



425 S again, and it was a disaster. The 180 m of vent bag were in even worse shape than they were a week ago when I had last reported it to AJ. It had more new cuts in it, the old cuts had frayed and were even larger, and the bag was another 25 m longer. There were too many cuts in the bag to even count. It literally was a sieve and it leaked like one.

It was a very simple matter for me to measure its effectiveness. I stood by the fan and measured the total amount of air returning — it was about 30 cubic meters per second ( $\text{m}^3/\text{s}$ ). Then I walked to the far end of the bag, near the face, about a meter or two back from the end of the bag and measured the amount of air returning there. It was about 3  $\text{m}^3/\text{s}$  — not enough to blow out a candle. In other words, of the 30  $\text{m}^3/\text{s}$  that was being pumped into the bag by the fan, 27  $\text{m}^3/\text{s}$  were being lost through leaks and only 3  $\text{m}^3/\text{s}$  were getting to the face where they were needed.

The workers were divided — some cared about it, but others didn't. But that didn't matter to me, it wasn't their problem. It was mine.

I checked with the shift-boss and he estimated it would take at least 12-18 hours to replace the bag and overall we would lose about 24 hours. It was worse than I thought. If we lost a full day out of the seven days that we had left in the month, we would lose any production gain that AJ had hoped we could catch up on.

## Making the Decision

The fact that we were operating the drift at a ventilation quantity below the minimum legal limit didn't really bother me much, because I knew that the legal limit had a huge safety factor built into it, and our air quantity was still not harmful. The thing that worried me most was that the men working there were uncomfortably hot, and they knew the vent conditions were illegal. They knew that I was the mine's Ventilation Officer, even though I was "Manager for a day or two" and they trusted me to look after them. I could not afford to let them down.

The contractor's manager also wanted to keep the heading open. They were paid by the meter and he wanted 5 m advance every day to make his budget. But, at what cost?

I made my decision. The current situation was intolerable, and I could not justify it in any way. I called the shift-boss on the radio and ordered him to shut down the drift,



Replacing the vent tubing didn't take as long as expected and the lost production was quickly recovered. (Photo: Turnstone Industrial Solutions).

pull all the old bag out and replace it with new. "Do not fix the old bag. Do not patch it. Pull it all out and put in new." I said.

"But AJ said it's our top priority heading," he protested. "We need the production."

"I know what our priorities are," I said angrily into the radio. "And to h\*\*\* with the production. Fix the vent!"

"I'm not sure if we've got enough bag in stores," he said.

"I know where there is more if you run out. Just get it done." I said. I was willing to "take the heat" if we lost a day of production.

It was 4 pm, I had given the order, and now I left the crew to make it happen. I made up my mind to have nothing more to do with the process until I started back at work the next day. So, I went to the surface, focused on other important issues, finished the shift at 6 pm and went back to the camp.

I started at 6 am the next morning with the pre-shift meeting and my first question was "What is the status of the 425 South drift?"

"It went well," the shift-boss told me. "We had plenty of new 750 mm vent bag in stores. We pulled out the old bag and had the new stuff installed by about 10. We got back operating by midnight."

I thought to myself, "Hmm ... only 8 hours delay. So much for all the drama and the exaggeration." But I said cheerily "That's great. You must have pulled out all stops to get it all up so fast."

"Oh, it was nothing," he said. "Our blokes are pretty good."

Later I checked the production for that day to see how much we had lost in terms of gold production. There was no loss. In fact, we produced more that day than any day for the last week.

For the next week we achieved much faster daily progress in the 425 South, than we had for the past month. So, our total gold production was markedly up too.

The miners were pleased as well. The 425 S was a much nicer place to work than it had been for more than a month, so the men could work better and get more done. They all knew I had pushed to get the vent fixed and they all thanked me for it.

It was a valuable lesson for me as a young engineer. Do not cut corners, and do not sacrifice safety standards for production. The underground crew will appreciate improvements and when they know that you will make production sacrifices to ensure their safety they will all talk about it amongst themselves, and they will do their utmost to keep the mine running well.

Enforcing these sensible safety standards *always* pays off in the end.

*Mike Walsh is a mining engineer, mine manager and mining consultant. He plans to share some of his experiences with a series of articles. He can be reached at: [mike.walsh@1208.net.au](mailto:mike.walsh@1208.net.au).*

# Dewater, Derisk, Deliver

*Dewatering is a vital component of safe, productive mining operations, but its role and impact are often misunderstood*

By Carly Leonida, European Editor



A mine water disposal pond. (Photo: Itasca Denver)

The law of gravity dictates that the creation of an open-pit mine — essentially, a giant funnel cut into the earth through layers of rock — will channel and collect water. No matter the scale of an operation, it is inevitable that the excavation will intercept groundwater flows at some point and, depending upon the local conditions, surface water or run-off is also likely to pool in certain areas.

Effective dewatering benefits every function within an operation, from mine design and slope stability, to blasting and haulage. Yet the impact of a good strategy, prepared and executed well in advance with the consultation of experts and reviewed regularly is often underestimated.

A lack of understanding across the workforce surrounding the role of dewatering and associated infrastructure can lead to mines losing sight of dewatering targets, lack of sufficient resources and, if left unchecked, a major safety incident.

So, *E&MJ* asked experts from two leading consultancies to help enhance our collective understanding.

## Developing an Effective Strategy

First up was Itasca International; the firm specializes in solving complex geomechanical, hydrogeological and micro seismic issues in mining.

Houmao Liu, General Manager/Principal at Itasca's Denver office, Martin Brown, Hydrogeology Manager for Itasca

Chile, and Loren Lorig, Principal for Itasca's Minneapolis team, joined *E&MJ* for the discussion.

"Historically, in open pits the mine designers would come up with a design, and the hydrogeologists would say 'okay, this is how we think it's going to look from a hydrogeology standpoint'," Lorig explained. "They would pass that information to the people doing the slope stability studies. We would take a look and determine which areas were meeting design acceptance criteria, and which weren't.

"We'd pass it back to the hydrogeologists, and they would tweak the design in terms of dewatering from wells, horizontal drains, drainage tunnels, or whatever the options were. This would continue to go back and forth, and it was very time consuming.

"In recent years, there's been a move to streamline that process and make it more rational. The idea now is that the mine comes up with a design, and the geotech people look at it and say 'if you want to mine to this particular design, here are the targets that we need the hydrogeologists to meet.'

"The hydrogeologists then go away and come up with schemes that will meet those targets.

"This approach has the added advantage of providing targets for instrumentation and monitoring, because anything that deals with geology, geochemistry and hydrogeology is extremely uncertain.

"We never have enough information to do all of the things we would like to do; it's just impossible to collect that much information. But if we have targets for dewatering then, as the teams mine down, they can put in piezometers, and find out if those targets are being met or not.

"If they are, fine. Maybe we can steepen the slopes. But if they're not being met, then you have to think about putting in additional dewatering measures. Or, if that's not possible, flattening the slopes.

"So, this notion of providing dewatering targets is something which is useful in the design and analysis part, but also in the implementation and operation of the mine, because it greatly simplifies the whole process."

## Get an Early Start

Brown explained that hydrogeological characterization should be done as early as possible in a project's life.

"You need to have hydrogeological data at the feasibility stage in order to understand how groundwater will move when you start excavating the pit," he told *E&MJ*. "And then, of course during the operations, as mines are so dynamic. Hydrogeological and geotechnical teams need to be in constant interaction to define the right dewatering targets.

"There are operations in Chile that invest US\$15-20 million a year on dewatering infrastructure. To make sure resources are available to meet the defined targets, mines need to start planning as early as possible.

"Also, there are a lot of social issues associated with mining and water. What happens with the groundwater when mining activities stop? It's something that goes on for the whole life of the mine."

The last point is a valuable one. In many areas, water is a scarce resource, one that the mining industry competes with local communities for. It should therefore be managed responsibly and, where possible, mines should look for intersections between their own dewatering efforts and



the needs of local communities. Water removed from mining operations could potentially benefit other stakeholders.

Liu explained that, ideally, the dewatering strategy should be assessed and investigated at the desktop study stage. Field investigations should be conducted for the pre-feasibility study and continue as the project proceeds. These usually include a baseline study, hydraulic testing such as packer testing, short-term pumping tests, installation of piezometers, collection of hydrogeologic data, and development of a groundwater flow model. Then, at the feasibility stage, a long-term pumping test (30-60 days) may be required, along with pilot testing of a production dewatering well.

The groundwater flow model should be continuously updated, and its predictions validated with new data to guide the dewatering program.

“One thing investors are looking for when deciding if they want to fund a project is hydrogeology and dewatering, because it involves a lot of uncertainty,” said Liu. “So, when you get to the field investigation, you should at least have a good test team and groundwater flow model, and the installation of piezometers. All this should be interfaced and supported to give the funding agency confidence, and to help them understand how it will work and what the cost would be.

“If a major dewatering effort is needed to keep the open pit dry, that would involve tighter testing to help design the right dewatering wells. Each well costs over \$1 million to install, so we need to make sure that we get design the right.”

“This process involves continual learning and updating,” added Lorig. “The earlier you start to understand what’s going on, the better prepared you are to deal with surprises. Because there are always surprises. And if you wait too long to discover them, that leads to problems.”

## Impacts of Excess Water

Another firm renowned for its expertise in hydrogeology and geomechanics is SRK Consulting.

Goktug Evin, Principal Hydrogeologist, and Cristian Pereira, Principal Hydrogeologist, both from SRK Consulting’s Denver team, spoke to *E&MJ* along with their colleague Daniel Mackie, Principal Hydrogeologist for SRK’s Vancouver office.

Evin explained: “Excess water associated with mine dewatering can have se-

vere impacts on many aspects of a mining operation. Direct impacts could include loss of access to some or all of the working levels of the operation. Unmanaged excess water, if significant, can also be a threat to operational safety.

“Another direct impact is the capital investment and operational costs for the pumping system that is required to dewater the open pit. In most cases, once excess water is allowed in the pit, the quality of the contact water deteriorates rapidly and this raises the need for treatment, thereby increasing the overall cost of water management. Direct impacts are usually noticeable, and mine operators focus on mitigating them during mine planning or when these impacts are faced during the operation.

“In addition, there can be hidden impacts of water on the operation that can cause inefficiency throughout the life of the mine if not identified and addressed. One is the high cost associated with blasting under saturated conditions. In most cases, this leads to a high demand for explosives usage, ineffective blasting, or may require the use of special/expensive types of explosives.

“Wet hauling is also an issue, as the operator must haul the unwanted water with the ore. Trafficability is adversely impacted in such conditions. Equipment wear and tire wear are checked by the operator at the end of the day, and costs related to this type of wear are rarely associated with improper water management.

“Above all, I think the major impact of water on an open-pit operation is its impact on slope stability, which can be a game changer.”

While there are negative impacts associated with excess water, there are also potentially positive ones too. In very arid environments, water recovered via dewatering can be used to feed the processing plant and, in certain cases, with the right treatment, can even be used in local municipal applications.

Itasca’s Brown spoke to this: “There are mining companies in Chile that depend on dewatering to supply around 30% of their process water. There are environmental permitting challenges associated with that approach but, most of the time, it becomes an important source.”

## What, Where and Why?

Before we delve into slope stability, let’s look first at the factors that typically determine the amount and type of water ingress.

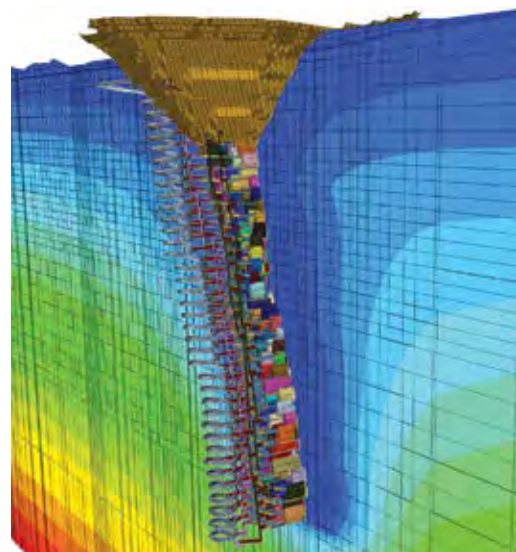
SRK’s Pereira explained: “Most of the factors that determine the amount/type of water ingress are related to the source of the water. One is groundwater storage. In this case the water levels, storability and, indirectly, the hydraulic conductivity are key. Recharge water bodies such as rivers or lakes need to be evaluated in terms of connectivity to the planned mine. Sediments, rocks units and faults that connect the source of water and the mine also need to be characterized in terms of geometry and hydraulic conductivity.”

The mining method can also conduct sources of water. For instance, block caving and the associated fracture propagation can open a direct channel connecting recharge from precipitation to the mining operations; Grasberg mine in Indonesia is a typical example.

In open pits, the depth of the excavation, slope angle, and the rate of mining will help determine how aggressive a dewatering strategy is required. Hydrogeological conditions, such as localized and regional groundwater flow, and interactions between the surface water and groundwater are also important.

The local climate, and surface runoff from precipitation (the amount of which depends upon the duration, frequency and intensity of rainfall events) is another factor; one which, depending upon the mine’s location, could change as global warming accelerates.

“Climate change has altered the rainfall patterns in the north of Chile



A MineDW model plot showing groundwater pore pressures around a sublevel retreat mining zone. (Photo: Itasca Denver)

where we have started to see less frequent rainfalls, but with higher intensity,” Brown explained. “So, mining operations that were designed to manage groundwater that recharges from the high Andes, slowly flowing to mining works as they progress, these have been forced to migrate to a strategy that includes surface water management as part of their dewatering strategy.

“Some areas used to have just one millimeter of rainfall a year, but now they have ten millimeters a year, every three or four years. That’s a huge change when managing water.”

## Water and Slope Stability

In simple terms, the presence of water in the voids of a rock mass works against the forces that hold it together. This can promote the movement of the rock mass, with the help of gravity.

SRK’s Evin explained: “If a slope has an elevated pore pressure, the likelihood of failure is higher when compared with a slope that has reduced pore pressure. Besides safer mining, mitigated pore pressure can lead to the creation of steeper slopes, less waste rock, less hauling and a reduced mine footprint. Based on SRK’s experience obtained from large open-pit studies, financial investments focused on dissipating pore pressure can return to the operation as cost-savings with a 1:5 to 1:10 ratio.”

Pore water pressure and its role in stability has been well understood since

Terzaghi developed his theory of shear strength in the early 1920s. Practitioners are well aware that, in order to keep the slope stable at the desired angle, the only parameter that can be mitigated is the pore pressure. However, there are still loose ends in current applications when it comes to fully mitigating pore pressure for slope stability and design.

