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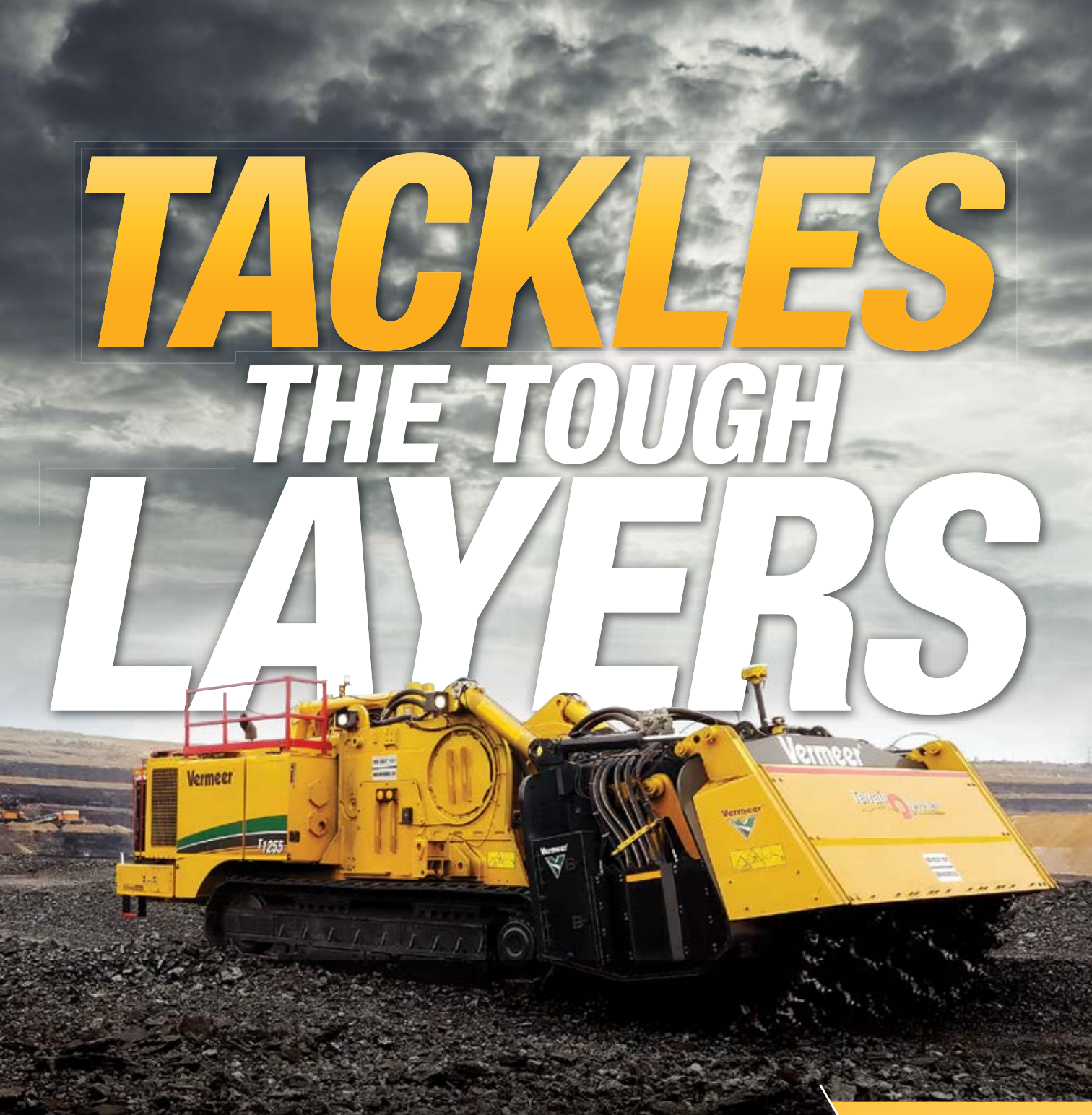

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E&MJ ENGINEERING AND MINING JOURNAL

FEATURES

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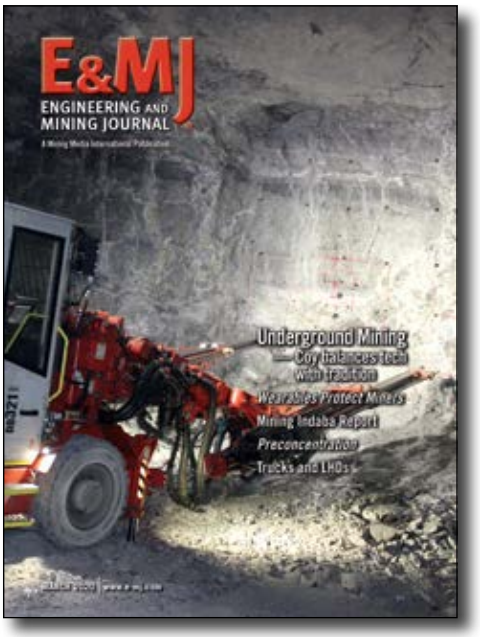
AROUND THE WORLD



This month, E&MJ *reports on activities from the American zinc mining district in Tennessee. On the cover, new equipment allows Coy miners to drill more holes per shift accurately. (Photo: Nyrstar)*

DEPARTMENTS

Steve Fiscor
Publisher & Editor-in-Chief

Coronavirus Fears Take Hold

The media hype surrounding the coronavirus was starting to build during the annual meeting of the Society for Mining, Metallurgy and Exploration (SME). By the time the annual meeting of the Prospectors and Developers of Canada (PDAC) opened the follow week, concerns were reaching a fever pitch. Some companies were banning unnecessary travel, especially to large international gatherings. Organizers were canceling other small conferences as this edition of *E&MJ* was going to press.

Both events were disrupted by protestors. SME took place in Phoenix this year during late February and a labor union picketed the entrance demanding concessions from Grupo Mexico's local Asarco division. Anti-mining protestors attempted different disruptive activities at PDAC, but failed to gain much traction except with the local press that day. People don't seem to care for their misinformed, in-your-face approach.

This year, SME had an overwhelming amount of information related to tailings management. It was discussed in the keynote session, *The Executive's Role in Tailings Management*, and in at least three or four other technical sessions. The keynote speakers included Mosaic's Nancy Case, Freeport-McMoRan's (FCX) Red Conger, Newmont's Dean Gehring and CONSOL Energy's Daniel Connell. It was nice to see that SME gave coal (i.e., CONSOL Energy) a seat at the table instead of treating the industry like lepers. All four talked about management's responsibility for active tailings storage facilities (TSFs) as well as inactive, legacy TSFs. The general consensus was that anytime a mine experiences a spill anywhere, the entire mining industry suffers the consequence, and mining companies were treating TSF education and management openly like it has with safety over the past decade or more.

PDAC is different from SME. SME predominantly serves engineers working at established operations, while the PDAC convention is geared more toward mining investment and exploration, and it has a huge international draw. The PDAC keynote, *Discoveries of the 21st Century*, included Barrick Gold's Mark Bristow, Pretivm's Joe Ovsenek and Ivanhoe's Robert Friedland. Showing a map of Tier 1 gold assets in less-than-desirable locations, Bristow urged mining explorers to return to their pioneering roots. A protestor interrupted Bristow and the crowd booed until security dragged her from the room. Bristow warned the audience that, if they intend to keep doing business, they need to create a dialog with these people. Ovsenek walked the delegates through the Brucejack project's timeline from permitting to operations. In his speech, a Stars Wars parody titled *Revenge of the Miners*, Friedland discussed how a greener society as well as the coronavirus will ultimately benefit miners worldwide. He cited anti-bacterial copper as the alternative to stainless steel. He told the audience that the underinvestment in mining has never been this high, saying the world will need to invest $250 billion in mining in the next five years to meet future metals demand.

FCX is based in Phoenix and Conger welcomed SME attendees to Arizona and copper country. Less than a week later, Friedland thanked people for having the courage to gather in a room to listen to his presentation. That's how quickly this virus is impacting business. While travel and face-to-face meetings may be curtailed for the near term, *E&MJ* will keep the mining industry informed through its print and digital products. Enjoy this edition of *E&MJ*.

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Newmont Reports Largest Gold Mineral Reserves in Company History

Newmont Corp. reported a 53% increase in gold mineral reserves for 2019. Reserves stood at 100.2 million attributable ounces (oz) for 2019 compared to 65.4 million oz at the end of 2018. The company attributed this to the acquisition of Goldcorp and creation of the Nevada Gold Mines joint venture, as well as "ongoing exploration success."

President and CEO Tom Palmer said, "Our reserve and resource base will support stable production of more than 6 million oz per year for decades to come."

Most (88%) of the company's gold reserves are located in the Americas and Australia. The reserve base has an operating reserve life of more than 10 years and average reserve grade of 1.05 grams per metric ton (mt), the company said.

Newmont re-adjusted the year-end reserve figure below the 100 million oz mark to 95.7 million oz after accounting for the KCGM and Red Lake divestments. Newmont completed the sale of KCGM in January and said it expects to close on the divestment of Red Lake in the first quarter of 2020. Combined, these sites represented approximately 4.5 million oz of gold reserves and 2.6 million oz of measured and indicated gold mineral resources.

The company added 42.2 million net oz of gold reserves through its acquisition of Goldcorp and formation of the Nevada Gold Mines (NGM) joint venture.

The Coffee project and Dome pit as part of the Century project were reclassified from mineral reserves to mineral resources, due to feasibility study requirements, the company said. The project revisions were 1.7 million oz and 4.4 million oz, respectively.

Notable reserve additions for the year included 2.5 million equity oz from NGM, 1.5 million oz at Tanami, 70,000 equity oz at NuevaUnión, 500,000 oz at Merian and 400,000 oz at Ahafo underground.

Falco Resources Will Purchase Golden Queen Mining

Falco Resources Ltd. has entered into an agreement with Golden Queen Mining Consolidated Ltd. to acquire all of the issued and outstanding common shares of Golden Queen. The acquisition is expected to be completed by way of a statutory plan of arrangement under the Business Corporations Act.

Through this non-cash transaction, Falco is offering a 15% premium on the forecast net cash balance of Golden Queen at the closing of this transaction, in consideration for the issuance of 15,968,075 common shares of Falco to holders of Golden Queen shares.

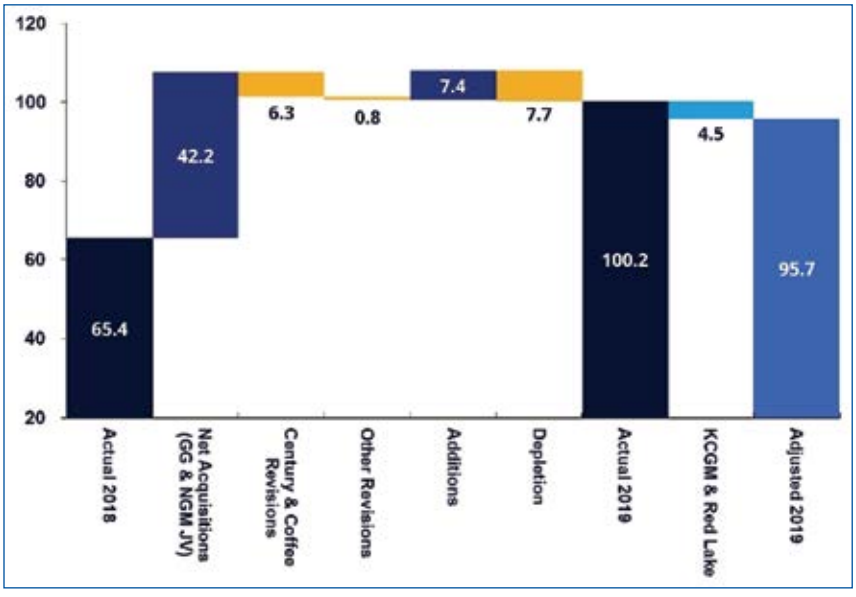
President and CEO of Falco Luc Lessard said, "We are pleased to reach this agreement with Golden Queen as it will provide Falco with a stronger balance sheet and a broader shareholder base, which will benefit from the development of the Horne 5 Project. In addition, we believe that Falco has acquired cash at a reasonable price, in the context of the challenging equity market. With this transaction, Falco will secure approximately $4.2 million in cash resources, which can be invested on the Horne 5 Project."

CEO and CFO of Golden Queen Guy Le Bel said, "The board of directors mandated that we focus the search for an advanced gold project within North America while balancing potential risks and return on behalf of the Golden Queen shareholders. The Horne 5 Project is a world-class 6 million-plus ounces (oz) gold equivalent in proven and probable reserves and is located in a mine permitting-friendly jurisdiction.

"We are confident in this project's execution ability with the Falco Resources team. Further, our shareholders receive an immediate premium to the cash and value of the company in providing this project, creating a positive transaction for both sides."

Golden Queen Shareholders will be entitled to receive 1.18 Falco Shares in exchange for each Golden Queen Share held.

The arrangement will require the approval of Golden Queen shareholders at a special meeting expected to take place at the end of March.



The above chart shows where Newmont saw gains and losses in reserves for 2019. (Image: Newmont)

Strong Q4 Caps Good Year for Barrick

Barrick Gold Corp.'s gold production for 2019 of 5,465,000 ounces (oz) was at the top end of its guidance range while copper production of 432 million pounds was above the guidance range, the company reported.

The company reported net earnings per share of $2.26 for the year and noted

that its adjusted net earnings per share were up 46% year on year while debt net of cash was halved from 2018 to $2.2 billion. The quarterly dividend was increased by 40% from the third quarter, to $0.07 cents per share, which was itself a 25% increase from the second quarter.

President and Chief Executive Mark Bristow said the successful formation of the Nevada Gold Mines joint venture during the year had resulted in the North American operations delivering at the midpoint of its production and cost guidance ranges. There were also strong performances from Barrick's Latin American, Asia Pacific and Africa Middle East operations.

"In the year since the completion of Barrick's merger with Randgold Resources, we have transformed the new company while creating the world's largest gold mining complex in Nevada in a transaction that had been unsuccessfully pursued for two decades," Bristow said. "The Acacia minorities' buy-out enabled us to settle that company's long-running dispute with the Tanzanian government and to integrate its assets into our operations.

"We've also started selling off non-core assets with the disposal of our stakes in the Kalgoorlie gold mine in Australia and the agreed sale of the Massawa project in Senegal."

"We started the year with five Tier One gold mines and ended it with six, thanks to the Nevada deal. We've also succeeded in replenishing our reserves and resources, net of depletion, at a higher grade."

Bristow said the pace of these achievements was attributable to a flattened management structure and the transfer of responsibilities from the corporate office to the operations.

"We now have agile multidisciplinary teams capable not only of executing complex, industry-leading corporate transactions but also of running our operations efficiently while pursuing new growth opportunities," he said.

Goncalves: Cliffs Finishes 2019 on Exciting Note

Full-year 2019 consolidated revenues were $2 billion, compared to the prior year's revenues of $2.3 billion. Cost of goods sold were $1.4 billion, compared to $1.5 billion reported in 2018. For the full-year 2019, the company recorded net income of $293 million. This compares to net income of $1.1 billion recorded in the prior year, which was positively impacted by a $461 million release of a tax valuation allowance in the United States and a one-time gain of $228 million related to historical changes in foreign currency translation. For the full-year 2019, adjusted EBITDA was $525 million, compared to $766 million in 2018.

"We finished 2019 on an exciting note with the announcement of the acquisition of AK Steel by Cleveland-Cliffs," Chairman, President and CEO Lourenco Goncalves

Fraser Report: 4 US States Rank in Top 10

The Fraser Institute, www.fraserinstitute.org, released its 2019 Annual Survey of Mining Companies. The survey attempts to assess how mineral endowments and public policy factors such as taxation and regulatory uncertainty affect exploration investment. The survey's Investment Attractiveness Index combines the Best Practices Mineral Potential index, which rates regions based on their geologic attractiveness, and the Policy Perception Index, a composite index that measures the effects of government policy on attitudes toward exploration investment.

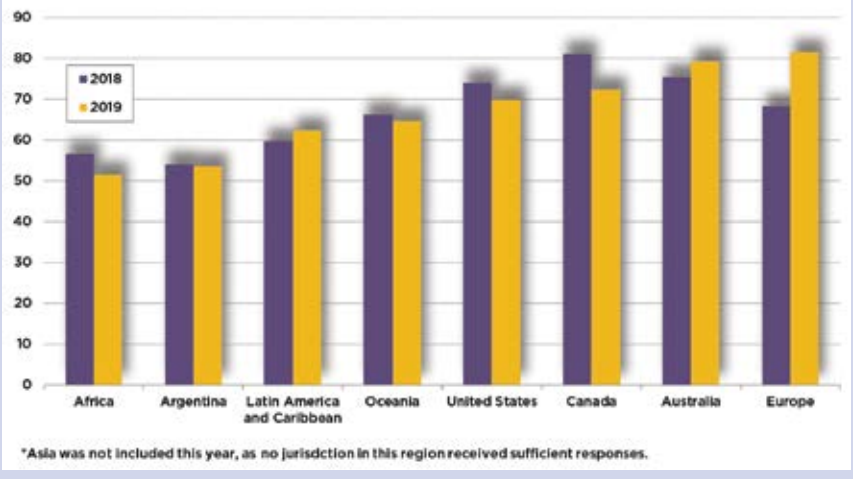
The top jurisdiction in the world for investment based on the Investment Attractiveness Index is Western Australia, which moved up from second place in 2018. Finland moved into second place after ranking 17th the previous year. Nevada moved down two spots from first in 2018 to third in 2019. Alaska ranked fourth this year, and Portugal improved from 46th in 2018 to fifth in 2019. Rounding out the top 10 are South Australia, the Republic of Ireland, Idaho, Arizona and Sweden.

When considering both policy and mineral potential in the Investment Attractiveness Index, Tanzania ranks as the least attractive jurisdiction in the world for investment. This year, Tanzania replaced Venezuela as the least attractive jurisdiction in the world. Also in the bottom 10 (beginning with the worst) are Chubut, Argentina; La Rioja, Argentina; Guatemala; Dominican Republic; Zambia; Venezuela; the Democratic Republic of Congo; Mali; and Nicaragua.

While geologic and economic considerations are important factors in mineral exploration, a region's policy climate is also an important investment consideration, the report said. The Policy Perception Index (PPI) is a composite index that measures the overall policy attractiveness of the 76 jurisdictions in the survey.

Finland displaced Saskatchewan from the top spot this year with the highest PPI score of 100. Finland was followed by the Republic of Ireland in the second place, which moved from fourth in the previous year. Along with Finland and Ireland, the top 10 ranked jurisdictions are Nevada, Utah, Western Australia, Alberta, Idaho, Newfoundland and Labrador, Saskatchewan and Arizona.

The 10 least attractive jurisdictions for investment based on the PPI rankings (starting with the worst) are Venezuela; Zimbabwe; Tanzania; Chubut, Argentina; Mendoza; Bolivia; the Democratic Republic of Congo (DRC); Zambia; Guinea (Conakry); and La Rioja, Argentina.



Regional Median Investment Attractiveness scores for 2018 and 2019. (Image: Fraser Institute)

Cleveland-Cliffs Inc. makes significant progress at advancing the Toledo HBI project (above) to an ahead-of-schedule completion.

said. "With this transformational acquisition, we will become a leading supplier of the most sophisticated carbon and stainless-steel products to high-end clients, including engineered parts to the automotive industry as a Tier 1 supplier to several different models of cars, SUVs and trucks. On top of that, we will be totally self-sufficient in pellets and rely only on ourselves to get our iron ore feedstock, while preserving our ability to supply customized pellets to other steel mills, as we have been doing so successfully for a long time. The performance of the new Cleveland-Cliffs will be less subject to the volatility of commodity indices and more reliant on fixed-price contracts, which will provide us with much more predictable free cash flow generation."

In 2019, Cliffs also made incredible progress in advancing its Toledo HBI project to an ahead-of-schedule completion, Goncalves explained. "We remain on track to start producing and selling this highly sought-after product to the marketplace in the first half of this year," Goncalves said. "With both the upcoming completion of the acquisition of AK Steel and the Toledo HBI plant coming online, 2020 will be a transformational year for us, and we can't wait to deliver on all of the potential Cleveland-Cliffs has in store."

Pellet sales volume in the fourth quarter of 2019 was 5.8 million metric tons (mt), a 10% decrease when compared to the fourth quarter of 2018. The decrease was a result of reduced customer demand, partially offset by intercompany sales to the Toledo HBI plant.

Realized revenues were $91/mt in the fourth quarter of 2019. "The quarter's results were negatively impacted by an unfavorable true-up of previously sold volumes due to lower pellet premiums and HRC prices, as well as unfavorable customer mix," Goncalves said.

Fourth-quarter cash cost of goods sold rate of $64/mt decreased 3% compared to the prior-year quarter, as a result of lower royalties and employee-related expenses.

Gold Fields Moves Forward With Salares Norte Project

During mid-February, Gold Fields announced that its board approved the construction and development of the Salares Norte project in Chile thanks to an increase in profit in 2019.

The company completed a placement of about 41.43 million new shares, which raised about $252 million and will help to develop the project.

"The project is expected to meaningfully change the future profile of Gold Fields, providing growth in production and a reduction in group AIC," CEO Nick Holland said. "The project capital is expected to be funded from the capital markets, the strong operational cash generation and existing debt facilities, if required."

This will allow Gold Fields to maintain a 100% interest in the project. The Salares Norte project has an expected life of 11.5 years and average annual production of 450,000 ounces (oz) of gold equivalent for the first seven years. Construction is expected to begin in the fourth quarter, with first production in the first quarter of 2023.

The project's Environmental Impact Assessment was approved in December.

The updated capital expenditure estimate is $860 million, scheduled over a 33-month period commencing in April.

The Salares Norte project is expected to produce 450,000 ounces of gold equivalent for the first seven years. (Photo: Gold Fields)

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PolyMet Files Appeal With Minnesota Supreme Court

Poly Met Mining Inc. filed a Petition for Review to the Minnesota Supreme Court seeking to overturn a decision made by the Minnesota Court of Appeals back in January that remanded the company's Permit to Mine and dam safety permits back to the Department of Natural Resources (DNR) for a contested case hearing.

"We are respectfully asking the Supreme Court to right what we believe is a wrong," President and CEO Jon Cherry said. "The court of appeals effectively opened the door to an unpredictable loop of review and additional litigation for Minnesota permittees with its interpretation of the statute."

He added that the ruling will increase uncertainty and the timeframe for permitting for not just mining-related projects, but ones that require DNR or Minnesota Pollution Control Agency permits.

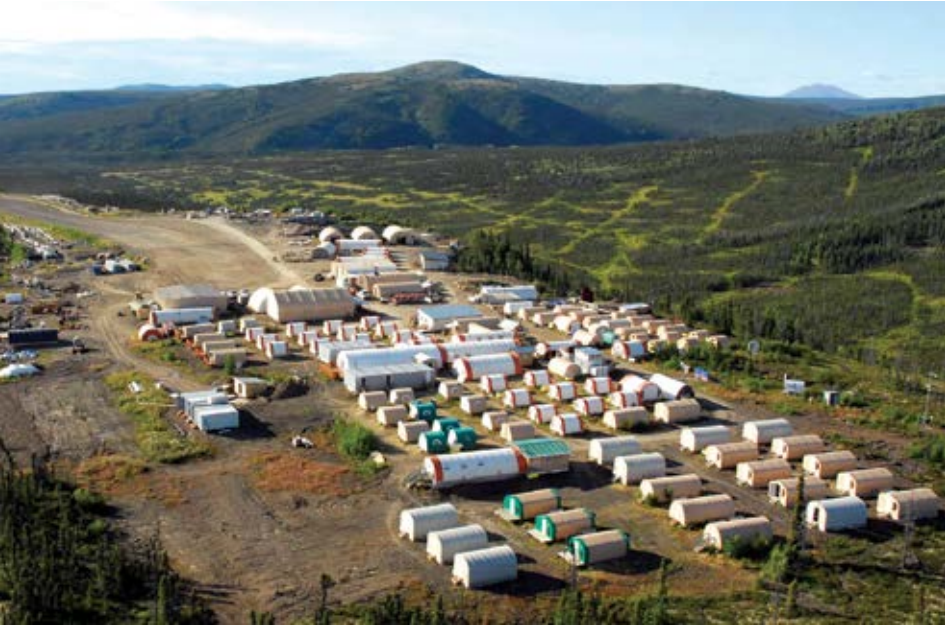
The company's appeal said the court of appeals' ruling conflicts with relevant statute and the Supreme Court's precedent, and agencies should not be required to hold a contested case hearing when there is no reasonable basis for thinking that such a hearing would help them make a decision.

In the court of appeals decision, Chief Judge Edward Cleary said the DNR's decision to deny a hearing "was affected by an error of law in its overly narrow interpretation" of a Minnesota statute and "unsupported by substantial evidence." The court also found that the DNR failed to include a "definite term" when issuing the NorthMet permit to mine. "Any permit issued following remand, the DNR shall determine and impose an appropriate, definite term," the court document stated.

Cherry said the company is determined and confident that it will advance Minnesota's first copper-nickel-precious metal mine on the Iron Range, which will create nearly 1,000 jobs. "We have proven that we can meet Minnesota's strict standards," he said.

Donlin Gold Receives Key Natural Gas Pipeline Permit

The Donlin gold project in southwest Alaska has received the final state right-of-way authorization for a buried, 316-mile-long, natural gas pipeline to support power generation at the project site. The proposed pipeline would be 14 inches in diameter and typically buried 3 to 6 feet deep, providing a reliable natural gas supply regardless of weather or season.



Alaska's Donlin gold camp (above) is one of the largest, high-grade, open-pit gold projects currently under development. (photo: NovaGold)

Donlin Gold LLC, the operating company for the Donlin project, is an Alaska-based company owned equally by NovaGold Resources and Barrick. The project is located near the Kuskokwim River about 280 meters (m) west of Anchorage and is one of the largest, high-grade, open-pit gold mine projects currently under development anywhere in the world.

The project has approximately 541 million metric tons (mt) in measured and indicated mineral resources, inclusive of proven and probable mineral reserves, at an average grade of 2.24 grams/mt gold, for a total of approximately 39 million ounces (oz) of contained gold. Once in production, the Donlin mine is expected to produce an average of more than 1 million oz per year (oz/y) of gold over a 27-year mine life.

