Project Survey 2020
— Mining construction projects continue to grow

OceanaGold Ramps Up Production at Haile Mine
Battery-electric Equipment
Screens & Media
SAFER • POWERFUL • PRODUCTIVE • RELIABLE

Z50 50 TONNE HAUL TRUCK
A4 4 TONNE LHD
A10 10 TONNE LHD

ZERO EMISSIONS

WELCOME TO THE FUTURE OF MINING

ARTISAN VEHICLES
FEATURES

2020 Global Project Spending Outlook
Construction activity in the mining sector continues to increase

Haile Ramps Up
OceanaGold makes major capex investments in South Carolina
gold mine and mill

Battery-electric Vehicles: Brightening the Mining Industry’s Future
E&MJ looks at some of the collaborative projects driving BEV development and adoption, and mulls over the technology’s place in the future of the mining sector

Sustainable Water Supply for Chile’s Copper Mines
Investigating current and emerging trends in mining desalination projects in Chile

Technology Lets Blasters Load Precise Rounds
Advances with electronic initiation systems, blast design software and monitoring systems improve safety as well as fragmentation

Screening Solutions
Miners make novel use of screens and media to solve problems

When Old Beats New
Suppliers say reman exchange programs are on the rise primarily because the products are superior

LEADING DEVELOPMENTS
Newest US Copper Project in a Decade Starts Production
Equinox Gold, Leagold Will Merge
Zijin Buying, Buriticá Project in Colombia
Northern Star Will Purchase Other Half of KCGM

AROUND THE WORLD
U.S. & Canada: Hecla Ramping Up Lucky Friday Mine to Full Production
Latin America: Fruta del Norte Ships Concentrate
Australia/Oceania: Kirkland Lake Sees Potential Second Mining Front at Fosterville
Africa: Barrick Sells Interest in Massawa Project
Asia: India Becomes a Net Copper Importer
Exploration Roundup: Newcrest Hitting High-grade at Havieron Gold Project

DEPARTMENTS
Calendar
Classified Advertisements
Equipment Gallery
From the Editor
Markets
Operating Strategies
People
Processing Solutions
Suppliers Report
This Month in Coal

This month, E&MJ’s Project Survey documents the substantial amount of money mining companies are investing in future mining operations. One of those companies, OceanaGold, invited E&MJ to see the investments being made at the Haile mine and mill in South Carolina. On the cover, another Komatsu 730E-10 is assembled at the laydown yard at the Haile mine. (Photo: OceanaGold)
A New Decade Dawns for Mining

Looking back over the last decade, two questions emerge: What have we learned and what does the future hold? Annually, E&MJ publishes its Project Survey (See p. 20), which details the different stages of mining-related investments. Some of these projects may come online in the next few years and some may never see the light of day. In 2010, mining-related construction investments had slowed to $57 billion in the wake of the 2007-2008 Global Financial Crisis. Recovery was on the horizon and today mining-related construction spending is pegged at $209 billion and it’s still growing.

Looking through this month’s news, readers should note that in 2010, Nevada Copper’s Pumpkin Hollow mine was at the feasibility stage; Hecla was exploring the feasibility of Shaft No. 4 at its Lucky Friday mine; construction was beginning on Oyu Tolgoi in Mongolia; and Fruta del Norte was a gold exploration camp in Ecuador owned by Kinross Gold. Barrick Gold’s Cortez Hill mine was under construction, BHP’s Jansen Project was at the EIS stage, and North American Palladium (NAP) was restarting the Las Iles mine. Our cover story this month, OceanaGold’s Haile mine (See p. 26), was also at the feasibility stage under the ownership of Romarco Minerals. E&MJ would like to thank OceanaGold for the invitation to see and report on the developments at the Haile mine.

Many names disappeared during the last 10 years and new ones emerged. Most recently, NAP became Impala Canada. Glencore bought Xstrata. Newcrest purchased Lihir Gold. Sibanye acquired Stillwater. BHP spun out several operations as South32. PotashCorp and Agrium merged to create Nutrien. Cleveland Cliffs became Cliffs Natural Resources and then returned to Cleveland Cliffs.

Triumph and tragedy put mining on the world stage. Everyone cheered when 33 copper miners were rescued in Chile. Three coal mine explosions in 2010 killed dozens of miners at each operation. The world watched as the Samarco tailings dam collapsed and an orange plume flowed through rivers in Brazil to the Atlantic Ocean. It would happen again and take the lives of more than 200 miners.