“SRK has seen various examples, ranging from completely underestimating the role of pore pressure to overvaluing it, which turns the case to a ‘tail wagging the dog’ situation,” said Evin. “At the end, it’s a geotechnical problem and you should understand the rock mass first.”

Itasca’s Lorig added to this:

“In general, water and high water pressures lead to slope instabilities through something called the effective stress principle. It can also load vertical tension cracks, which tend to push slopes out,” he explained.

“So, the ability to minimize pressures from water are absolutely critical to the designs of open-pit slopes and, by far, the most cost-effective way to do it. The other option that we have is to flatten the slopes, the cost of which would be far greater than any dewatering scheme.

“That’s why studies of pit dewatering are fundamental in most mines to their slope stability. There are mines that are situated above water levels which don’t have to worry about it at all, but those are only 5% or 10% of the world’s mines.

“Most mines have some issues with water. It may be that water pressures are low, and they can be dealt with simply by sump-pumping into the bottom of the pit and pumping the water out. Others require some form of engineered dewatering, whether it’s wells or horizontal drains, to achieve their geotechnical stability targets.”

In depressurization, the aim is generally to reduce pore pressure as far as economically and practically possible to ensure safety around slopes and access to reserves. There are some soils, for example, very weak weathered soils, that act like sand and, if you were to somehow remove too much water, would lose apparent cohesion, also causing instability. But these are the exception rather than the norm.

## Dewatering System Design

Identification of the main factors that determine water ingress into a mine will define the dewatering strategy and monitoring system required.

“An early recognition of these factors is very important, as they will define the monitoring plan from pre-dewatering to post dewatering-conditions,” explained SRK’s Pereira.

Piezometers and flow meters are generally installed in key areas to monitor the effectiveness of dewatering.

“In Chile, most of the mines have a strategy that is based on pumping wells to try and avoid water entering the pit, which helps reducing pore pressures in pit slopes,” said Brown from Itasca. “And, in cases where rainfall is significant, surface water channels are added to divert runoff from the pits.”

How would this contrast with the dewatering strategy for a mine in a tropical setting? *E&MJ* wondered.

“One of the projects we worked on receives over two meters per year of rainfall,” Liu said. “People automatically assume that means there is a lot of water recharging the groundwater systems. But actually, with rainfall of that intensity, most of it becomes runoff. A lot depends upon the competency of the ore and its hydraulic conductivity.

“On the other side, at one of the projects we worked on in the Congo, groundwater recharge is a really big issue. The water just runs into sinkholes and recharges that way. We had to identify those locations and put in quite rigid dewatering wells to try and intercept the water before it got into the pit.”



Borehole drilling for field hydrogeological investigations. (Photo: Itasca Denver)



Whatever strategy is selected, it's important that dewatering performance is monitored and adjusted regularly according to the assumptions made in the conceptual model.

"The dewatering strategy should be revised every time the mine goes through a major change," Brown explained. "For example, if a mine moves from open pit to underground operation, or if climatic conditions are expected to change significantly.

"But, if things remain the same, it's probably necessary to revise your strategy once every two years. Especially considering the CAPEX and OPEX involved."

Lorig added: "Another time that you would consider updating analysis and modelling would be when your instrumentation suggests a significant variation from what is predicted. Mines are continually collecting data, so it may just be a matter of getting the new data into the simulations to update the predictions."

Liu chipped in: "It's really site dependent. It's up to the mine and consultant to determine the frequency of updates to the dewatering strategy."

## Data Quality and Accurate Modelling

In recent years, advanced software and modelling tools have made it possible to achieve higher resolution in site hydrogeological conditions, and improvements in computational speed and cloud services have enabled modelers to test multiple dewatering permutations in a short period of time. This is especially useful for sensitivity and uncertainty analyses that contribute to important decision making.

However, the accuracy and predictability of models still depend heavily upon the quality of the data available, the experience of the modelers, and how realistic the model is in representing site hydrogeologic condition and operations.

Itasca's Liu explained: "There is a misconception that advanced software means we have a higher confidence level in the model result," he said. "That's not usually the case. Some models, even though they look very nice and have been well presented, are ill conceptualized; they do not accurately represent the hydrogeological conditions at the mine site.

"For example, if I have an open pit, the pumping well should sit a certain level below the open pit, and the model margin should be much lower than the pumping



Dewatering well located at the bottom of an open pit mine. (Photo: Itasca Chile)

well. Instead, some models put the model margin near the pumping well or above it. So, those are the ill conceptualizations."

Brown agreed: "It's true that software has improved and developed a lot along the years, but the most important thing is to have the correct conceptual model. If we don't achieve that, we don't achieve a realistic understanding of hydrological and hydrogeological factors affecting the mining operations."

SRK's Pereira supported this: "Numerical tools as codes and software give us the possibility to recreate the hydrogeological conditions and predict the dewatering requirements and their potential impacts in great detail," he explained. "Finer meshes/grids in areas of concern (mine, tailings, rivers, lakes, etc.) can simulate water levels and flows in high resolution. However, a robust conceptual model supported by field data is still the main factor for an accurate prediction.

## Avoiding Common Pitfalls

*E&MJ* asked if there are any other common mistakes that mines make in their dewatering strategies and, if so, how can these be avoided?

"Common mistakes include not starting dewatering early enough, ignoring discharge quality which leads to more significant treatment requirements, or not having appropriate staff on a project during operations to interpret, manage and make the system work," SRK's Mackie said. "Schedule delays during mining due to higher than expected flows can also be a significant problem for mine economics."

Pereira emphasized: "Early monitoring programs, even during the exploration phase, are key to obtaining valuable hydrogeological data. The impacts of dewatering and the prediction of inflow into

the mine are more accurate with long-term transient information.

"Resource exploration, infilling or geotechnical drilling programs can all be used for groundwater data collection. This usually represents a small fraction of the total cost and will save time and money for the mine dewatering design and closure program."

The team at Itasca stated similar findings.

"Most of the time, there's not enough time allowed for dewatering and depressurization," said Liu. "Starting dewatering and depressurization early will significantly reduce the associated risk.

"The second issue is inadequate monitoring data. Sufficient monitoring is a critical factor for improving dewatering performance.

"Third is conflict between production and dewatering needs. The location of dewatering infrastructure, especially within pits, is chosen to allow the mining method to be as aggressive as possible. However, these locations can sometimes conflict with the mine plan.

"It's crucial that all teams understand the importance of dewatering to help avoid or resolve those conflicts."

Lorig added: "One of the biggest mistakes mines make is not following through on plans to install wells, instrumentation, connect those things up and pump the water out.

"Dewatering is sometimes seen as an expense that can be nibbled away at. Mines that don't understand or appreciate it and relegate its' level of importance... they're the ones that can get into trouble.

"And it's very hard to recover from, because dewatering is something that needs to be done in advance of the mining, not in hindsight."



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# Mining in Peru

*The engine to rebuild an economy*

## TABLE OF CONTENTS

---

Mining in the shadow of COVID-19.....	p66
Mining Production.....	p69
Junior Exploration.....	p73
Engineering, Construction and Consulting.....	p76
Equipment and Services.....	p79

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# Mining in the shadow of COVID-19

## Peru faces a new challenge

With the exception of political turbulence – something the country is accustomed to – 2019 was a year of relative stability for Peru. In contrast to the social unrest and economic volatility that upset some of its South American counterparts, a stable currency and strong fiscal balance sheet had positioned Peru for solid growth above its modest 2.6% GDP appreciation rate in 2019. Mining investment that year to the tune of US\$6.15 billion, the highest mark since 2015, continued to be the cornerstone of Peru's economic health, as the industry accounts for 60% of the country's exports and over 50% of foreign investment.

2020 started on a positive note for Peru as the signing of a "phase one" trade agreement between the US and China on January 15th pushed the price of copper to a nine-month high of US\$2.88/lb. Although cumbersome bureaucracy has threatened the country's mining competitiveness, the development of large-scale projects Mina Justa and Quellaveco offered a near-term path to substantially increase the production of Peru's biggest mineral export.

By early February, a Chinese dynamic of a different kind conspired to send the red metal crashing to US\$2.50/lb, a 13% drop



Martín Vizcarra, President, Republic of Peru.

in reaction to the escalating COVID-19 outbreak, and a precursor to the freefall in March that saw copper dive to US\$2.10/lb, its lowest point since 2016. In February the supply chain had already been disrupted as miners were sent home, demand from China weakened and shipping companies became reluctant to expose workers to the virus, creating bottlenecks.

While the warning signs were there, few could have predicted the transformational impact of what actually occurred. Despite a 10% drop in attendance and the appearance of hand sanitizer at exhibition booths, the mood at PDAC in Toronto from March 1st to 4th was upbeat, buoyed by a large Peruvian

delegation led by Minister of Energy and Mines (MEM) at the time, Susana Vilca. Merely one week later, the World Health Organization (WHO) would characterize COVID-19 as a global pandemic and, on March 15th, President Vizcarra declared a country-wide stay-at-home order effectively shutting down the Peruvian economy and leaving only essential services running.

Anglo American withdrew the majority of its 15,000-strong workforce from its Quellaveco project in mid-March, maintaining only critical works, although CEO Mark Cutifani affirmed in April that the company still expects production to start in 2022. At sites already in production, such as Yanacocha (Peru's largest gold mine operated by Newmont), critical activity such as heap leaching and environmental maintenance continued as operations scaled down. MMG declared force majeure on copper concentrate supplies from its Las Bambas mine, followed by the company withdrawing its 2020 production forecast for Las Bambas on April 13th. "The first quarter was very challenging for the entire business, but particularly for our largest operation, Las Bambas," said Geoffrey Gao, MMG's CEO.




Since April several mining operations have reported COVID-19 cases among their workers. A case in point was Antamina, owned by BHP and Glencore, which reported 210 positive cases of COVID-19 on April 27th. Worryingly, 87% of the positive cases were asymptomatic, an indication of how easily the virus can spread undetected.



As the first country in Latin America, and one of the first outside China, to enforce a nationwide lockdown, Peru's mining industry has felt the economic effects more acutely than other leading mineral producers. Peru, the world's second-largest copper, zinc and silver miner, produced 768,463 metric tons (mt) of copper (down 22.6%), 398,771 mt of zinc (down 29%), 83,723 mt of lead (down 33%), 6,196 mt of tin (down 26.4%), 1.16 million ounces (oz) of gold (down 32.8%) and 33.76 million oz of silver (down 31.6%) from January to May, according to MEM figures.




The government's hard stance to ensure the health and safety of its population is commendable considering the country relied on only 200 ventilators at the start of the pandemic. However, despite the draconian lockdown measures enforced by the government, the country has been unable to flatten the curve. Official cases rose above 300,000 in July (the second highest in South America), and

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daily death rates plateaued around the 180 range, without showing signs of a noticeable downward trend.

President Vizcarra was able to act quickly due to Peru's fiscal strength. According to *Bloomberg*, the Andean country has accumulated savings in the past decade equal to about 15% of GDP, or 117 billion soles (US\$34.4 billion). The government can spend savings during the peak of the pandemic and tap into bond markets when conditions are favorable. "Investors are taking the long view and rewarding countries that are being proactive in tackling the virus," said Guido Chamorro, co-head of hard-currency debt at Pictet Asset Management in London, a statement Peru will hope holds true as the country looks to resuscitate its economy in the wake of the pandemic.

On April 29th, the Peruvian government announced a four-stage reactivation plan designed to open up its economy gradually. From a mining standpoint, large-scale open-pit operations and construction projects of national interest restarted in May. In June, large-scale underground mining (over 5,000 mt/d), medium-scale open-pit mining (more than 350 mt/d), greenfield exploration, and worker camps reopened. In July, medium-scale underground mining and greenfield exploration without camps (including processing plants) began.

In an online conference on July 9th, Minister of Energy and Mines (at the time) Susana Vilca told foreign reporters: "We are confident that production will be back at 100% by the end of July, and we will see a major recovery by December."

Less than a week later, on July 15th, Vilca was replaced by Rafael Belaunde Llosa, Peru's third Minister of Energy and Mines in 2020. For the country to fulfil its geological potential and become a more competitive mining jurisdiction, greater political stability is surely required.



Víctor Gobitz, President, IIMP.

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## The Industry Responds

"The lockdown on March 15th caught the mining industry by surprise," stated Víctor Gobitz, president of the Peruvian Institute of Mining Engineers (IIMP) and CEO of Antamina.

In his interview with Global Business Reports, Gobitz spoke of the peculiarities the sector presents, with isolated camps where miners work and live on shifts that are typically 14 days long, with seven days off. "To adapt to the pandemic, these shifts could be extended to 30 days work and 15 days off, or to even longer periods like in the 1990s, if the mining workers agree," he suggested, adding that extended shifts will become the new norm when the industry reopens during 2020, with very strict protocols to control people and cargo movement.

Mining companies do not operate as isolated entities, and extending new work protocols to all suppliers and contractors will be key. "I think we will see a consolidation period whereby mining operators will try to work with less contractors," said Gobitz, suggesting that contractors should be able to follow the same shift model as the mining operators themselves.

For the mining contractors in charge of large workforces at mine sites, the COVID-19 pandemic will have a significant and permanent impact, according to Gianflavio Carozzi, general manager of AESA: "It will also present opportunities to introduce change at a faster pace as we have had to react (by necessity) to cope with the crisis, which has brought down paradigms such as remote work and the use of technology."

Elaborating on the practical changes that will need to be implemented at mining operations as production is ramped up, Carozzi summarized: "It will change the way we operate and interact. It will change current health and safety protocols in order to preserve social distancing, and it will change the way we staff operations as mobilization will be limited."

What could these safety protocols be and how will they be measured? Professor Neil Ferguson of Imperial College London has said that a significant level of social distancing could be necessary until a vaccine is found, which optimistic estimates envisage is at least 12 months away. As lockdown restrictions are loosened and mining companies ramp up production, monitoring employee behavior for larger workforces will be paramount to mitigate risk. With this in mind, Canadian startup Minetell has created an enterprise SaaS (software as a service) platform that measures and monitors COVID-19 risk exposure and controls performance, and is offering a 60-day free trial to help essential service workers during the height of the pandemic. "Our platform delivers actionable and reliable information into the hands of decision-makers so they can ensure their workplaces are safe for their employees and their families, contractors and community partners," explained Michael Hartley, CEO and founder of Minetell, who added that the remote deployment model the company has been using since its inception two years ago means it does not have to adjust to the current context.

Social organization CopperAcción reported that nearly 1,000 miners had been infected from the beginning of the pandemic until the end of June, with over half coming from Horizonte (over 300 workers with the virus) and Antamina (229). In July, the suspension of operations at Trevali Mining's Santander mine, Hochschild Mining's Inmaculada mine, Fortuna Silver Mines' Caylloma mine, and Pan American Silver's La Arena mine, show that mining companies in Peru will have to adhere to the strictest health and safety protocols in a nation that is struggling to contain the virus.