The Donlin property has substantial exploration potential beyond the designed footprint, which currently covers 1.9 miles of an approximately 5-mile-long gold-bearing trend. Current activities are focused on state permitting, optimization work, community outreach, and workforce development in preparation for construction and operation of the project.

The Alaska Department of Natural Resources issued the Donlin pipeline permit on January 17, 2020. Three days later, on January 20, the department also issued final authorization of the easement, land leases, land use permits, and material site authorizations for the proposed transportation facilities and easement for a fiber optic cable on state lands.

NovaGold President and CEO Greg Lang said, "We are very pleased to see

the issuance of key transportation and energy infrastructure approvals for Donlin Gold ... These achievements would not have been possible without the dedication of the professionals at the Alaska Department of Natural Resources to advance permits and approvals for the project in a transparent as well as environmentally and socially responsible manner with strong adherence to governance best practices.

"We are proud of the work supporting the issuance of these permits carried out by the teams at Donlin Gold, Barrick and NovaGold, and appreciate the support and contributions from our Native Corp. partners, Calista Corp. and the Kuskokwim Corp," Lang said.

Excelsior Optimizing Gunnison ISR Copper Project

Excelsior Mining reported in early February that, following the first month of mining operations, it has collected a significant amount of data that will support optimization programs that are currently being implemented at its Gunnison in-situ recovery (ISR) copper project in Cochise County, Arizona, 65 miles southeast of Tucson.

Included in these programs are improved preventive maintenance to limit pump and wellfield downtime; retrofitting of injection wells with pumps, allowing them to be used as recovery wells when needed; and reconfiguration of wellheads and related piping to allow for both injection and recovery operations in each well. This latter addition will make the wellfield entirely reversable in terms of fluid flow, thereby allowing for greater flexibility during operations.

Excelsior has decided to implement these changes during the ramp-up period to assist with production optimization. These changes are not material in terms of capital outlays, but the work is expected to push first copper production into the second quarter of 2020.

Fluids recovered from ISR operations will be treated through existing SX-EW processing facilities at the previously operated Johnson Camp mine a little more than a mile from the wellfield. The plant will produce copper cathode sheets, with product sales now expected to begin during the second quarter of 2020.

Roughly 150,000 mt of ore had been stockpiled ahead of the crusher at Relief Canyon and was waiting to be placed on the leach pad.

The availability of the Johnson Camp processing facilities allowed the Gunnison project to come in at low initial capital expenditures of $49 million.

The Gunnison project is targeting an initial production rate of 25 million pounds per year (lb/y) of copper, expanding to eventual production of 125 million lb/y. Mine life is projected at 24 years at all-in sustaining costs of production of $1.33/lb of copper produced.

Excelsior President and CEO Stephen Twyerould said, "Our initial copper recoveries are highly encouraging, and the implementation of these improvement programs keeps us focused on achieving long-term, low-cost copper production as soon as possible. We remain absolutely confident in our capacity to deliver low-cost copper production while maintaining our commitment to safety and the environment."

Relief Canyon Pours First Gold

Americas Gold and Silver poured the first gold at its Relief Canyon open-pit, heap-leach gold project in northwest Nevada in mid-February. Relief Canyon is a previously producing property, and the current project benefits from an existing processing plant. Production is forecast at about 90,000 ounces per year (oz/y) of gold over an initial six-year mine life at all-in sustaining costs of about $800/oz.

Proven and probable reserves at Relief Canyon currently total 27.2 million metric tons (mt), grading 0.75 grams/mt gold and containing 653,000 oz of gold.

Americas Gold and Silver began actively mining ore at Relief Canyon in early December 2019. As of mid-February, the operation had approximately 200,000 mt of ore placed on the leach pad. The ore crushing and stacking circuit were performing as expected, and the ADR plant was fully functioning.

Mine operations were ongoing on a 24-hour-per-day basis, stacking ore at rates of approximately 14,500 mt/d. Approximately 150,000 mt of ore had been stockpiled ahead of the crusher and was waiting to be placed on the leach pad. Waste stripping was ahead of plan, with mining activities focused on the North and Lightbulb areas of the pit.

Construction at Relief Canyon was completed within its budget of $28 million to $30 million. The project is scheduled to reach commercial production before the end of the second quarter of 2020.

The Relief Canyon property has significant exploration potential, with only about 20% of the 11,700-ha land package explored to date.

The project is located is approximately 95 miles northeast of Reno. Electricity is available on the property, and water is available from two wells located east of the processing plant. The town of Lovelock is located approximately 19 miles by road west-southwest of the project.


Natascha Viljoen

Following the departure of CEO **Chris Griffith** after more than seven years at the helm, *Anglo American Platinum Ltd.* (*Amplats*) has appointed his replacement from inside the company. Current Group Head of Processing for Anglo American **Natascha Viljoen** will take over on April 16. Griffith decided to step down to pursue other career opportunities. Prior to joining Anglo American, Viljoen was executive vice president of processing at Lonmin while also leading the company's sustainability, employee health, environmental and stakeholder relations work at various times.


Mauricio Ortiz

Antofagasta plc announced that CFO **Alfredo Atucha** will be retiring on March 31 and will be replaced as group CFO by **Mauricio Ortiz,** current vice president of finance of the Mining Division. Ortiz joined the group in 2015. He previously held mining leadership roles in the finance and project development areas of Codelco and BHP. **Vivianne Blanlot,** an independent nonexecutive director, will join the Nomination and Governance Committee, and **Ramon Jara,** a nonexecutive director, will join the Sustainability and Stakeholder Management Committee.


Hinda Gharbi


Jennifer Nason


Ngaire Woods

Hinda Gharbi, executive vice president of reservoir and infrastructure at Schlumberger Ltd., and **Jennifer Nason,** a global chairman at JP Morgan Chase & Co., joined *Rio Tinto*'s board. **Ngaire Woods,** professor of global economic governance at Oxford University, will join the board on September 1.


Javier Cordova

Para Resources Inc. appointed **Javier Cordova** president and CEO of the company. **C. Geoffrey Hampson** has resigned as CEO, **Ian Harris** has resigned as the president and as a director, and **Randy Martin** has resigned as COO. Hampson will remain the executive chairman of the board of directors. Cordova has been active with the company as a consultant since early 2018. Previously, Cordova was the first minister of mining of Ecuador, serving from 2015 until 2018.


Ernesto Lima

Endeavour Silver Corp. appointed **Ernesto Lima** as the director, project development, to oversee the development of the Terronera and Parral mine projects in Mexico. Most recently, he was the COO of Valor Resources on a large silver-copper mine project in Peru that was sold last year to Rio Tinto.


Kalidas Madhavpeddi

Glencore plc appointed **Kalidas Madhavpeddi** as an independent nonexecutive director. Madhavpeddi has more than 30 years of experience in the international mining industry, including being CEO of China Molybdenum International (China Moly) from 2008 to 2018.


Graham du Preez

Harte Gold Corp. appointed **Graham du Preez** as executive vice president and CFO. **Rein Lehari** will continue to serve as CFO on an interim basis. Most recently, du Preez was the CFO of Alloycorp Mining Inc. and Buffalo Coal Corp.


Jacques Mallette

Board of Directors of *Nemaska Lithium* is announcing the departure of President and CEO **Guy Bourassa.** The board also appointed **Jacques Mallette** as chairman of the board. Mallette has acted in capacity of director of the corporation since March 8. Mallette has more than 35 years of experience as CEO, CFO and director of international companies.


Frédéric Ruel


Benoit Brunet

Osisko Gold Royalties Ltd. appointed **Frédéric Ruel** as CFO and vice president, finance, **Iain Farmer** as vice president, corporate development, and **Benoit Brunet** as vice president, business strategy. Ruel has served as vice president, corporate controller, of Osisko since 2015. Farmer has been involved in the mining industry for nine years having most recently served as director of evaluations for Osisko. Brunet joins Osisko from the Quebec Private Equity group of the Caisse de dépôt et placement du Québec.


Sheila Murray

Teck Resources Ltd. announced that **Sheila Murray** has been appointed as board chair. Murray was appointed acting board chair following the resignation of Dominic Barton in September 2019. She has served on Teck's Board since April 2018. She is the former president of CI Financial Corp.


Luke Gleeson

Bellevue Gold Ltd. appointed **Luke Gleeson** as head of corporate development. Gleeson was previously head of investor relations and a business development officer with Northern Star Resources for five years.


Selma Lussenburg

MAG Silver Corp. announced that **Selma Lussenburg** has joined as a member of the board of directors. Lussenburg is a business executive, former general counsel, corporate secretary and current board director with more than 35 years of business experience.


Rachel Goldman

Paramount Gold Nevada Corp. announced that **Rachel Goldman** has joined the company as CEO and a director. Most recently, she was managing director of Institutional Equity Sales for a major Canadian brokerage firm.

Belo Sun Mining Corp. appointed **Peter Nixon** as the new lead independent director of the company. Nixon replaces **Bruce Humphrey.**


Colin Kinley


Michael Haworth


Petra Decher

Coro Mining Corp. announced changes to the board of directors, including **Colin Kinley** from nonexecutive chairman to a nonexecutive director role and the appointment of **Michael Haworth** as the executive chairman. **Petra Decher** was also appointed as the lead independent nonexecutive director, and Kinley assumed the role of chairman of the Compensation Committee. Haworth is a co-founder and senior partner of Greenstone Resources.


Douglas Meirelles

Gold Lion Resources Inc. appointed **Douglas Meirelles** to the board of directors. Most recently, he worked as country manager for Equinox Gold, overseeing the Aurizona gold mine through to recommissioning and commercial production. **Dorian Banks** has resigned as a director.


Lars Engström

Lars Engström will join the *Normet Group* Board of Directors. He has previously served as president of Sandvik Mining & Rock Technology, CEO BE Group, CEO Munters Group and divisional president at Atlas Copco AB.


Mikko Tepponen

FLSmidth appointed **Mikko Tepponen** as the new chief digital officer. Coming to FLSmidth from Wärtsilä, Tepponen will start working for FLSmidth on June 1.

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Escondida Will Give Up Using Water From Atacama

The Escondida mine (above) has decided to not extract high Andean waters from Salar de Atacama after receiving backlash from local communities. (Photo: BHP)

Escondida, the largest copper mine in the world, will give up its request to extend its rights to use fresh water in the Salar de Atacama (northern Chile), which it will replace with resources from its desalination plants. The site, controlled by BHP, was waiting on a permit to continue extracting 428 liters per second of an aquifer located in the Salar de Atacama. However, some local communities have opposed the plans of copper miners and lithium producers in the Salar due to the lack of information on the possible impact their mining activities will have on the area.

"BHP's decision advances by 10 years its commitment to stop extracting high Andean waters for use in Escondida, originally scheduled for 2030," the company said in a statement. BHP added that the decision also considered "conversations held with the community from the surrounding town of Peina, backed by the council of local communities."

In 2018, the government banned granting new water rights in the Salar due to overexploitation. The Escondida and Zaldívar mines sought to extend the use of water in the region. Zaldívar argued that, for the mine, it is not feasible to invest in a desalination plant.

Updated PEA Supports Gramalote Gold in Colombia

B2Gold has announced positive results from an updated preliminary economic assessment (PEA) of the Gramalote Ridge deposit at the Gramalote gold project in Antioquia province, Colombia. The project is a joint venture between B2Gold and AngloGold Ashanti. B2Gold assumed the role of manager of the joint venture on January 1.

Assuming an effective date of January 1 and a gold price of $1,350 per ounce (oz), Gramalote Ridge economic highlights include an open-pit gold mine with an initial mine life of 13.6 years based on current indicated and inferred mineral resources for the Gramalote Ridge deposit only. Life-of-mine gold production is estimated at 3.85 million oz, including an average of 416,600 oz per year (oz/y) during the first five full years of production.

Average life-of-mine all-in sustaining costs are estimated at $648/oz of gold produced. Preproduction capital costs are estimated at $901 million, including approximately $160 million for mining equipment.

Accelerated mining is planned for the early years of operation to provide higher-grade feed to the plant while stockpiling lower-grade material. The final four years of plant feed are from low-grade stockpiles and oxide ore. Oxide ore, which only makes up about 3% of the plant feed, will be stockpiled and processed at the very end of the project life, as blending this material with fresh ore does not yield optimal gold recoveries.

Processing is planned to include crushing; grinding; flotation, with fine grinding of the flotation concentrate; agitated leaching of both the flotation concentrate and the flotation tails; and carbon-in-pulp recovery to produce doré bullion. Plant throughput is planned at 11 million mt/y. Gold recovery is estimated at 94.3%.

B2Gold is currently completing approximately 42,500 meters (m) of infill drilling at Gramalote Ridge to convert existing inferred mineral resources to indicated and 7,645 m of geotechnical drilling for site infrastructure. The mineral resource estimate that forms the basis for the PEA includes indicated mineral resources of 70.1 million metric tons (mt) grading 0.92 grams/mt gold for a total of 2.07 million oz of gold and inferred mineral resources of 79 million mt grading 0.79 g/mt gold for a total of 2.01 million oz of gold.

The PEA is based solely on production from the Gramalote Ridge deposit and does not include potential production from the nearby Trinidad deposit or the Monjas West zone.

B2Gold and AngloGold Ashanti have budgeted approximately $37 million for a feasibility study of the Gramalote project, with completion of the study expected by the end of 2020. Feasibility work will include completion of all planned drilling by the end of May 2020, an updated mineral resource estimate, detailed mine planning, ongoing environmental studies, additional metallurgical test work, engineering, and detailed economic analysis.

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Newmont Brings First Autonomous Haulage Fleet to Gold Mining Industry

The fleet of autonomous CAT 793F mining trucks (above) will be fully operational in 2021 at Newmont's Boddington mine in Australia and will be the first autonomous haulage system in an open-pit gold mine in the world. (Photo: Business Wire)

Newmont Corp. has approved investment in an Autonomous Haulage System (AHS) at Boddington in Australia to enhance safety and productivity, while also extending mine life. Once fully operational in 2021, Boddington will be the world's first open-pit gold mine with an autonomous haul truck fleet.

"Not only does Boddington continue to deliver strong performance, our investment in autonomous haul trucks will generate an internal rate of return greater than 35% with a more controlled and efficient haulage operation," President and CEO Tom Palmer said. "We are also uniquely positioned in the gold sector to support effective implementation and operation of the fleet thanks to the technical capabilities and previous experience of leaders in our business. Simply put, Boddington will be a safer, more productive world-class gold mine in a top-tier jurisdiction."

Total net investment in Boddington's AHS will be $150 million, with efficiencies expected to extend the mine's life by at least two years. The company also sees additional upside potential from the replication of the AHS at other Newmont operations.

Boddington's autonomous Caterpillar haul trucks will feature rigorous safety controls that reduce employee exposure to potential vehicle interactions. No injuries have been recorded from AHS operations since their introduction into the mining industry. Newmont is also executing a robust people strategy at Boddington, providing opportunities for reskilling and redeployment of haul truck drivers to other roles supporting the AHS.

Boddington is Western Australia's largest gold producer, delivering 709,000 ounces of gold and 77 million pounds of copper in 2018. The mine directly employs approximately 2,000 people and is located 135 kilometers southeast of Perth in Western Australia.

Fortescue Invests $450M in Pilbara Generation Project

Fortescue Metals will invest US$450 million into the Pilbara Generation project, the next stage of its Pilbara energy connect program. The Pilbara Transmission project consists of 275 kilometers (km) of high-voltage transmission lines connecting Fortescue's mine sites, while the Pilbara Generation project will include 150 megawatts (MW) of gas fired generation, together with 150 MW of solar photovoltaic (PV) generation. This will be supplemented by large-scale battery storage and will be constructed, owned and operated by Fortescue.

Together, the transmission and generation projects, totaling US$700 million, form the Pilbara energy connect program of works providing Fortescue with a hybrid solar gas energy solution that will enable low cost power to be delivered to Iron Bridge. This allows Fortescue to leverage its existing energy infrastructure including the Fortescue River Gas Pipeline and generation capacity at the Solomon Power Station and support the incorporation of large-scale renewable energy.

The Pilbara Energy Connect project builds on the Chichester solar gas hybrid project, which was announced last year. This landmark agreement with Alinta Energy will see up to 100% of daytime stationary energy requirements of the Chichester Hub iron ore operations powered by renewable energy. Alinta will build, own and operate the 60-MW solar PV generation facility at the Chichester Hub and 60-kilometer (km) transmission line linking the Christmas Creek and Cloudbreak mining operations with Alinta Energy's Newman gas-fired power station. On completion, this will integrate with the Pilbara energy connect program, via the Pilbara Transmission project.

"The lack of an integrated transmission network in the Pilbara has been a key barrier to entry for large-scale renewables and Fortescue's investment will address this issue," CEO Elizabeth Gaines said. "Fortescue's commitment of US$700 million in electricity generation and transmission infrastructure will complete the integration of Fortescue's stationary energy requirements in the Pilbara into an efficient network, while lowering the overall cost of electricity to existing and future sites."

By installing 150 MW of solar PV as part of the Pilbara generation project, Fortescue said it could avoid up to 285,000 metric tons of CO_2 per year in emissions, as compared to generating electricity solely from gas.

Rio Tinto: Update on Tropical Cyclone Damien

Rio Tinto's iron ore operations in the Pilbara, Western Australia, have resumed following the passing of Tropical Cyclone Damien. The cyclone caused infrastructure damage across our entire Pilbara network, including impact to access roads, electrical and communications infrastructure and accommodation. All mine sites experienced some disruption and will take time to return to normal operations.

As a result, Rio Tinto's Pilbara shipments in 2020 are now expected to be between 324 million metric tons (mt) and 334 million mt (100% basis) versus previous guidance of between 330 million mt and 343 million mt. Rio Tinto is working with its customers to minimize any disruption in supply.

Safety remains our top priority as we ramp up operations, and undertake the necessary remediation work, following the passing of the cyclone.

Red River Targeting New Mine at Thalanga in Queensland

Red River Resources has announced plans to develop the high-grade, gold-rich, polymetallic Liontown deposit as the next mine at its Thalanga operations in northern Queensland. Thalanga is an ongoing mining operation producing copper, lead, and zinc concentrates, with significant gold and silver credits. The Thalanga mill has 650,000 metric tons per year (mt/y) of throughput capacity with current utilization at 350,000 mt/y to 450,000 mt/y, so opportunity exists to process additional tonnage at incremental processing costs.

Red River has received all assays from its recent drilling program at Liontown, which delivered further high-grade, gold-rich, polymetallic results from the New Queen lens and intersected high-grade copper-gold mineralization in the Carrington lode. One notable 1.10-meter (m) intercept assayed 0.5% copper, 13.7% lead, 29.6% zinc, 9.8 g/mt gold, and 371 g/mt silver from 56.20 m down-hole.

The company is updating a mineral resource estimate for Liontown, which it expects to complete in March.

Continued high-grade polymetallic results from Liontown have led Red River to prioritize development of the deposit ahead of the zinc-rich Waterloo deposit, which will be placed on hold. Mine production from Liontown will increase mill throughput at Thalanga, as well as gold and silver production.

Red River has an existing mining lease at Liontown, which may enable early works to commence for development of the New Queen lens.

Red River Managing Director Mel Palancian said, "Given the results from Liontown, in particular the New Queens lens in 2019 drilling, there is a strong rationale for fast-tracking Liontown's development as our next priority. We are finalizing a mineral resource update and mine planning for the deposit.

"Prioritizing development of Liontown will allow us to increase production of gold and copper at Thalanga while we continue restart studies for our Hillgrove gold project in New South Wales.

"We previously planned to develop Waterloo as the third deposit at Thalanga, but the discovery of the Liontown East deposit and the New Queen drilling results have shown that Liontown is a much larger mineralized system, and it is still open along strike and at depth."

PFS Supports Proposed West Musgrave Open-pit Cu-Ni Mine

OZ Minerals and Cassini Resources have reported the results of a prefeasibility study (PFS) of development of mining operations on the Nebo and Babel deposits on their West Musgrave property in the far east of Western Australia. The project is a joint venture between OZ (70%) and Cassini (30%).

The PFS has demonstrated positive potential for long-life, open-pit copper and nickel sulphide mining operations. It is the first development opportunity within the broader West Musgrave province, which includes a number of additional highly prospective opportunities, including the nearby Succoth copper deposit.

An initial probable ore reserve of 220 million metric tons (mt) grading 0.36% copper and 0.33% nickel supports about 22 years of mine life in the PFS analysis. The balance of the estimated 26-year mine life is underpinned by a combination of indicated and inferred mineral resources.

Processing capacity to produce separate copper and nickel concentrates is planned at 10 million mt per year (mt/y). Life-of-mine annual production of contained metals would average about 28,000 mt/y of copper and 22,000 mt/y of nickel. Preproduction capital costs are estimated at about A$995 million. Project payback from a decision to mine is estimated at about six years.

Mining is modeled to be conventional drill, blast, load, and haul and is assumed to be contractor operated during the first five years of operation, transitioning to owner operation in year six. The haulage fleet will comprise up to 25 220-mt haul trucks, and optionality is being maintained to allow for these trucks to be fully autonomous in the future.

An innovative mineral processing plant will be built on site. The grinding circuit consists of two stages of crushing followed by two parallel vertical roller mills treating nominally 5 million mt/y each.

Vertical roller mills are widely used in the grinding of cement plant feeds and products, slag, coal, and other industrial minerals. Benefits in using the mills at West Musgrave include reducing power consumption by about 15%, no requirement for ball charge grinding media, higher flotation recovery, and flexibility in throughput in response to the availability of low-cost renewable energy.

The project will operate as a fly-in/fly-out operation. An airstrip and 400-person-accommodation village will be constructed at the site. Approximately 60 staff will be employed in operations monitoring, control, and planning functions in an off-site integrated operations center.

Critical path activities are continuing while the West Musgrave project is being assessed under OZ Minerals' capital allocation framework. The PFS provides a solid platform for discussions with potential lenders and advisors on how best to fund and structure the project prior to moving to the next phase.

OZ Minerals CEO Andrew Cole commented, "The PFS is now complete and has confirmed that the project can be a low-carbon, low-cost, long-life mine … During this study, we have partnered with the traditional owners, government agencies, and industry experts to design a project to meet our objectives in relation to low carbon intensity, innovation and adding value for our key stakeholders. We thank them all for their contribution and look forward to their ongoing support."

AngloGold Ashanti Will Sell South African Assets to Harmony Gold

The sale includes the Mponeng gold mine (above). (Photo: AngloGold Ashanti)

AngloGold Ashanti reached an agreement to sell its remaining South African producing assets and related liabilities to Harmony Gold Mining Co. Ltd., with expected proceeds of around $300 million.

The sale includes the Mponeng mine; Tau Tona and Savuka mines and associated rock-dump and tailings storage facility reclamation sites, mine rehabilitation and closure activities located in the West Wits region; First Uranium Ltd., which owns Mine Waste Solutions Ltd. and Chemwes Ltd.; Covalent Water Co. Ltd.; AngloGold Security Services Ltd. and Masakhisane Investments Ltd.; and rock-dump reclamation, mine rehabilitation and closure activities located in the Vaal River region.

In May, AngloGold Ashanti announced it was undertaking a process to review sale options for the portfolio of assets. The sale is part of the process of streamlining AngloGold Ashanti's portfolio to create a more focused business with enhanced operating and financial metrics, according to the company.

A nine-month sales process identified Harmony as the most suitable party to acquire these assets, given its financial capacity and proven technical capability in operating ultra-deep, hard-rock mining assets in South Africa, the company said.

"From the beginning of the process, an objective has been to sell our SA assets to a strong, capable and responsible operator that will ensure their long-term sustainability; we believe that this transaction achieves that," CEO of AngloGold Ashanti Kelvin Dushnisky said. "This sale helps deliver on our commitment to sharpen our management focus and capital allocation on the highest return investment options available to us."

AngloGold Ashanti has 14 gold-producing operations in nine countries.

The transaction consideration comprises three elements: $200 million in cash payable at closing; and two components of deferred consideration that includes $260 per ounce payable on all underground production sourced within the West Wits mineral rights (comprising the Mponeng, Savuka and TauTona mines) in excess of 250,000 ounces per year for six years starting January 1, 2021; and $20 per ounce payable on underground production sourced within the West Wits mineral rights (comprising the Mponeng, Savuka and TauTona mines).

Ivanhoe Builds High-grade Copper Resources in DRC

Ivanhoe Mines has reported an updated mineral resource estimate for the Kamoa-Kakula copper project in the Democratic Republic of Congo (DRC). The project is a joint venture between Ivanhoe Mines (39.6%), Zijin Mining Group (39.6%), Crystal River Global Ltd. (0.8%) and the DRC government (20%).

An initial 3.8-million-metric-ton-per-year (mt/y) mining operation on the Kakula deposit is nearing startup, with first concentrate production scheduled for the third quarter of 2020.

The new total mineral resource estimate for the Kamoa-Kakula property is the culmination of an infill drilling program designed to better define higher-grade copper zones. At a 1% cut-off, indicated mineral resources now total 760 million mt grading 2.73% copper, containing 45.8 billion pounds (lb) of copper, while inferred mineral resources total 235 million mt grading 1.7% copper, containing 8.8 billion lb of copper.

At a 3% cut-off, the new mineral resource estimate boosts indicated mineral resource tonnages by 15% and contained copper by 15.5% to a total of 256.8 million mt at a grade of 4.15% copper. At the same 3% cut-off, inferred mineral resources now total 13 million mt at a grade of 3.51% copper.

The majority of recently added copper resources are hosted in the Kamoa-Kakula property's ultra-high-grade Bonanza Zone and the Far North Zone. The initial indicated mineral resource estimate for the North Bonanza Zone includes 1.5 million mt grading 10.7% copper at a 5% cut-off.

The Bonanza and Far North zones were discovered within previously drilled areas following a review of the mineralization controls evident at the Kansoko, Kakula, and Makoko discoveries on the Kamoa-Kakula property. An intense focus on understanding these controls and how to recognize them from available data provided the exploration team with the ability to target high-grade zones, leading to infill drilling that included the two highest-grade intersections ever drilled at the Kamoa-Kakula project.