Large open-pit mines, such as Grasberg and Chuquicamata, transitioned to underground mining operations. And, the Bingham Canyon mine recovered from a massive landslide that seemed nearly impossible at time.

Time and again mining engineers prevailed, inventing new methods and optimizing existing operations. When mineral exploration dollars dried up, junior miners discovered drones, which have now become ubiquitous. Gearless drives became a reality for SAG Mills and long, large conveyor systems. Sensor technology and dashboards helped miners understand the usefulness of data. Equipment manufacturers transitioned from a bigger-is-better mentality to mining smarter. Mining operations began making the leap from automated mining equipment to fully autonomous operations. Today, underground mines are quickly adopting battery-electric equipment (See p. 32).

What does the future hold? Leaf through this edition of E&MJ and readers will see where the mining industry stands today and where it is headed. The Project Survey details tomorrow’s mines. Our job is to oversee steady improvement while providing a safe, secure and sustainable source of minerals for tomorrow’s world.

A New Decade Dawns

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

FROM THE EDITOR
AMP
Advanced Modeling Program

Drilling simulation software to iterate the perfect bit design, to your specific blast hole requirements.

Headquarters: Carrollton, Texas • varelmining.com • 1.800.827.3526 • 1.972.242.1160
Newest US Copper Project in a Decade Starts Production

Nevada Copper Corp. has commenced production at Pumpkin Hollow’s processing plant in Yerington, Nevada. The first shipment of concentrate and first revenues are expected in the coming weeks.

Ramp-up to full-scale commercial production at the Pumpkin Hollow underground mine will be under way through the first half of 2020.

The company said the project has a strong and growing production profile of 65 million pounds of annual copper equivalent production with further expansion potential. The current mine life is 13.5 years of reserves, with a further 636 million lb of inferred resources.

“This is a transformational moment for Nevada Copper, and I want to thank our team, construction and finance partners for their dedication throughout this process,” Matt Gili, CEO of Nevada Copper, said. “Considering the construction decision was made only 16 months ago, it is a remarkable achievement to have reached this point on schedule and it speaks to the commitment of our team and the support of our shareholders.”

Gili explained that this is the first key milestone for the company and that Pumpkin Hollow has multiple avenues for growth, including an advanced-stage, large-scale open-pit project and significant regional exploration targets.

Equinox Gold, Leagold Will Merge

Equinox Gold Corp. and Leagold Mining Corp. plan to merge, creating one of the top gold producing companies operating entirely in the Americas. The combined entity will continue as Equinox Gold and be headquartered in Vancouver, Canada.

Pro forma gold production of 700,000 ounces (oz) in 2020 will grow to 1 million oz during 2021 and beyond. Equinox Gold will operate six operating mines in the U.S., Mexico and Brazil. With a strong balance sheet and cash flow, the company said it will have the ability to fully fund two development projects and two expansion projects. A pro forma market capitalization of $1.3 billion will provide scale, liquidity and re-rate potential, according to the companies.

The new Equinox Board, led by Ross Beaty (former Equinox chairman), will have eight members with four from each company. The company will have an experienced management team led by Neil Woodyer as CEO, Christian Milau as executive vice president of corporate, Attie Roux as COO and Peter Hardie as CFO.

“In addition to having strong financial and operating metrics, our large scale will provide improved liquidity, greater asset and country diversification and a lower risk profile for all shareholders,” Beaty said. “This is the kind of gold company investors want today and I’m very pleased we are combining forces to achieve it.”

Leagold shareholders will receive 0.331 of an Equinox Gold share for each Leagold share held. This implies at-market consideration of C$2.70 per Leagold common share, using closing prices for both Equinox Gold and Leagold common shares on the Toronto Stock Exchange on December 13. At closing, existing Equinox Gold and Leagold shareholders will own approximately 55% and 45% of the merged company, respectively, on an issued share basis.

Equinox Gold is producing gold from its Mesquite gold mine in California and its Aurizona gold mine in Brazil. It is also constructing its Castle Mountain gold mine in California with the target of pouring gold in the third quarter of 2020. Leagold owns four operating gold mines in Mexico and Brazil, along with a near-term gold mine restart project in Brazil and an expansion project at the Los Filos mine complex in Mexico.

The transaction is subject to regulatory approvals. It is expected to close in the first quarter of 2020.