The mining industry will play a key role in Peru's economic recovery as the country opens up, but the highest level of stewardship from both the government and the private sector is now required to negotiate this challenging period.



# Mining Production

## Copper's rebound offers hope

Before the COVID-19 pandemic grounded the majority of Peruvian mines to a halt, save for essential measures such as heap leaching, processing and environmental care and maintenance, Peru had experienced three years of stable copper production. In 2019, Peru's copper production stayed within a percentage point of the previous year's figure, reaching an annual total of 2.46 million metric tons per year (mt/y), a 0.8% year-on-year increase. Having experienced sharp growth between 2014 and 2017, moving from an annual average of less than 1.5 million mt/y in the years previous, this period of stability preceding the new decade was expected to be followed by growth. While it is hard to predict the full extent of the damage caused by the novel coronavirus, a robust near-term pipeline of expansion projects, anchored by two high-profile greenfield projects – Mina Justa and Quellaveco – gives Peru a solid platform for growth when operations are able to ramp up.

Furthermore, the market revival of the red metal in 2020, despite a depressed world economy, will inject much needed liquidity into producers looking to make up for time lost during lockdown. In March, copper traded below US\$2.00/lb, its lowest level since the global financial crisis of 2008-2009, but in a remarkable turnaround, a recovery of nearly 50% saw spot prices reach just shy of US\$3.00/lb by mid-July. High imports from China were the main catalyst for this rise, and government-backed infrastructure projects across the globe enhance a robust outlook.

In 2021, Southern Copper's Toquepala expansion will see its first full and uninterrupted year of production. Minsur's Mina Justa operation was expected to open by the end of 2020, but will now ramp-up in 2021, due to lockdown delays, and is expected to produce 100,000 mt/y of copper, including 58,000 mt of copper cathodes. Anglo American's Quellaveco will contribute a further 300,000 mt/y of copper starting in 2022. In February 2020, Hudbay Minerals secured a surface rights agreement with the community of Chilloroya for the Pampacancha satellite deposit located near the company's flagship Constancia copper-gold mine, the lowest cost open-pit sulphide copper mine in South America according to Hudbay, which announced it expects to be mining ore from the deposit in early 2021.

However, in the medium to long term, ambitions to close the production gap with Chile will be delayed. Although Chilean production fell by 0.8% in 2019 on the back of declining ore grades and financial issues at state giant Codelco, catching up to Chile's total of 5.78 million mt/y would require numerous district scale projects to move into production. Before the coronavirus outbreak, the Ministry of Energy and Mines (MEM) had predicted an increase in Peru's copper output of 27% by 2022, but progress will be partly dependent on the ironing out of social issues that have interrupted production at Las Bambas and delayed projects such as Southern Peru's Tía María and Southern Peaks Mining's Ariana.



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"Ariana is currently in a state of limbo and what is happening is not only a threat for the Ariana project, but for all new mining operations in Peru," stated Adolfo Vera, Southern Peaks' president and CEO, who clarified that, while there is no local opposition to Ariana, an NGO contesting the project caused Southern Peaks to reduce the rate of construction while awaiting a decision from the Constitutional Court. Underlining the role the mining industry plays in the country's economic development, Vera suggested that this source of income should be protected instead of fought against. "Once the non-sensical claim is rebuffed, the Ariana project is approximately 18 months away from being completed," said Vera, who went on to detail the progress made by Southern Peaks in 2019 by reinterpreting the geology of its Condestable flagship asset, increasing the life of mine significantly, and growing resources by a multiple of 2.4, a mark Vera expects to improve on again in 2020. "As soon as we obtain the permit, we will start to further expand the capacity at Condestable in light of the new size of the resource and reserve," he explained, adding that the company hopes to have completed a feasibility study on the expansion of Condestable by 2021.



Adolfo Vera, president and CEO, Southern Peaks Mining.



Luis Rivera, executive vice president of the Americas region, Gold Fields.

Despite decreasing production, Peru remains the sixth biggest gold producer in the world and the second biggest silver producer. Declining output is being offset by surging prices, as gold approached US\$2,000/oz in July 2020, surpassing the all-time high set in 2011. Activity in the silver market surpassed gold, as it traded above US\$24/oz, its highest mark since 2013.

Buenaventura (BVN) is Peru's biggest precious metals producer, with a wide array of its own operations and a stake in Yanacocha (Peru's largest gold mine operated by Newmont). Víctor Gobitz, Buenaventura's former CEO, acknowledged that the downward trend in gold production and diversification into base metals is being reflected in the company's portfolio, with production falling at Orcopampa and La Zanja, and Yanacocha's production currently stable at around 0.5 Moz/y, but expected to decrease in the coming years. "So, in the medium term, San Gabriel will be a key project for us as it will be a breaking point; while Yanacocha, Tantahuatay and La Zanja will become gold-copper producers and not just gold producers," he explained.

When asked how base metals are playing an increasing role in Buenaventura's production profile, Gobitz emphasized the idea that Buenaventura should be a long-lasting investment vehicle with consistent financial results, which can be achieved through diversification. "In this respect, it is easier to find larger deposits in base metals than in precious metals. We will always have a big focus on gold and silver, but industrial metals are becoming increasingly important," he said.

Evidence of this came in December 2019, as Buenaventura announced a strategic investment into Canadian base metals junior Tinka Resources, who are advancing the Ayawilca zinc project.

Meanwhile, Gold Fields continued its growth in South America in 2019 with the advancement of its Salares Norte project in Chile, as well as the completion of a feasibility study at its Cerro Corona mine in Cajamarca, northern Peru, where mine life has been extended to 2030 – an extension of seven years. With a scoping study set to be performed in 2020 aimed at further extending the LOM at Cerro Corona to 2034, Luis Rivera, Gold Fields' executive vice president of the Americas region, gave an overview of the milestones achieved by the company and its growth ambitions in Peru: "Gold Fields' South American operations have the company's lowest running costs in the world. The net profit coming out of Peru is 21% of the company's entire profits. Our Peru business contributes approximately 310,000 gold equivalent ounces per year (oz eq/y), and our objective is to acquire another asset to reach a 500,000 oz eq/y target."

Elaborating on Gold Fields' priorities moving forward, Rivera added that key areas of focus include water stewardship, mine closure and the reduction of carbon emissions and energy usage.

## A Precious Metals Bull Market

In Peru, gold production declined for the fourth consecutive year in 2019, with an output of 4.13 million ounces (Moz/y), a 9.94% decline from 2018. Likewise, silver saw a 7.24% decrease from 133.8 Moz/y to 124.1 Moz/y, its third consecutive year on a downward trend.

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## Maintaining Peru's Project Pipeline

On January 29th, President Martín Vizcarra announced that Southern Peru's Tía María mining project in Arequipa will not be carried out during his government. "In this government no, there is no way," he affirmed, declaring that granting a construction permit does not necessarily imply having a social license. Although Vizcarra mentioned that other mining projects were being successfully developed, the risk that a project as high-profile as Tía María becomes the poster child for resource development in Peru, at least in the eyes of the general public, is not something that should be taken lightly.

"If you look at the outcome of the congressional election, you will notice that politicians with anti-mining rhetoric won in regions where mining is prevalent," observed Claudia Copper, who has been appointed the president of PERUMIN, the country's main mining convention and exhibition, for 2021. "Despite the mining sector giving a lot of money to the regions it operates in, there is still a lot of anger," she added, advising companies to be proactive in their engagement with communities instead of leaving the relationship building to the state.

Why does this anger exist? Augusto Cauti, Vice Minister of Mines, spoke of the lack of trust that has grown in recent years amongst all parties in the mining sector and the need to present appropriate, transparent and clear information. "The mining sector is complex and not always easy to comprehend and comprehensive to be explained, and the challenge is to show the benefits the industry can provide to improve the quality of life to the inhabitants with something tangible rather than just rhetoric," he said, continuing: "I believe that developing projects in a low-profile manner and/or just as a good neighbor should be things of the past – the sector has to have a more visible face and involve more in alliances with people and local activities from the surrounding areas."

With a lack of major greenfield projects on the horizon after Quellaveco, which is expected to move into production in 2022, projects currently in the pipeline such as Bear Creek Mining's Corani silver-lead-zinc deposit in Puno have taken on elevated importance. Furthermore, in light of the need to revive the economy in a post-pandemic landscape, project development should become a priority. On a micro level, for the regions that host the projects, the importance of project development can be fundamental, a fact illustrated by the National Institute of Statistics (INE) declaring Puno as the poorest district in Peru. "Mining Canon (amounting



Anthony Hawkshaw, president and CEO, Bear Creek Mining.

to 50% of income tax, transferred to the regions and areas of influence of projects) has been decreasing in recent years, mainly due to the lower contributions from Minsur's San Rafael mine related to lower metal prices as well as production. The direct and indirect revenues to local communities from a project the size of Corani will have a transformational impact in the region," stated Elsiario Antúñez de Mayolo, Bear Creek's COO and general manager.

Andrés Franco, vice president, corporate development, elaborated how Bear Creek is working towards the diffusion of information by educating the local population on the project's environmental impact: "Selected community representatives were enrolled in an intensive program that covers the Environmental and Social Impact Assessment, or 'ESIA'," he explained, with the training covering such topics as use of chemicals and the milling processes. "These people now have extensive knowledge about the ESIA and are qualified to, and have been engaged to, explain environmental matters related to the Corani project to community members and visitors," Franco added, noting that such an initiative stimulates community engagement and provides a high level of transparency and, at the same time, mitigates any risks that stem from a lack of knowledge about the impacts of the project.

Bear Creek contracted Common Ground to undertake a follow up social review in 2019, and their findings highlight an important point occasionally overlooked when considering the dynamics of the relationship between mining projects and communities – once the locals are on board, they expect work to go ahead. "Common Ground's December 2019 report showed that we have done an excellent job in earning social license, but their one area of concern is that the people want the mine to be built and are waiting for us to start work to further improve their lives," observed Anthony Hawkshaw, Bear Creek's president and CEO.



# Junior Exploration

## Cumbersome permitting is holding Peru back

While mining producers had to adjust their yearly production forecasts in light of strict lockdown procedures, Peru's junior community was faced with a new set of challenges that compounded the already daunting task of advancing projects in a country that has seen exploration budgets decrease for the previous three years, dropping 13.5% from US\$413 million in 2018, and to US\$357 million in 2019. Buoyant metals prices in early 2020 offered fresh hope for downtrodden explorers; hope which was soon dashed by the COVID-19 wrecking ball that caused commodity prices to tumble and drilling programs to be put on hold. The S&P Global Market Intelligence Exploration Index dropped to a four-year low on April 16th, with pipeline activity, metals prices, drill results, financings and initial resource announcements all decreasing in March.

Looking at the Ministry of Energy and Mines (MEM) statistics, although investment into Peru's mining industry increased by over 20% in 2019, exploration was the one area which went down, as permitting issues delayed drilling campaigns, thwarting exploration activity. Paul Murphy, manager of the South America region for technical consulting firm Mining Plus, has noticed the worrying trend in junior activity: "Peru is just too well endowed geologically to ever be ignored by explorers, but in the current climate where drill permits are taking a considerable amount of time to be approved and with ongoing social challenges, this is testing the friendship between the jurisdiction and juniors," he said, adding that Peru has to be aggressive in ironing out corruption to attract more investment into its exploration sector.

"The government needs to see where there is potential and act quickly, because investors are tired of waiting two or three years to know if there really is potential and cannot continue to invest if they are uncertain there will be a sufficient or a timely ROI," stated Jorge Granda, general manager of AK Drilling, who remarked that by losing these opportunities, Peru loses its competitiveness and funds go to other jurisdictions.

Even before the pandemic, the leading authorities in Peru's mining industry were vocal in their acknowledgement that the climate for exploration must become more attractive if Peru is to maintain a healthy project pipeline. Augusto Cauti, Vice Minister of Mines, stated that stimulating exploration is a key government objective in 2020. As evidence of the government's commitment, Cauti pointed to the decree of urgency enacted on December 27th 2019, that grants the definitive rebate of VAT for the next three years. "Furthermore, we reinstated legislation that allows companies that invest large amounts in the country to perform accounting in US dollars," added Cauti, commenting that MEM is planning to review more adjustments to specific legislation to see how the permitting processes can be expedited.

Manuel Fumagalli, president of the National Society of Mining, Petroleum and Energy (SNMPE), was keen to emphasize the intention of the mining authorities to push for change. "Permitting times and regulations have increased in the last decade and the country has lost competitiveness," he said, revealing that the SNMPE is working with the government to streamline the permitting process, as the discussion to move the ILO



Jorge Granda, general manager, AK Drilling



Manuel Fumagalli, president, SNMPE.



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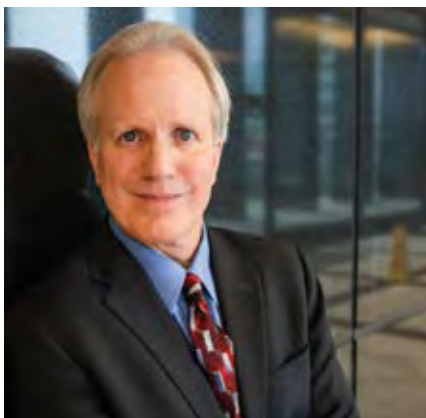
Convention 169's public consultation (consulta previa) from the exploration stage to the feasibility mining project development stage gathers pace.

### Are fortunes about to change?

Despite the bleak backdrop of a turbulent first half of the year, the summer of 2020 has breathed new life into Peru's junior community. For a start, metals prices have flourished since the mid-March liquidity crunch that saw investors sell off stocks en masse. By July copper had reached a two-year high (US\$2.98/lb), silver was trading above US\$20/oz for the first time since 2016, and gold had surpassed the US\$1,900/oz for the first time since 2011. Even zinc started to show signs of life, recovering from a low of US\$0.83/lb in March to reach the US\$1/lb mark in July.

Perhaps more importantly, Peru's mining rules and regulations are set to be updated, with permitting touted to be high on the agenda. On July 9th, Susana Vilca, Minister of Energy and Mines at the time, announced in a meeting with the foreign press corps that two regulatory updates, the "Regulations of Mining Exploration" and the "Regulations of Mining Procedures," would be rolled out to reflect the new realities of exploration in a post-lockdown landscape. While details have yet to be released, the commission set up to produce the regulations is reported to have focused on the cumbersome bureaucracy surrounding permitting in Peru. As well as potentially reinvigorating Peru's exploration sector, these measures could provide a timely boost to an economy that has suffered greatly during the pandemic.