Two drill rigs currently are drilling in the Kamoa North area, testing the typical Kamoa-Kakula shallow mineralized horizon on previously identified, high-grade copper trends.

The ultra-high copper grades intercepted to date in the North Bonanza Zone are believed to be the result of an east-west growth fault focusing copper-rich fluids to interface with both the typical mineralized horizon at Kamoa-Kakula and the overlying, highly sulphidic and reduced Kamoa Pyritic Siltstone (KPS).

This has resulted in a new, upper mineralized zone hosted in the KPS characterized by the bonanza-grade copper found in the vicinity of hole DD1450.

Ivanhoe Mines Vice President of Resources George Gilchrist said, "The delineation of indicated mineral resources at the North Bonanza Zone and the Far North Zone continues the long history of exploration success at Kamoa-Kakula. We see excellent opportunity to add further shallow, higher-grade copper resources in the northern portion of the mining license in the general vicinity of these zones, as well as on our adjoining, wholly-owned Western Foreland exploration licenses, which should allow us to further unlock the exciting potential of this resource area."

Flotation cells recover copper and cobalt at Katanga Mining's Kamoto concentrator.

RUSAL Suspends Operations in Guyana

Russian aluminum producer Rusal suspended its operations in Guyana as the unrest continues. As a result of serious illegitimate actions that have gone beyond the control of government and enforcement agencies, including arson of the electricity pylon basement and other corporate property, and blocking of the river, RUSAL said it was prudent to suspend and mothball operations of the Bauxite Co. of Guyana (BCGI). Written notices of termination have been sent to 326 employees.

As the unrest impacting the company's operations continues, RUSAL said it believes the opportunities for doing further business in Guyana are now severely limited. All expatriate employees have been relocated. The suspension of BCGI will have no impact on the company's overall performance, as the expected decline in the overall bauxite supply from Guyana will be substituted with raw material from other mines, the company said.

Samsung SDI Extends Cobalt Partnership With Glencore

Glencore has signed a five-year agreement with Samsung SDI for the supply of cobalt hydroxide. Glencore will provide up to 21,000 metric tons (mt) of cobalt contained in cobalt hydroxide between 2020 and 2024. The cobalt will be sourced from Glencore's industrial mining operations located in the Democratic Republic of the Congo.

Glencore and Samsung SDI said they are committed to ensuring the ethical and responsible production and procurement of cobalt. Both parties agree that Glencore's DRC operations will be independently audited each year against the "Cobalt Refinery Supply Chain Due Diligence Standard." This standard is defined by the Responsible Mining Initiative (RMI).

"We are pleased to extend our partnership with Samsung SDI by entering into this long-term cobalt supply agreement," Head of Copper and Cobalt Marketing for Glencore Nico Paraskevas said. "This demonstrates a further continuation of Glencore's cobalt hydroxide marketing strategy to secure long-term supply agreements with key players in the lithium-ion battery supply chain.

"This also illustrates Glencore's important role in supplying the materials that enable the energy and mobility transition and Glencore's commitment to responsible production."

Cora Gold Scoping Mali Gold Project

Cora Gold has reported the results of an initial scoping study of its Sanankoro gold project in southwest Mali that validates the project's future economic potential. The study, overseen by Wardell Armstrong International, investigated the potential development of near-surface oxide resources, which Cora expects to expand significantly to incorporate additional oxide and sulphide potential.

The scoping study indicates that at a $1,400 gold price a 1.5-million-metric-ton-per-year (mt/y) heap leach mine could deliver more than 45,000 ounces per year (oz/y) of gold at all-in sustaining costs of $942/oz over an initial mine life of three years. Preproduction capital expenditures are estimated at $20.6 million.

Cora CEO Bert Monro commented, "This scoping study shows Sanankoro has the potential to be a highly profitable stand-alone oxide mine, delivering a high IRR and short capex payback, with an annual average free cash flow of more than $19 million at a $1,400 gold price. The key will be to drill out more oxide resources to extend the mine life and sustain the cash flow well beyond this maiden study.

"To date, we have only drilled about 25% of the total strike length of the potential mineralized zones identified on the permit area. Drilling is currently ongoing, and SRK, which handled the resource estimation and mining aspects of the scoping study, has a defined exploration target of 1 million to 2 million oz of gold to a depth of 100 meters (m)."

The Sanankoro project has several distinct mineralized zones. Oxide resources at the project, all inferred, currently stand at 4.5 million mt grading 1.6 g/mt gold. The scoping study anticipates that mining will be predominantly free digging.

In a subsequent announcement, Monro said, "Cora has successfully intersected multiple higher-grade gold intercepts at Sanankoro in its latest drill program. This set of results mainly tested continuity of mineralization at depth, in part below the limit of the existing resource pit shells. The current resource has a range of pit depths from about 40 to 100 m, so there is significant scope to increase the open-pit resources with further successful drilling.

Turquoise Hill Commits to New Coal-fired Power Plant for Oyu Tolgoi

The proposed 300-MW coal-fired power plant will supply power to the Oyu Tolgoi mine (above). (Photo: Turquoise Hill Resources)

Oyu Tolgoi LLC has submitted a feasibility study to the government of Mongolia for the Tavan Tolgoi Power Plant (TTPP) Project, which involves building a 300-megawatt coal power plant. The plan will allow the company to secure domestically sourced power for the Oyu Tolgoi copper mine, which is owned by the government and Turquoise Hill Resources.

Under the 2009 Investment Agreement (IA) between Turquoise Hill, the government of Mongolia and Rio Tinto, and the subsequent Power Source Framework Agreement signed in 2018, the company must secure a domestic power source for the mine by June 30, 2023.

Rio Tinto, which owns 50.8% of Turquoise Hill Resources and manages the mine, said it is also progressing alternative options to source domestic power, including a renewable power component.

Rio Tinto Copper and Diamonds Chief Executive Arnaud Soirat said, "Rio Tinto, Turquoise Hill and the government of Mongolia are all committed to securing a reliable and long-term domestic power source for the Oyu Tolgoi mine and are working together to achieve this."

The TTPP Feasibility Study envisages a 300-MW power plant with a project cost estimate of around $924 million. This is already included in the group capex guidance of $7 billion in 2020 and $6.5 billion each in 2021 and 2022.

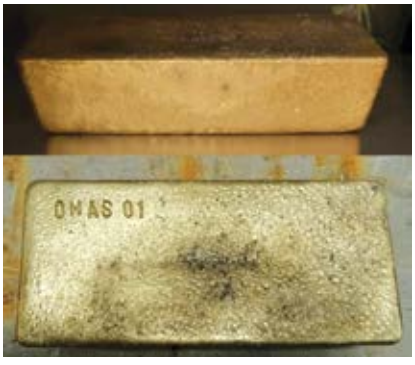
Centerra Gold Pours First Gold at Öksüt Mine

Centerra Gold Inc. announced that the first gold pour from its Öksüt Mine in Turkey occurred on schedule and ahead of budget. Additionally, the project achieved a significant safety milestone, achieving 2 million work hours Lost Time Injury Free.

President and CEO Scott Perry said, "This is an important milestone for the project and for the growth of the company as Öksüt is now our third operating mine and our third source of gold production going forward. Reaching the first gold pour is a testament to the dedication and hard work that our Öksüt team has put in to reach this goal safely.

"This milestone would not have been achieved without the initial conviction and perseverance from the Centerra exploration team given that the Öksüt mine originally started as a greenfield exploration venture in 2009.

"Finally, I would like to thank all of the stakeholders of the Öksüt Project, including the local communities and the relevant government authorities, who have worked with us constructively over many years."



Öksüt mine's first gold bar is created on January 31. (Photo: Centerra Gold)

Rusal Invests in Modernizing Smelters

RUSAL, a Russian aluminum producer, will invest RUB 5.2 billion ($86 million) this year in modernizing its Sayanogorsk and Khakas aluminum smelters.

The largest projects will be carried out in the Khakas casthouse and the electrode production at Sayanogorsk with further improvements to equipment on the site. In the Khakas, a new system of cleaning the crude aluminum in 10-metric-ton (mt) ladles will be installed. Its application will increase the purity of the metal and ensure the growth of its potential for product sales. To intensify the reliability of the power supply at the reduction plant, two transformers will be replaced at one of the silicon rectifier substations, the company said.

As part of the modernization of the Sayanogorsk smelter, RUSAL will be carrying out a large-scale modernization of anode baking furnaces at the electrode production of the smelter, which will cost a total of RUB 12 billion ($190 million), with RUB 3.6 billion ($57 million) being spent this year. Specialists are drafting the details for the engineering and design, while surveyors carry out relevant examinations. It is expected that the project will be carried out in several stages and completion of the work is planned for late 2023.

"The ongoing development and modernization of our sites is essential to maintain the consistently high-level production which is expected of our company," CEO of RUSAL Evgenii Nikitin said.

Newcrest Agrees to Divest Gosowong for $90M

Newcrest Mining Ltd. has signed an agreement to sell Newcrest Singapore Holdings Pte Ltd. (NSH), which owns a 75% interest in PT Nusa Halmahera Minerals (NHM) that operates the Gosowong mine in Indonesia, for a total consideration of $90 million in cash. The transaction also includes PT Puncakbaru Jayatama, which employs exploration personnel in Indonesia to PT Indotan Halmahera Bangkit (Indotan).

(Continued on p. 24)

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Kennecott Earning Into Emgold's New York Canyon Property in Nevada

Emgold Mining has signed an earn-in with option to joint venture agreement with Kennecott Exploration, a subsidiary of Rio Tinto, covering Emgold's New York Canyon property 30 miles east of the town of Hawthorne in west-central Nevada. The property hosts both copper oxide skarn and copper-molybdenum-gold-silver sulphide porphyry mineralization in three known targets: Longshot Ridge, Copper Queen and Champion. Kennecott can earn up to a 75% interest in the property by completing a total of $22.5 million in exploration expenditures over three options periods of five years, three years, and three years, each.

While earning in, Kennecott will make exploration and development decisions for the project.

"The agreement with Kennecott represents another successful example of Emgold's business strategy of acquiring assets, adding value, and monetizing them through sale, option, joint venture, or other business transactions," Emgold President and CEO David Watkinson said. "In this case, we are pleased to have Kennecott earn into and, if successful, become a joint-venture partner with Emgold and take the lead to advance New York Canyon." (*emgold.com*)

Exploration Briefs

Alianza Minerals has signed an option agreement with a wholly owned subsidiary of **Coeur Mining** relating to a letter of intent to explore the road-accessible Tim property in southern Yukon Territory, Canada. Exploration at Tim is targeting high-grade silver-lead mineralization similar to the mineralization at Coeur's Silvertip operation 12 kilometers (km) to the south.

Coeur can earn an 80% interest in the property by funding $3.55 million in exploration over five years and making scheduled cash payments to Alianza totaling $575,000 over eight years. Coeur must also fund a feasibility study and notify Alianza of its intention to develop a commercial mine on the property on or before the eighth anniversary of the date of notification of the Class 1 exploration permit.

The 2020 exploration program will target high-grade silver-lead-zinc carbonate replacement mineralization similar to that found at Silvertip. Coeur's tentative exploration plans for the year consist of detailed mapping, soil geochemical surveys, and reopening old trenches, which date back to 1988.

"We are very pleased to have partnered with Coeur to advance the Tim silver property," Alianza President and CEO Jason Weber said. "Tim looks to be a Silvertip analog, and the Coeur team is an obvious choice to move the project forward. It will be a great advantage to have Coeur's geological expertise applied to the project." (*alianzaminerals.com*)

Bluejay Mining has been awarded a new mineral exploration license surrounding its existing Kangerluarsuk zinc-lead-silver project in west-central Greenland. The 586-km^2 license expands Kangerluarsuk by more than fivefold to 692 km^2. The company plans to initiate its first drilling program on project later this year, along with other exploration activity, as part of its 2020 field season.

Bluejay CEO Roderick McIllree commented, "We are delighted to have been granted this new license area at Kangerluarsuk. Our decision to increase our land holding by over five-fold is testament to our confidence in the license's prospectivity.

"With this in mind we are excited to commence our 2020 field season. This includes a relatively low-cost maiden drilling campaign (subject to approval by Greenland's Mineral Licence and Safety Authority), which will target known zinc, silver, lead, and copper occurrences that have correlations with the neighboring former Black Angel zinc-lead-silver mine.

"We look forward to updating shareholders in due course on developments relating to the upcoming summer work program, as well as at our advanced Dundas ilmenite project and the Disko-Nussuaq project, both also in Greenland, as we prepare for a highly active 2020." (*www.bluejaymining.com*)

Canada Cobalt Works reported in late January that ongoing drilling from surface has greatly expanded the potential scale of its Castle East Robinson Zone high-grade silver discovery immediately adjacent to three robust past producing mines in northern Ontario's Gowganda camp, 75 km southwest of Kirkland Lake.

Significantly, native silver has been observed in drill core at shallower levels near the contact of the Nipissing diabase with the Archean volcanics, as much as 100 m above and northwest of previously known occurrences, while drilling has also intersected another native silver vein 95 meters (m) below and northeast of the first vein shoot. This gives the discovery a minimum potential 200-m vein zone vertical extent. It remains open in all directions as drilling continues.

Canada Cobalt Vice President of Exploration Matt Halliday stated, "It is now apparent from surface drilling that the initial discovery falls within a much broader and productive horizon associated with a 300-m-thick sill. This drill core is displaying textbook signatures of a Gowganda-style high-grade silver system, with extensive veining and alteration, native silver-filled fractures, and structures interpreted to be spatially related to high-grade mineralization." (*canadacobaltworks.com*)

Exore Resources' reverse circulation drilling at the Veronique prospect within its Bagoe project in northern Cote d'Ivoire has returned additional high-grade gold assays, including a 2-m intersect grading 44.08 grams per metric ton (mt) gold from 62 m down hole. The mineralization remains open in all directions.

The Veronique drilling results confirm potential to define shallow, high-grade, free-milling gold mineralization to complement shallow oxide gold mineralization being defined at Exore's Antoinette gold discovery 12 km to the north. Step-out drilling is currently under way at Antoinette testing for shallow oxide extensions to the Antoinette Central discovery, along with testing of the parallel Antoinette West target. (*www.exoreresources.com.au*)

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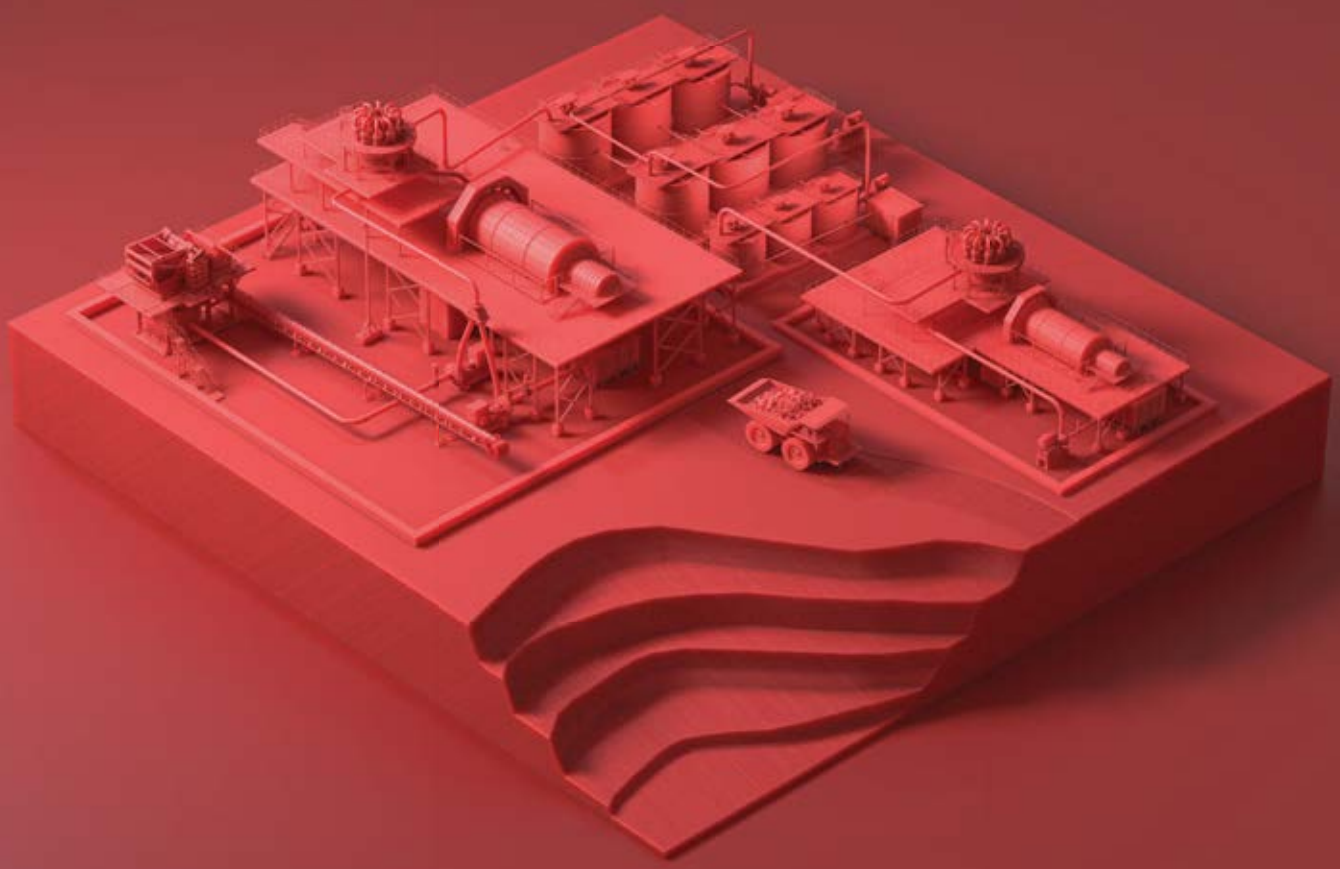

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Peabody Moves to Lower Costs in US, Considers Options for North Goonyella

During the quarter, the Wambo complex (above) has improved production, which contributes to strong segment cost performance of $30.68/ton, Peabody says. (Photo:Peabody)

Peabody Energy announced its full-year 2019 revenues totaled $4.62 billion compared to $5.58 billion in the prior year, due to an 11% decline in production and lower pricing. The company posted a full-year 2019 loss of $188.3 million, while adjusted EBITDA totaled $837.1 million.

"During the fourth quarter, Peabody made a number of operational improvements in Australia, reduced costs in four of five operating segments, opportunistically repurchased bonds to reduce debt, generated substantial cash from commercial settlements and progressed the regulatory process for the proposed Powder River Basin (PRB)/Colorado joint venture," President and CEO Glenn Kellow said. "For 2020, we are targeting improved met coal volumes and costs, lower [non-production related costs] and reduced North Goonyella holding costs. Those benefits are expected to partly offset current lower pricing in all segments, lower U.S. thermal volumes, and the loss of some $200 million in contributions from the closing of the Kayenta and Millennium mines."

Peabody's seaborne thermal segment exported 3.3 million tons at an average price of $64.83/ton, with the remainder delivered under a long-term domestic contract in the fourth quarter. For the full year, Peabody's export thermal sales totaled 11.5 million tons with domestic shipments totaling 8 million tons. During the quarter, the Wambo complex had improved production, which contributed to strong segment cost performance of $30.68/ton and underpinned fourth-quarter seaborne thermal margins of 33%. In addition, the Wilpinjong mine had record railings in 2019. Peabody also formed the United Wambo joint venture (JV) following government approvals.

Fourth-quarter seaborne metallurgical coal sales totaled 1.9 million tons. Production improved significantly at the Coppabella and Moorvale mines, with the fourth quarter marking the highest quarterly production volumes for the year, the company said. As a result, the metallurgical segment delivered a 10% cost-per-ton improvement compared to the prior year, excluding North Goonyella costs, despite 17% lower year-over-year volumes. North Goonyella, a major met mine in Australia, was idled because of fire in the third quarter of 2018.

Fourth-quarter seaborne metallurgical cost performance of $88.91/ton (excluding North Goonyella costs) improved 15% relative to September year-to-date costs per ton. As anticipated, fourth quarter North Goonyella costs were significantly reduced to $16.9 million following the reduction in workforce in late October 2019, Peabody said.

Within the U.S. thermal business, Peabody successfully concluded its negotiations with the Salt River Project that purchased coal from the Kayenta mine, resulting in a one-time $69 million settlement related to recovery of additional contract costs. In addition, the company reached a favorable $20 million settlement with a PRB customer. Fourth quarter PRB shipments declined 8% from the prior year to 27.6 million tons.

Looking toward 2020, Wambo JV production is targeted to begin late in 2020, with the potential to extend the life of the open-cut operations beyond 2040. The Wilpinjong Extension Project continues to progress.

Peabody said it expects 2020 seaborne metallurgical sales to be approximately 8.3 million tons, saying production would be weighted toward the back half of the year as Shoal Creek is expected to return to normal production levels, following a several-week outage in the first half of the year to finalize an upgrade of the main line conveyor system.

Following a significant reduction in holding costs, Peabody is "commencing a commercial process" for the North Goonyella mine in parallel with the existing and ongoing mine development plan. The company said it's considering options such as a strategic financial partner, joint venture structure or a complete sale of North Goonyella. Peabody said it is currently in discussions with the Queensland Mines Inspectorate regarding ventilation and re-entry of Zone B.

For 2020, Peabody has a strong U.S. contracted position with 96 million tons in the PRB and 20 million tons in other U.S. thermal mines, and has the flexibility to increase volumes should demand warrant. Production from its three PRB mines (Caballo, North Antelope Rochelle and Rawhide) totaled 108 million tons in 2019, according to data from the U.S. Mine Safety and Health Administration.

Contura Energy Lowers Guidance for 2020

Contura Energy updated its guidance for 2020, which decreased 700,000 tons for both metallurgical and thermal coal sales.

Met shipments will range from 12 million tons to 12.6 million tons, from the previously announced guidance of 12.7 million tons to 13.3 million tons. The range for Central Appalachia (CAPP) thermal shipments was reduced to 2.7 million tons to 3.3 million tons, from a previously announced range of 3.4 million tons to 4 million tons. Northern Appalachia (NAPP) shipment guidance remains as previously disclosed at a range of 6 million tons to 6.8 million tons.


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(Regional News-Asia - from p. 18)

Newcrest will pay a deposit of $5 million upon execution of the sale and purchase agreement and $55 million when the transaction is complete. The remaining $30 million will be deferred until 18 months after completion.

The company said the sale of NSH follows a strategic review of the asset and complies with the amended Gosowong Contract of Work, which required Newcrest to sell down to at least 49% of PT NHM by June 30.

"Gosowong has been a valued part of our operating portfolio since we discovered it in 1993, with first production commencing in 1999," Newcrest Managing Director and CEO Sandeep Biswas said. "Over the last 30 years, we have built valued relationships with our Indonesian joint venture partners, suppliers, employees, government and community stakeholders, and together achieved the strong culture we see today, which is based on safety, trust and teamwork."

Newcrest said it expects to take a $44 million loss on divestment of its 75% interest after taking into account the sales proceeds less written down value of the assets sold and transaction costs.

The transaction includes the Gosowong mine (above) in Indonesia. (Photo: Newcrest Mining)

Alrosa Unearths Large, Colored Diamond

A bright yellow gem-quality diamond weighing 17.44 carats was recovered in mid-February from ALROSA's Zapolyarnaya kimberlite pipe, a part of Russia's Verkhne-Munskoye deposit. The transparent crystal with a habit transitional between octahedron and dodecahedron has dimensions of 18 x 20 x 9 mm.

Alrosa recently recovers this 17.44-carat yellow diamond.

"This is the first rough diamond with bright color found at the Verkhne-Munskoye since it was launched in 2018," Deputy CEO Evgeny Agureev said. "The United Selling Organization of ALROSA will assess and evaluate this stone in detail. We hope this deposit will give us more large and interesting discoveries in future."

ALROSA mines natural color rough diamonds mostly in the Arkhangelsk region and in the north of Yakutia. There are less than 0.1% of colored gem-quality stones in the overall output of ALROSA. They are sent to Diamonds of ALROSA, the company's cutting and polishing division. This is where unique pieces as the Fancy Vivid Yellow Firebird diamond (20.69 ct) and Spirit of the Rose 14.8-ct Fancy Vivid Purple-Pink diamond were produced.

Global resources of colored rough that could be cut and polished into fancy color diamonds are scarce, according to ALROSA. That is why vivid fancy diamonds of important tones may be valued 10 times higher than colorless ones. According to GIA, only one in 10,000 diamonds has a fancy color.

NEWS - CALENDAR OF EVENTS

APRIL 20-24, 2020: **Expomin, Santiago, Chile.** Contact: Web: www.expomin.cl.

APRIL 21-23, 2020: **MiningWorld Russia, Moscow, Russia.** Contact: Web: www.www.miningworld-events.com.

MAY 3-6, 2020: **Canadian Institute of Mining (CIM), Vancouver, Canada.** Contact: Web: https://convention.cim.org/2020.

MAY 23-30, 2020: **ALTA 2020 Nickel-Cobalt-Copper, Uranium-REE, Gold-PM, In Situ Recovery, Lithium & Battery Technology Conference & Exhibition, Pan Pacific Hotel, Perth, Australia.** Contact: Web: www.altamet.com.au/conferences/alta-2020/.

JUNE 1-5, 2020: **Elko Mining, Elko, Nevada, USA.** Contact: Web: www.elkocva.com.

JUNE 2-5, 2020: **UGOL & Russia, Novkutznesk, Russia.** Contact: Web: www.ugol-rossii.com.

JUNE 9-11, 2020: **Euro Mine Expo, Skellefteå, Sweden.** Contact: Web: www.euromineexpo.com.

SEPTEMBER 7-11, 2020: **Electra Mining, Johannesburg, South Africa.** Contact: Web: www.electramining.co.za.

SEPTEMBER 28-30, 2020: **MINExpo INTERNATIONAL, Las Vegas, Nevada.** Contact: Web: www.minexpo.com.

MARCH 14-17, 2021: **Haulage & Loading 2021, Hilton El Conquistador Resort, Tucson, Arizona.** Contact: Web: www.haulageandloading.com.