Zijin Buying, Buriticá Project in Colombia

Zijin Mining Group and Continental Gold announced in early December they have entered into a definitive agreement where-
by Zijin will acquire all of the outstanding shares of Continental in an all-cash transaction valued at about $1.4 billion. Continental’s primary asset is its underground Buriticá gold project in northwest Colombia. The project is scheduled to come into production during the first half of 2020 and is planned to produce an average of about 250,000 ounces per year (oz/y) of gold over a 14-year mine life at life-of-mine all-in sustaining costs of about US$600/oz.

Zijin Chairman Chen Jinghe said, “The Buriticá project in Antioquia, Colombia, is one of the largest and highest-grade gold projects in the world and represents a highly complementary addition to Zijin’s international asset portfolio. We believe the sizeable, high-grade mineral resource of 16.02 million metric tons (mt) at an average gold grade of 10.32 grams/mt presents excellent opportunities to expand production and extend mine life.

“Continental has successfully advanced and substantially de-risked the Buriticá project, with commercial production now clearly in sight and first gold pour expected in the first half of 2020. Continental also holds a sizeable and highly prospective land package in Colombia that, combined with the Buriticá project, provides Zijin with the leading position in an emerging, world-class, gold-producing region.

Newmont Goldcorp and directors and officers of Continental collectively holding approximately 21.5% of the outstanding Continental common shares have entered into voting support agreements to support the transaction.

Ari Sussman, CEO and a director of Continental, said, “The all-cash offer at a significant premium to market is an excellent outcome for our shareholders and is a testament to the extraordinary effort of the Continental team and its stakeholders in pioneering a new and modern gold industry in Colombia. In the span of a decade, Continental has transformed the Buriticá project from a grassroots discovery into one of the world’s largest and highest-grade gold projects.

Zijin Mining is based in Fujian, China, and is a leading global mining company specializing in gold, copper and zinc. Listed on the Shanghai and Hong Kong stock exchanges, its main existing projects are distributed in 18 provinces in China and 11 overseas countries.

Northern Star Will Purchase Other Half of KCGM

Northern Star Resources has struck a deal with Newmont Goldcorp’s Australian subsidiary to acquire its 50% stake in Kalgoorlie Consolidated Gold Mines (KCGM), which operates the Super Pit gold mine, for $775 million and additional associated assets for $25 million, taking the total consideration to $800 million. A month ago, Barrick Gold sold its 50% interest in KCGM to Saracen Mineral Holdings Ltd. for $750 million.

Northern Star’s total resources will increase to 28.3 million ounces (oz), including 9.8 million oz in reserves, with four Tier-1 assets in Tier-1 locations. The acquisition also includes a separate parcel of nearby leases owned by Newmont and a transition services arrangement to ensure a smooth transfer of the asset into Northern Star’s portfolio.

Northern Star also has been granted an option to acquire Newmont’s power assets, which supply power to KCGM. Under the terms of the option arrangement, Northern Star has an exclusivity period to conduct due diligence and finalize a transaction with Newmont. The $25 million option fee will be credited against any price agreed or, if Northern Star elects not to proceed, will be refunded when Newmont sells Newmont Power to a third party.

Northern Star Executive Chairman Bill Beament said the acquisition would create substantial value and provide enormous short-, medium- and long-term opportunities.

“This is one of the world’s greatest gold systems, as shown by the fact that it contains up to 60,000 oz per vertical meter,” Beament said. “To put this in context, our Junee mine, which is itself a Tier-1 asset, contains around 13,000 oz per vertical meter.”

Located in Western Australia, KCGM is part of the globally significant “Gold-en Mile,” which has a total endowment of approximately 80 million oz. A top-five Australian gold asset by production for the past two calendar years, it has produced on average about 590,000 oz per year (oz/y) at an all-in sustaining cost (AISC) of $913/oz.

Northern Star expects its share of KCGM to add 120,000 oz to 140,000 oz to its FY20 gold production at an AISC of $997/oz to $1,066/oz, increasing Northern Star’s FY20 guidance to 920,000 oz to 1,040,000 oz at an AISC of $852/oz to $921/oz.

KCGM Operations include the Fimiston Open Pit (the Super Pit), the Mount Charlotte underground mine and the Fimiston and Gidji processing plants. As of December 31, 2018, and on a 100% basis, KCGM had proven reserves (non-JORC) of 7.3 million oz at 1.2 grams per metric ton (mt) and resources of 11.7 million oz at 1.3 g/mt, as well as significant upside, primarily through ongoing underground development, providing a foundation for long-life gold production.