One of the silver linings to emerge from the post-pandemic landscape should be the elevated role that the mining sector will



John Black, CEO, Regulus Resources.

play in reviving global economies, especially in countries such as Peru that rely on the taxes and royalties paid by metals producers. "The pandemic will emphasize the importance that the mining industry has to Peru's economy and in the communities in which we work," suggested David Kelley, president and CEO of Chakana Copper.

The lockdown also offered the opportunity for juniors to spend time advancing work relating to the geology, engineering and economics of their projects. In the case of Regulus Resources, it has allowed the company to consider bringing forward the PEA for its AntaKori project to early 2021, according to CEO John Black. "When these crashes happen in the markets, like we have seen in reaction to COVID-19 and we saw in the global financial crisis in 2008, for juniors it really highlights the importance of having an excellent project, experienced management team and access to capital to come out the other end," he reflected.

Another junior poised to weather the COVID storm is Tinka Resources, after raising C\$18.5 million in January 2020 through



David Kelley, president and CEO, Chakana Copper.

a strategic partnership with Buenaventura, which bought a 19.3% stake in the company at a remarkable 100% premium to the share price when it was announced. Discussing how the current crisis could impact the markets moving forward, Tinka CEO Graham Carman commented: "On the positive side, there will be a reduction in supply from the shutdown or production cuts at many operations, which will mean base metals prices should recover quicker once we get back to more normal supply-demand conditions."

### Copper

With copper surging to two-year highs in July on the back of heightened demand from China, and a longer term outlook reinforced by the growing electronic vehicle (EV) market, major producers will be on the lookout for district scale projects that can guarantee long term production. Considering the scarcity of sizeable junior copper assets globally, a name frequently brought up as a buyout candidate is Regulus Resources, whose AntaKori project has produced five of the top 20 copper intercepts reported worldwide over the

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Graham Carman, president and CEO, Tinka Resources.

last two years with mineralization close to surface, according to John Black. Black provided an update on the company's phase II drill program, mentioning that the focus has been to extend the mineralization, mostly to the north of the project. He also noted that the resource already announced has given Regulus a strong foundation to build upon, with 250 million mt of 0.48% copper and 0.29 g/mt gold in the indicated category and 267 million mt of 0.41% copper and 0.26 g/mt gold in the inferred category.

The Regulus management team has already had success with Antares Minerals, which was sold to First Quantum for C\$460 million in 2010, and Black believes they have the same scale of project or better with AntaKori. "We have already demonstrated a sizeable resource with great opportunity for expansion. We have the security of a solid investment premise on the known deposit, but also the benefit of additional exploration upside," concluded Black.

Another Canadian junior active in Peru, Chakana Copper, used the investment received from Gold Fields in May 2019 to start a 20,000 m drill program at its Soledad project in June 2019, with the aim of testing numerous targets and completing definition drilling on additional mineralized breccia pipes, according to president and CEO, David Kelley. After drilling 5,700 m of the program in 2019, Chakana made the decision to halt drilling and wait until an expansion of its drill permit had been granted to allow access to other parts of the property that have not been drilled yet. Kelley spoke of how Soledad is evolving from a mineralization standpoint: "Looking at the value of what we have drilled up to date, approximately 60% of the value sits in gold and silver and the remaining 40% sits in copper. I believe as we go deeper, copper will become more dominant."

When asked about the potential scale of the project, Kelley outlined Chakana's initial

target for publishing a resource is 10 million mt, which will allow for investor confidence and put the company in a position to raise money to continue aggressive exploration. "There are approximately 40 to 50 breccia pipes. Each breccia pipe varies in size and we have confirmed that the breccias become bigger at depth. We have never seen the bottom of a breccia pipe, even though our deepest breccia intercept is over 700 m."

## Zinc

The dire performance of zinc in 2020 has left some producers operating at a loss, and zinc-focused juniors looking to raise money at the risk of severe dilution as share prices have fallen in tandem with a demand decimated by COVID-19. However, for well-financed juniors with the capacity to weather the current bear market while they increase resources and reserves, the hope is that when their projects have advanced to development stage, the supply and demand dynamics will have swung back in their favor.

Graham Carman of Tinka Resources explained how the Ayawilca project will come online in about four years, and the company is fully cashed up (C\$21 million in the bank and no debt as of April 2020) and permitted for exploration work through to 2021. Acknowledging that work at Ayawilca in 2020 has been impacted due to Coronavirus, Carman gave an update on the current project timeline: "We expect to have an expanded and improved zinc resource late 2020, and then be able to commence a PFS during 2021-2022. As long as permitting can be completed on time, first production at Ayawilca could be in 2024."

Another junior with a path to produce zinc concentrates, as well as lead, silver and gold, is Cerro de Pasco Resources (CDPR), which in November 2019 announced it would acquire Volcan Compañía Minera's Oxidos de Pasco asset for US\$30 million. On March 17th both parties agreed to extend the closure date of the acquisition until June 27th in light of the COVID-19 situation. Steven Zadka, CDPR's executive chairman, suggested that CDPR is treading on different territory to most juniors as it is acquiring a producing company: "As we are going to be producing revenue, we now have the ability to tap into non-dilutive capital sources such as streaming and debt," he said, noting that there is also a lot of equity upside for investors considering the 140 million mt of material inside the mine in addition to exploration potential. "When an equity IRR is supplemented against a non-dilutive capital, you are looking at a really high return on investment," stated Zadka.

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# Engineering, Construction and Consulting

## Growth through consolidation

On January 2nd, 2019, the first act in a wave of consolidation that would define the mining industry took place as Barrick merged with Randgold, followed by Newmont's acquisition of Goldcorp in April. Consolidation was not confined to the precious metals producers, as some of the largest EPCM and consulting houses ramped up M&A activities to bolster their service offerings with clients increasingly looking for a one-stop-shop instead of outsourcing to multiple suppliers.

In April 2019, Australian EPCM giant WorleyParsons announced the completion of the US\$3.2 billion acquisition of Jacobs ECR (Energy, Chemicals and Resources) division, rebranding to "Worley" in the wake of the transaction. On the consulting side, ERM (Environmental Resources Management) acquired CSA Global in July, a coming together of mining and environmental expertise – another of the prevalent themes in recent years – as environmental social governance (ESG) has moved quickly to the forefront of strategy for mining companies. In February 2020, ERM acquired Critical Resource Strategy & Analysis – a specialist sustainability advisory company.



Alexandra Almenara, general manager, Peru, SNC-Lavalin.

One of the major international engineering firms to have strengthened through acquisitions in recent years is SNC-Lavalin, which, in 2019, enjoyed its best year since starting operations in Peru, according to general manager Alexandra Almenara. Affirming that the company had gained the trust and respect of the Peruvian market, Almenara mentioned that a focus on studies, construction management and supervision, and environmental work have been driving business growth in Peru. "Building upon the 2017 acquisition of WS Atkins, our consulting services in innovation and new technologies have grown," she said. "Mining companies in Peru are becoming more eager to listen

to alternative solutions on how they can optimize their production, become more efficient and more sustainable," observed Almenara, listing services provided by SNC-Lavalin such as laser scanning for brownfield projects, drones for surveillance and monitoring, 3D, 4D and up to 7D modeling for engineering designs, and the implementation of road maps for new technologies in the future.

Innovation has also been a growth driver for Wood, since the US\$2.2 billion merger of Wood Group and Amec Foster Wheeler, according to Franco Pedraz, operations manager for mining & minerals at Wood's Peruvian office. "We believe that if a company and its operations are digitized, the initial capex investment will decrease the opex significantly. I think as soon as people have enough examples of projects where technology impacted the opex savings, they will place a bigger emphasis on the implementation of innovation."

Patrick Smith, managing director and CEO of AMC Consultants, commented that the ability to start a mine with new innovations is more feasible for those with bigger budgets and large-scale, long-life mines, such as open-pit copper operations, for example. "However, it is more common for companies to evaluate their projects on the basis of tried and tested technologies, and then, after they have built the mine, implement extra technologies to improve the operation," he explained.

### Local Players in the Market

2019 was also a successful year for Peru's local engineering firms, as brownfields expansion projects for medium-sized operations, rather than the big EPCM jobs suited to the international heavyweights, offered opportunities for growth. This was the case for BISA Ingeniería de Proyectos, which enjoyed its first full year of independence from Buenaventura in 2019, and has worked with Yanacocha, Antamina, Nexa Resources, Buenaventura and Chinalco in recent years. Federico Schwalb, BISA's CEO, explained that the company was restructured in 2016 to focus on its core business – engineering, consulting and construction management – leading BISA to break even in 2017, followed by revenue increases of 25% in 2018 and 21% in 2019.

Of the services offered by BISA, Schwalb has seen a growing demand for the PMO (Project Management Office) service, where a third party company can be the eyes and ears of an operation, showing the mining company how to execute a project properly. "BISA has realized that a good way to take on projects is by integrating a PMO

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The circular diagram illustrates a process flow: TRAINING (top) leads to Engineering & Consulting Services, which leads to Project Delivery Services, which leads to Asset Management Services, which leads to Innovative Digital Solutions, which leads to DIGITALIZATION (bottom). The diagram also includes icons for a person, a gear, a bar chart, and a checkmark.



which can plan, execute and control,” he said, adding: “We expect this area of business to grow in 2020 and I think that we will become the PMO partner for many more projects.”

## Underground Mining Contractors

The global mining industry is migrating underground as ore grades decline and the incremental extraction of earth's finite resources continues. In some countries, such as Canada and South Africa, underground mining is the norm, with operating depths more than 3 km below the surface. In neighboring Chile, Codelco's Chuquibambilla, at one point the largest open pit copper mine in the world by excavated volume, opened its underground operation in August 2019, allowing the state copper giant to exploit the remaining resources located below the current ore deposit until 2058.

While there are currently no large scale underground mines in Peru, there has already been growth in this segment with medium to small scale operations, and the myriad of mining contractors active in Peru are preparing for the impending growth opportunities in the years to come, with the likes of Yanacocha underground, Corococha and Antamina all expected to transition underground in the new decade.



Gianflavio Carozzi, general manager, AESA.

In 2017, a joint venture agreement was signed between underground Australian contractor Byrnecut Offshore (Byrnecut) and local Peruvian firm San Martín with the transition to large-scale underground mines in mind. The move to the type of underground mining Byrnecut specializes in – large open stopes, sub level caves and block caves using bulk mining methods with large tonnage – has yet to gather pace in Peru, as projects such as Yanacocha underground have suffered delays due to metallurgical issues moving from an oxide ore body to a sulphide ore body. However, Byrnecut remains committed to South America in the long run, ac-



Greg Jackson, managing director, Byrnecut Offshore.

According to managing director Greg Jackson, as the company sees the move to large-scale underground mining as inevitable. Jackson explained how Byrnecut works directly in the R&D phase with OEMs, providing feedback on how equipment can be developed to suit the specifics of different mines. “As Peru does not yet have experience in large-scale underground operations, when the transition happens Byrnecut will be well placed to suggest the most suitable mining methods and technology to implement,” he said.

Many projects also begin as underground operations with no open cut component at all, such as Nexa Resources' Cerro Lindo



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polymetallic mine in Chinchá, one of the world's 15 largest zinc mines. INCIMMET is one of the contractors working at Cerro Lindo and Eduardo Cossio Chirinos, INCIMMET's CEO, spoke of the new technology being introduced to the operation to boost productivity and cut operational costs: "Within the new fleet we will have at Cerro Lindo we purchased a machine that performs the cable bolting service and requires only one operator, compared to the old machines that require seven for the whole process."

Another of the major players in Peru's underground mining value chain is AESA, which achieved record sales in 2019 due to a combination of new projects as well as ramp ups on existing projects, according to Gianflavio Carozzi, CEO. Detailing how a sharpened focus on safety has been key to AESA's growth, Carozzi explained how the company reshaped its policies, standards and procedures in order to address a reality in Peru: low reading comprehension rates. "You cannot just assume that your policies, procedures and training material are going to be well understood," he said, continuing: "We thus decided to use alternative methods of delivery, particularly a bigger use of visual aids. As such, we started the use of comics and animated videos to inform on critical aspects of safety."



Enrique Sattler, CEO, Robocon.

### Technological Advancements

Extracting ore at depth can be a complicated, costly and dangerous business, and a worrying rise in the number of fatalities at Peru's mine sites in 2019 (40 deaths, versus 27 deaths in 2018) has heightened the need to remove workers from areas of risk. One of the ways this risk is being mitigated is through technology, and in particular the mechanization of services.

Peruvian company Robocon is the only shotcrete contractor in the world to be affiliated with EFNARC (European Federation for Specialist Construction Chemicals and Concrete Systems), and has been mecha-

nizing underground processes with the likes of Buenaventura and Pan American Silver. Furthermore, Robocon has been integrating with contractors to work on tenders for small mines that are transitioning from dry to wet shotcrete, according to CEO Enrique Sattler. Discussing Robocon's latest technologies, Sattler explained how the company tailors its solutions depending on the context of the mine: "Our solutions will transform narrow vein mining, as tasks that used to take 1.5 days (or three shifts) can now be completed in 30 minutes in a secure operation," he said, adding: "The objective is to mechanize the shotcrete solutions, rather than use a larger workforce."

One of the innovations being used in Volcan's Chungar mine in Peru by Robocon is the slick line shotcrete transportation method – a vertical pipe that takes shotcrete from the surface to depth through gravity. Working in collaboration with Tumi Raise Boring and Robocon's sister company Tecnomecánica, Robocon can ensure the tunnel has the correct proportions so the shotcrete is transported downwards efficiently. "This saves mining companies time and has significant cost benefits – the investment is paid off in only 12 months and increases the productivity of the mine," affirmed Sattler.

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# Equipment and Services

## The dichotomy between innovation and price

Just as the downturn seemed to be in the mining industry's rear-view mirror and the focus had shifted from cost-cutting exercises to increasing production efficiency, COVID-19 struck. In a post-pandemic climate, will operators favor lower-cost suppliers, or will mining companies look to compensate for lost production by investing in new technologies that boost metal output?

Fernando Samanez, VP mining equipment and sales for the Pacific Rim at Metso, believes the need to recover production lost during Peru's extended lockdown could benefit service providers: "When things restart and ramp up, there could be a lot of opportunities as mining producers look to compensate for lost production by increasing throughput," he reflected, adding: "When plants are restarted and looking for 5% more throughput, for example, new technology will have to be implemented."