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To Future-proof, Coy Taps Top Talent, Traditions, Tech

Longtime underground zinc mine innovates to improve workplace conditions and production, but also uses effective processes and technologies from days of yore

By Jesse Morton, Technical Writer

At Stope 1092, from left to right, Justin Cobb, superintendent; Bill Hart, manager; Chris Moody, drillman; and Ricky Sircy, utilities coordinator.

Nyrstar's Coy mine, a pure-play underground zinc operation in East Tennessee, shares much in common with other underground mines. Ventilation, communications and water management challenges top the list.

Coy is also quite unique in one aspect. According to Justin Cobb, the mine's superintendent, the miners there, to date, have had the luxury of using an adjective rarely used to describe zinc mining jobs: stable.

"A couple of years ago, we had some particularly low prices," Cobb said. "Nyrstar had several opportunities to lay off and shut the doors or to run on skeleton crews. But they didn't."

Cobb said the reason relates to the quality of work at the mine. "We strive to mine it cleaner and cheaper than anybody in the world," he said. "And in doing that and in trying to keep our costs down, we are setting ourselves up, no matter where the zinc price falls, for stability and jobs."

When Cobb talks of job stability, he also means in the truest sense of the term. Skills and knowledge gained at Coy should prove to be valuable at any mine site on the planet, he said.

Coy is situated in a bustling suburban center. The headframe is almost visible from the main four-lane artery through Jefferson City, population 8,500, located on the watershed of Cherokee Lake and the Holston River. The city has a population density of roughly 1,300 per mi^2. The mine is sandwiched between sprawl malls, and backs up to an established subdivision of cozy middle-class homes. A couple of blocks over is Carson Newman University, with roughly 2,500 liberal arts students.

"We're not out in the plains. We're not out in the mountains. It is not like in Australia where you drive six hours out on a bus and you are out in the desert," Cobb said. "We are literally right in the middle of multiple neighborhoods, elementary schools, Wal-Mart, several different shopping centers and restaurants."

Plus, the mine isn't deep. "You've got Jefferson County's water table that rests between the surface and a lot of our working areas," Cobb said. "We've got a lot of moving parts when it comes to the community, to habitat, to water table, to several different variables. So, we've got to do our due diligence to make sure that we hold to our mine plan to keep from interfering in the community's daily life."

Due diligence, Cobb said, means no "cowboy mining." It means attention to seismographs. It means endless surveys, exactitude with explosives, and carefully pacing overall extraction. "If we've got big bulk stopes that we want to take, just to be cautious of the area, we may only take half of it at a time," Cobb said.

"We do every step we possibly can to make sure we don't overshoot, overbreak, overload anything," he said. "Drilling is the same way. We make sure that we have good surveys, and make sure that we drill a little bit slower to keep our deviation minimal."

Such painstaking exactitude is the right strategy for the orebody, Bill Hart, mine manager, said.

"These seams are real thin. They are fingers. They run in spurts," Hart said. "A zinc body will do that. It will be running level and then it will dive, and then it will go up. So, we are just basically chasing it all the time."

Complicating matters, zinc prices perpetually guarantee that the margins will be low. "We are only keeping 3% to 5% of what we blast. So you have to be really strategic on sizing and how much you take," Hart said.

Such is the paradox of Coy and of Nyrstar's East Tennessee operations, which includes two other nearby mines. There is not much money in zinc to begin with and the orebody, while comparatively rich, swerves, jerks and spiderwebs erratically through the granite just beneath a populous civilian center. To answer, Hart and Cobb deploy a robust mix of the traditional and the high tech, the field proven and the cutting edge.

For some challenges, "we're still using systems and stuff that has been in place

since the 1980s and 1990s," Hart said. "But they are good, fundamentally sound systems." For others, Coy uses state-of-the art equipment and gear.

Both Cobb and Hart said the underlying philosophy behind the approach at Coy is safety centrism. It goes the safer an operation is, the more productive it will be. "I've never seen an unsafe operation that is productive," Hart said. "I don't think it exists."

To illustrate that philosophy in action, Hart and Cobb took *E&MJ* to its deepest stope and showcased a handful of solutions. The tour revealed the conscientious diligence of the miners, the copious challenges faced by management, and the sincere importance given to safety. It also revealed how operating on a shoestring budget and targeting a complex orebody quickly sifts out the chaff, leaving only the capable and dedicated, the type that will always know job stability.

Traditional Solutions

The Coy mine is roughly 1,200 ft deep. It employs 94. Annually it produces in the range of 600,000 metric tons of ore that is shipped out by transit truck. That ore is processed in a plant nearby and the concentrate is then shipped to Middle Tennessee. Some of the original literature on the mine still available online from when Nyrstar bought it a decade back states it is a room-and-pillar operation. Cobb said the description works for a general audience but technically it's imprecise. "This mine is different," he said. "If we get to turn a pillar, we are lucky. What you see is a lot wider and a lot taller stopes where we just pretty much run a drift and follow the orebody instead of turning pillars."

The lift drops to three levels. The middle level leads down, around, and to stope 1092. "It has been a really good stope for us," Cobb said. "There is still quite a bit of mining left to do there."

Getting there takes one first past a panning station, accessible through a door in the wall of the drift. Stacked on the workbenches are square Tupperware containers of gray muck. At a shallow sink on the far wall, using water from a rubber hose, geologist technician Matthew Duck pans for zinc.

Duck said each container has chip samples taken from a different long hole drill hole. "Every still is 6 ft long. They stop, flush it good, and take from it a sample," he said. "They put a tag in it and a lid on it and they put it in the crate, and then they just keep going." The samples make their way to Duck, who systematically processes them based on drill hole location and orientation.

Duck takes a container, dumps it in a pan, adds water, swirls, works out the granite, and then measures the remaining sphalerite dust. "You get all these rock chips out of it and then we take pinky sizes," he said. A pinky-width of sphalerite "is 1%."

Management uses the results for planning. "For the most part, it is an estimate," Duck said. "And it can tell you very accurately whether you have ore grade mineable stuff or if it is waste."

Duck said so long as the estimate is within a range, it is actionable. "The trouble we have is telling you the difference between a three and a four," he said.

Below that range is largely unactionable. "It is when we get down to a two or three is when it is borderline," Duck said. "I want to check my borderline stuff to see where I am at."

His work is audited by a third-party lab. "What that does is it comes back and tells us how close or bad I am," Duck said. "So far, there is nothing else that can train me better."

The process has worked for the mine for decades. "If we were in a gold deposit, all this would be scanned with XRF," Duck said. "What we do is low money. It is just a quick and dirty way to get an estimate of what we've got in front of us."

Down and around from the panning station is what Cobb called a super sump, an underground retention pond visible from the main drift and extending back into the deep darkness beyond. It is another example of a proven process that ensures the viability of the mine. Coy is a wet mine, Cobb said. "Water is a huge risk and I think we do a pretty good job of mitigating that," he added.

The sump is an old drift into which water is routed. Sensors measure the water height and activate pumps when it gets to a certain level. "Those probes will be set at a certain level. When that water rises and hits those probes, those probes will read it, kick the pump on and start pumping," Cobb said. "That way there is no overflow."

Similarly, the sensors kill the pumps when the water level drops to a certain point. "That way we don't let the water get pumped down low enough to where that pump is pumping air," Cobb said. "Once the pumps start pumping air, it will burn them up."

Cutting-edge Solutions

The drift angles downward. A turn left dead ends at working area 1092, more than 1,000 ft below the surface. Arcing

Geologist technician Matthew Duck analyzes ore.

lines of zinc-bearing quartz crisscross the face. There, a new Sandvik DD321 drill rig bores holes into the granite. Presently the rig quiets, and the operator, Chris Moody, steps out.

Described by leadership as the top drill man in Coy, Moody has been with the company for 10 years. When asked about the superlative, he shrugged and told *E&MJ*, "you are only as good as your last round."

The same would likely hold true for the rig, which Moody described as a Cadillac. "It is comfortable and easy to operate. All the hoses are managed well," he said. "We have the assist on the drilling with the TCAD system. We also have the air mist on it. It doesn't use near as much water" as the Oldenburg drills did.

The rig, one of two, has been in operation for close to half a year. It had to be cut up and, piece by piece, bound to the underside of the lift to be dropped into the mine, and then reassembled in the shop. Smarter, cleaner and more efficient than its diesel predecessors, it offers several benefits.

The TCAD control system "reads back sight center line, which helps with stability in your drill pattern, making sure they don't deviate and making sure they keep a square flush face," Cobb said.

Leadership at Sandvik told *E&MJ* the TCAD drilling instrumentation package along with the Sandvik iSURE drill plan and analyses office tools should allow Coy to design an optimum drill pattern suited to the explosives being used and based in part on the local rock characteristics.

"The plan can be sent to the drill and the machine assists the drilling operator to follow a given drill pattern by visualizing it through the onboard touch screen display," Johannes Välivaara, product manager, underground development drills, Sandvik, said. "By simply following given plans, the operating staff can achieve better and much more consistent blasting results with minimum over break. This goes round after round each day consistently."

The rig is electric, which helps with ventilation costs, Cobb said. "It has been a game changer for Coy," he said. "The industry is getting farther and farther away from diesel-running equipment, going to electric. And this is the future, by all means."

At roughly 7 ft wide, 8 ft high and 40 ft long, the rig is compact, which is critical in Coy, with its meandering drifts.

Finally, the rig performs. "These things pump out the drill holes," Cobb said. "When you are looking at 100 to 125 with an Oldenburg diesel rig and you're looking at 185 to 215 with the Sandvik rig, it is just a lot more efficient as far as your drilling. It is a lot more efficient as far as overall production holes, and it is a lot more efficient as far as just max capability."

Välivaara said that beyond increased production, operators should enjoy increased "cabin comfort and the reduction in noise level over their previous drills."

Cobb said Moody's numbers so far for the shift are telling. "By 12:17, he's already got a 65-hole cut drilled out and he is starting to drill this slab," Cobb said. "He will be completely done in here by about 1:30. He'll have well over 100 holes drilled by 2 p.m. That is pretty efficient."

Previously it would have taken Moody a full 12-hour shift on an Oldenburg rig to drill 100 to 125 holes. "He is getting that in about half the time," Cobb said. "Don't get me wrong. I like Oldenburg drills. They are not as efficient and clean as these new Sandvik Drills, which are a perfect fit for what we are trying to do for these guys."

Safety Solutions

On the way out, Cobb pulls a chain across the entrance to the working area. Centered on it and dangling from it is a rolodex of laminated signs roughly the size of civilian street signs. He flips through and stops on the one that reads Active Workplace. "That means we've mined this place out and don't go in unless you have prior authorization," Cobb said.

Other signs in the deck include Scaling Required, and Loaded Round. "Loading in Progress means there are people down there loading up a round," Cobb said. "That way everybody is alert and understands what is going on."

The idea for it was borrowed from a surface mine, Cobb said. And while low tech, even pedestrian, the tool is effective.

"You hear of a lot of fatalities of people going into workings and getting maimed, injured or killed," Cobb said. "We want to prevent that the best we can," he said. "We've found out if you keep everything black and white, simple, easy to understand, it is a whole lot easier to follow through on the process."

A detour on the way back to the skip reveals another innovation aimed at improving work conditions and productivity.

For decades, the skip tender was situated at the very bottom of the shaft, operating air control levers that dumped the measuring bins onto the skips to be hoisted out. "At the end of the day," Cobb said, "when we were looking at what our current situation was with our skip tender, it simply needed to be a safer, more productive environment for our employees."

Several solutions were considered, and leadership settled on a construction job, which went to the utilities coordinator, Ricky Sircy.

Sircy was tasked with turning an indention in the drift wall into a new skip

The burn cut drilled in this face is ready to shoot, but a closer look reveals Coy's geology and the zinc-bearing quartz crisscrossing the face.

pocket, effectively a rustic office big enough for two desks, monitors and other equipment. The vision was "a safe location where they are fully encapsulated, fully enclosed," Hart said.

The job would go from being a relatively high-risk position, with exposure to moisture and positioned almost in the shaft, to being a desk job.

So situated, the tender will be "able to run the exact same amount of controls that he was able to down there, but he'll be running off of sensors, cameras and a monitoring system," Cobb said.

Based on the monitors, "he'll be able to see the cage go in, and everything spot, and he'll load up," Sircy said.

He will then remotely "measure his hoppers up, and when it is time to release it to the top, off she goes," Cobb said.

The office will also accommodate a foreman.

Hart described the office as a win-win. "We are just trying to reduce risk to the people and increase efficiency at the same time," he said.

For leadership, the win had three tangible effects.

First, the mine saved money and garnered wider staff buy-in by doing it in-house. "This has been Ricky's project and a group effort," Hart said. "When you do stuff like this internally, there is more ownership. You can see the fruits of your labor. It has worked out good for us so far."

Second, it is an example of leadership following through on a planned change to improve workplace conditions. "That is one of my big things that I've tried to instill. Let's show people that when you have high integrity, you do what you say you are going to do," Hart said. "That is important with these miners here. There has been a lot of management changes over the years. Sometimes that affects morale. We've tried to really focus on following up and following through. If we say we are going to do something then we do it."

Cobb agreed. "Stuff like this goes a million miles with the workforce," he said. "And we are trying to make this type of effort in everything we do."

Third, it better situates the mine to resolve a recurring problem with millhole bin loading and pulling. Historically, on the 3rd Level, if the skip tender's timing was off and the bin was pulled before it was full, the safety barrier fingers in the chute could be damaged.

When it happened, dumping had to be halted. Hart said that at its worst it was likely costing the mine up to 12 hours per week of downtime over a six-week period.

Surveillance Solutions

The screens and controls in the new skip pocket will leverage a new camera and sensor system that will simplify the task of timing the pulling of the bins. Currently, the cameras feed a monitor in the back office on the surface. That capability alone has paid dividends.

"With these cameras, we've been able to not only increase our efficiency on how much we pull out, but we've also been able to increase the duration and durability of the work that's been put in at 3rd Level," Cobb said.

The system was installed internally. The project spanned six months in 2019 and was managed by the electrical superintendent, Leslie Jarrell.

Jarrell said the system was necessary. Previously, the mine tried an audible alarm system, which remedied some issues but failed at others. "We had dropped some things down the shaft before, and had some misconceptions trying to load things," Jarrell said. "We couldn't see people coming on and off, couldn't see our skip pockets. With limited numbers of people and resources, we put cameras in to be able to see everything going on."

Previously, Jarrell worked with Pillar Innovations on installing an exacqVision platform-based system, running on a fiber-optic backbone and using Hykvision cameras, on a belt conveyor at Nyrstar's Middle Tennessee underground zinc operation. "We just brought it here," he said.

"Now each group can work together," Jarrell said. "If we are having issues, we can troubleshoot together and keep everything stabilized."

The system is IP based, which allows users to remote into it. "I can see it from our Beaver Creek office," Jarrell said. "If we have a camera go down, our IT guys can work on it from our corporate office, whereas if you were to go with analogue, you would physically have to go to it to work on it."

It can support up to 36 cameras, each of which must be licensed and each of which can feed one of 36 small rectangular windows on the big screen in the corner of the back office.

The system offers up to four weeks of storage capacity, which helps to resolve lingering conflicts that can arise between areas when stories don't align.

Already, it has nearly nixed the downtime arising from communication faults between the skip tender and hoist man. "We are almost there," Hart said. "We have some lasers we are going to put on the bin to let us know when it is filled up. We are trying to make it more automated. That is the last phase to get it done."

Future Solutions

Plans in the works include a ventilation system upgrade project that includes the installation of four doors and brattice walls to help with pressure equalization, as well as a new fan purchased from Spendrup.

The fan model that was selected was chosen, in part, because it could be most easily cut in half, lowered down the shaft, and later reassembled, according to Brad Davenport, safety and health superintendent.

Davenport said the fan would pay for itself within two years. "There is a sizeable capital expense up front," he said. After two years, though, it would save the mine money relative to previous years.

Hart said the project and most of the others that have occurred under his tenure were meant to improve workplace conditions and safety.

"My background puts that front and center with me," Hart said. "I'm a fifth-generation miner. When my dad died, black lung was a contributing factor. I'll make sure I do whatever I can do to make sure that doesn't happen to these guys, to make sure guys like Moody are not breathing dust or diesel particulates."

The various projects bode well both for the mine and for job stability there, Cobb said. "The beautiful thing about it is this company believes in this mine's potential," he said. "They've invested quite a bit of money into our capital development program. That tells us that they are looking to the future."

How far out that future goes is debatable. Hart said that, unofficially, leadership believes the mine could produce economically for another half century.

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Mining Indaba Highlights the Issues the Industry Faces in Africa

Social license and the value mineral extraction has on society was very much the focus at this year's Mining Indaba — the first of the new decade

By Gavin du Venage, South African Editor

Hon. Gwede Mantashe, minister of Mineral Resources for South Africa, welcomes delegates to the Mining Indaba.

CAPETOWN, South Africa — This year began with excellent news for South Africa's struggling industry: mines would now be allowed to generate their own electricity, and no longer be subject to hours of power cuts each day. "This is a really big deal, that's been part of Indaba discussions," CEO of Minerals Council Roger Baxter said. "Clearly, we can't grow mining without electricity, so this is a practical step forward."

Communication with the government and minerals ministry had once again been restored, after having completely broken down two years ago. "Robust engagement" and discussion around issues such as power were now taking place on a regular basis. "Business is not being shy about what the issues are, but we're not just complaining, we're coming forward with solutions," Baxter said.

However, mining continued to shrink by as much as 3% over 2019, figures produced by the Minerals Council showed. South Africa only draws around 1% of global exploration and much had to be done to reawaken interest in the mining sector. "We should draw 3% to 5% of global exploration spend — a lot of this is due to issues such as electricity," Baxter said. He added that initiatives such as allowing mines to access electricity outside the state-owned utility Eskom, would likely encourage further exploration interest.

Mining Minister Gwede Mantashe took up the theme in his keynote address, when he acknowledged the decline of the industry. "This reality forced us to take serious measures, and allow mining companies to generate electricity themselves," he said. Mines will not need a license or permits from the state to set up their own power plants, as has been the case up until now.

Nor will they be forced to buy from Eskom as their sole supplier as the law has previously required. Eskom has raised prices more than 300% over the past five years, but if the mines can provide their own electricity at a cheaper rate, they should do so, Mantashe said. "If the price of electricity keeps going up, mines will close."

Turning to safety, Mantashe commended the industry for advances over the years. Fatalities fell from 81 in 2018 to 51 last year. He recalled that in some years the toll of dead was far, far higher. In 1960 for instance, the Coalbrook mine collapsed, killing 437 men in what has remained the largest disaster in South Africa's mining history. It was, therefore, a good indication of advances made that each year saw a reduction in fatalities, said Mantashe. "This year is our record low, and evidence that a fatality-free mining industry is possible," he added.

Adding Value

Mark Cutifani, CEO of Anglo American, used his time on the podium to remind the industry that it still struggled with an image problem. "Despite its many contributions to the world, mining continues to draw negative criticism," Cutifani added. The reality was, however, that the world population was headed to 9.5 billion people, all who want consumer goods. Only mining could deliver the required raw materials to scale. Cutifani warned that extraction and processing of minerals would come at a cost.

"In 1990, it took 2 tons of rock to extract 40 kilograms of copper," Cutifani said. "Now, to extract the same amount of copper will require 16 tons of rock to be processed."

The industry could work to alleviate some of the environmental harm it did, however, through technology and new methods of extraction. Anglo for instance was moving toward replacing diesel at its operations with hydrogen. He said the company would soon launch the world's largest hydrogen fuel cell truck at its Mogalakwena platinum group metals mine. "We believe mining can be a carbon neutral activity," he said.

Into Africa

Beyond South Africa, the Indaba gave plenty of attention to other regions on the continent. West Africa in particular, where burgeoning gold exploration and project development is thriving, to some extent eclipsed the host nation.

Gold remains the main attraction in West Africa, said Mark Bristow, CEO of Barrick Gold. "Gold is the leader because it doesn't need the same level of bulk infrastructure as other mining. West

Africa needs to invest in infrastructure such as rail and ports if the region wants to exploit other resources such as iron ore."

The wave of exploration and successful finds up until now were overshadowing southern Africa, the traditional destination of miners. "Ten years ago, I would never have put West Africa as a favorite," said David Awram, director of Sandstorm Gold, a financial investment firm that funds mining companies in exchange for royalties. "The region has, however, had a hard run. The risk factor has now gone up." Just five years ago, for instance, Burkina Faso was the hot play for gold explorers. Today it is wracked by factional infighting and plagued by militant groups, while suffering one of the fastest growing displacement crises in the world. Consequently, exploration has come to a halt and only the bravest would consider investing in the country.

Yet, the region as a whole continued to draw investor interest precisely because of the risk, said John Welborn, CEO of Resolute Mining. The company is building what it said will be the world's first fully automated mine at Syama in southern Mali. "People looking to invest in juniors are looking for alpha," Welborn said, referring to a class of investor who gets in early and has a high-risk, high reward approach. "West Africa has this, and now we need more juniors to make discoveries, then put themselves up for sale."

Cathleen Cox, head of exploration in Africa and Europe for Newmont Africa, concurred. "Yes, it is risky, but there's also a good payoff," Cox said. "That's why we are there."

One of the challenges though is that West Africa already has a long history of energy production. "It is difficult for governments to understand that hard rock mining is not the same as oil and gas," Welborn said. "Oil and gas are capital intensive, but once you have your discovery and wells in place, it's all profit. Mining requires an entirely different and ongoing capital structure."

How mining is done is not merely about governments and technology. Increasingly, the public is becoming aware of resource extraction in vulnerable locations such as the Democratic Republic of Congo (DRC).

"There's a lot of emphasis on how minerals are sourced in the country," said Kirsten Lori Hund, senior mining specialist at the World Bank. Concerns over child labor and unsafe work

Barrick CEO Mark Bristow fields questions from reporters on the show floor.

The mood was upbeat and business was brisk on the floor of the 2020 Mining Indaba exhibit area.

practices make headlines regularly. Even though formal mining firms are usually not involved in human rights violations, the public struggles to differentiate between artisanal operations and industrial extraction.

This meant broad consumer concerns were pushing for action on these fronts, even if humanitarian concerns were at times misguided. "At least 300,000 people in Katanga province depend on artisanal mining; just kicking them out isn't a solution," Hund said.

Ultimately though, mining companies had no choice but to operate in contentious locales. "The geology is there — that's why we go," said Cyrille Mutombo, DRC country manager for Barrick Gold.

Anglo American CEO Mark Cutifani discusses the challenges that South African miners face.

Artisanal mining is especially challenging for the companies operating there, especially as the diggers target the same ore body as the formal operations. Laws existed to keep the public out of the mine sites, but implementation was erratic. It was often left to the mines themselves to provide security to keep out pirate operators.

Business First

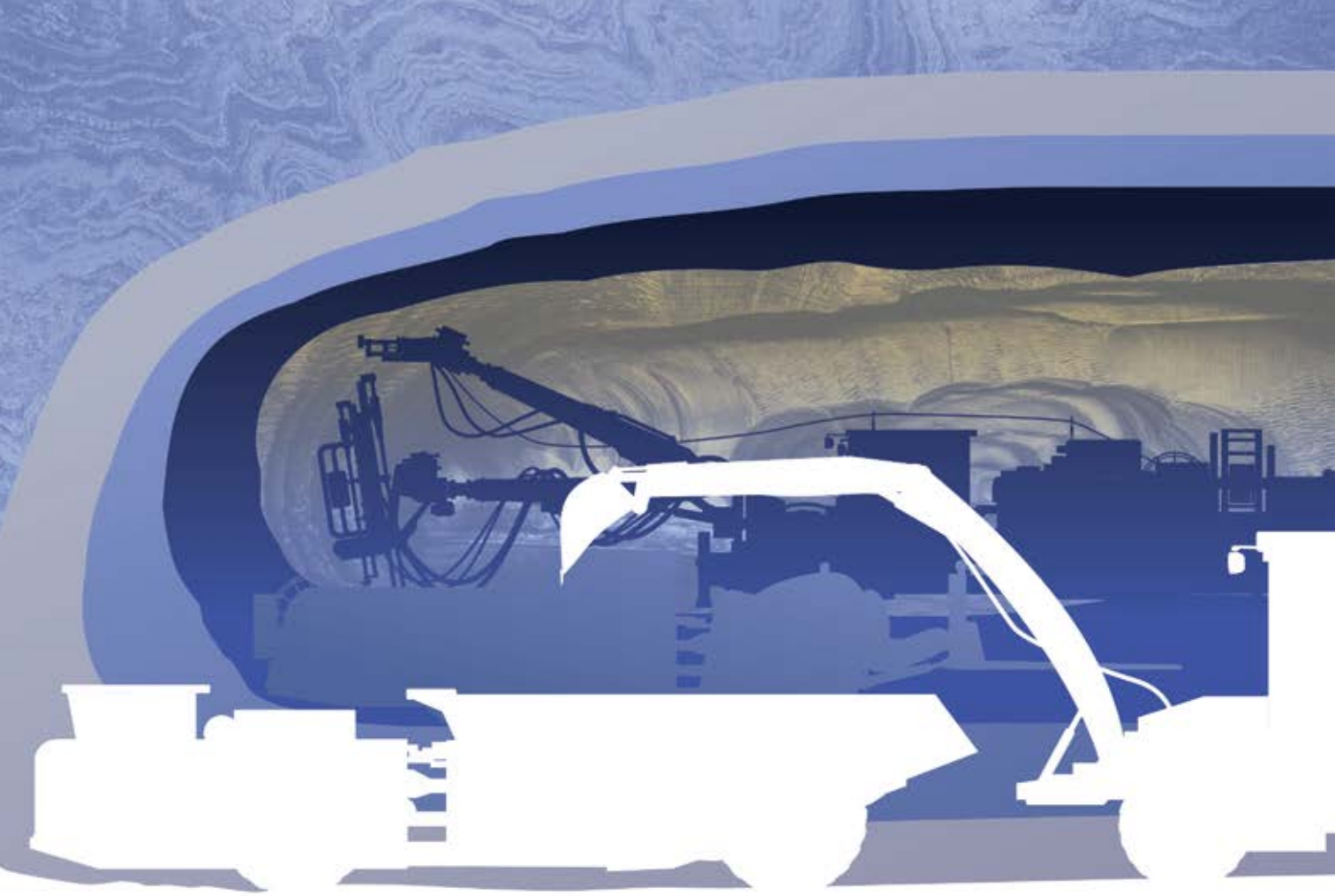
Louis Watum, who heads up Ivanhoe's DRC projects, said companies should accept the limits of what social changes they can bring. "Mining is never going to be the engine for change in the Congo," Watum said. "Only government fill this role."