The $800 million cash consideration will be funded through a combination of new secured debt facilities of A$480 million with Northern Star’s existing lending group; and a fully underwritten institutional placement of approximately A$765 million, and existing cash reserves of A$5 million.

Completion of the acquisition is subject only to approval of the Western Australia Minister of Lands, with the acquisition expected to close by early January.

The Super Pit (above) has produced 590,000 oz/y of gold on average. (Photo: KCGM)
Hecla Ramping Up Lucky Friday Mine to Full Production

On Monday, December 16, union members of the United Steelworkers (USW) Local No. 5114 voted down an option to ratify a tentative agreement between the USW and Hecla Mining Co.'s negotiating committees. The union has been on strike at the Lucky Friday mine in Mullan, Idaho, since March 2017. Following the vote, Hecla said it was committed to bringing the mine back to full production and will be hiring more employees and contractors.

“For much of 2019, we have employed a number of hourly workers who, combined with our salaried workforce, have operated the Lucky Friday on a limited basis,” said Phillips S. Baker Jr., president and CEO, Hecla Mining. “We will now accelerate hiring and utilizing contractors with the goal of reaching full production by year-end 2020.

“While we would have preferred ratification of the agreement reached by the two negotiating committees, after three years of negotiating we believe the best interests of the company and community is the Lucky Friday in full operation. The mine has operated for 75 years, and we believe its best days with projected higher grades and more cash flow, are in front of it.”

Baker acknowledged the salaried and hourly staff at Lucky Friday, who kept the mine operating during the strike. “They have operated in a very safe manner, and were recently recognized with a Sentinels of Safety Award from the National Mining Association,” Baker said.

Lucky Friday is a deep underground silver, lead, and zinc mine located in the Coeur d'Alene Mining District in northern Idaho. The mine began operating in 1942 and celebrated its 75th anniversary in 2017. In 2018, the mine produced 169,041 ounces (oz) of silver and it is expected to have another 20-30 years of mine life. In 2016, Lucky Friday produced 3.6 million oz of silver.

Golden Predator Installs All-season Camp at Brewery Creek Mine

Golden Predator Mining Corp. has established a 49-person, all-season camp at the Brewery Creek mine site located near Dawson City, Yukon, Canada. The new camp facilities, which include dorm rooms, an 80-person industrial kitchen, recreational and mud room, and arctic corridors, will be added to the current 24-person camp and maintenance/office facilities and will provide all the on-site accommodations required for contemplated development and operational activities at the Brewery Creek mine.

The proximity of the Brewery Creek mine to the community will allow much of the workforce to live and work from Dawson City, with anticipated shuttle service, significantly reducing the personnel required to be housed in camp, according to Golden Predator Mining.

“The camp is now installed with maintenance work ongoing through the winter to ensure a fully operational camp for the spring startup,” said Janet Lee-Sheriff, CEO, Golden Predator. “In addition to realizing significant upfront capital savings, the camp enables a more aggressive execution schedule once anticipated construction begins.”

In related news, the company recently appointed Mike Maslowski as COO. He will lead the mine development team and is charged with advancing the Brewery Creek mine through development toward planned operations. Maslowski will coordinate and manage all the construction, mine development and activities at the Brewery Creek mine.

Santa Fe Gold Will Recommission Billali Mine to Boost Production

U.S.-based Santa Fe Gold Corp. said it will begin recommissioning its Billali mine to substantially increase output of its economic grade, high silica vein gold and silver siliceous vein material. This is in addition to its already expanding production from its Jim Crow mine for delivery to a major smelter, under arrangement to ship all of its maximum attainable output as it builds to higher levels, according to the company.

Management said it will continue to develop and increase production of gold and silver siliceous vein material from the Jim Crow mine.

Both of these mines are said to have potential for expansion by developing already known parallel veins and extending the present workings along known strike lengths and by developing new levels throughout.

Chairman Brian Adair said, “This should enable Santa Fe to ramp up production substantially over coming quarters and beyond. Thereafter, it is expect-
Pit-to-plant harmonisation
- are you missing opportunities to optimise your mine?

Improved throughput combined with lower expenditure and operating costs. These are some ways you could benefit from working with the only OEM that provides market-leading solutions throughout your process chain.

But complete pit-to-plant coverage means more than just solutions - it means holistic knowledge, optimised practices and an integrated approach when it comes to identifying ways to improve your operations.

And since we also deliver downstream solutions, we can work with you to maximise productivity throughout your mine. Discover how we can take your productivity to the next level.