However, those expecting sweeping changes should probably not hold their breath, as technology that disrupts tried and tested mining methods will face opposition from a low-cost labor force in need of work. "Right now, I do not think it is the right moment to incorporate disruptive changes that would involve big job losses," remarked Víctor Gobitz, president of the Peruvian Institute of Mining Engineers (IIMP) and former CEO of Buenaventura. Speaking in April, Gobitz commented that the adoption of new technology will have to happen step by step: "At the moment, people are our first priority;



Alejandro Caicedo, general manager, Peru, Orica.

the second priority is keeping the essential care and maintenance on our sites; the third priority will be to restart mining operations. Only when we have a stable operation will we look at new technology and efficiency measures."

On the other hand, measures will have to be taken to ensure that mining operations comply with new safety standards, and in this case the implementation of new technologies to mitigate the risk of COVID-19 spreading will be necessary. "COVID-19 is accelerating the adoption of certain technology-based solutions in order to be more efficient and more secure," said Marcos Wieland, general manager of digital transformation company Sitech, part of the Ferrycorp group that includes Caterpillar distributor Ferreyros. "For instance, the vision of having a paperless



Miguel Ángel Arenas, general manager, Geotec.

mine through digitalization is becoming a must," he affirmed, as the use of digital tablets negates the need for workers to pass paper from hand to hand.

Considering the financial burden caused by COVID-19, will investment in innovation become an afterthought? While acknowledging the impact the pandemic will have on mining budgets, Wieland believes it is not the time to eliminate or turn down technology projects: "On the contrary, we believe it is the opportunity to strengthen the digital transformation agenda: efficiency is required more than ever and technology can help."

For Jorge Granda, general manager of AK Drilling, technology should be used to improve machine efficiency, but not to remove human operators, underlining their importance for matters of safety and quality:

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"Drilling is an artisanal practice where the human factor goes hand in hand, and therefore we do not believe that 100% automation will be achieved or is recommended," he said.

On the topic of how to price services, Granda mentioned it would be ambitious to claim that drilling clients are all willing to pay for quality, but the importance is starting to be understood after some of the majors suffered poor results attributed to cheap drilling. "Our challenge for 2020 is to provide a sophisticated product with front-line technology and highly-trained personnel at low prices," he said, mentioning the new technologies AK Drilling is developing in liaison with IDS, such as horizontal drilling, deep-pit drilling and automated diamond drilling.

"The price is still very important for many customers, however, more automated services with higher safety standards are becoming increasingly popular," observed Miguel Ángel Arenas, general manager of Peruvian drilling contractor Geotec, who has also noticed customers becoming more sophisticated in their requests for new technologies. "An example of this is the directional drilling service Geotec implemented in Peru along with our partner in the US," he said.

Automated drilling equipment is becoming more commonplace in Peru, particularly with the biggest players in the industry, such as at the Newmont-operated Yanacocha mine, where Geotec has been using the Epiroc Smart rod handling machines. "Although this represents a bigger upfront investment, they increase safety and productivity significantly," stated Arenas, who explained that the capital investment is paid back as the machines can drill during downtime. Expanding on this theme, Arenas commented that Geotec is working on an artificial intelligence (AI) project to increase production and remove drilling workers from the firing line, a key focus area for 2020.

Environmental concerns are also high on the agenda for mining companies as public scrutiny and stricter regulations require operations to have smaller footprints, which has led Geotec to bring more compact and automated drilling rigs to the market, according to Arenas. Explaining how Geotec has developed smaller equipment that cuts water usage and reduces footprint as part of the company's three-year contract with Las Bambas, he added: "Since Las Bambas has a commitment with the local communities, we had to develop new working strategies to reach the high standard of service that they have set for their project."

The competitive market for blasting services in Peru is served by both international and local explosive companies, including large players such as Orica, Famesa, Enaex and Maxam. So how does a business differentiate itself from the competition? One way is to buy the competition. On February 18th 2020, Orica announced it would acquire Exsa, Peru's largest manufacturer and distributor of industrial explosives, which Orica's managing director and CEO Alberto Calderon stated will immediately establish Orica as the number one player in Peru.

For Alejandro Caicedo, Orica's general manager in Peru, the winning players in the medium and long term will be those who can provide value and technology, rather than those that offer the lowest price. Giving the example of Orica's introduction of the Bulkmaster 7 Mobile Manufacturing Unit in Antamina, Caicedo added: "We are developing a fully automated blasting process, which considers innovations like WebGen, the world's first wireless initiating system that operates remotely, and BlastIQ, a cloud-based digital platform designed specifically to enable continuous improvement of blasting outcomes."

Discussing how products are developed in the blasting industry, Caicedo was keen to stress that Orica looks for an integrated solution rather than simply a product, citing the company's acquisition of GroundProbe as evidence of Orica's commitment to offer an 'end-to-end' approach.



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# Construction Management Tool Offers Firm Control of Project Phases

A steady stream of corporate announcements regarding project suspensions, restarts and delays underpins the stark fact that no segment of mining is immune from the impact of the COVID-19 pandemic, including construction. Contractor reliance on supply chain integrity and high levels of manual labor can lead to difficulties for mine project owners in the current business environment; they know the financial clock begins ticking with the signing of a mine construction contract and never ticks louder than when progress is delayed due to miscommunication, missing data or misplaced documents.

The geographic scope of the pandemic's impact and the unpredictability of its cost in terms of worker health, availability and productivity in general – and the local, regional and national response measures imposed on the industry – have expanded the list of possible project complications significantly. As law firm Holland & Knight pointed out in a recent client advisory, pandemic-related impacts on construction projects might include contract or project notices for default, scheduling and adjustments; project suspension, termination and reinstatement; occupational safety and health and workplace safety compliance; work force management; material, subcontractor and supply chain delays and impacts; risk management and insurance; claims

avoidance or, alternatively, claims management; and dispute processes.

In this environment, the informed involvement of all parties in a construction agreement seems essential, supported by reliable, comprehensive recordkeeping. Construction software developer InEight, a subsidiary of Kiewit Corp., offers a modular, cloud-based project management platform that uses Integrated Project Delivery (IPD), a methodology which seeks efficiency and involvement of participants through all phases of design, fabrication, and construction. *E&MJ* asked Dr. Dan Patterson, chief design office at Arizona-based InEight, to explain how IPD could benefit the mining industry.

***E&MJ:*** *What are some of the more significant weaknesses or stress areas in a typical mine construction project process? How would InEight's solution alleviate these typical problems?*

**Patterson:** Like any major Capex project, the complexity of not only mining construction but also engineering and procurement is enormous. Historically, the toolsets used to try and manage this have been provided by multiple point solution vendors. As a result, it has been very difficult for planning information to flow through to execution. This has resulted in huge inefficiencies and even worse, a total lack of insight into status, issues and performance. Integrated platforms such as InEight overcome this. In-

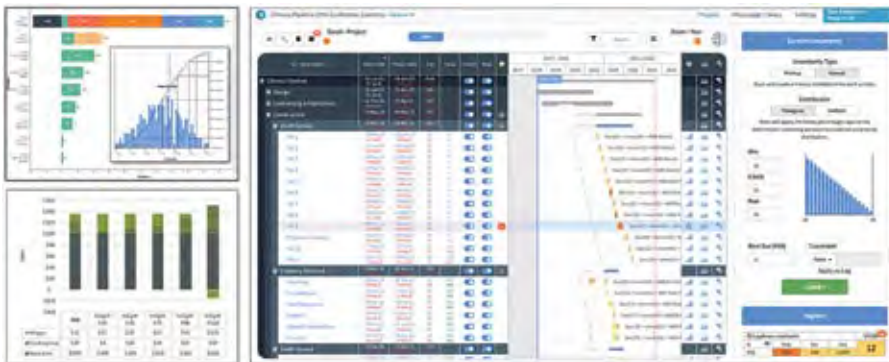
formation is seeded from the very early stages of the project and carried forward through detailed planning, execution and even closeout. Along the way, multiple contributors can add to and enrich this data set enabling the project as a whole to have the timely insight needed to manage the project. Having a simple import and export of data between tools does not enable such frictionless knowledge flow – the InEight platform does.

***E&MJ:*** *Is IPD commonly used in mine-scale construction projects?*

**Patterson:** IPD is a relatedly new methodology that is designed to better align owners and contractors during the project lifecycle. Traditionally, owners and contractors, while engaged on the same project, have not always had the same commercial motivations. As a result, delays, disputes and litigation have all too often been the norm rather than the exception. IPD changes that. In simple terms, under an IPD umbrella, owners and contractors treat the project as a joint venture. The owner and contractor effectively become part of the same team more transparently sharing information but also are motivated to achieve more common commercial goals. While not common practice yet, IPD is for sure emerging within the mining space. As more owners recognize the benefit of this approach, that trend will continue.

***E&MJ:*** *InEight's solution makes use of Artificial Intelligence (AI). Can you provide some examples of useful AI capabilities that might tie-in to mine construction project management?*

**Patterson:** The InEight platform is enhanced through the use of AI. The AI engine is used to intelligently mine historical prior project information to help better forecast and benchmark the current project in hand. The engine is smart enough to infer matches and patterns pertaining to productivity rates, potential risks and even optimal sequence of work. Not only that, but the software learns from the project team as well – in other words, it naturally gets smarter over time. It is worth mentioning that we do not see the A in AI as representing “Artificial.”



Compared with the traditional Design-Bid-Build model, an Integrated Project Delivery (IPD) approach to project management has all constituents – owners, engineers, subcontractors and others – operating under the same governing contract. InEight's IPD solution aims to simplify collaboration and manage iterative versions of a project's budget, schedule and design models. Shown here is the system's Schedule interface.



Instead we see it as “Augmented.” Our software doesn’t replace the expertise of your team – it enhances and supports decisions made by the team with regards to planning and forecasting.

**E&MJ:** *Is specialized training or knowledge necessary to use the solution effectively? And, as the mining industry moves toward increased remote-from-office workforce staffing and follow-the-sun scheduling of works groups located around the world, does InEight’s solution offer features that support these trends?*

**Patterson:** Firstly, the software does not require highly structured data sets, nor does it require thousands or even hundreds of historical projects. Secondly, the software has been specifically developed to support remote capturing of information from multiple contributors who are geographically disparate. We call this Human Intelligence or HI. The HI then in turn feeds the AI engine.

**E&MJ:** *Has InEight been able to identify and quantify savings, in terms of dollars, resources or time, through the use of its solution in a mine construction application?*

**Patterson:** The platform is proving very valuable both from a time savings perspective during planning as well as inherently helping in generating more realistic forecasts. Organizations can expect to save up to 40% in planning time and effort in generating a plan using the InEight knowledge-based approach. On top of this, the degree of confidence and realism that the resulting plan brings to the project is tremendous.

**E&MJ:** *On what basis is InEight’s solution offered: license, subscription, etc.? Do clients typically need help in tailoring the solution to their specific project needs? If so, what type of support is available?*

**Patterson:** InEight is a SaaS subscription model. The software is cloud-based and accessible through a web browser. Unlike many other PPM platforms, the solution can be largely configured without the need for specific customizations. One of the powerful capabilities is the reporting and analytics module which includes both off-the-shelf canned reports as well as the ability to easily create and configure custom reports. This pertains to use cases for both owners and contractors or EPCs. The solution includes full support, web-based training and on-line guidance.

## A New Tack for Technical Audits?

Engineering projects face a growing range of audits, assessment and monitoring, but will COVID-19 restrictions on movement make it difficult for consultants to carry out this work?

The answer lies in leveraging information systems and communication platforms and finding innovative ways of verifying information that used to be confirmed during a site visit, according to SRK Consulting principal environmental scientist Chris Dalglish. While some audits monitor a range of project risks on behalf of financiers or investors, others are necessary to satisfy regulatory requirements.

“Meeting clients face-to-face on a project site has usually been considered by consultants as an integral part of conducting an audit or assessment,” said Dalglish. “But lockdown conditions have forced us to look at other ways of verifying information. This might include the sharing of satellite imagery online, or live data reviews with the client as part of the audit record.”

He explained that most audits require a combination of desktop work – analyzing documentation and data from the client – and on-the-ground observation conducted during a site visit. “In many of the larger, international projects where we monitor environmental and social performance against good international industry practice (GIIP) such as the Performance Standards of the International Finance Corporation (IFC), it is certainly very useful, even essential, to be physically present,” he said.

This is particularly the case where an audit needs to ascertain the capacity of health, safety and environment (HSE) teams, and to assess whether something has been done to the required standard. “Other types of audits require us to analyze past performance rather than current activities, and here the documentation is really the focus,” he said.

The amount of time required on site also depends on the phase of the project, said Sharon Jones, also a principal environmental scientist at SRK. “For instance, South Africa’s National Environmental Management Act (NEMA) requires statutory audits against Environmental Authorizations,” said Jones. “These focus in a fairly binary manner on whether the

conditions of these authorizations are being implemented on site.”

Many of these are conducted when the project is already operational, so much of the work has already been undertaken and the project is either compliant or not. “These kinds of audits lend themselves more to document review, where we scrutinize the systems in place and the documented evidence of action,” she said. “This aspect is usually more important than observing directly what is being done on site.”

She said the same usually applies to audits for Water Use Licenses and Atmospheric Emissions Licenses. Here, documented evidence must be supplied by the client, for the consultant to audit against local compliance limits and international standards. This data is provided in good faith that it is accurate and valid.

“In the past, there has generally been a ‘close out’ session with the client, in which the consultant returns to site following an audit, to report back,” she said. “Working remotely under lockdown conditions, it is clear that some of these interactions can be conducted remotely.”

However, there are minimum requirements for a remote audit to be an acceptable alternative to a site visit. For example, the consultant will generally have seen the site before, and on-site conditions must not change between seasons. Also, the consultant will have to be satisfied with the culture in place at the client’s operations, in terms of overall adherence to good international practice. This would provide assurance that audit data provided by the client is correct and reliable. Under these conditions, there may be an opportunity for clients and consultants alike to save on the cost and time of travelling to site.

Dalglish noted that digital communication platforms are proving invaluable in making remote audits more feasible. “Meetings and conferencing using online platforms can often facilitate the iterative nature of our role, where we may need to be in close contact with a client over a period of time,” he said. “Doing this remotely can also make the process more focused and economical.”

Apart from the time and cost savings of not travelling to site, these tools allow specific people within an organization to be targeted for discussion as and when necessary, instead of having a large client team on standby.

# Zyfra, Huawei Trial 5G Robots in Russian Coal



Autonomous BELAZ haulers and a 5G system by Zyfra and Huawei are being trialed at a surface coal mine in Russia. (Photo: Zyfra)

An open-pit mine operated by the Siberian Coal & Energy Co. (SUEK) in Khakassia, Russia, is trialing a 5G connectivity and autonomous hauler system developed by Zyfra and Huawei.

The trial involves a fleet of 130-ton BELAZ-7513R autonomous mining trucks and a 1.5-km wireless 5G network built on Huawei equipment. Two 5G transceiver stations operate in standalone mode. The mine site channel operates at 100 MHz.