Mines should stick to what they do best and pay their taxes. Governments in turn direct financial resources toward social development.

"Otherwise, what is left for the youth to do, but join militias or become artisanal miners?" Watum asked. "Without a formal economy, there's no jobs."

It was clear, however, that mines would find themselves increasingly squeezed by governments that wanted to increase returns from the country's natural resources. Which is why the first wave of mining codes in the post-colonial era are now being rewritten, said Willem Jacobs, COO for Africa and Middle East of Barrick Gold. "Mining codes that were written decades ago were intended to draw investment," Jacobs said. "Now, countries are looking at them and asking if they get the best deal out of it."

Mining companies operating across Africa will therefore have to adapt to a changing environment where social license becomes a dominant theme. As was spelled out over the weeklong Indaba, governments are under pressure to deliver more to their citizens, and for many countries, mining is the cash cow there for the taking. The coming decade will require astute leadership to navigate this issue.



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Abrasion-resistant Materials Protect High-wear Zones

New kit allows miners to prolong replacement times and increase availability

By Steve Fiscor, Editor-in-Chief

Mining is a constant battle that pits steel against rock. Whether it's the dipper on the shovel crowding the face or the tray of the haul truck receiving the load, the rock slowly grinds the steel surface. Ultimately, steel loses the battle in its sacrificial role and will need to be replaced, which can be kind of tricky depending on the location of the high-wear area.

Obviously, the ground engaging tools (GET) that surround the mouth of the dipper see the most action in the pit. Over the years, GET have improved as engineers and metallurgists sought to improve performance. In addition to the teeth, the "cheeks" of the dipper see a fair amount of wear as well. A failure in this area could lead to additional downtime for those that are unprepared.

More recently, the trays on the haul trucks have attracted attention. Readers might recall the rubber liners announced last year at bauma. This year, the steel industry is responding with solutions that extend equipment life and increase the payload by a few percentage points.

The problems, however, don't end in the pit. High wear areas can be found anywhere along the process stream from the dump point through the crushers. Finding those areas and applying properly engineered products could save an operation from prolonged hours of downtime.

This shovel bucket has been rebuilt with CQMS Razer's PACplate.

Australian Solutions Applied in Canada

Across commodities, CQMS Razer (CR) agrees, seeing a great need for wear protection on capital equipment exposed to high abrasion and high impact applications. This include chutes, crushers, truck bodies and buckets. The most varied use of its plate, block and wear products occurs on excavator buckets. Miners choose CR's PACplate solutions and Laminate wear buttons and bars for their buckets and equipment because it extends the service life of the floors and walls, protecting and reducing wear on the primary capital equipment. All of the CR's plate, block and wear solutions are specifically designed and strategically placed across the assets to ensure the life expectancy of equipment is met.

When it comes to wear, it's not one size fits all. CR, for example, offers custom-wear package options, based on the mine's needs and requirements. These can include CR PACplate products as well as high wearing consumables such as Laminite Chocky Bars, Buttons and Skid Bars for additional protection. With the recent acquisition of Berkeley Forge, CR customers now also have access to the field-proven Saberlock Wear Protection solutions including the Saberlock pads, which can be used as an entire wear package for buckets. Recently at an iron ore mine in Western Australia, CR commissioned a PACplate wear package solution on a haul truck tray. The result was an extended tray life that now matches the life of the truck itself. The data gathered on this solution showed a life expectancy of 13 years.

CR recently entered into a collaboration with an independent materials consultancy group based in Vancouver, Canada, to develop a solution for breaker screens at a site in Fort McMurray. This collaboration saw solutions created in Newcastle, Australia, and fitted on a site in Canada. The CR Laminite product was at the core of their breaker screens. Previously, the site had experienced on average 30-days-per-year downtime through maintenance and repairs due to their screens. After the installation of the Laminite breaker screens, the site was able to reduce the downtime to five days per year. The Laminite screens lasted 24 months without the need for any major repairs.

CQMS Razer has also helped customers reduce weight in their buckets from switching their wear packages from a thicker Q&T plate to a harder wearing, thinner overlay plate (PAC Plate), reducing their maintenance and downtime on site, while keeping the structural integrity of the bucket intact.

Combining its knowledge and industry experience with Berkeley Forge has delivered fantastic benefits for miners, according to CR. The engineers have worked together to improve the stabilization of the adapter design to reduce lip maintenance. A bucket repair shop recently confirmed that the CR-Berkeley lip required two weeks less maintenance work when compared to other similar products.

CR has been at the forefront of recent developments and digital technology integration in the mining industry including RazerOptics, which enables mine sites to measure wear rates of plate, block and wear on their equipment in real-time. The innovation highlights potential problem areas before they arise and reduces risks of underlying capital equipment being unprotected and damaged. With RazerOptics, operators can use real-time data to predict and schedule replacement of wear products during scheduled downtimes rather than waiting for it to fail and cause unscheduled shutdowns. This innovation has given a new lease of life on wear products and allows us to measure and quantify the value wear products bring to the solution.

Smarter, Lighter Solutions

Using Hardox wear plate and Strenx performance steel from SSAB, Australia's

Columbia Steel offers many of its replacement parts with Xtend Process high hardness carbide facing.

Taurus Mining Solutions has managed to lower the weight of its mining buckets, increasing the capacity of the buckets by up to 10% while still keeping their durability. "It's a good mix because our idea of coming up with innovative products was to have lighter and stronger parts that are hard-wearing," said Oliver Sabu, one of Taurus's owners.

The result is a mining bucket that weighs 1 ton less compared to the previous model. This helps the mines achieve four-pass loading in truck-shovel applications. It also means improved bucket life and decreased downtime. As an example, a mine site in northern Queensland, Australia, is currently using a bucket and tray combination that improves productivity by 10%-18%.

The Taurus buckets are mainly used for loading and transporting coal and overburden. The company's biggest bucket is for its Hitachi 5600 excavators, which have a 36-m^3 capacity. For the bucket's wearing areas, Taurus mainly uses Hardox 450 steel. The sheet sizes vary. Sidewalls are usually around the 25-mm range and the cheeks around 80 mm to 100 mm.

"Inside the bucket, we use Hardox wear plate on the floor and sidewalls," said Travis Van Rooy, fabrication and workshop leading hand at Taurus. "On the outside, we use them on the floor as well, and if it's required, on the external of sidewalls and cheeks."

Some Strenx performance steel is also used in the bucket, at high-stress points such as the hitch and the torque tube areas, to withstand the weight of the bucket and the operational forces of the machine.

The use of Hardox and Strenx steels also benefits Taurus's production process by improved fabrication times and less pre-heating.

"When designed right, and processed right, and all the parameters are maintained, the weldability of Hardox is excellent," Sabu said. "The strength of the material is without comparison, and it's always consistent, which are the reason we use SSAB steel in our buckets."

SSAB reported that a couple of mines are planning to rebuild haul truck bodies with a new, tailored Hardox truck bed liner kit in 2020. The kits consist of high-end, high-hardness Hardox grades, including Hardox 450, Hardox 500, Hardox 550 and Hardox 600. Using wear-resistant steel grades in the 550 and 600 Brinell hardness range, such as Hardox 550 and 600, would be a first for the mining business.

Using a harder, more consistent steel could reduce the weight of the trays by as much as 5,000 lb. In addition to increasing the payload by 2.5 tons, SSAB believes new kits will extend the service life by 30%-50% (1.5 years) compared to an AR450 liner kit.

Modified Replacement Parts

After extensive development and use in the field, Columbia Steel offers many of its replacement parts with Xtend Process high hardness carbide facing. The company said its field studies confirmed that Xtend bi-metallic parts offer significant advantages in many applications, which include:

- Increased total wear life;
- Reduction of localized wear;
- Longer maintenance of original profiles;
- Superior performance and production;
- Better metal utilization;
- Reduced downtime of changeouts; and
- Lower cost per ton of material processed.

When its H series martensitic high strength steels are used as the basis for the Xtend process, Columbia said the base casting alloys may range from 286 to 512 Brinell Hardness, with surface hardness up to 700 Brinell Hardness in the high-chromium white iron overlay.

When applied to Columbia L and R series of manganese steels, the base alloy will retain its toughness and ductility in the 200 Brinell Hardness area, while the Xtend overlay can be delivered at up to 575 Brinell Hardness with the potential to work harden to an even higher hardness. When the manganese steel is eventually exposed due to wear, it can work harden up to 500 Brinell Hardness depending on the application.

In controlled, every-other-tooth tests against other brands of dragline, dipper and loader teeth, Columbia Xtend points have demonstrated 50% to 100% longer wear life, yielding a net cost-effective advantage of 25% to 50%. Depending on the application, Xtend overlays may cover only a small area of the tooth point, or the entire tooth surface.

Graphene Wear Liners

After 12 weeks of full-scale trials, a new wear lining material, developed by First Graphene and its partner newGen Group, is demonstrating how graphene is transforming the properties of conventional

The images above show two mining shovel buckets: one lined with newGEN's PureGRAPH enhanced rubber — known as Armour-GRAPH — and the other with a standard rubber wear liner. The latter shows clear signs of wear at the rear of the bucket.

A technician installs FerroCer wear panels. Each panel has a set of abrasion-resistant ceramic inserts enclosed in a matrix of malleable steel.

rubber products. The graphene-enhanced rubber wear liners are being tested in mining shovel buckets at a major iron ore mine in Australia, where they are being used alongside standard wear lining materials to demonstrate the advantages of graphene additives.

The results after 12 weeks have been impressive, as Craig McGuckin, managing director of First Graphene, explained, "Although the trials are continuing, the initial results at the half-way stage indicate that there will be a considerable reduction in wear rates; we're estimating an improvement of at least 100%, which will result in major cost savings for mine operators."

The addition of graphene to elastomers can have a dramatic impact on their mechanical and physical properties. This can include, for example, an improvement of up to 500% in abrasion resistance, an increase in tensile strength by 40% and tear strength by around 50%. These enhancements can be achieved with just a 1% blend of graphene by volume, to the rubber compound.

Impact Wear Panels

In March 2019, India's Hindustan Zinc Ltd. (HZL) confirmed that its installation of FerroCer liners had completed about 16 months in operation and has withstood nearly 2.5 million mt of lead-zinc ore conveyed through the U-13 tripper chute after the primary crusher at HZL's Rampura Agucha mine. In other words, the mine had experienced precisely zero wear-panel related downtime in 16 months. That is a significant improvement on the previous 40-mm-thick manganese steel liners, which had a life span of only 23 to 25 days.

Before FLSmidth suggested FerroCer, one of the challenges HZL faced was the high wear in the material transfer chutes. The material handling system needed to be frequently shutdown so the worn-out liners could be replaced with new manganese steel liners, which weighed about 50 kg each. Because of the elevated location of several chutes, replacement of the liners required days of safety preparations to allow workers inside the chutes to handle the liners.

FLSmidth inspected the chutes at Rampura Agucha in June 2017 and recommended FerroCer wear panels to address the high wear issues in the material handling chutes. Each panel has a set of abrasion-resistant ceramic inserts enclosed in a matrix of malleable steel, which ensures only the top surface of the insert is exposed to material impact. The sides of the inserts are tapered within the matrix, keeping them in place and preventing material particles and fluids from damaging the panels.

"FerroCer has reduced maintenance time due to the much-longer replacement cycle, eliminated possible damage to the mother plate and spillage of material due to the highly abrasive nature of ore, and significantly reduced safety hazards," said Praveen Bhardwaj, assistant general manager (mechanical), for HZL Rampura Agucha. HZL now intends to install FerroCer impact wear panels in all the high impact wear locations.

Ceramic Hose Extends Wear Life

Weir Minerals recently launched its newest offering in the slurry transportation space: Linatex ceramic hose. The ceramic hose combines Linacure rubber with high-quality, 92% alumina ceramic tiles, providing a robust option for operators dealing with abrasive minerals.

Linatex ceramic hose is suitable for sites handling hard. "It's the quality of our rubber that really sets us apart from the competition, providing superior penetration of the tile layer and preventing tiles from dislodging during operation. To maximize resistance, Linatex ceramic hose also utilizes hexagonal tiles, which are more resistant to dislodgment and wear than traditional square patterns," said Rod Dawson, regional rubber applications manager for Weir Minerals Australia.

"For a new product to be able to fall under the Linatex brand, it must provide the very best in performance. We've put a lot of energy and resources into developing a hose that meets the demands facing miners around the world, and I can't wait for more customers to see the results for themselves."

Through exhaustive testing, the tile size has been optimized, ensuring they're large enough to withstand severe abrasion but small enough to reduce cracking.

An inside view of the Linatex ceramic hose shows an optimized tile pattern.

The tiles are available in 3-, 6- and 12-mm-thick configurations to suit a wide variety of applications, with half-tile options to ensure optimal resistance in high-wear areas around the flange.

Both Linacure 40 and Linacure 60 rubber can be used with the new ceramic lining, which can be deployed to reinforce the high-wear outer edge of a bend. The Linatex ceramic hose also supports the Linatex Wear Indicator System, which can be connected wired or wirelessly, where it can transmit hose data up to 1.5 km by radio.

"We've been making hoses for 40 years. Over that time, the Linatex range of hoses has grown to include a variety of solutions that meet the most demanding slurry transport applications. Linatex ceramic hose complements our industry-leading range of slurry hose liners, such as Linatex, Linagard OSR and bromobutyl," said Mark Doyle, global product manager-rubber, spool and hose for Weir Minerals.

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Upgraded Haulers Sell in OZ, Elsewhere

The latest reported advances speak to improving cycle times, better battery technologies, and creating a safer work environment

By Jesse Morton, Technical Writer

An LHD dumps its load in a new Sandvik TH663i truck.

Being a MINExpo year, disruption is in the cards for the underground haulage equipment space. Until the event in Las Vegas this fall, suppliers are keeping their hands close to their vest. Company insiders told *E&MJ* Sandvik is gaining market share in Australia, Aramine is perfecting its miniLoader, and Komatsu is fielding interest in a couple powerful Joy loaders.

Insiders at companies with impending big releases provided only summaries. Artisan Vehicle Systems, now a subsidiary of Sandvik, will announce a new machine at MINExpo. RDH-Scharf reported it will release a new machine later this spring.

In every case, the technological advances inherent to the machines making the news center on improving production rates, better battery technology, and meaningful contributions to work site safety. A summary of the latest news from the top suppliers illustrates.

New Transmissions, Better Cycle Time

Sandvik reported the first orders for TH551i and TH663i trucks that come standard with the new transmissions announced in December were placed by customers in Australia. "Based on the feedback we received at the Digitalization in Mining event in Brisbane, our customers are really looking forward to these trucks," Pia Sundberg, product line manager, trucks, Sandvik Mining and Rock Technology, said. "We are expecting a global fleet within a year."

The new transmissions are the latest updates to the trucks, and are the result of years of research and development driven largely by customer feedback. "They wanted to reduce the costs of ownership, increase uptime and improve operator comfort," Sundberg said.

Sandvik and a supplier put "thousands of hours" into the development project, which culminated with trials at mine sites in Finland, Ireland and Australia, she said. "Different duty cycles were tested, both driving the truck uphill fully loaded, which represents the typical cycle, but also driving fully loaded downhill, which is used in some mines where backfilling is done."

Company literature states the main benefits of the new eight-gear transmission include improved truck performance, availability, and transmission lifetime.

It improves truck performance by enabling maximum truck speed and efficiency in varying ramps and with differing loads. "The fully proportional, more powerful hydraulic retarder operates simultaneously with the engine brake, enabling easier downhill control and higher speed," Sandvik reported. "Further lock-up to lock-up gear shifting enables quick and smooth shifting and keeps speed better while driving uphill."

Sundberg said one possible result is shorter cycle times.

With a robust, simple and application-specific design, the new transmissions offer improved reliability over the old ones, the company reported. "Compared to the previous six-gear model, the transmission lifetime is expected to be longer, and less gearbox changeouts are required during the truck lifetime, reducing costs."

Improved reliability can translate to increased availability, Sundberg said.

The transmission control system features improved self-diagnostics capabilities that are fully integrated into the Sandvik Intelligent Control System, "enabling easy and fast trouble shooting without external diagnostic tools or laptops," Sandvik reported.

Sundberg said such is a "fine example" of how Sandvik seeks to marry the "robust and reliable" to "today's technology" to ensure dependability. "Safer, stronger, smarter, as we say."

In trials, operators noted the easy operation and extremely smooth gear shifting, she said.

"It makes the ride much more comfortable," Sundberg said. "If we add this new extra value to the already ergonomic TH551i and TH663i cabin, what we like to call the industry-leading cabin, it is really nice for the operator."

The smooth ride can increase operator wellbeing, she said. "We have got really positive feedback specifically on how smooth the new transmission is, and how comfortable our TH551i and TH663i cabins are," she added.

The new transmissions speak to the needs of mines running deeper and need-

ing to move increasing amounts of rock. "As ore bodies close to the surface are becoming depleted, mining is going deeper and getting hotter, and truck haulage to the surface needs to be more efficient," Sundberg said. "Long ramp drives, be it either up the ramp or down the ramp, require a lot from the technology."

Also, the longer life of the new transmissions aligns with sustainability efforts at many mines, Sundberg said. "Longer component lifetimes mean that less component changeouts are required, and also the truck stand-still time is reduced," she said. "This again can be turned to lower costs per metric ton (mt) hauled, linking nicely the sustainability and cost benefits."

The new transmissions can be bought separately and installed on existing trucks. "The transmission change is typically done at the same time as the midlife repair, which is around 12,000 to 14,000 hours, depending on the equipment usage and the exact components," Sundberg said. "The transmission conversion kits will be made available in mid-2020."

To get the full benefits, the axles and coolers should be upgraded at the same time that the transmission is replaced.

The new cooler performance has been optimized to match specifically with the new transmission, Sundberg said. "The coolers are made of aluminum, are easy to clean and have simpler design, helping to reduce total cost of ownership."

Since their release shortly after MINExpo 2012, both trucks have been upgraded a couple of times.

Announced in Las Vegas and released in 2013 in Europe, the TH663 was upgraded in 2015 with a sintered metal diesel particulate filter, which reduces diesel particulate emissions by 99% and can be cleaned with a steam cleaner. The following year it was offered with a 565-kW Volvo Penta D16 engine, which offered longer life and lower fuel consumption, and required fewer consumables.

"We have continuously worked to improve the engine and powertrain technology in our trucks," Sundberg said.

Along with the TH551, which was originally released in 2013 with a Tier 4 engine, in 2017 the TH663 was offered AutoMine-ready.

"With AutoMine Trucking, the TH551i and TH663i can be used for autonomous haulage for both transfer level and decline ramp applications," Sundberg said. "When used on automation, the trucks can be operated from the surface during blast clearance and shift changes, increasing safety, truck utilization and productivity."

The evolution of both trucks was steered by Sandvik to ensure measurable gains in offered productivity and efficiency, she said. "The trucks are rugged and made for heavy-duty use and demanding ramp applications. And they are smart, too," Sundberg said. "Our Sandvik Intelligent Control System allows us to build impressive solutions for digitalization and connectivity needs."

Customer feedback suggested the trucks offer optimal operator comfort. "The ride is smooth thanks to the front frame suspension; there is air conditioning, noise and vibration reduction, adjustment possibilities in the seat and more," Sundberg said. "I personally believe the best feedback for me was when I heard that 'the operators just loved it,' or, from another mine, 'it was the operator's No. 1 choice.' Operator safety and comfort is a top priority at Sandvik."

miniLoader Adds Optionality

Aramine reported a mobile charging station for the miniLoader L140B will be released later this year. The station is equipped with a hydraulic crane for streamlined battery changeouts for the LHD, and for moving the battery nodules. Connected to a mine's electrical network, the station can be easily piloted by remote control, the company reported.

Arnaud Paul, sales director at Aramine, told *E&MJ* that the new system will make changeouts easier and safer, and thus help improve productivity at an operation.

The crane was developed based on demand and feedback from customers, Marc Melkonian, president, Aramine, said. "The mobile charging station solves all customer concerns about the autonomy and ease of replacing batteries on the LHD," he said.

The mobile station will provide charging and changeout scenario optionality beyond the currently available methods.

One current method is to simply plug the loader in and let it sit.

The L140B was "entirely designed and developed around a fully integrated battery system," Sylvain Reynier, research and development director, Aramine, said. "Our R&D department worked hard to reorganize all components inside the machine and select an extremely reliable and safe connecting system."

This allows the machine to, whenever needed, be plugged into a wall socket anywhere in the mine. "The charging system doesn't need a big electrical installation as the power needed is about 7 kVA, compared to the 45 kVA needed for a cable-tethered electrical machine," Reynier said.

Aramine's mobile charging station for the miniLoader L140B is equipped with a hydraulic crane.

"The regeneration system will also recharge batteries when the loader goes downhill and when it brakes," he said.

A full recharge from a wall socket could take from two to five hours. "The autonomy is approximately three to four hours depending on application and usage, which allows mucking three to four faces before recharging," Melkonian said.

Another current method is the optional Quick Replacement System (QRS). For that, batteries are charged external to the machine and then swapped out as needed. Such "allows running the machine full time without immobilization during charging time," Aramine reported. "The system is ultra-fast and smart with a W-type aligning system and an auto-locking device." The device ensures optimal safety, the company reported.

"The R&D Department ran a lot of tests to find the perfect angle of adherence in the W-type system and to find the faultless self-aligning mechanism," Melkonian said. One result is "QRS features a quick, reliable and compact battery module with an auto-lock system without increasing the length of the machine."

To adopt QRS, the mine must have a battery change area and crane. "The battery change is stress-free, does not require a lot of equipment, and can be done quickly," Reynier said. "Indeed, it takes about 10 to 15 minutes and effectively allows unlimited operation of the machine."

QRS is ideal for a miner seeking to operate only one machine. The system is available for adoption as an aftermarket kit.

QRS is the latest innovation for a loader model that has evolved over the years apace with advances in emission-reduction, sustainability, and connectivity solutions, all of which contribute to improved worksite conditions and safety.

"We all know that one of the biggest issues in underground mining is the air pollution," said Sophie Layer, marketing and communications director, Aramine.

Previous generations of the loader were designed to address this issue. Roughly a decade ago, Aramine launched a diesel miniLoader with an exhaust purifier. Next, it released a cable-tethered electric unit. "That helped reduce mine ventilation issues and related costs," Layer said.

At the time, battery technology was prohibitively expensive and relatively unreliable. Battery technology advances over the years enabled the company to design the L140B, which spent two years in research and development.

Released in 2016, the loader comes standard with a LiFe PO4 (lithium iron phosphate) battery, a CAN-bus-type electrical system for diagnostics and programming, and "intuitive and ergonomic controls," the company reported.

"The lithium iron phosphate battery is the safest chemical composition for an underground mining battery vehicle," Reynier said.

Paul said the loaders are field proven. "With 20 units in operation, many with 10,000 hours on them, and with our rental equipment for tunneling applications, we can safely validate the efficiency and the reliability of our solution," he said.

For example, field results prove the loader effectively solved the air pollution issues related to the diesel predecessor model, Melkonian said. "This brings real comfort for the driver and the people working around the machine," he said.

By "ensuring zero CO_2 and zero NOx emissions," it nixes some stubborn ventilation and safety issues and costs, Melkonian said. "By ensuring they can breathe safely at work, it brings miners peace of mind."

Plus, it "is easier to maintain compared to the diesel model," he said. "You have no combustion engine maintenance or air filter maintenance."

Also gone is the diesel fuel tank and filters, as well as the hydrostatic transmission. Instead, there is an integrated electrical transmission. "This eases the maintenance and considerably reduces the downtime," Melkonian said.

Compared to the cable-tethered electric model, the battery-powered unit offers greater freedom and safety by eliminating cable management protocol, he said. "The electrical installation needed to charge the battery is far less than that needed to drive the electric machine with cable."

The L140B has a very low heat signature and, compared to predecessor units, is quieter, "which is crucial in an environment as constraining as that of a mine," Layer said.

Equally crucial, the L140B has the same or greater breakout force than the diesel competition, Reynier said.

"People tend to think that battery-powered machines are less powerful than diesel ones," he said. "This is totally untrue. Aramine battery-powered machines use an electric transmission that allows adjusting the torque depending on the mine conditions to give just enough power while preventing tire spinning."

With 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^3 bucket and can move fully loaded at up to 7 km/h.

The loader is described as ideal for narrow vein mines. From tip to tip, it is 5.3 m long, 2 m high and 1 m wide. Company literature describes it as "extremely narrow."

It was developed for miners "who do not want to oversize their galleries," Melkonian said. It is also for those who want to "increase productivity and reduce dilution by using small and medium gallery sections."

The optionality offered by the new mobile charging system aligns with the company mission to be at the forefront of technological innovation that contributes to sustainable mining, Layer said.

The Joy SR Hybrid LHD's control algorithms optimize efficiencies in applying torque to the ground, controlling wheel slip, and reduces fuel burn.

On that mission, the company plans to release a new battery-powered machine in late 2020. More information on that, she said, will be forthcoming.

Speedy Joy LHDs See Demand

Komatsu reported the Joy 18HD and 22HD hybrid loaders are gaining market share thanks in part to cost savings made possible by two groundbreaking diesel-electric drive technologies.

Bill Maki, product manager for the loaders, told *E&MJ* the loaders leverage Switched Reluctance technology (SR) and the Kinetic Energy Storage System (KESS), which sync to cut fuel burn by up to 30%. The combo "also results in fewer diesel emissions, making for a cleaner environment."

While the loaders are operating, the diesel engine runs at a constant speed for optimal performance. An SR generator mounted to the engine converts diesel to electricity, which powers the wheel motors.

When the operator eases off the accelerator, the demand for diesel stops. During deceleration, there is no need for the operator to use mechanical brakes as the electric drives inherent dynamic braking slows the machine.

And as the machine slows, the wheel motors act as power generators. The energy captured is stored by KESS.

When the loader is finished coasting, braking, digging or dumping, and when the operator "presses the pedal again, KESS supplies stored energy while the SR engine simultaneously supplies diesel energy," Maki said. "The result is the equivalent of a 375-hp (280-kW) engine being bolstered by an additional 550 hp (410 kW)."

SR has been used for surface mining wheel loaders designed and built at Joy's Longview, Texas, facility. Customer demand prompted the company to build the tech into LHDs.

LHD "speeds were much higher than they were with the surface loaders, and significant energy was available that we simply lost to heat," Maki said. "Komatsu developed the KESS to capture and reuse this energy."

The combo basically boosts acceleration without any additional fuel burn.

"The SR Hybrid LHD is suitable to all applications," Maki said. "The biggest benefits occur when higher speeds are achieved."

Related benefits include improved work cycle time, reduced operating cost, increased reliability, and reduced engine size, Komatsu reported.

"In current installations, Komatsu is seeing 15% to 20% less fuel consumption than its similar-sized competitors," Maki said.

The loaders feature "advanced SR control algorithms to optimize efficiencies in applying torque to the ground, controlling wheel slip to minimize tire wear, and significantly reduce fuel burn," he said. "We also have incorporated decades of mining duty traction motor design knowledge to ensure our motor and generator designs are rugged and reliable and up to the task of achieving long life in the tough mining environment."

The 18HD is 11.6 m long, 3.2 m wide, and 3 m high, with a 7.3-m outside turning radius. With a 10.6-liter engine, it has a bucket capacity of 9.2 m^3, tilt breakout force of 349 kN, and a payload capacity of 18,000 kg.

The 22HD is 11.7 m long, 3.7 m wide, and 3 m high, with a 7.5-m outside turning radius. With a 12.8-liter engine, it has a bucket capacity of 11.2 m^3, tilt breakout force of 347 kN, and a payload capacity of 22,000 kg.

Both LHDs come with a U.S. Tier IV Final (EU Stage IV Final) engine, a ROPS/FOPS-certified cabin and a simple control suite featuring an "intuitive human-to-machine interface," Komatsu reported.

Both have the LINCS II (CAN-based) vehicle control system, which enables high-speed monitoring and advanced diagnostics, including integrated data capture and storage, the company reported. The system can provide real-time load data, cycle times, production rates and an operational profile. It can connect to a radio dispatch system for remote-monitoring purposes.

Maki said the control system monitors every aspect of the machine and protects it from potential problems. "The control system also provides feedback to the operator and technician to quickly diagnose any issue that may arise," Maki said.

Which should be comparatively few, as the electric drive system has relatively fewer mechanical components, he said.

Offering significantly decreased diesel costs per ton moved, the loaders are fated to find a sizeable niche in the market, Maki said.

"It's continued innovations like these that are powering progress for our customers worldwide and moving us forward," he said. "Together, we will continue to revolutionize mining for a sustainable future."

Battery-powered Hauler Tours Oz

Artisan Vehicle Systems (AVS) reported a battery-powered Z50 haul truck was recently showcased at a handful of mines in Australia. The tour launched in December in Queensland and included stops in New South Wales, South Australia and Western Australia.

Each stop involved demonstrations, training, and education on the benefits of battery-powered haulage machines underground, said Joe Giraldi, business development manager, AVS, Sandvik Mining and Rock Technology.

"The tour has been a true success and is creating a lot of buzz," he said. "It will bring additional awareness to the fact that this technology is not only available today, but that it has been proven for almost a decade in the field. We deployed our first battery-equipped unit in 2011, and now have over 400,000 real production hours on our systems."

Currently there are six Z50s in the field with orders pending.

Announced in 2018, the unit was the world's first 40-mt battery-powered underground truck. It was readily adopted by Kirkland Lake Gold's Macassa mine in Ontario.

In 2020, the Z50 was launched at the Sandvik Digitization Event in Brisbane, Australia. Since then, it was adopted by a mine in Nevada, Giraldi said.

At 35 ft long and 11 ft wide, the Z50 comes with both a primary and a tramming (lithium iron phosphate) battery, offers peak torque of roughly 6,200 foot-pounds and has a 50-mt-capacity bed. Company literature reports the unit "generates twice the peak horsepower" with a fraction of the heat of the diesel equivalent.

"Because these are zero diesel emission vehicles, we are not horsepower restrained," Giraldi said. "Therefore, we are able to exceed the power metrics across the board for a diesel equivalent."

Spent batteries on the unit can be swapped out with charged ones in roughly six minutes.

Giraldi told *E&MJ* AVS will release its fourth Generation 3 model at MINExpo. Details, he said, will be forthcoming.

Reducing Mine Water and Waste Through Preconcentration

Preconcentration offers miners the opportunity to address some of the operational, environmental and CSR-based challenges that lie ahead

By Carly Leonida, European Editor

Collaboration is vital in advancing the development and uptake of preconcentration technologies. Here, CEEC members are pictured at the 2019 workshop in Kalgoorlie. (Photo: CEEC)

Preconcentration, as a concept, is not new. It is a commonly used process in base metals, coal, iron ore and phosphate operations, and selective ore sorting in the form of hand picking has been employed since the birth of mining to optimize processing.

At a commercial scale, processes such as gravity concentration, heavy media separation and ore sorting have been used, where cost effective, since the 1970s. However, there is renewed interest in preconcentration due to technological advances and shifts in the monetary and social costs of two key inputs to ore processing — energy and water. In line with this, there has been an increase in the number of patents registered for preconcentration technologies, particularly those targeted at reducing water consumption and improving tailings deposition as a result of benefication of valuable minerals at coarser particle sizes.

Preconcentration is vital to the future of the mining industry as it has the potential to lower the cost and risk associated with mineral transportation, processing and tailings disposal. It also cuts energy and water use and minimizes the environmental footprint of operations.

Reducing the amount of energy required for comminution by discarding waste material prior to grinding lowers greenhouse gas emissions and will be key in helping many mining companies realize their long-term goal of carbon neutrality. Lowering the quantity of fine material sent to tailings also reduces net water consumption and lessens the impact of operations on local communities, which is especially important in arid environments and remote areas, for example in high altitude South American locations.

"Preconcentration can potentially offer a higher rate of return, enabling new projects with low 'in-ground' grade to secure funding," said Greg Lane, director at the Coalition for Energy-Efficient Comminution (CEEC). "For existing projects, there are opportunities to retrofit in order to improve processing efficiency. In some cases, resource recovery can increase if the processing of previously sub-economic resource is enabled."

The CEEC is an independent organization dedicated to driving advances in mineral processing.

"Our focus is on highlighting existing and emerging technologies and processes that are practical, reduce energy and/or water consumption, and have potential for a favorable economic outcome," CEO Alison Keogh said. "Operators, researchers and collaborative groups are working with mining suppliers, services and software groups to develop and trial advanced preconcentration technologies. The rate of uptake will depend on the success of these technologies in the field."

In 2019, the CEEC Medal for Technical Research was awarded to Laureate Professor Graeme Jameson and Dr. Cagri Emer for *Coarse Chalcopyrite Recovery in a Universal Froth Flotation Machine*. The paper documents a novel flotation device, the NovaCell (more on this later), which features a fluidized bed for coarse particle collection and a high shear aeration zone for ultra-fines separation.

CEEC Director Joe Pease explained: "Coarse flotation is an important development that links with and amplifies the economic impact of preconcentration. For example, HydroFloat technology is being trialed to evaluate the possibility of improving metals recovery at Rio Tinto's Kennecott Copper operation in Utah, U.S., and to improve copper and gold recovery from tailings at Newcrest's Cadia Valley operations in New South Wales, Australia. HydroFloat developer, Eriez, is also sponsoring The University of Queensland's Julius Kruttschnitt Mineral Research Centre (JKMRC) in the formation of a Collaborative Consortium for Coarse Particle Processing Research."

The development of sophisticated, precise sensors is opening up opportunities for preconcentration in commodities such as gold and base metal sulfides using time tested techniques such as dense media separation, gravity concentration and in bulk

sorting — the latter is already being used in a semi-commercial application for sulfide ores at several sites, and there are a number of others implementing testing. CRC ORE is currently funding sensor development and demonstrations with groups including CSIRO, the University of Adelaide and the National Research Council in Canada.

Additionally, data science and integrated modelling approaches are enabling the assessment of which orebodies are amenable to upgrades using preconcentration and helping to quantify the benefits and impact of preconcentration.

"These types of collaboration help produce data that supports wider awareness and adoption of new preconcentration technologies," Lane added.

Engineering Grade

CRC ORE is a Cooperative Research Centre focused on Optimizing Resource Extraction for the mining sector. It is jointly funded by participants including mining and METS companies, research organizations and the Australian government, and is an independent technology broker and facilitator.

"We are working to minimize the impact of declining grades and improve the productivity, energy and water signatures of mining operations," CEO Ben Adair, explained. "We do this by enabling mining operations to reduce the amount of waste they process and identify increases in overall value. Operators can decrease their use of energy and water, leading to increased sustainability, greater profitability and a smaller environmental footprint."

Preconcentration is core to the work that CRC ORE is doing. Grade Engineering, one of its signature innovations, employs a combination of techniques to reject low-value material early in the mining process.

Adair said, "Preconcentration is important to the future of the mining industry as it enables operations to work smarter by processing less barren waste and instead focus on maximizing the processing of target minerals. This is particularly important as deposits are becoming increasingly difficult to mine, which in turn drives up capital expenditure. Any improvements that can be made to optimize resource extraction are extremely beneficial.

"Collaboration across our participant cohorts has been critical to the development of Grade Engineering. It is only through collaboration that we have been able to design, test and assess improvements that have resulted in preconcentration outcomes at sites."

Adding Value at San Cristóbal

A successful full-scale production trial of Grade Engineering was recently demonstrated at Sumitomo Corp.'s Minera San Cristóbal (MSC) operation in Bolivia.

The CRC ORE and MSC teams conducted site studies and analysis in 2017 to determine the level of opportunity available and a full-scale production trial using a Metso Lokotrack ST2.8 mobile screening plant began in 2018.

The trial focused on upgrading mineralized waste from the pit to determine if Grade Engineering could produce a new economic stream of valuable material that could then be combined with ROM feed through to the concentrator to produce a positive net smelter return.

Adair said the results are impressive: "The production trial resulted in a 75% rejection of barren material from sub-economic mineralized waste," he said. "The 'accepts' fraction, representing 25% of the mass has been upgraded to more than twice the grade of the traditional feed stock."

CRC ORE said this result is of significance to the operation, with work to date extending the life of mine by at least two years. Additional work is now being undertaken that will further extend this time considerably.

"The Minera San Cristóbal engagement has been an outstanding success where the intrinsic culture of the site has facilitated the rapid testing and deployment of the technologies," Adair said.

"We currently are engaged at several site trials nationally and internationally on behalf of our participants. This includes a number of Western Australian gold and base metal operations. These trials are focused on a number of gangue rejection techniques and are showing highly promising results for those involved."

High Voltage Pulse Enables Preconcentration

High Voltage Pulse (HVP) is a novel technology being developed at The University of Queensland's Sustainable Minerals Institute (SMI) with the potential to transform ore preconcentration in the mining industry.

"HVP applies electrical energy directly to ore fragments, which has a tendency to break mineral-enriched ore," explained Professor Frank Shi, technical director for the newly established High Voltage Pulse Collaborative Research Program. "This means that, by breaking fragments down into different sizes, the technology could enable ore preconcentration through size separation."

Research conducted at SMI's JKMRC has discovered that HVP energy is not distributed evenly to the particles in the processing zone. When subjected to nanosecond-short pulses, particles with high conductivity/permittivity minerals tend to induce a breakdown channel passing preferentially through the body of the particle, while the barren rock does not.

After this selective breakage, fragments from the mineral-enriched ore particles can fall through different sized holes in a screen below, but the larger barren rock does not. This produces a low-grade oversize stream and a high-grade undersize stream.

"The potential of HVP for preconcentration can be demonstrated using the laboratory results derived from gold ore with a feed size of 26.5-37.5 mm," Shi said. "It indicates the feed, after being treated by HVP, can split into two streams at a cut size of 19 mm with gold grades of 1 ppm and 0.3 ppm, respectively.

"The process recovers 90% of gold in the high-grade stream and rejects 23% of the feed into the low-grade stream. The HVP treatment of this feed size requires specific energy of 2.8 kWh/mt. If the low-grade stream can be rejected as a coarse tailings without the need to be further ground to micron size, the economic benefit is significant."

A conceptual sketch of the award winning NovaCell flotation cell. (Photo: Graeme Jameson)

Cracks or micro-cracks have also been found to be generated in the high-grade fragments, while the particles in the low-grade stream appear more competent. This means that the high-grade product after HVP-enabled preconcentration has been selectively pre-weakened, resulting in further energy savings in downstream comminution.

"Because preconcentration is enabled by HVP selective breakage, which is strongly related to particle grade rather than inferred from particle surface properties used in other types of ore preconcentration technology, the HVP-enabled technology can sort the feed ore particles more accurately and reject a larger amount of coarse barren rock," Shi said.

The Next Steps for HVP

Potential applications of the HVP preconcentration technology include the rejection of barren pebbles from grinding mill pebble streams to increase overall capacity of the existing equipment; coarse waste rejection at mine sites to reduce haulage; combined advantages of pre-weakening and preconcentration of mill feed; new engineering design of multigrade comminution and recovery circuits; and upgrading ore to allow the mined cut-off grade to be reduced, which has a huge impact on the total viable orebody.

Shi said that promising results have been achieved in laboratory-scale batch tests.

"Additional barriers remain for the industrial uptake of this technology, including the need to scale up the process and equipment, and demonstrate safe and effective performance in a continuous operation," he said. "In addition, knowledge gaps around ore composition and amenability to HVP, and the optimum means of incorporating HVP to achieve maximum benefits, into mineral processing circuits exist."

To address these gaps and sufficiently de-risk HVP in a pilot-scale continuous operation, further research is necessary. After detailed discussions with mining companies, the HVP Collaborative Research Program recently commenced at The University of Queensland, with major sponsorships from Newcrest Technology, Newmont USA and SMI's Complex Orebodies Program.

JKMRC and the Huazhong University of Science and Technology in China are research providers for the program.

"The aim is to collaborate with industry to address the challenges surrounding HVP comminution with the objective of delivering the next generation of comminution technology capable of resulting in more sustainable mining industry," Shi concluded.

ARC Centre of Excellence Opens its Doors

The new ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals (CoE) at the University of Newcastle is working with seven other Australian universities to develop transformational technologies that enable a competitive and sustainable future for Australia's minerals industry.

As preconcentration can help to address mine footprint, energy and water use and boost resources recovery — some of the most pressing challenges that mines face, not just in Australia, but globally — it is fundamental to many of the CoE's projects.

Centre Director, Laureate Professor Kevin Galvin, explained how preconcentration could impact flowsheets in the next 10-20 years, and some of the CoE's current projects.

"Preconcentration will increasingly be used in greenfield sites where there is the opportunity to deliver this kind of innovation," he said. "In the future, preconcentration will be project specific, requiring more planning, more ore characterization and improved models, especially for the newer technologies. The reduction in the environmental footprint will be central to the license to operate."

Galvin currently leads the CoE's novel system hydrodynamics project — the center's first program — along with Laureate Professor Graeme Jameson and Professor Bill Skinner. It is concerned with transforming the hydrodynamics of process systems at a macroscopic scale.

"We have a pipeline of technologies at different readiness levels," Galvin explained. "The work is supported by two other programs that focus on the physical chemistry of foams and emulsions at the meso-scale to effect separations, and the molecular scale in the development of new, more selective reagents."

Program one will investigate:

1. Characterization of ores using a broad range of techniques including X-ray CT scanning;
2. Different mechanisms in coarse particle separation;
3. Ultrafast methods of processing, utilizing hydrophobic interactions; and
4. Advances in solid-liquid separation.

"Our focus on coarse particle separations recognizes the need to promote hydrodynamic quiescence for supporting coarse particle flotation," Galvin said. "Multiple fluidized bed technologies will be investigated, and methods of gravity separation including a novel dry separation mechanism will also be investigated."

The Reflux Classifier

Galvin also developed the Reflux Classifier, a device used to achieve gravity separation of fine particles. An R&D agreement was reached between the University of Newcastle and Ludowici, and the technology is now being developed by FLSmidth. The machine uses a combination of a fluidized bed and inclined channels along with a laminar shear mechanism to drive density-based separations.

Early research into the Reflux Classifier was supported by ACARP and also the Australian Research Council to solve a previously intractable problem in separating fine metallurgical coal. In more recent years the technology has been applied across a range of commodities in more than 150 installations around the world. Galvin is currently working with FLSmidth on related technologies including the RCAir to achieve coarse particle flotation, and is due to commence a full-scale trial of an inverted device, the Reflux Flotation Cell, a new flotation technology offering an order of magnitude reduction in the cell footprint with extreme levels of cleaning.

For Galvin, industry collaboration is essential to developing approaches to preconcentration.

"Given the significant pressures on the sector to lower its environmental footprint, and reduce energy and water consumption, early adoption is needed. It is also important to connect capability in characterization, fundamental modelling, experimental validation, and end-user application to facilitate this development," he said.

"The entire industry is under a common pressure to minimize its environmental footprint. If the industry adopted a 'safety share' philosophy, then it would be possible to communicate the impact of measures being taken by the different operations around the world.

"This would promote and encourage innovation across the industry. Every feed scenario is different, but there are common elements that could be used in certain applications."

NovaCell — A New Way With Flotation

As mentioned earlier, Jameson, laureate professor at the University of Newcastle, and his colleague, Emer, received the 2019 CEEC Medal.

The duo showed that the use of the NovaCell in a typical base-metal concentrator could reduce the operating costs by 40%. In addition, because waste gangue from the NovaCell is so coarse, it is easier to de-water, allowing more process water to be returned to the mill. Coarse particles also create tailings dams that are more stable than those produced by older technologies.

Jameson described the NovaCell and the significance of fluidized bed technology.

"Undoubtedly the most interesting development in the field of flotation is the introduction of fluidized bed flotation," he said. "A major problem with conventional mineral processing is the generation of large amounts of very fine ore suspended in water. Ore usually contains only a very small quantity of valuable material and all the rest goes to waste.

"Currently, ore that enters the concentrator is finely ground, because of the limitations of conventional flotation machines. There is an urgent need for a new flotation machine that can separate valuable materials from waste at an early stage, eliminating the need for very fine grinding."

The NovaCell can be applied to a wide size range of particles including those beyond the size processed using conventional cells. It incorporates the quiescent conditions of a fluidized bed to ensure coarse particles remain attached to bubbles. The ore is ground to a top size that is much coarser than traditional flotation machines can handle (the top size is a function of the ore characteristics and could be as large as 5 mm). Using a combination of a high-shear aerator to capture the finest particles, and a fluidized bed to capture the coarse particles, high recoveries can be obtained across the whole size range.

"The flotation product at this stage may represent only 10-20 % of the feed material," Jameson said. "It is re-ground to liberate the values to give a high-grade product, and the gangue is discharged to waste at a relatively coarse size."

The NovaCell is now being commercialized with industry partners and the design for a 250-mt/h unit for a copper concentrator is currently being finalized.

One application for the Reflux Classifier is in the recovery of minerals from tailings as shown in this image of an RC3000 applied to recover high-grade ultrafine iron ore. (Photo: Kevin Galvin)

Teck Opts for Sorting at Highland Valley

Teck Resources has been involved with modern sensor-based preconcentration since 2010, with initial efforts centered around understanding the available technology, equipment scale and value driving potential. This work has now advanced into select lab, field and commercial testing at a variety of base metal projects and operations.

"Currently, we are using shovel-based ore sorting in full-scale operation at Highland Valley Copper in British Columbia, and we have advanced trials under way at two of our base metal sites," said Bryan Rairdan, technical director for processing at Teck Resources.

"We selected these locations as the technology was amenable to measuring the grades of these deposits, as well as a general understanding of the deposit heterogeneity that was available to leverage. We initially focused on shovel-based technology due to the fact that the sensing occurs as close as possible to the in-situ ore, preserving heterogeneity, as well as the minimal infrastructure required to integrate ore sorting into the operation."

The company's primary focus is on employing X-ray fluorescence (XRF) based technologies to reject gangue early in the mining process. Rairdan said that collaboration has been vital to Teck's efforts.

"We have partnered with some early-stage technology providers to help them advance their commercially available equipment," he said. "We are also working alongside industry partners to develop emerging sensor technologies that are advancing towards commercial deployment.

"Additionally, we are working with engineering firms to determine some of the ancillary equipment requirements and costs required to allow the sorting technologies to advance. The majority of our in-house efforts have been focused around deposit heterogeneity definition. Having a variety of different collaboration methods is important, as some of the challenges the discipline faces are common across the industry, while some are more deposit specific.

"We hope to see benefits across the mining value chain. More precise separation of waste and ore should result in reduced operating costs, reduced energy consumption, and reduced tailings storage requirements."

For now, Teck is continuing to advance its application and understanding of the shovel-based systems in use today and will be working to better understand the applicability of prompt gamma neutron activation analysis (PGNAA) technology.

"We are also exerting considerable efforts to better define deposit heterogeneity at a scale that allows ore sorting to be considered and to be able to calculate the expected benefit of the technology," Rairdan added.

Industrial Mathematicians Optimize the Pit-to-Port Supply Chain

Breaking down silos and automating decision processes allow miners to make more informed choices about stockpiling, blending and marketing

By Steve Fiscor, Editor-in-Chief

The engineers above, using BOLT, can see how production decisions can affect business outcome throughout the supply chain, by modeling multiple what-if scenarios.

When it comes to producing and exporting bulk commodities, such as coal and iron ore, the material is often stockpiled several times before it reaches the customer. Raw materials are stockpiled before the processing plant. Processed materials are stockpiled after the plant and before it is loaded for transport. Sometimes raw product is allowed to bypass the plant. The material is typically stockpiled again at a port facility before it's loaded on to a ship.

Many of the variables along this supply chain can impact the possible outcome adding complexity to the planning process. For example, the information about geology in the pit could change. Processing plant settings affect product quality and yield. Blending presents further opportunities and challenges. Poor performance can erode profit margins leading to costly contractual penalties or excessive demurrage charges as a ship waits to load.

Polymathian, a group of Brisbane, Australia-based software developers and industrial mathematicians, have recently solved some complex logistics puzzles for mining companies. They recently shared two case studies that showed how their BOLT platform not only provided an immediate financial return, but also gave the mining operation a new perspective in planning and marketing. Ultimately, they were able to help miners devise an optimal pit-to-port plan.

BOLT is a cloud-based supply-chain optimization support tool that automates, optimizes and centralizes the planning process. The system generates optimal planning solutions in minutes. Multiple planners can produce plans in parallel using the same information. The system has allowed mining companies to better align supply with demand to increase profitability. It also makes it possible to rapidly respond to unplanned disruptions. Because the results are available in minutes, planners can run multiple "what-if" scenarios to ensure mine operations continue as efficiently as possible.

Carrying Coal to Newcastle

An Australian thermal coal mine with a wash plant transports its product 130 kilometers (km) from the Hunter Valley to ports in Newcastle, New South Wales. Prior to Polymathian's arrival, the engineers at the mine produced strategic plans that covered development, production and marketing tasks. These planning processes needed to be improved to better manage the entire supply chain and maximize profit.

The mine was exporting about 11 million metric tons per year (mt/y). That equates to about 115 trains a month cycling between the port and the mine. Multiple customers wanted to purchase coal and each had certain quality specifications. Millions of variables needed to be simultaneously solved for across the supply chain and that's an area where Polymathian thrives.

The mine was using manual planning processes that were time-consuming and error prone. Each stage had silos of valuable information, which were not easily accessed, and slowed the operation's ability to respond to change.

After implementing the BOLT platform, the mining company realized a tenfold reduction in the level of effort required for the planning process, according to Polymathian. They also achieved a 10% improvement in profit

margins and they now have guaranteed pit-to-port planning optimality.

"Initially, we were given a production schedule," said Jonathon White, director and Polymathian co-founder. "We knew the quality associated with each coal block coming out of the mine for the next two years. We also had information about what will happen if the coal was washed in different ways. We determined how the product would flow through this complex network. In this case, we were really making decisions regarding stockpiling. Should the coal go to the run-of-mine (RoM) stockpile or the crusher? If it reports to the RoM stockpile, how long should it stay there? Once it passed the crusher, what type of processing should be used? How should the processing plant operate?"

In some cases, the coal could bypass the processing plant, White explained. "Bypassing the plant would provide a yield gain, but a quality loss," White said. "What specific gravity set points should be used? ... 1.3, 1.4 or 1.5? Dual- or single-stream wash? Those decisions were followed by more clean coal stockpiling decisions. Which trains should pick up the coal and when?"

The mine could export through either of two ports and there were additional post-port questions related to marketing. What would be the best blend that would meet specs, minimize exposure penalties and maximize potential for bonuses within specific contracts? For uncommitted coal, six months away, should the product become a semisoft coking coal or a low-quality thermal coal.

The tenfold reduction in planning effort was the direct result of the engineer's ability to develop plans. "Previously, they were manually generating plans from Excel spreadsheets that may have taken days to produce," White said. "All those processes were automated and the plans could be generated in five minutes. They could also run multiple 'what-if' scenarios and get the results quickly."

The decision-making process is both automated and optimized, White explained. "The profit margin improvement was mostly related to avoiding penalties, better wash plant operations and the improved marketing of unsold coal," White said. "Through modelling, the mine saw that they could make considerable gains by avoiding some coal blocks altogether, as they simply destroyed value when they were added to the system."

Brazilian Iron Ore Optimization

A Brazilian mining company was blending 15 million mt/y of iron ore and maintaining 10 different stockpiles at a port. The planning teams were trying to align strategic plans with production targets and contracted demand. They knew they needed to break down departmental silos to improve organizational collaboration.