The trial is videoed by high-resolution cameras along the perimeter. Thus far, the network demonstrated its reliability at supporting robotic equipment in open pit mines, Zyfra reported. "Robotic trucks allow for a significant increase in freight transport production rates, up to 30%, and an increase in the number of movements per shift, by approximately 20%," Pavel Rastopshin, managing director, Zyfra, said.

It is the first such trial in Russia, SUEK said. "Thanks to new generation network resources from Beeline and Huawei, we are currently reaching such unmanned machines production rates that are not possible with humans alone," Dmitry Sizemov, deputy director of information technology, SUEK, said. "The possibility of running robotic automation at other enterprises is currently being discussed at SUEK."

The miner is considering testing similar 5G solutions at the Chernogorsk open-pit mine in Chernogorsk, Khakassia.

China's Huawei said its 5G technologies will allow mining to be done by robots, which will turn mining jobs into desk jobs. "Having witnessed cases of a hologram call, remote operations and now remote mining, we believe that 5G will soon be available for all of us and for every industry," Aiden U, CEO of Huawei Eurasia.

The pilot project will last for several weeks, Zyfra reported.

SUEK is a top-5 global coal exporter and sells coal in 48 countries.

## Boliden Harjavalta Orders Metso Outotec Mills

Boliden Harjavalta selected Metso Outotec's SMD grinding mills to improve the capacity of its slag concentrator.

Based on tests, the Metso Stirred Media Detritor, specialized for fine grinding applications, was chosen as the grinding technology, Metso reported. "Now the slag concentrator can process larger amounts of material, without compromising the targets set for copper recovery," Timo Sarvijärvi, head of mining, Nordics market area, Metso Outotec, said.

In 2019, Boliden Harjavalta produced 120,000 metric tons (mt) of copper and 26,000 mt of nickel.

The order has been booked in Metso Minerals' Q2 2020 orders received.

Metso also reported it booked a \$15 million contract from Lynas Kalgoorlie for the

supply of a large rotary kiln and combustion system for baking rare earth minerals.

The companies will develop a rotary kiln system for Lynas' new cracking and leaching plant in Kalgoorlie-Boulder, Western Australia. The plant will process concentrate from the Mount Weld mine and provide an intermediate feed for further processing to produce neodymium and praseodymium.

Lynas described the order as an important milestone in the development of its Kalgoorlie processing plant. "The project is progressing to schedule and we look forward to working with Metso Outotec on the engineering and supply of the kiln," Amanda Lacaze, managing director, CEO, Lynas, said.

Commissioning of the kiln is calendar for 2022.

Elsewhere, Outotec reported it won a \$23 million contract from La Sino-Congolaise des Mines SA (Sicomines) for delivery of a modular VSF X copper solvent extraction plant to the latter's project near Kolwezi, Democratic Republic of Congo (DRC).

The scope of the contract includes basic engineering, technology and equipment deliveries, and advisory services for mechanical installation, commissioning and start-up.

Outotec said the order would be fast-tracked. "The Sicomines project will be a great reference for Outotec in the active African copper/cobalt market," Kalle Härkki, head of Outotec's Metals Refining business, said.

## Salares Norte Buys FLSmidth Islands

FLSmidth reported it sold three complete process islands to Gold Fields for the Salares Norte project in Chile. The large Downstream Gold product line project comprises a Merrill Crowe island, an AARL elution circuit, and a refinery.

The islands were selected for their quality and durability, FLSmidth reported.

FLSmidth said, considering how few new mines are being opened, the order is a testament to the viability of FLSmidth offerings. "These orders are the result of



work well done and close collaboration,” Jorge Carvajal, project sales director, FLSmidth, said. “This, in conjunction with a strong focus on our customer during the entire process, was crucial in solidifying our position as a key technical solutions provider in the gold market.”

The process plant will treat 2 million metric tons (mt) of ore per year and is expected to produce an average of 2.6 million oz of silver and 286,000 oz of gold annually during its first seven years.

The mine is at 4,500 m in elevation in the Atacama region of northern Chile.

Separately, Technology Metals Australia selected FLSmidth to supply solutions for the roasting kiln section of its Gabanintha vanadium processing plant in Western Australia.

The award follows successful pilot testing for the feasibility study, during which a bulk sample of magnetic concentrate was roasted. The contract includes an engineering study and the supply of the complete roasting kiln section of the plant.

FLSmidth said the contract shows how the company is a leading equipment supplier in the battery minerals sector. “FLSmidth is well placed to support this growing mining segment,” Manfred Schaffer, president, mining, FLSmidth, said.

Vanadium is used in steel alloys and in vanadium redox flow batteries.

## Vale Mines Buy Epiroc Battery Service, Machines

Two Vale mines in Canada adopted Epiroc’s new Batteries as a Service (BaaS) offering.

With BaaS, the supplier and the customer develop and follow a battery management plan designed to increase the uptime and availability of battery-electric mining machines. Epiroc technically owns and monitors the rechargeable batteries used by the customer, and replaces and updates them as needed. Battery lifespan is guaranteed, and battery status is carefully tracked by Epiroc with the goal of reducing downtime.

Epiroc reported the service should help customers maximize the benefits of using battery-powered solutions while farming out some of the accompanying challenges.

“BaaS helps our customers benefit from the latest battery technology without having to worry about facilitating upgrades and removals,” Fredrik Martinsen, head of marketing Rocvolt, products and services, Epiroc, said. “They can fo-

cus on their business and we make sure they have all the power they need.”

Vale also contracted Epiroc to provide 10 battery-electric vehicles: four Scooptram ST14 loaders, two Boomer M2C drill rigs, two Boltec MC bolting rigs, and two Minetruck MT42 trucks. The miner also bought three charging cabinets and seven charging posts.

The equipment is calendared for delivery prior to the end of Q1 2021.

## Malvern Tapped for Lab for Rio Tinto’s Koodaideri

Scott Technology contracted Malvern Panalytical Ltd for engineering, design, equipment supply and the provision of a fully automated analytical system at Rio Tinto’s Koodaideri iron ore project in the Pilbara region of Western Australia.

The lab will incorporate multiple fusion bead sample preparation, X-ray spectrometry instrumentation, and automated Thermogravimetric analysis equipment.

Initial testing capacity will be 600 samples per day, with the potential for future expansion to double that number.

Malvern Panalytical said it will deliver a world class facility. “As a major supplier of analytical X-ray instrumentation, Malvern Panalytical has a long-established business relationship with Rio Tinto Iron Ore,” Huub Smit, sector director, primary materials, Malvern Panalytical, said. “However, this project is a major step in the evolution of SCOTT and Malvern Pan-

alytical as providers of automation solutions across Australia and Asia and follows on from our success in supplying automation systems to laboratories in Europe.”

Completion of the laboratory facility is slated for mid-2021.

## Sandvik Partners with Exyn, Calendars Webinar

Sandvik reported it partnered with aerial drone supplier Exyn Technologies to provide solutions for mapping and visioning underground mines. The partners will research how to apply and generate 3D views and perceptions of underground spaces autonomously, while leveraging the full potential of Sandvik’s AutoMine system.

Exyn said the goal is to develop solutions that allow customers to map the entirety of their underground operations, even in dangerous GPS-denied environments, while making mining safer and more productive. “Through this partnership, we hope to empower efficient decision-making for customers and drive towards the vision of fully autonomous mining operations,” Nader Elm, CEO, Exyn Technologies said.

Separately, Sandvik announced it will host the Innovation in Mining Virtual Event, Sept. 29 to 30, 2020, where they will roll out new equipment, solutions and technology. The event will offer the opportunity to learn more about Sandvik’s most innovative solutions for the mining industry. Attendees can do an online tour of the company’s Rock Drills facility and Test Mine, interact



Sandvik partnered with Exyn Technologies to develop solutions for mapping underground mines. (Photo: Sandvik)

with virtual booths, meet with Sandvik reps, ask questions and attend live presentations.

## Strata to Rep, Distribute CSE Safety Gear

Strata Worldwide and CSE Corp. signed a global strategic partnership on a portfolio of solutions. The former will represent and distribute CSE's line of mine safety products in the U.S., Canada and Mexico.

CSE products available through Strata include the self-contained self-rescuers, a machine-mounted methane detector, a hand-held multi-gas gas detector, and an MSHA-approved cordless cap lamp.

Strata Worldwide said the partnership will allow it to better serve the mining and tunneling industries. "We look forward to adding CSE's products into our safety offerings, while expanding their reach and increasing market share."

## Aramine to Sell Astec Offerings in W. Africa

Astec Industries signed a distribution contract designating Aramine its official dealer in several countries in West Africa.

Previously Aramine offered strictly the Astec BTI range of rock breaker and boom systems.

The partnership allows Astec Industries Africa Middle East to develop a new customer proximity offer, the company reported. "With the expansion of the Astec portfolio distributed by Aramine, this is an important evolution in our commercial relations, as we collaborate in very active and demanding markets in West Africa and the Maghreb," Vinesh Surajlall, director, material solutions, Astec Industries Africa Middle East, said.

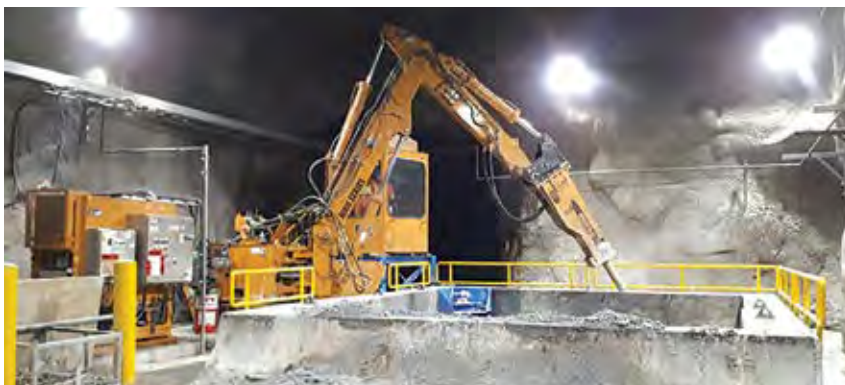
Under the contract, Aramine will be the official dealer for Astec Industries in Mauritania, Mali, Senegal, Guinea, Ivory Coast, Burkina Faso, Benin, Togo, Niger, Algeria, Tunisia and Morocco.

## RPMGlobal Acquires Competitor

RPMGlobal acquired Revolution Mining Software (RMS).

The latter makes Schedule Optimization Tool (SOT), a financial mine scheduling optimization solution.

RPMGlobal said it will invest in developing RMS software solutions. "RPMGlobal was born from the belief that mine planning needs to be built on sound economics and the RMS products strategy is



Astec Industries contracted Aramine to be its official dealer in several West African countries. (Photo: Aramine)

completely aligned with that core value," Richard Matthews, CEO, RPMGlobal, said.

SOT enables mine planners to improve productivity and profitability by optimizing the net present value of the mine schedule, RPMGlobal said. Other RMS solutions include Attain and SurfaceSOT.

After the acquisition, all RMS personnel will become RPMGlobal personnel and will continue to focus on innovative software solutions, RPMGlobal reported.

## Datamine Acquires Snowden

Datamine acquired Snowden, incorporating the Supervisor and Reconciler software solutions and its advisory consulting business. Supervisor is a complementary solution to Datamine's existing resource estimation suite.

Datamine said the development brings together two aligned companies. "Snowden has a strong, expert brand with a wealth of experience, and has developed industry-leading products that complement Datamine's software portfolio," John Baily, executive general manager, Datamine, said.

The Snowden advisory consulting business extends Datamine's service offering with an experienced team of qualified individuals to produce high quality resource estimates and advice across all commodities, mineralization styles and regions, Datamine reported.

## ASI, MS4M Make Solutions Compatible

ASI Mining entered an agreement with MS4M for compatibility between ASI Mining's Mobius Platform and MS4M's ControlSense fleet management system (FMS) software for autonomous vehicles.

The development will give existing MS4M users the ability to implement ASI

Mining's Autonomous Haulage System (AHS) using an open FMS/TMS interface. Future MS4M customers will also have assurance of a pathway to AHS by leveraging this same interface.

MS4M said the agreement is an opportunity to collaboratively support OEM-agnostic solutions that enable the deployment of mixed autonomous fleets within the same operation.

"Integration of our world-class mine management and optimization suite of products with ASI Mining's traffic management and onboard autonomy will provide mines with a significant degree of flexibility and optionality as automation migration paths are developed and implemented," Wilder Pando, CEO, MS4M, said. "Beyond supporting a staged approach in the presence of mixed fleets, this will mitigate the dependency on a single-solution provider."

## Partnership To Put Gas Sensors in Wearables

NevadaNano partnered with Blackline Safety Corp. to integrate the former's combustible gas sensors into the latter's cloud-connected safety wearables.

The partnership will allow the companies to build NevadaNano's Molecular Property Spectrometer Flammable Gas Sensors into Blackline's G7 wearables.

The sensors monitor the environment for the lower explosive limit levels of the 12 most common combustible gases, delivering a reading for individual gases and gas mixtures.

NevadaNano said the partnership will strive to develop solutions that help solve longtime gas detection and related work site safety challenges. "Together with Blackline, we're challenging the status-quo with redesigned flammable



gas detection that will enhance safety and performance, while keeping teams focused on their important work,” Bob Christensen, senior director, business development, NevadaNano, said.

## Sleipner, TowHaul Partner For Total Solution

Sleipner Finland Oy and TowHaul Corporation signed a cooperation agreement whereby the latter will sell and service Sleipner products as an exclusive dealer in the U.S. and Canada. Under the agreement, the partners will offer customers a Total Mobility Solution that can consist of products from either company. TowHaul reported the agreement ensures the best possible offerings for mobility solutions for the mining industry in the U.S. and Canada.

## Liebherr Opens Virginia, U.S., Campus

Liebherr announced it formally moved into a newly expanded campus in South-eastern Virginia, U.S., in April. The facilities there house employees who work in administration, finance, human resources, sales, information technology, marketing, product support and distribution for nine different product units under the Liebherr USA brand.

The development closes a project that began in July 2018. Approximately 500 people now work on the new campus in Newport News.

Liebherr lauded the message the development sends to customers. “Apart from investing in research and design for cutting edge technology, we have a long-term focus while looking at our business and the relationships with our customers,” Torben Reher, managing director, Liebherr USA, said. “We want to grow

together and our new site is the evidence for this approach.”

## Rare Earths Plant to Make Sanitizer

Geomega Resources announced it retrofitted its pilot rare earths processing plant for the production of hand sanitizer for the Québec market.

Earlier the company obtained the natural product number and approvals from Health Canada to manufacture and distribute hand sanitizer.

The plant will produce up to 675 liters per week.