They wanted to better track the four qualities of iron ore the mine produced. The system they were using was a time-consuming process that required the manual entry of daily data into Excel to produce a weekly plan, which could take as much as eight hours. The system produced estimates for stockpile levels and attributes with no visibility over actuals. Without optimization, they were just meeting demand by filling vessel quotas.

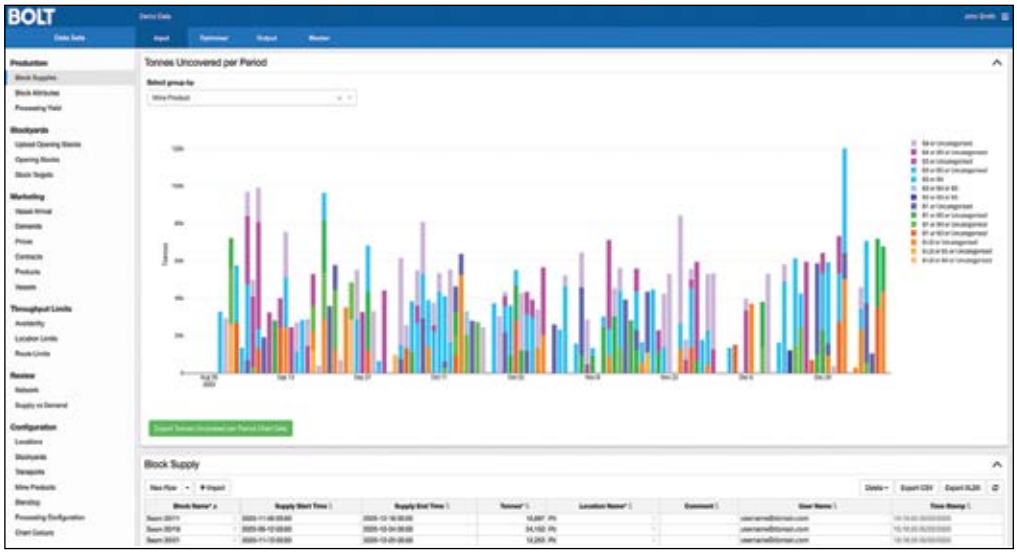
Using BOLT, they were able to review projections from 3 months up to 1 year in advance to better track key performance indicators for sales. Another strategic tool provided production projections over a 5-year period to optimize sales portfolios. A historian tool tracked stockpile actuals to compare with planned projections over time to validate the planning process.

"They needed help scheduling everything from the plant to the vessel," White said. "If, for example, they had demand for a high-quality cargo in two weeks, they needed to start stockpiling

A BOLT visualization of the optimal plan for material movement and storage between the mine and the port.

high-quality ore now. The system also showed them how they could incur demurrage intelligently. If they could incur one day of demurrage today to avoid 10 days of demurrage down the road, the savings would be immense."

BOLT also made marketing decisions for uncommitted tons of iron ore. It solved multiple problems across the supply chain from stockpiles to blending to demurrage to marketing.



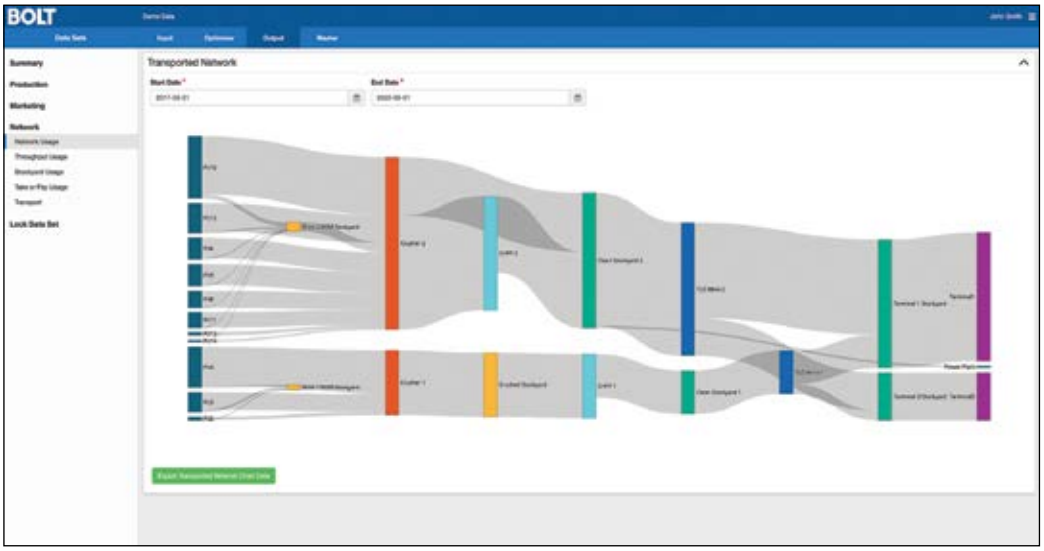
A BOLT visualization showing the mining schedule by source.

Breaking Down Silos

BOLT solves for the entire value chain all at once, White said. "The individual teams that were trying to model the supply chain before now enter their respective data," White said. "The miners will enter what's coming out of the pit. The marketing team enters the sales. The plant will enter product quality data. BOLT makes decisions on supply and demand based on the data input into the system."

The Polymathian approach differs from other analytics companies, who review historical data to see what happened. Polymathian excels in the prescriptive side of analytics, applying advanced mathematics to solve complex problems by looking at the current situation and showing the possible outcomes. These solutions are mathematically optimal.

For something as complex as BOLT, it usually takes a mining company about three months to adopt the system. Polymathian deploys it using an Agile methodology. "We assess the customer's situation," Eustace said. "We work with the departments that need the most help. If necessary, we can generate a report that explains how much value we can bring to the organization. Had you selected BOLT two months ago, these are the types of improvements you would have realized, compared to the current manual planning process."



A BOLT visualization showing the material movement decisions taken at various stages throughout the supply chain.

"Understanding the mining company's situation is key to designing a model that delivers value quickly,"Eustace said.

"The framework we are working with for optimization is the way a supply chain currently operates," Eustace said. "A lot of coal and iron ore supply chains are configured specifically to support manual planning processes, with associated inefficiencies. That includes zoning parts of the yard to associate with a particular berth or a dump station. There are all sorts of aspects about the way we manage stockpiles, which are currently inefficient." Better management of the stockpiles digitally could significantly improve efficiencies.

Wearables at Work

Personal protective equipment lines draw on new technologies to get tougher and smarter

By Russell A. Carter, Contributing Editor

In today's tech-focused environment, market attention toward connecting everything to the local network or the cloud often puts a spotlight on wearable electronic gear that can report biometric and environmental data and detect safety-related trends. However, advances in familiar personal protective gear such as gloves and footwear can in many cases offer an immediate, practical approach for preventing some of the most prevalent on-the-job injuries.

For most of us, what we wear on the job is generally a matter of comfort, convenience and maybe even style. For others who routinely work around heavy machinery, high voltage or in consistently harsh environments, wearing the right gear can mean the difference between staying comfortable and finishing a shift safely, or incurring an injury that could have a major impact on a worker's quality of life and future employment options.

New products and technology, updated standards and changing corporate-culture mindsets are driving developments in Personal Protective Equipment (PPE) and other types of "wearables" that workers can choose to use or be required to wear while on the job. Suppliers of hardhats, gloves, footwear and wearable electronic devices are taking advantage of new materials and improved data collection, communication and analysis capabilities to develop products that in many cases offer much better direct-injury protection or greater situational awareness to boost worker safety and productivity.

The potential appeal of wearable electronic safety gear that can tap into emerging technologies such as Augmented Reality (AR), advanced communications and biometric monitoring is powerful and fits hand-in-glove with the industry's rising interest in digitalization, IoT and automation. It's a fertile field for innovative, fast-moving tech startup companies as well as for established industry suppliers such as Caterpillar (Smartband fatigue monitor) and Hexagon Mining (HxGN Mine Personal Alert proximity warning device), for example; along with major producers — BHP, Anglo American, Rio Tinto and others — that have the resources to tailor technology to their needs.

Hardhats are probably the most common form of PPE for miners and other mine-site personnel, and because of their familiarity and acceptance have been the focus of a number of wearable-tech initiatives. One of the earliest entries in this sector was from Smartcap Technologies, which developed a fatigue-monitoring wearable that uses brainwave monitoring technology that originated in Mining3, a cooperative research center established by the Australian government.

Smartcap's technology has been used at several large base metal and coal operations. In September 2019, BHP reported on a long-term project conducted at its Escondida copper mine in Chile. The mine's location at 3,000 m (9,850 ft) altitude poses particular problems involving worker fatigue and drowsiness, according to the company, and starting in 2017 BHP's Health, Safety and Environment team began using Smartcap technology to monitor and warn mobile equipment operators about apparent fatigue and diminished alertness. SmartCap devices were used to read wearers' brainwaves, identify micro-sleeps, alert operators and identify the hours of greatest risk. The BHP team also evaluated sleep disorders and conditions associated with working at altitude and engaged external providers to perform sleep assessments on the most vulnerable mine operators and transport providers.

Since the program's inception, 739 employees have been evaluated and 178 have received specialized treatment for associated sleep disorders, according to the company. Smartcap said that over the course of two years during which Smartcap was used by employees at the Escondida site and another BHP operation in Australia, zero fatigue incidents were recorded.

Smartcap technology has evolved to its most current product, the LifeBand, which as its name implies is a flexible band that can be worn inside a variety of headwear or by itself. A dedicated smartphone app allows users to monitor their fatigue levels whenever desired via Bluetooth connectivity.

Another wearables developer, Guardhat, offers "smart" helmets and proprietary software designed to actively monitor a user's location, pulse, body temperature and work environment. This, according to the company, provides a holistic view of each user's work environment and instant alerts in the event of a fall, exposure to toxic gases, lockout zones and proximity to moving equipment. Guardhat claims its helmets are particularly effective in minimizing the risks of falls. They can detect whether someone is wearing appropriate safety gear for work off the ground and thus help to prevent them from working at height if they are unequipped for the job. Also, the hat's communications system immediately notifies safety operators and emergency services if a worker falls from a considerable height. Guardhat is collaborating with IBM to integrate its KYRA IoT platform with IBM's Maximo Worker Insights solution to provide what it describes as near real-time situational awareness.

Safeguard Equipment, a relative newcomer to the sector, has developed a wearable PVCD (personal voltage and current detector) that clips to the brim of a hardhat. The Compass PVCD, according to Safeguard, detects electrical and magnetic fields emanating from sources anywhere in a 360° zone around the wearer. LED proximity alerts are triggered well before the wearer comes into contact with an energized source, and after the initial proximity alert is shown the device displays the approximate direction of the detected source.

An auto-sensitivity feature allows users to silence redundant alerts by pressing the center button on the device. Alerts are reactivated if the user moves closer to the source.

The IP6X-rated Compass PVCD is powered by a lithium-ion battery that is rechargeable via the unit's 5-v USB 2.0 Micro B port. According to the company, it has a 10-day battery life with non-frequent alert intervals, or five hours during rigorous activity with frequent alerts. Recharge time is 1.5 hours and depending on use, the battery has a typical life of three to five years before charge capacity begins to degrade. Power-saving features include automatic shutoff if the unit remains motionless for five minutes and ability to extend battery life by reducing power functions when energized sources aren't present. The company also offers the Compass LV, a lower-voltage detector claimed to be ideal for workers in environments where operating voltages are in the 120- to 600-v range.

Although personal safety is a primary design objective for many wearables, their scope of usefulness has quickly expanded to include facility access control and productivity enhancements such as on-the-job training and task guidance. For example, iMotion, a Montreal, Quebec-based IP security integrator, designs tailored safety and risk management systems for the mining industry using technology and equipment from a variety of suppliers and running on a unified platform such as Gallagher Security's Comment Center.

The Gallagher Command Center integrates Physical Access Control Systems (PACS); fatigue management; biometrics; perimeter security; staff and visitor flow management and locker management. The Gallagher solution can also integrate into a company's human resources management system, where it can be customized for each mine according to specific challenges and type of activities. Wearable items employing either contact (magnetic or chip cards) or non-contact (RFID chips embedded in badges, objects such as key rings, etc.) technologies can be incorporated into an overall security system that suits the clients specific requirements.

RealWear specializes in developing hands-free, rugged, wearable Android tablets. The company said its Head-mounted Tablet models HMT-1 and HMT-1Z1 (ATEX + IECEx Zone 1 certified) are designed for hot, rugged, dusty, physical, PPE-mandated environments and facilitate the real-time flow of data and information over vast distances as part of expert-to-trainee, worker to IIoT sensor-cloud and DCS, ERP-to-worker and many other operational conversations, without reducing the situational awareness of that worker around heavy machinery and potential danger. The HMT can easily be moved out of the way when not needed, and its hot-swappable batteries can provide up to nine hours of service on a full charge.

Benefits and Challenges

Consulting, advisory and analytics company Deloitte and the Northern Center for Advanced Technology (NORCAT), a nonprofit tech and innovation center in Sudbury, Ontario, have collaborated since 2017 on a strategic partnership aimed at helping the global mining industry better understand the latest mining technology and innovation trends. NORCAT has an operating mine on site that enables various organizations and commercial clients to develop, test, and exhibit innovative technologies in an operating underground environment.

The alliance has produced a series of reports focusing on key trends in the mining industry, including one published a year ago titled the *Future of Mining with Wearables: Harnessing the Hype to Improve Safety*, which pointed out that implementation of wearables across the industry offers potential gains in personal safety and productivity, but also brings a handful of major issues to the table. These include personal and union concerns about data privacy, challenges in getting workers to accept new approaches to on-the-job safety, and implementing sophisticated systems that require unprecedented levels of interconnection in an environment that is typically hostile to communication technology in general.

There are strong incentives to consider wearables for the mining workforce, according to the report. These include:

- Environmental monitoring—remote sensing technologies can help frontline workers anticipate and companies respond to risks of overheating.
- Focus on workers' health—biometric devices can provide real-time alerts of physically stressed operators who are at risk of injury or causing accidents.
- Training with new technology adoption—real-time virtual and augmented reality training applications can accelerate skills and knowledge development.
- Incident rates at new or exploratory mine sites—tracking and communication technologies can bolster overall response capability.

However, companies still face the challenges that typically accompany the introduction of new and potentially intrusive technology to an industry sector. The report lists some of the main issues and primary objections or concerns from affected stakeholders:

- Being on-point regarding privacy – Lack of data privacy for both workers on site

Safeguard Equipment's Compass and Compass LV clip-on voltage/current detectors visibly alert users to potentially hazardous nearby electrical sources in a 360° zone around the wearer.

and the industry in general. "Unions often take the perspective that, contrary to monitoring the environment, wearables do monitor the worker, including management monitoring confidential health data that a frontline worker may not be comfortable sharing."

- Driving leadership buy-in – Leadership stalling the implementation of wearables within existing operations. "A common challenge in technology implementations is leadership slowing down the process by seeking full-blown solutions, while also following conservative protocols for IT/ERP implementation."
- Developing workplace culture and adoption – Workplace culture and lack of engagement with frontline workers. "A common view held by frontline workers is that wearables are intrusive, lack clear benefits at best and at worst, undermine workers' rights, while shifting the relationship between employee and employer."
- Designing for the human interface – Wearables designed to gather data, but not with the user or worker in mind. "Aimed primarily at gathering data as opposed to meeting end-user needs, wearables are often seen by frontline workers as bulky and an unnecessary add-on to existing encumbrances of everyday gear."
- Connecting to the technical infrastructure – Availability of reliable technical infrastructure, including strong connectivity. "Successful implementation of wearables in mining requires reliable technical infrastructure, including strong network connectivity to ensure that — where appropriate and secure — data can generate actionable insights in real time."

Balancing Design: Productivity vs. Privacy

In addition to smart hardhats and other types of headwear, wearables developers are pursuing a variety of device designs that can be integrated into various industrial applications, offering built-in capabilities to monitor a range of environmental parameters that can enhance safety performance and trend analysis. As with any device which may be perceived by workers as capable of collecting personal data, developers must navigate a course through the choppy waters of data collection, processing, dissemination and privacy issues to reach a safe design haven that satisfies most of these concerns for companies, workers and other interested parties.

MākuSafe says its patented system combines a robust safety management software platform with innovative wearable technology that provides immediate access to real-time EHS data with predictive value.

E&MJ spoke with Mark Frederick, chief technology officer and co-founder, and Thomas West, strategic relationships manager of MākuSafe, an Iowa, USA-based safety analytics company that is preparing to introduce its wearable device and software platform to the market in 2020. The MākuSafe wearable is a small device attached to an armband worn outside a worker's clothing. A built-in CPU and sensor array gather a range of environmental data in real time to provide indicators of current conditions, potentially hazardous motion data, and facilitate voice-recorded near-miss and other observations from workers as well as location of occurrences at a work site.

Frederick said the company's platform objectives were guided by the realization that safety managers often function in reactive mode, where actions come mostly in response to actual safety incidents and injuries. Their plan was to devise a system that monitored a worker's real-time experience, collecting environmental and movement data and using predictive analytics to guide safety managers toward discovering problems before they resulted in incidents.

"We use a small wearable device to collect a lot of data about the worker's environment and experience — air temperature and pressure, lighting level, motions that might indicate a slip, trip or fall, location — and the worker also can press a button on the device to record a short voice memo that is converted to text and sent to the safety manager," Frederick explained. The company's MākuSmart cloud platform receives the data from the wearable devices, along with data gathered from additional IoT sources, and uses machine learning to identify high-risk trends at a work site. The wearable "core" devices currently communicate with a base station over a WiFi network; however, Frederick said the company's product roadmap includes a future transition to Bluetooth mesh networks.

West noted that the wearable device doesn't collect data considered to be personally identifiable information, such as biometrics. "And, we're not continuously tracking the worker. We're looking for potentially hazardous environmental conditions as well as possibly hazardous worker motion coupled with force and using our machine-learning capability to identify patterns in motion that could indicate a slip or fall, for example. When a pattern emerges we call attention to the location of the activity so management can be guided towards correction action."

Workers are given an armband holster that holds the core device, which is stored in a slot at a small, kiosk-type station; after checking-in the device they insert it in the holster and return it to a kiosk slot at the end of the shift. The device's single push-to-talk button is designed for use by workers wearing heavy gloves, provides a tactile response when pushed and is recessed to avoid accidental activation. In line with the design intent of being a device that is 'outward looking' to sense environmental conditions around the worker, the holster is made to be worn outside a person's outer layer of clothing. Frederick said it had been pilot tested for several months by foundry workers exposed to high heat and dusty conditions, with good results.

Users access the data through an app that runs on a wide range of handheld devices, and receive notice within 30-40 seconds after the core device detects an environmental condition that exceeds a preset threshold. The app dashboard is customizable to provide updated graphs, tables or other formatted data objects for specific needs.

Data security, said Frederick, is ensured because the system never "pushes" personal identification out from the cloud. A wearer is identified only by a unique de-

vice identifier assigned to their device, and the wearer/device identifier data remains within the cloud, which in turn is protected by the security measures put in place by MākuSafe's cloud hosting service.

New Standard for Gloves

In today's tech-focused environment, market attention toward connecting everything to the local network or the cloud often puts a spotlight on wearable electronic gear, but notable advances in hand protection and footwear can in many cases offer a more immediate and practical approach for preventing common injuries. For example, a number of studies indicate that injuries incurred while handling material are the most prevalent type of safety incident in both surface and underground mining, with slips and falls following closely behind.

While biometric sensing devices and apps often can identify trends pointing to where and when these types of injuries occur, the right glove, boot or hardhat can provide direct protection against injury — and go a long way toward keeping injury-associated costs under control. A white paper released by industrial PPE provider HexArmor claims that treatment and handling for a cut on a worker's finger that would have been preventable with the proper glove can often mushroom to a total cost of $40,000, with an estimated $400,000 in future sales needed to pay for it. Other estimates pin the average cost of general hand injuries at around $20,000.

One of the difficult tasks facing corporate safety and purchasing departments is choosing the most cost-effective glove for specific job requirements. In recent years, industrial glove suppliers have started offering styles with better cut resistance, improved visibility, fingertip touchscreen compatibility, palm coatings that provide better grip and other options to meet specific safety needs. Yet, until early last year the existing glove standard in North America was ANSI/ISEA 105, which addressed cut, abrasion, tear and puncture performance, but didn't consider impact (back of hand) protection, which is a major concern for workers handling heavy, awkward items such as drill rods, GET parts or giant tires. Suppliers could advertise that their gloves were effective against crushing and pinching injuries, but there was no standard by which to measure or validate such claims. That changed in 2019 when ANSI/ISEA 138 took effect: the standard, which is voluntary, describes an agreed-upon testing method for glove impact protection, includes three well-defined performance levels and pictogram marks for each level, and mandates that products be tested in a certified accredited laboratory that meets ISO/IEC 17025:2017 requirements.

The new ANSI standard resembles the 2016 European Union EN388 standard in certain respects, the main difference being that EN388 applies just to knuckle protection, not knuckles and fingers. The International Safety Equipment Association notes that ANSI 138-compliant gloves are evaluated for their capability to dissipate impact forces on the knuckles and fingers and are classified accordingly. The resulting classifications, said the ISEA, can now be used by employers as a reliable means of comparing different products on an equal basis when selecting hand protection relative to the tasks being performed.

Renewables Enable Innovative Energy Solutions

The newest waste heat recovery systems for diesel genset installations are based on conventional steam turbine technology, but at a smaller scale suitable for remote minesite applications.

With more than a dozen renewable energy projects announced over the past year or so, it's clear that rising energy costs and potential savings from renewable-energy technologies are on the mining industry's mind. As Mark Cutifani, CEO of Anglo American, pointed out in a speech given at Mining Indaba 2020 in January, the amount of energy required to produce 40 kg (88 lb) of copper has risen by a factor of 16 since 1900, while the industry is undergoing increasingly closer scrutiny of its energy, land and water usage practices.

Mining companies are spending money to save money. In the past few months:

- Anglo American Platinum CEO Chris Griffith announced that the company has applied to the South African government for approval to build a 75-MW solar power facility to serve its Mogalakwena mine.
- Rio Tinto approved a $98 million investment in a new solar plant at its Koodaideri mine in Western Australia, along with a lithium-ion battery energy storage system to help power its entire Pilbara power network. The 34-MW solar photovoltaic plant is expected to supply all of Koodaideri's electricity demand during peak solar power generation times and approximately 65% of the mine's average electricity demand.

The plant, Rio Tinto's first company-owned solar facility, will consist of an estimated 100,000 panels, covering an area of 105 ha (260 acres). Construction is expected to begin later this year, subject to government approvals, and is due to be completed in 2021. Complementing it will be a new 12-MWh battery energy storage system in Tom Price that will provide spinning reserve generating capacity to support a stable and reliable network. Rio Tinto Iron Ore Chief Executive Chris Salisbury said the company is investigating additional renewable energy options in the Pilbara, as well as other opportunities to reduce emissions across its global holdings.

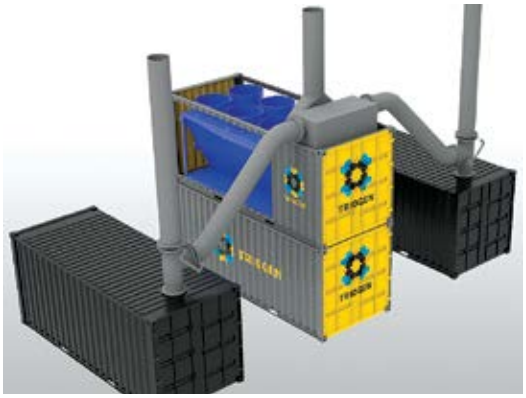
- Resolute Gold's Syama mining complex in southern Mali signed a contract with modular-power supply specialist Aggreko for a hybrid power plant that combines solar, battery and heavy fuel oil (HFO) technologies. Once the system is installed, Aggreko will operate and maintain a 40-MW thermal power plant and a 10-MW battery storage system, with a further 20 MW of solar power planned in 2023. The hybrid solution will reduce Syama's power costs by an estimated 40%. By using a rental approach, Syama was able to de-risk its investment in greener energy by avoiding the need to invest capital into the power solution.

Dr. Thomas Hillig, managing director of THEnergy, a Germany-based management consultancy specializing in cleantech innovations, said that over the last few years, successful energy projects have bolstered confidence in solar- and wind-based renewable energy technology and independent power producers (IPPs) have started financing solar and wind plants at remote mining sites. IPPs sell electricity to miners on a power purchase agreement (PPA) basis. To mining companies, the PPA-cash flow is similar to what they are used to from diesel contracts, but it comes with cost reductions.

Hilig said advances in diesel genset efficiency optimization have also sparked interest. Diesel engines only convert 40% of fuel energy into electricity. However, waste heat recovery systems can reduce diesel consumption by approximately 7%. "Waste heat recovery is the low hanging fruit in the diesel reduction game," Hillig said. "Renewables have recently opened the door for new approaches because they have increased the acceptance of more capital-intensive solutions in the mining industry."

The newest waste heat recovery systems for diesel genset installations are based on conventional steam turbine technology, but at a smaller scale. According to Hillig, the approach has been proven in applications such as biogas engine heat recovery, biomass combustion, industrial waste heat and geothermal heat.

Hillig noted that Dutch manufacturer Triogen has developed a containerized "e-box" with potential benefits for remote mine sites. It is designed to allow easy upgrading of any diesel genset without changing its operations and thus without affecting maintenance or warranty requirements. The solution is based on conventional steam turbine technology, yet is fully automated, compact and simple to install. Two standard 20-ft shipping containers are connected to the exhaust gas stack of diesel gensets and the e-box generates electricity from the waste heat. The electricity is fed into the local grid, taking the place of energy normally provided by diesel gensets and thus cutting fuel consumption.



Triogen's modular diesel genset waste heat reacovery system can be shipped and set up in two standard-sized freight containers.

Triogen's technology reportedly has accumulated more than 1 million operating hours, at 50 installations. The e-box solution has successfully been field-tested for mining applications and is now being deployed at the remote site of a blue-chip mining company. Henning von Barsewisch, CEO of Triogen, said: "Our containerized e-box has created sustained awareness from mining companies, IPPs, diesel genset OEMs and rental companies because of its short payback time of 2 years and its quick and easy deployability."

Because the Triogen e-box converts waste heat, it is a zero-carbon technology, which addresses the drive for cleaner mining. The company claims a single e-box saves 300,000 liters of diesel per year — approximately the same as a 0.7-MW solar power plant in a sunny region — while annual CO_2 reductions can amount to 800 tons per e-box.

Online Course Examines Mining 4.0 Trends and Tech

Hexagon's Mining division and the University of Arizona recently announced the launch of Mining 4.E, an online course designed to broaden the understanding of modern mining and its associated technologies.

The course will cover the complete mining cycle, from discovery to reclamation, as well as the innovation and technology spurring improvements at each step. Participants will learn about the overriding importance of safety in all aspects of mining and the radical changes in mining and processing methods that are expected to reshape the industry over the next 20 years.

The trend toward automation and data exchange is commonly referred to as Industry 4.0. Mining 4.E will take students on a seven-week learning journey through big data analytics, sensors, Internet of Things (IoT), 3D simulation, modeling, Artificial Intelligence (AI) and machine learning. Online learning tools will include video lectures, virtual field trips, auto-graded quizzes and E-interviews with industry professionals. Mining 4.E's first cohort will comprise Hexagon employees before being offered to the public through open enrollment.

University of Arizona professor and head of Department Mining and Geological Engineering, John Kemeny, said, "Students can expect to achieve a solid understanding of the mining cycle and its associated steps, including ore deposits, mine valuation and economics, planning and design, operations, and safety and risk management.

"All of this will be presented through a 4.0 lens for context and perspective on the industry's direction."

MacLean, GHH Announce Global Partnership

The partnership is announced at a ribbon cutting on February 21 held at MacLean's newest manufacturing plant in Querétaro, Mexico.

Canada's MacLean Engineering signed an agreement with Germany's GHH Fahrzeuge GmbH for mutual product sales and support, leveraging each company's respective branch footprints and mining application knowledge. The partnership was announced February 21 at a ribbon-cutting event held at MacLean's newest manufacturing plant — the first outside of Canada, a 5,600-m^2 facility in Querétaro, Mexico.

The initial focus of the strategic partnership will be on the North American, Eastern European and Central Asian mining, tunneling and construction markets. This approach will build on the existing MacLean platform of field service and sales support in Canada, the U.S. and Mexico. It will allow mining and tunneling operations in these countries to immediately benefit from a MacLean product line integration of the GHH load and haul product offering, while at the same time building off of GHH's extensive branch network in Russia, Kazakhstan, Uzbekistan and India to support the introduction of MacLean mining vehicles into those regions.

"The combination of the MacLean and GHH product lines is a significant turning point for both companies, but in the context of a global industry that is increasingly looking to reduce the complexity of supply chains to achieve better maintenance, total cost of ownership, safety and productivity outcomes, it simply makes good sense," MacLean President Kevin MacLean said.

"We're very optimistic about the prospects of combining forces with a company like GHH that has a stellar and time-tested reputation for design quality, mining know-how, and innovation that works in the challenging underground environment — just like MacLean."

"GHH is continuously striving to improve our customer support through increasing our product and support offering," CEO of GHH Dr. Jan Petzold said. "Partnering with key, well-established companies in critical markets, gives us 'feet on the ground' providing customers with effective and efficient solutions to all mining and tunneling projects."

MacLean manufactures underground mining mobile equipment in the ground support, ore flow and utility vehicle product categories. GHH has a line of LHDs and trucks purpose-designed for the rigors of underground mining. GHH's offering also includes narrow-vein loaders and specialized super low-profile vehicles.

Australia's Roy Hill to Automate Mining Haul Truck Fleet

Epiroc signed a contract with Roy Hill to deliver a fully automated haul truck solution for its iron ore mining operation in Western Australia. Epiroc, in partnership with automation specialist ASI Mining, will convert Roy Hill's haul trucks from manned to autonomous use. Epiroc and ASI Mining will deliver a safe and interoperable solution for Roy Hill's mixed truck fleet, with an ability to expand to other mining vehicle types and manufacturers, and capability to integrate with existing Roy Hill systems. Epiroc and ASI Mining will also be working closely with Roy Hill and its partners Hitachi and Wenco on truck conversion and integration of the Wenco fleet management system.

"Epiroc is proud to collaborate with Roy Hill, ASI Mining and other partners to automate Roy Hill's haul truck fleet, boosting safety and productivity for a crucial aspect of its mining operation," Epiroc Senior Executive Vice President of Mining and Infrastructure Helena Hedblom said. "This is a very strong example of how automation will take a mining company's operation to the next level."

"Roy Hill is well-positioned to transition to automation," Roy Hill CEO Barry Fitzgerald said. "Our teams on site and in our Remote Operations Centre (ROC) in Perth have demonstrated a clear capacity to deliver complex projects, sustainable change and operational excellence with the recent success of our autonomous drill program and fleet optimization initiatives. Now is the right time to bring the combined expertise of Roy Hill, Epiroc, ASI Mining and Wenco together to convert our haul truck fleet.

"Care is one of our core values, with safety at the heart of everything we do," Fitzgerald said. "Roy Hill's Smart Mine program is driving innovation across our business, and the automation of our haulage fleet is central to delivering safety and production improvements."

The project will see a phased implementation, with testing and production verification of up to eight trucks undertaken in the initial phase prior to the second phase of full fleet expansion from mid-2021.

Roy Hill is an iron ore mining project in the Pilbara region of Western Australia. Its ROC in Perth provides end-to-end integration of operations.

U.S.-based ASI Mining provides technology solutions for the autonomous operation of mining vehicles. Epiroc announced in October 2018 that it had acquired 34% of ASI Mining.

Austin Partners With ETT

Australian-based Austin Engineering has signed a partnership agreement with South Africa's ETT to market and support their combined mining-oriented product ranges throughout Africa.

Signed and sealed: Peter Forsyth, Austin Engineering managing director (L), with ETT Managing Director Andre McDuling.

The agreement will bring together two of the southern hemisphere's largest mining equipment design and manufacturing entities.

With headquarters in Brisbane, Austin Engineering has more than 50 years of experience in engineering and manufacturing equipment for the mining industry with operations in Australia, Asia, North and South America, and now South Africa.

"We are looking forward to growing this partnership," Austin Engineering Managing Director Peter Forsyth said. "It gives both companies a solid and reliable platform from which to offer customers, throughout the continent, proven world-class products backed up by world-class service."

ETT, a privately-owned South African company based in Richards Bay, with product already distributed in more than 20 countries around the world, celebrates 25 years of engineering excellence this year.

ETT Managing Director Andre McDuling said, "ETT's manufacturing and innovative record as well as our strong presence and product supply into Africa is one of the key reasons why this partnership was formed. We are confident that the industry is ready for a partnership like this that will provide the widest range of mining attachments and support products in the world."

Both companies are well-established and acknowledged globally for their unique, engineered mining equipment. The combined product range of the new partnership will include customized dump truck bodies, water trucks, diesel lube trucks, gooseneck-equipped recovery vehicles, tire handlers, lowbed off-road trailers and excavator buckets.

Modular Opens Customer Experience Center

Modular Mining, a leader in computer-based mine management solutions, unveiled its new Customer Experience Center (CEC) during a ribbon cutting ceremony in late January. Located in the company's corporate headquarters in Tucson, Arizona, USA, the CEC's opening coincides with Modular Mining's 40th anniversary.

"Our new Customer Experience Center is designed to showcase how mine management solutions can improve the safety, efficiency, and productivity of mining operations, and help our customers do so sustainably," President and CEO Jorge Mascena said. "Today's announcement marks our third major renovation project in six years at this facility. Tucson is evolving into a key mining technology hub, and this expansion demonstrates our commitment to leading this transformation as a long-term member of this community."

Pictured from left to right: Richard Fimbres, Tucson city councilmember Ward 5; Jorge Mascena, CEO, Modular Mining; Greg Lanz, vice president business development, Modular Mining; Ramón Valadez, Pima County supervisor District 2; and Tom Murphy, mayor of Sahuarita.

Established in Tucson in 1979, Modular Mining advanced technology for the open-pit mining industry with the development of the DISPATCH Fleet Management System. It was the first of its kind in the industry and served as the springboard for further innovation, including the ProVision High-Precision Machine Guidance system, the MineCare Maintenance Management system, and others.

Anchor Design for Refractories: What You Need to Know

By Dan Szynal

Following industry-standard recommendations for refractory anchor installation can increase service life and maximize refractory performance.

It is estimated that up to 40% of refractory lining failures can be attributed to a problem with the design of the anchor system or improper installation. This is a significant number. When designing a refractory lining for an industrial application, anchor design becomes one of the most important factors in creating a robust lining that is supported properly. In particular, the tips of the anchors experience the highest temperatures because they are closest to the hot face and thus become an important consideration.

Anchors have several functions. They hold the refractory to the wall to keep it from falling in. They also prevent wall buckling due to the internal thermal stresses created by high temperatures. And, to a lesser degree, anchors can also help support the load of the refractory weight.

To create a monolithic refractory lining that is properly supported and maximizes service life, here are three important metallic anchor tips to know.

Type and Temperature

For refractory linings in which metallic anchor systems are used, refractory engineers and designers almost always use Class III austenitic stainless-steel anchors of various qualities. The typical grades of stainless steel used are AISI 304, 309 and 310. These contain chromium and nickel to provide the best corrosion resistance and ductility at high temperatures. For some applications in which temperatures are more extreme, and the use of ceramic tile anchors is not practical for various reasons, AISI 330 and even Inconel 601 is sometimes used. These anchors have higher nickel content for superior oxidation resistance and tensile strength at temperatures of 2,000°F or higher. Inconel 601 gives the added advantage of good resistance to both carburization and sulfidation in extreme applications.

Anchor Type	Service Limit (°F)
Mild Steel	800
304 SS	1,700
309 SS	1,850
310 SS	2,000
330 SS	2,100
Inconel 601	2,200

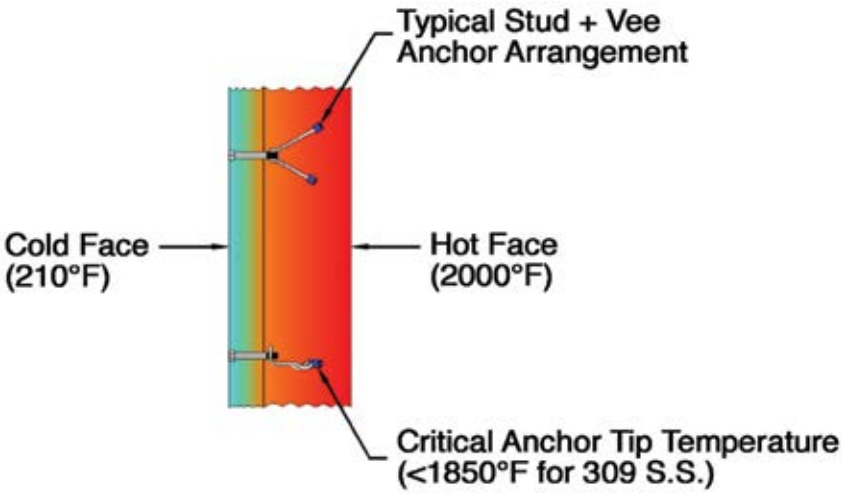
Recommended anchor tip temperature limits for various common alloys.

Best Practices

Anchor sizing for a refractory lining depends on the refractory thickness and number of components. Some designers use the practice of sizing the anchor height to be 75%-85% through the main dense castable or gunned lining. Other rules of thumb used in the industry dictate that the anchor tip should be no more than 2 in. from the hot face of the refractory for thicker lining designs greater than 6-7 in.

For refractory applications, it is useful to know the temperature gradient through the refractory lining, from the hot face to the cold face, to choose the proper anchor size so that one doesn't exceed the temperature limit of the alloy being used. To help calculate the correct temperatures at different points in the refractory lining, many industry professionals will use a heat loss calculator/estimator, which enables the user to choose the proper anchor height by determining the anchor tip temperature it will experience. There are numerous heat loss applications that can estimate the cold face of a furnace lining given the input conditions of a thermal unit. As part of its value-added service as a refractory solutions provider, Plibrico Co. LLC has a Web-based heat loss application that gives a good estimation of the thermal gradient of the refractory lining from hot face to cold face to maximize the anchor thermal performance.

For example, in the accompanying diagram, one can see a 9-in. side wall of refractory lining using 6 in. of a typical 60% alumina low-cement castable and 3 in. of 2,300°F lightweight insulating castable for



Typical refractory anchor lining configuration.

an application operating at 2,000°F with an ambient temperature of 80°F. For this application, they would select 309 SS or 310 SS metallic anchors because the intermediate temperature at about 80% of the main lining thickness is approximately 1,900°F. Although 304 SS anchors would be more cost effective and are most commonly used in the industry, the anchor tips would oxidize at this temperature and would essentially burn out.

A Word on Anchor Tips

Standard practice for years has been to allow for expansion of the anchor tines by covering the anchor tips with plastic caps, dipping them in a wax, or putting tape on them. Metallic anchors expand at about three times the rate of alumino-silicate refractories. The expansion material affixed to the anchor tips burns out at low temperature and allows the anchor a space to expand without causing cracks in the refractory.

Best practices in metallic anchor design also must include anchor spacing. As a function of the specific equipment and geometry size, refractory engineers must consider the specific installation area. For example, anchor spacing patterns will be different in a flat wall or roof, as compared to a section that has a transition of geometry or a less critical area of a vessel.

Anchor spacing should be based on the features of each specific project, such as mechanical properties of the anchor, and the refractory lining as a function of the temperature. Refractory engineers will use these properties in mathematical models to help create the optimal anchor spacing pattern and plan.

Often, failures commonly attributed to the refractory component can, in fact, be caused by deficiencies in the anchoring system. A robust anchoring system is key to maintaining monolithic refractory lining integrity, even when it is cracked, to prevent a total structural collapse.

To prevent vessel lining failures, increase service life, and maximize refractory performance, incorporate these metallic anchor recommendations. With these tips, it is possible to design and optimize an anchoring system that will work well with the demanding needs of refractory linings today.

For more information about metallic anchors and refractory anchoring systems, contact the Plibrico Co. at contact@plibrico.com or +312-337-9000.

Dan Szynal is vice president of engineering and technical service for the Plibrico Co.

Hydrocyclones Minimize Circuit Recirculation

Weir Minerals reported the installation of 19 Cavex 400CVX10 hydrocyclones at OceanaGold's Didipio gold and copper mine in the Philippines has led to savings of more than $800,000 annually through a dramatic reduction in grinding circuit recirculation.

The Didipio mine expanded its production capacity, which increased the incumbent cyclones' feed density beyond what they could effectively manage, leading to a circulating load of up to 700%, Weir reported.

The Cavex 400CVX10 hydrocyclones significantly improved separation efficiency due to their finely tuned spigot liner diameter, and the strength and corrosion resistance provided by its cast housing.

Thus, the hydrocyclones reduced the circulating load from 620% to 374%, Weir reported. The direct savings in power consumption, ball consumption, cyclone and pump maintenance costs exceed $815,000 per year.

www.global.weir

Trolley Assist Ups Hauler Availability

Caterpillar released the trolley assist system for their electric-drive mining trucks. Currently available for the 795F AC truck as a retrofit kit, the solution aids in reducing carbon emissions, lowers fuel and engine costs, and boosts speed-on-grade for greater productivity, the company reported.

The solution reduces engine emissions at the mine via substitution of electricity during the most demanding part of the truck work cycle, Cat reported. Powering a 337-metric-ton (mt)-payload 795F AC via trolley on a 10% grade as it climbs the ramp out of the pit saves up to 40 liters of diesel fuel per kilometer of trolley line.

Trolley assist was trialed at Boliden's Aitik mine in Sweden, where it helped up both availability and speed-on-grade, leading the miner to deploy it more broadly.

www.cat.com

AMR Develops Collision Avoidance Technology

Through development of its Mine Net and Mine Net Mesh systems, AMR PEMCO has more than a decade of experience implementing personnel and asset tracking systems based on received signal strength indicator (RSSI) technology. The company wanted to expand its systems for additional uses such as collision avoidance, but determined that RSSI lacked the accuracy and dependability needed for close-quarter applications. So, AMR PEMCO developed an Ultra-Wide Band solution that uses two-way synchronous

ranging technology, which is far more accurate in determining the distance from one piece of mobile equipment to any other equipment and/or personnel tags.

AMR PEMCO's new Collision Avoidance Protection System (CAPS) provides precise proximity detection with simplicity, reliability and cost-effectiveness. Using this new technology, data is continuously transmitted between two or more pieces of equipment/tags, and the distance is immediately determined between them. If the equipment or tag is within a preset Warning or Alarm Zone (within 1 meter accuracy), the equipment operator will receive visual and audible warnings. Single CAPS units utilize one Smart Antenna on smaller equipment, while two to four Smart Antennae systems are needed on larger equipment. CAPS includes Smart Antennae; a user interface in the operator cab with output contacts for additional alarms, pushbuttons for temporary alarm acknowledgement, and an LED for system heartbeat; an optional vehicle braking system module to control speed; and a small and lightweight personnel tags, the company said.

www.amrpemco.com

Conveyor Covers Prevent Loss

Precision Pulley & Idler (PPI) launched its Conveyor Cover line, which, the company reported, helps protect conveyed material and the environment against dust and noise. It also helps eliminate product loss due to wind, while reducing belt wear due to weather, the company reported.

The product will be available in full (100%) 180° and 75% 135° styles in standard 4-ft-long sections. The covers are galvanized steel.

Separately, the company launched Pro Tracker, which is described as a solution for belt-tracking issues. The lagged, return trainer pivots to guide the belt to its central position, resulting in reduced belt damage, decreased material loss and better tracking. It mounts with two adjustable brackets for easy installation and is designed with no exposed frame, eliminating material buildup.

The product is offered in SBR Diamond Groove lagging or urethane lagging for shedding material and extended roll life, belt widths of 18- to 72-in. and adjustable mounting in 1-in. increments. The PPI Pro Tracker is a complementary product to other PPI belt-tracking products.

www.ppi-global.com

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COVID19 Impacts Aluminum Market

By Xinlin Chen

The outbreak and subsequent spread of the coronavirus (COVID19) is fuelling uncertainty for all the base metals, including the aluminum market. The price for aluminum on the London Metal Exchange (LME) hit a two-year low of $1,687 per metric ton (mt) in early February. It has since recovered some, but the market remains wary of weaker economic activity and demand growth, logistical backlogs and the impact on output across the value chain.

Even before the virus outbreak, Wood Mackenzie's (WoodMac) base case outlook for the metal was already showing a market moving into surplus, with all the risks pointing to a much larger oversupply position. For the time being, there are many permutations as to the outcomes from the coronavirus outbreak. What is clear is that China's economy and its aluminum sector command a far greater share of the global totals. Any significant dislocation in China will have far reaching reverberations.

Downstream aluminum output takes an immediate hit. Semis exports to follow? WoodMac believes that the plants that rely on ingots or billets produced at smelters some distance away are now struggling to secure adequate supplies of metal. However, semis plants that purchase in-situ liquid metal — around 12.4 million mt in 2019 — are unlikely to be affected. If downstream output does not recover soon, WoodMac expects semis exports to fall rapidly through to March. Given that most downstream facilities typically operate at no more than 50%-65% utilization, there is enough "give" to raise operating rates higher once the virus outbreak has been contained. In effect, the impact on demand in China for the year may not be as significant as the numbers may suggest over the short-term if the epidemic is contained.

Logistic bottlenecks trigger alumina cuts. The coronavirus outbreak has disrupted the delivery of raw materials to alumina refineries, especially in Shanxi and Henan provinces. These two provinces account for 41% of alumina refining capacity in China and supply to the smelting hub in the Northwest. At the time of writing, refineries in Shanxi province were reported to have 10-20 days of bauxite stock compared with 1-2 months. Meanwhile, refineries in Henan province with captive mines are operating as usual but those using third-party or imported bauxite are struggling to secure the required tonnages to maintain normal operations.

Apart from bauxite, refineries are also short of caustic soda supplies. Some caustic plants have suspended production, thereby resulting in a shortage. Coal gas is also in short supply forcing a few refineries to switch to natural gas, which has increased costs.

Stranded alumina stock inland... Refineries that are operating, as usual, are unable to truck alumina to smelters due to transport restrictions. Smelters in Xinjiang and Inner Mongolia that are farther inland are the most impacted. Some smelters in the province are operating with low levels of alumina stock. However, smelters in Xinjiang are low cost and, therefore, better placed to pay above market rates for alumina.

...increases the demand for imported alumina. Smelters in East Inner Mongolia can receive alumina from the Bayuquan port, but smelters in the west of the province have insufficient alumina stock. These smelters must secure timely supplies from refineries in either Shanxi or Henan to avoid production cuts.

What is the risk of aluminum production cuts? Smelters in Guangxi and Guizhou have indicated that they are operating as usual but there are concerns around the timely shipment of anodes. Pitch, which is used in anode production, is also facing logistic bottlenecks. The shortage is so acute that even smelters with captive carbon plants in Shandong and Shaanxi are purchasing anode blocks as they cannot produce anodes.

Refining cuts in China could reach 5.2 million mt (annualized), representing 7% of the country's estimated production.

Xinlin Chen is Wood Mackenzie's aluminum associate.

E&MJ PRICES INDEX

(March 3, 2020)

Precious Metals ($/oz)		Base Metals ($/mt)		Minor Metals ($/mt)		Exchange Rates (U.S.$ Equivalent)	
Gold	$1,640.10	Aluminum	$1,706.00	Molybdenum	$20,790	Euro (€)	1.114
Silver	$17.19	Copper	$5,668.00	Cobalt	$33,000	U.K. (£)	1.281
Platinum	$863.00	Lead	$1,900.00			Canada ($)	0.746
Palladium	$2,510.00	Nickel	$12,555.00	Iron Ore ($/dmt)		Australia ($)	0.662
Rhodium	$12,300.00	Tin	$16,750.00	Fe CFR China	$87.14	South Africa (Rand)	0.065
Ruthenium	$250.00	Zinc	$1,986.00			China (¥)	0.144

Gold and silver prices provided by KITCO Bullion dealers (www.kitco.com). Platinum group metals prices provided by Johnson Matthey (www.platinum.matthey.com). Non-ferrous base and minor metal prices provided by London Metal Exchange (www.lme.co.uk). Iron ore prices provided by Platts Iron Ore Index. Currency exchange rates were provided by www.xe.com.

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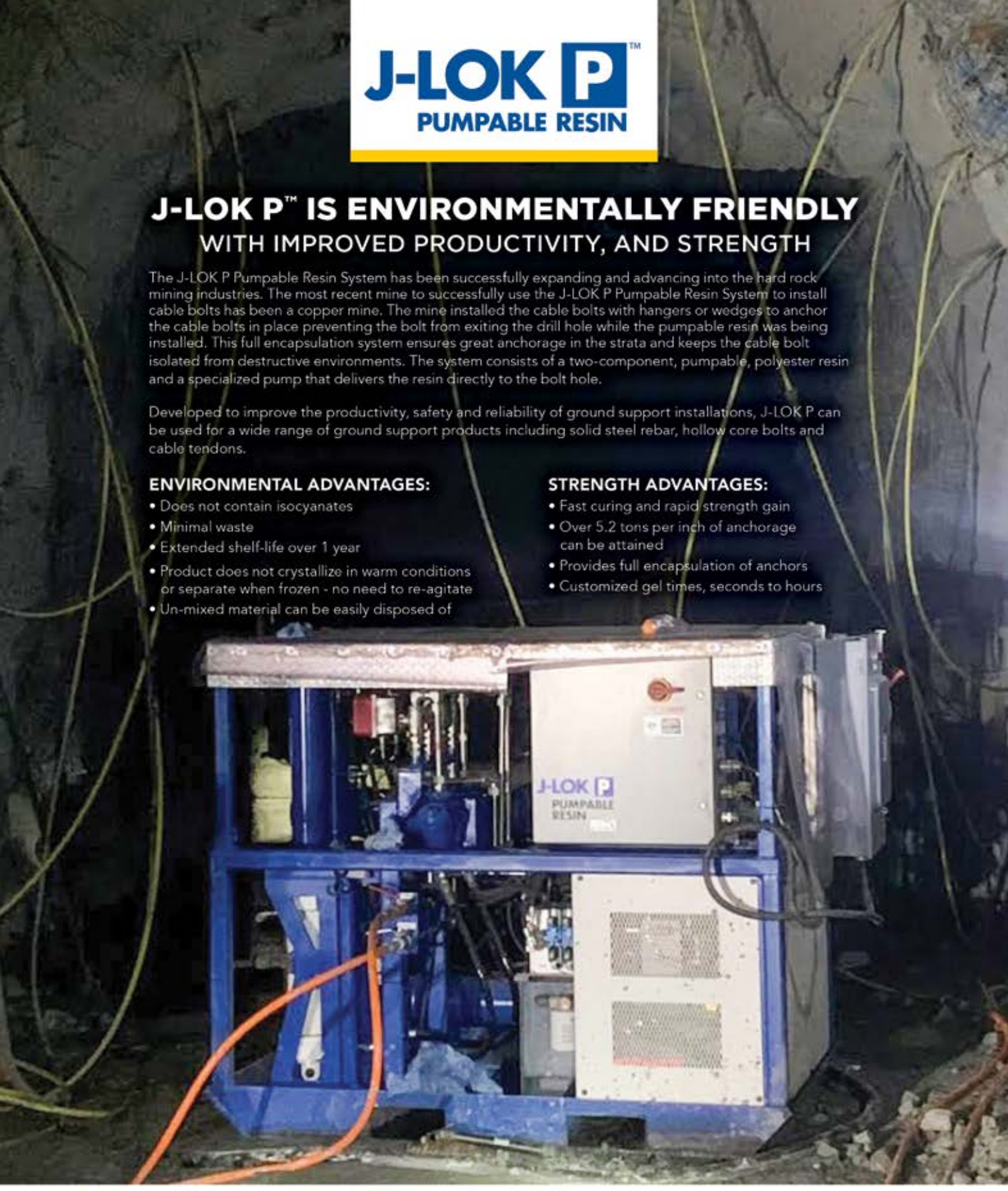

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