Geomega said the retrofit will not affect the projected launch date of the company's demonstration plant in St. Bruno, Québec.

Geomega owns the Montviel rare earth carbonatite deposit, and holds a 19% stake in Kintavar Exploration Inc., the exploration company advancing the Mitchi stratiform copper project in Québec.

## Partnership Advances Battery Research

NOVONIX and the Professor Mark Obrovac Research Group at Dalhousie University announced it can manufacture single-crystal NMC cathode material using its patented Dry Particle Microgranulation technique.

Single crystal cathode materials are reportedly able to outperform traditional polycrystalline cathode particles and therefore are in demand by the lithium-ion battery industry, NOVONIX reported.

NOVONIX said the single-crystal NMC cathode material could aid in the development of lower-cost, higher-performance battery materials. “The single-crystal cathode development complements



Partners NevadaNano and Blackline will build tiny gas sensors into wearables. (Photo: NevadaNano)

NOVONIX's PUREgraphite anode product, both addressing the ultra-long-life battery performance requirements critical to the achieving the million-mile battery life being sought by leading EV automakers,” Phil St. Baker, managing director, NOVONIX said.

## Allu Launches R&D Center

Allu Group announced it launched Allu Innovation and Research Center Oy, which will focus on researching and developing future attachment technology, solutions and equipment. It will operate parallel to but independent from the other existing Allu manufacturing, production and general business operations.

Allu Innovation and Research Center Oy will “form the cornerstone of Allu's ongoing R&D program, providing cutting-edge solutions aimed to make customers more efficient, productive, environmentally friendly, and profitable,” the company reported. The company will be headed by an Allu Group founder and chairman.



Allu Group launched an R&D company to focus on attachment tech. Above, Allu transformers lined up and ready for delivery. (Photo: Allu Group)



Ground broke on the new campus in July 2018, and in April 2020 Liebherr announced its personnel were being relocated there. (Photo: Liebherr)

# New Platform Links AI with Expertise for Process Improvement



The ore-beneficiation optimization solution comprises several “Optimization as a Service (OaaS)” applications that can be configured for individual mine sites within three months.

Global chemical company BASF and IntelliSense.io, an industrial artificial intelligence (AI) company, announced in July an exclusive partnership that will combine their capabilities in mineral processing, ore beneficiation chemistry and industrial AI technology. The two companies said the joint offering, called ‘BASF Intelligent Mine powered by IntelliSense.io’, delivers AI solutions combined with BASF’s mineral processing and chemical expertise and will enable mine operations employing the solution to become more efficient, sustainable and safe.

BASF said the new offering is an open, real-time, decision-making platform that can be configured for individual sites, typically within three months. Each mining process, such as grinding, thickening, flotation and pumping, is supported by an Optimization as a Service (OaaS) application that predicts and simulates future performance, generating process-specific recommendations for insights and optimization. As multiple OaaS applications link together, customers can generate efficiency gains throughout the entire mine-to-market value chain.

Remote operations access allows for 24/7 visibility of mine operational and financial performance, with BASF process experts available to provide real-time support. Additionally, the in-built simula-

tion tool can be used to test alternative operating conditions, train staff and run non-intrusive ‘what if’ scenarios.

The AI solutions are based on a hybrid cloud architecture, enabling both on-site and cloud deployments, to help mining industry partners accelerate their digitalization programs in their operations.

The two partner companies noted that mineral sands producer Image Resources, an early adopter of the platform, reported promising results from the Intelligent Mine deployment. “Image Resources is both excited and optimistic about the potential the BASF Intelligent Mine powered by IntelliSense.io can have to positively impact the accuracy and efficiency of our process control functions to meaningfully improve our bottom-line,” said Patrick Mutz, Image Resources managing director.

“Our partnership with IntelliSense.io combines state of the art artificial intelligence and decades of ore beneficiation experience in to a powerful, fast and easy to deploy optimization platform,” said Damien Caby, senior vice president, BASF Oilfield Chemicals & Mining Solutions. “Efficiency improvements resulting from the first implementations by our joint dedicated team are helping customers accelerate digital transformation.”

“In a tough economic climate, the need to focus on mining productivity, within

sustainable and remote operational constraints, is driving pressure on operating and capex budgets and requires innovative solutions with accelerated value delivery,” added Sam G. Bose, CEO of IntelliSense.io. “The partnership between BASF and IntelliSense.io ensures mining organizations have a partner that understands both their operational risk as well as new technologies.”

## Outotec Reveals Compact Fine-grinding Mill, Cyanide Reduction Process

Outotec recently introduced several new mineral processing products and services, including a modular fine-grinding solution and a process claimed to significantly reduce cyanide consumption in refractory gold ore treatment.

The company, now known as Metso Outotec after completion of the merger between the two Nordic process equipment manufacturers, said its HIGmill plant (HMP) consists of a vertical HIGmill unit and pre-engineered auxiliary equipment modules designed to reduce engineering, delivery, construction, and commissioning time and cost while still providing a safe solution with the flexibility to meet various process, layout, and regulatory requirements.

“The HMP combines Outotec’s leading fine grinding technology with faster installation and compact footprint while maintaining safety standards. This stand-alone modular solution comes in easily installable pre-assembled sections to speed up returns on investment,” said Riddhika Jain, product manager.

The HMP includes an Outotec PSI 500i particle size analyzer for continuous online process monitoring and feedback, while the HIGmill provides process flexibility by adjusting the speed to match the energy input for the required product particle size. This minimizes the risk of operational challenges and reduced recoveries resulting from variable process conditions, according to Outotec. Key benefits offered by the HMP are listed as:

- Space-efficient footprint with flexible modules that can be arranged according to plant layout;



- Optimized delivery lead time and site construction planning;
- Dedicated switch room control;
- Optional media-handling system guarantees easy shutdown and improved safety; and
- Shipped pre-assembled for superior quality, minimum fabrication risk, and lower construction costs.

The company also unveiled its MesoTHERM BIOX, noting that cyanide consumption with conventional bio-oxidation residues is typically higher than with residues produced through other oxidative technologies. The MesoTHERM BIOX process, based on Outotec's mesophile BIOX process, is claimed to offer an easy, cost-effective upgrade path that can cut cyanide consumption by as much as 50% compared with conventional bio-oxidation.

The Outotec MesoTHERM BIOX process enhances the established mesophile BIOX process by combining mesophile bio-oxidation technology with a higher-temperature thermophile oxidative stage to enable an even more effective overall sulfide oxidation step.

Outotec said MesoTHERM BIOX also significantly reduces the formation of thiocyanate – a common and stable cyanide species traditionally formed as a further by-product. Solubilized species prevalent in the mesophile stage are decanted off in an inter-stage thickening step between the two oxidative processes, simplifying operation of the thermophile stage.

According to the company, upgrading to BIOX MesoTHERM is a relatively simple process that involves reconfiguring the circuit with the addition of Outotec's High Rate Thickeners for inter-stage thickening and Outotec OKTOP Atmospheric Reactors for the thermophile step.

"Our conventional mesophile BIOX process has enabled the production of over 25 million ounces of gold to date. This novel process takes advantage of these proven technologies to help our customers achieve significant cost savings while also reducing their environmental footprint," said Craig van Buuren, an Outotec senior process engineer.

## New Spiral Offers Better Recoveries for Ferrochrome

Following years of test work in the ferrochrome sector, Multotec said it has successfully developed and proven a spiral concentrator that eliminates beaching

and enhances recoveries in the 1- to 3-mm fractions of high-density material. Significantly, when compared to traditional spirals the new spiral has shown extraordinarily higher metal recoveries, even for minus 1-mm fractions in ferrochrome slag, according to the company.

"Our SC25 spiral concentrator features steeper angles which facilitate the flow of material and increase separation efficiency," said Hlayisi Baloyi, applications engineer at Multotec. "It also widens the particle size range that can be treated by the spiral."

Traditionally, spirals would struggle to efficiently treat material above one millimeter in heavy mineral applications, but this spiral can go well beyond that. The spiral has been a game changer even for the minus one-millimeter size range where higher separation efficiencies have been achieved on chromite ore."

Baloyi said that this innovation provides an interesting alternative to jigs in the minus 3 to plus 1 size range, which have been one of the conventional methods of separating larger particles. The

company said the solution is cost effective as spirals use no electricity and are also easy to maintain. The first order for the commercialized version has been placed.

Multotec claims the economic benefits of the Multotec SC25 spiral for ferrochrome producers are substantial, as some plants were losing the value of their 1- to 3-mm material to tailings. Many of those who used jigs to treat this fraction were also finding that their efficiencies were low.

"Ferrochrome is not the only commodity that we have successfully tested," said Refentse Molehe, process engineer at Multotec. "We have even seen improved recovery in heavy minerals below one-millimeter size, alluvial chrome, manganese slag and there is potential in industrial recycling."

Multotec said the recycling application opens up options for urban mining – recovery of metal particles from associated waste. Multotec said it has received a number of requests and conducted tests to recover metals from recycled electronic goods and from customers who intend to recover metal from industrial scrap.

## Collaboration to Study Solar-thermal Comminution

The Coalition for Energy Efficient Comminution (CEEC) announced a collaboration sponsorship with the University of Adelaide's Institute for Mineral and Energy Resources (IMER) to research solutions that use solar thermal heat in the comminution process.

Prior IMER research findings indicate solar thermal heat can weaken rocks, reducing the need for fossil fuel-derived

mechanical energy used in crushing and grinding, according to IMER manager Chris Matthews.

He said the ongoing IMER and CEEC relationship previously contributed to the research. "After involvement in CEEC's workshop, we forged new collaborations, including an exciting industry partnership, which plans to trial the use of solar thermal energy to enhance comminution."



# Sandvik Bullish on New Toro Machines



Sandvik reported it will reintroduce a number of beastly loaders and trucks as Toro family models.

Finnish underground equipment maker Tamrock established the Toro brand and it began to fade away after Sandvik acquired Tamrock in 1997.

In Spanish, *toro* means bull, an animal universally revered for its size, strength and tenacity.

The name and image fits, and now applies to, several robust machines that feature upgrades that distinguish them from predecessor models, Sandvik reported. For example, the new Toro family models are i-series machines and will operate “safer, stronger, and smarter.”

First to be reintroduced are three loaders and two trucks.

The new Toro LH517i and LH621i loaders come with several design up-

grades to boost productivity, reduce total cost of ownership and improve operator experience, Sandvik reported. Both come with a Stage V engine and feature the Sandvik Intelligent Control System to limit speeds, support downhill tramming, and minimize brake wear.

The large loaders feature a new traction control system to reduce wheel spin and slippage, and to extend tire life. Both come with Digital Trainer, a training simulator.

The new Toro LH625i electric loader is the “world’s largest payload capacity underground loader,” Sandvik reported. The cabled unit offers a whopping 25,000-kg payload capacity.

The TH551i and TH663i trucks are both now Toro family models, and feature upgraded transmissions, coolers, and low-emission engines. The i-series trucks offer reduced maintenance costs compared to predecessor models.

Sandvik said i-series machines have garnered positive feedback from customers. “Reducing costs in addition to already-reported positive operator feedback shows we are on the right track,” Wayne Scrivens, vice president, load and haul, Sandvik, said. “Which benefits the Toro family.”

Separately, Sandvik launched My Rock Tools – Analyze, a mobile app de-

signed to help customers improve their rock tool performance through analyzing failure and discard reasons. The app adds to the Sandvik Rock Tools suite.

With it, customers can increase productivity and profitability by using analysis results to improve their drilling operations, Sandvik reported.

The app is available to Sandvik customers and runs on either iOS or Android. To use it, the customer enters key product information and uploads photos of their worn out tool. Sandvik will respond with feedback and analysis.

[www.rocktechnology.sandvik](http://www.rocktechnology.sandvik)

## Large Grinding Mills Lower OPEX

Outotec launched a grinding mill with an open-ended discharge, the OED Mill. This large high-capacity grinding mills offer reductions in both CAPEX and OPEX.

Instead of using pulp lifters, the OED Mill discharges material directly through the grates. It uses a novel grate-supporting spider to maximize slurry transport and minimize slurry pooling, the company reported.

Key benefits offered include highest possible discharge capacity, maximized slurry transport and impact energy with lowest possible slurry pool level, and optimized serviceability and availability.

The mill enables circuit designs with reduced equipment requirements, low-







ering CAPEX. Reductions in OPEX stem from a reduced need for grinding media.

Separately, Outotec released the Mill Equipment Transporter, a specialized mobile unit for the safe and reliable transportation of feed chutes and more. It has independently driven wheels and independently controlled rear steering, enabling it to turn on the spot. The pivoting rear axle ensures that all four wheels are always in contact with the deck, while large rubber tires optimize load distribution.

It has a built-in safety system and a multi-language display. Benefits include improved safety when moving large loads, real-time feedback for the operator, and compatibility with smaller deck designs.

Outotec also released the Tube Mill Reline Machine, a compact relining solution for smaller SAG and ball mills.

Tube design minimizes the required mill opening size while maximizing the usable area for liner delivery. It provides fixed three-axis hydraulic crane support.

Benefits include the safe relining of smaller SAG and ball mills unsuitable for traditional reline machines, easier navigation of small mill decks, user-friendly operation, and lower capital cost and simplified maintenance.

[www.outotec.com](http://www.outotec.com)

### Surface Miner Bests Dozer in Trial

Wirtgen reported a 220 SMi 3.8 surface miner outperformed a crawler dozer solution in a field trial at a chalk quarry in Chouvrot, France.

In the trial, which included wet conditions, the goal was to mine 500 m<sup>3</sup> per

hour. Among other parameters, cutting performance, turning time and fuel consumption were tracked and compared.

The surface miner features adjustable longitudinal and cross slopes for water drainage. It offers a cutting depths of up to 350 mm and a uniaxial compressive strength of up to 35 MPa. For the trial, it first used a 3.8-m-wide cutting drum, designed specifically for soft-rock mining, and then switched to a 2.2-m-wide drum.

The machine achieved a peak cutting performance of 1,400 m<sup>3</sup> per hour. Output also remained high on slopes with a gradient of up to 16%, Wirtgen reported.

When deployed as part of a fleet for a shift, it cut at two depths, 20 cm and 30 cm. It produced significantly smaller and more uniform grain sizes than did the dozer solution, the company reported.

The 220 SMi 3.8 ultimately bested the dozer, and delivered “maximum performance and cost-effectiveness,” the company reported.

[www.wirtgen.com](http://www.wirtgen.com)

### Back-up Solar Microgrid

EnTech Solutions launched the Xcape microgrid, described as a resilient energy and battery storage solution that can provide seamless back-up power.

The solution operates on solar panels and stores excess energy in a battery system. At night or when sunlight is blocked, power is provided by the battery system. The microgrid can also be connected to a utility grid.

The three options ensure dependable, resilient power at all times, EnTech Solutions reported.

The scalable units are designed for customers interested in microgrid technology but priced out of engineering one, the company reported.

[energybyentech.com](http://energybyentech.com)





## Telescoping, Self-Contained Conveyors

Superior Industries introduced a new set of TeleStacker Conveyor models with on-board power. The conveyors are described as self-contained, radial, telescoping conveyors equipped with a 96-kW Cat 4.4 Tier 4 Final engine. They are designed for remote sites where access to permanent electrical power transmission is not practical, the company reported.

The conveyors are designed in 36-in belt widths and fully extended operating lengths of 110, 130 and 150 ft. Custom widths and lengths are available.

Standard features include XTP swing axles, hydraulic drives, Superior brand idlers and pulleys, and an onboard counterweight.

The units deliver cost-efficient material handling that boosts stockpile volumes and loading capacities, while preventing material segregation and additional material handling, the company reported.

[www.superior-ind.com](http://www.superior-ind.com)

## Monitoring Solution for Drive Couplings

Voith introduced the OnCare.Health IOLIS digital monitoring solution for industrial fan



and pump drive trains. The solution uses smart sensors and connected components to increase availability. It allows for easy machine health monitoring and predictive maintenance, the company reported.

Benefits include data-driven optimization, streamlined maintenance, and ease of integration.

[voith.com](http://voith.com)

## Heavy-duty 4x4 Minibus

TORSUS announced TERRASTORM, a 4x4 minibus capable of transporting up to 21 passengers.

Based on a Volkswagen Crafter 4Motion chassis, the vehicle features an uprated heavy-duty off-road suspension and is powered by a EURO VI engine.

The bus will be available in Q3, the company reported.

[www.torsus.eu](http://www.torsus.eu)



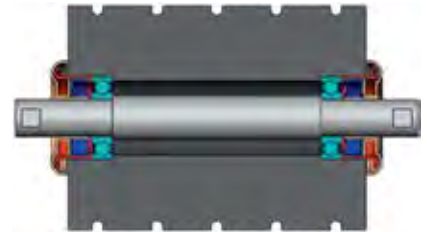
## Conveyor Bearings Survive Harsh Conditions

NKE Austria GmbH released single-row deep groove ball bearings with optimized performance capabilities and a longer life over standard bearings for conveyors in harsh conditions.

The bearings have a special cage construction of low-friction synthetic material, improved raceway geometry, adjusted radial internal clearance, special low-friction seals and a specific lubricant. The bearings maintain their function under heavy loads and without increased fric-

tional torque, the company reported. They reduce the risk of fire, reduce energy consumption, increase conveyor system reliability, and lower overall operating costs.

[www.nke.at](http://www.nke.at)



## Certified Exoskeleton Nixes Overload

Comau reported the MATE is the first exoskeleton to receive the Ergonomic Assessment Work-Sheet certification from Italy's Ergo Foundation. The gear was certified for reducing the risk of biomechanical overload on the upper limbs.

The certification proves MATE reduces the physical stress of, and improves the comfort of, users, Comau reported. It reduces the risk of developing musculoskeletal pathologies over time.

MATE, a passive mechanical exoskeleton was co-developed by IUVO and ÖSSUR.

[www.comau.com](http://www.comau.com)



## Shortest Overshot Surveying System

Devico AS released the Overshoot Xpress (OX), which the company described as the shortest overshot surveying system on the market.

The OX is powered by the DeviGyro, a high-speed miniature and continuous gyroscopic surveying instrument. Surveys can be performed while retrieving the core tube. Compact design makes handling safer and easier.





The OX is supplied with the DeviCounter for precise depth control, and an Android device. The data can be uploaded to DeviCloud.

[www.devico.com](http://www.devico.com)

## Concrete Mix Management System

Carmix reported Concrete-Mate provides extremely accurate data on concrete quality. The mix design management system uses four electronic load cells on the drum bottom to weigh concrete mix directly inside the drum.

The system can store up to 15 different mix designs with up to 99 components each. Multiple combinations can be created and stored, and the software suggests doses, process sequence, and timing.

The operator can see data on aggregates as they are loaded. After loading, the system prints a ticket with the data. After the process is complete, it issues a certificate with all analytical data. The data can be accessed online for monitoring purposes.

[www.carmix.com](http://www.carmix.com)



## Dynamic IoT Monitoring Solution

ClearBlade and MultiTech announced their joint out-of-the-box Industrial IoT smart monitoring solution, which they described as configurable, scalable, secure and affordable.

The solution leverages MultiTech's gateway and Clearblade's software platform and is managed by a single dashboard or streamed into existing systems.

Benefits include multiple profiles, an industry-leading battery life, extreme configurability, enterprise integrations, easy data sharing, simple rule configuration, and remote configurability, ClearBlade reported.

[www.clearblade.com](http://www.clearblade.com)

## Mapping and Data Collection Software

Juniper Systems introduced Uinta Mapping and Data Collection software, described as a powerful, hassle-free data collection software.

Uinta's data collection tools include detailed mapping with points, lines, areas, as well as form-based notes for digital recordkeeping. Top benefits include efficient data capture, professional mapping, ease of use, and live support, the company reported.

Customization options allow organizations to create templates based on data type and which can be shared.

The software is designed for a Mesa 3 Rugged Tablet running Windows 10 and a Geode Sub-meter GPS Receiver.

[www.junipersys.com](http://www.junipersys.com)



## Wear Plates for Dozers, Shovels, Loaders

Kostecki Technologies reported the K-TECK OEM 100 wear plate, available in tungsten, is an entry-level cost-efficient wear-resistant steel plate best suited for medium abrasion and impact liners.

The company's WRS OEM tungsten and niobium wear plate offers a nominal hardness of 1,600 on the Vickers scale. It is available in three surface finishes.

K-TECK WRS applications include apron feeders, pan feeders, crusher liners, conveyor skirt liners, transfer chutes, cyclones, buckets, train load out chutes, dozer blades, truck beds, buckets, and loader liners.

[www.wearplateusa.com](http://www.wearplateusa.com)

## Durable Filter Cloth Cuts Moisture

Micronics Engineered Filtration Group (MEFG) introduced MINE-XLL Filter Cloth, which offers a long life and decreased frequency of filter cloth change-outs. The cloth achieves a lifetime three times that of traditional polypropylene felted mining cloths, the group reported.

Other benefits include better cake release, greater mechanical resistance, less fabric binding, lower cake moistures, and more machine uptime. In field tests, the cloth reduced cake moisture by 2.6%, the group reported.

MINE-XLL can be manufactured to fit all OEM brands of mine filter presses, MEFG reported.

[www.micronicsinc.com](http://www.micronicsinc.com)

## Connectors for Harsh Environments

TE Connectivity released Extra Rugged Circular Connectors (XRCs), Sealed Rectangular Connectors (SRCs), ML-XT Connectors, and XRC terminals.

The connector products, which were formerly produced by Molex, are perfect for harsh environments, the company reported.

The XRC circular connectors are heavy-duty plastic connectors available in two shell sizes with 18-14- and 24-31-contact arrangements. The SRC rectangular connectors are a sealed high-pin-count hybrid solution available in 8-contact arrangements. ML-XT sealed rectangular connectors are offered in two, three, four, six, eight, 12 and 18 positions. XRC terminals deliver current ratings up to 13 amps.

The key benefits for the terminals are their reliability, ease of use and flexibility for harsh environment applications, the company reported.

[www.te.com](http://www.te.com)



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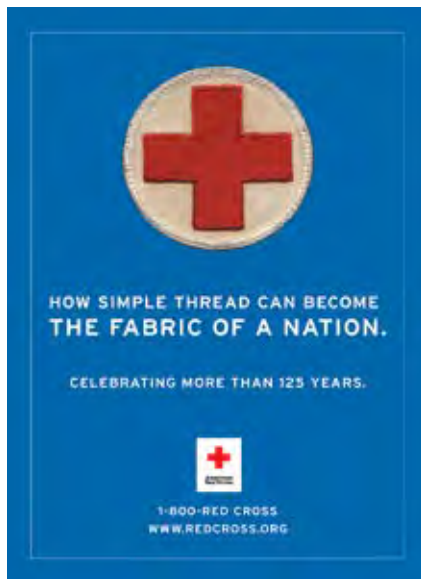


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AK Drilling Int'l S.A.....	68	Gold Fields .....	69	Red Valve Co Inc .....	15
American Exploration & Mining Assoc. ....	49	Haulage & Loading 2021.....	45	Regulus Resources Inc .....	73
Aramine.....	27	Hilliard Corp.....	43	Robocon Shotcrete Solutions .....	70
Bear Creek Mining Corp.....	72	J.H. Fletcher & Co .....	11	Schurco Slurry.....	23
BISA .....	66	Jennmar Corp .....	25	SNC-Lavalin .....	76
Byrnescut Offshore Pty Ltd.....	77	Liebherr Holding GmbH .....	19	Southern Peaks Mining.....	71
Chakana Copper.....	74	Longwall USA 2021 .....	47	Superior.....	31
Columbia Steel Casting Co Inc.....	BC	MacLean Engineering.....	57	Tinka Resources .....	75
CR Mining (CQMS Razer Americas) .....	17	Metso .....	IBC	Valley Forge & Bolt Mfg Co .....	55
E&MJ Website.....	64	Mining Media Int'l - Mining Magazines ...	81	Varel Mining & Industrial .....	33
ERIEZ – Mineral Flotation Group .....	56	Mining Media Int'l - Social Media.....	50	Weber Mining .....	3
Ferreyros-CAT .....	67	Modular Mining Systems Inc .....	41	World Mining Equipment (WME) .....	95
FLSmith.....	7	Motion Industries Inc.....	13		

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# Gold Closes at Its Highest Level Ever

By Steve Fiscor, Editor-in-Chief

Precious metals prices surged in July. During the last month, metal prices finished high across the board. Gold reached a new record high of \$2,063.20 per ounce (oz) on August 6. While that was great news, silver was no slouch, closing at \$28.89/oz, an increase of more than 60% in the last months and a seven-year high for silver. In March, silver had slumped to a 12-year low of \$11.60/oz. Palladium prices also regained their momentum, increasing 16.7% to \$2,252/oz.

"The gold price surged 12% in July to hit new record levels," said Cameron Alexander, director of precious metals research at Refinitiv. "This momentum has carried into August with gold tearing above the never-seen-before levels of \$2,000/oz mark on the third day of trading. The rally in gold has been powered by the safe-haven appeal for the metal due to the worsening economic conditions resulting [a global] pandemic. The central banks around the world continue to inject stimulus to resuscitate domestic economies, which has led in some cases to currency devaluation especially with the dollar and lower in-

terest rates, further supporting the rally. Tensions between the U.S. and China simmered, while U.S. President Donald Trump's controversial statements on the upcoming elections in the country kept the investors interested in gold. With all these factors in the backdrop, the journey of gold in August looks promising, but profit taking could lead to consolidation of prices after such a rapid rally."

Base metals and iron ore also rallied during the last month. Zinc prices improved by \$370/mt to \$2,377.50/mt (\$1.08/lb). Nickel prices also moved 14.5% higher to \$14,381/mt (\$6.54/lb). Copper was getting a lot of attention

as it neared the psychologically important \$3/lb level. The *E&MJ* Price Index is reporting \$118.89 per dry mt for iron ore, more than \$20/dmt higher (or 21.3%). Cobalt prices also increased by \$4,600/mt to \$33,100 mt (\$15.05/lb).

While some of these percentage figures for the last month, especially for precious metals price gains, look impressive, many of the base metals are just recovering to where they were at the beginning of the year. Copper, for example, hit a low of \$2.12/lb on March 23. For all the price swings, lead is even with where it stood at the beginning of the year.

## Advancing Metal Prices

	8/6/20	7/1/20	Monthly Diff	Monthly Increase	1/2/20	YTD Diff	YTD Increase
Gold (\$/oz)	\$2,063.20	\$1,770.30	\$292.90	16.5%	\$1,538.30	\$524.90	34.1%
Silver (\$/oz)	\$28.89	\$18.00	\$10.89	60.5%	\$18.09	\$10.80	59.7%
Platinum (\$/oz)	\$986.00	\$822.00	\$164.00	20.0%	\$987.00	-\$1.00	-0.1%
Palladium (\$/oz)	\$2,252.00	\$1,930.00	\$322.00	16.7%	\$1,949.00	\$303.00	15.5%
Aluminum (\$/lb)	\$0.78	\$0.72	\$0.06	8.3%	\$0.81	-\$0.03	-3.7%
Copper (\$/lb)	\$2.93	\$2.73	\$0.20	7.3%	\$2.80	\$0.13	4.6%
Lead (\$/lb)	\$0.87	\$0.80	\$0.07	8.7%	\$0.87	\$0.00	0.0%
Nickel (\$/lb)	\$6.54	\$5.71	\$0.83	14.5%	\$6.40	\$0.14	2.2%
Zinc (\$/lb)	\$1.08	\$0.91	\$0.17	18.7%	\$1.05	\$0.03	2.9%
Cobalt (\$/lb)	\$15.05	\$12.95	\$2.10	16.2%	\$14.77	\$0.28	1.9%
Iron ore (\$/mt)	\$118.89	\$98.01	\$20.88	21.3%	\$93.17	\$25.72	27.6%

## E&MJ PRICES INDEX

(August 6, 2020)

Precious Metals (\$/oz)		Base Metals (\$/mt)		Minor Metals (\$/mt)		Exchange Rates (U.S.\$ Equivalent)	
Gold	\$2,063.20	Aluminum	\$1,722.00	Molybdenum	\$16,190	Euro (€)	1.185
Silver	\$28.89	Copper	\$6,445.50	Cobalt	\$33,100	U.K. (£)	1.314
Platinum	\$986.00	Lead	\$1,913.00	Iron Ore (\$/dmt)		Canada (\$)	0.753
Palladium	\$2,252.00	Nickel	\$14,381.00			Australia (\$)	0.722
Rhodium	\$9,350.00	Tin	\$17,900.00	Fe CFR China	\$118.89	South Africa (Rand)	0.057
Ruthenium	\$270.00	Zinc	\$2,377.50			China (¥)	0.144

Gold and silver prices provided by KITCO Bullion dealers ([www.kitco.com](http://www.kitco.com)). Platinum group metals prices provided by Johnson Matthey ([www.platinum.matthey.com](http://www.platinum.matthey.com)). Non-ferrous base and minor metal prices provided by London Metal Exchange ([www.lme.co.uk](http://www.lme.co.uk)). Iron ore prices provided by Platts Iron Ore Index. Currency exchange rates were provided by [www.xe.com](http://www.xe.com).



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