FLSmidth.io/IPCC
ed Santa Fe will begin preparations to commence production from its Gold King and Imperial Mines, as sustainable output is achieved from Billali and Jim Crow to maintainable levels."

"With shipments to smelters getting under way, the potential ability to attain profitable production from the Jim Crow mine and soon the Billali and other mines in the Steeple Rock district, coupled with the longer-term development of the Alhambra mine and other mines in the Black Hawk district, along with higher asset prices, continues to augur well for Santa Fe Gold as a particularly unique opportunity," said Dan Gorski, consulting geologist for Santa Fe Gold Corp.

Iamgold Adds Interest in Nelligan Project in Quebec

Iamgold has exercised its option to increase its undivided interest in the Nelligan joint-venture project 60 kilometers (km) southwest of Chibougamau, Quebec, to 75%. Vanstar Mining Resources holds the remaining 25%. The project is organized under an earn-in option to joint-venture agreement, with Iamgold as the operator.

Under the terms of the agreement, Iamgold exercised its option to increase its ownership interest in the property from 51% to 75% by completing a mineral resource estimate and making remaining cash payments to Vanstar totaling C$2.35 million. Iamgold retains a further option to acquire an additional 5% interest by completing and delivering an NI 43-101-compliant feasibility study.

The Nelligan project currently hosts pit-constrained inferred resources totaling 97 million metric tons (mt), averaging 1.02 grams/mt gold, for 3.2 million ounces (oz) of contained gold.

In the coming months, additional metallurgical tests will be completed to provide additional information on the metallurgical recoveries from the various zones of Nelligan mineralization and to help optimize process flowsheet parameters.

Planning for future drilling programs is ongoing, with objectives that include additional infill drilling to improve resource classification and convert inferred resources to indicated resources, evaluation of potential resource extensions in the deeper parts of the deposit, and evaluation of potential resource expansions along strike. Regional exploration will continue to define and test other priority targets on the property.

Iamgold Senior Vice President of Exploration Craig MacDougall said, "The exercise of the option to increase Iamgold’s ownership to 75% consolidates our ownership in this new discovery and further supports our view of the favorable exploration potential for the discovery of additional resources. We look forward to continuing to work with Vanstar as we advance our exploration efforts on the project."

Rise Gold Looking to Reopen Historic Idaho-Maryland Mine

Rise Gold Corp. has submitted an application to Nevada county, California, for a "Use Permit" to allow the reopening of the historic Idaho-Maryland gold mine. The mine is located in the Sierra Nevada mountains of northeast California. The Use Permit application proposes renewal of underground mining at an average rate of 1,000 short tons per day (st/d).

The existing Brunswick shaft, which extends to about 3,400 ft below surface, would be used as the primary rock conveyance from the mine. A second service shaft would be constructed by raising from underground to provide for the conveyance of personnel, materials and equipment.

Gold processing would be done by gravity and flotation to produce gravity and flotation gold concentrates. Processing equipment and operations would be fully enclosed in modern buildings, and numerous mature trees located on the perimeter of the Brunswick site would be retained to provide visual shielding of above-ground project facilities and operations.

Barren rock from underground tunneling and sand tailings would be used to create approximately 58 acres of level, industrial-zoned land for future economic development in Nevada county.

A water treatment plant and pond using conventional processes would ensure that groundwater pumped from the mine is treated to regulatory standards before being discharged to the local waterways.

Approximately 300 employees would be required if the mine reaches full production.

Rise Gold has completed 20,600 meters (m) of exploration core drilling at the Idaho-Maryland mine site. Numerous high-grade gold intercepts have been encountered, both near the existing mine workings and to depths significantly below historic mining areas. The company believes its drilling program has been successful, but cautions that no current mineral resources or mineral reserves have been defined.

The company has not completed a feasibility study and, therefore, has not demonstrated economic viability for redevelopment of the mine.

Rise Gold is incorporated in the state of Nevada and maintains its head office in Vancouver, British Columbia, Canada.

A long section shows the Idaho Veins system and drill highlights.
All the power you need

Our ambition is to boost your productivity, enhance safety and cut emissions – all while lowering your total cost of operation.

With our unique combination of battery electric vehicles and our new offering Batteries as a Service we can help you on your journey towards a zero emission future.
BHP has appointed a new chief executive officer, Mike Henry. He replaces Andrew Mackenzie who will retire. Henry has been president of operations, Minerals Australia, since February 2016. He has been a member of the executive leadership team since 2011. He joined BHP in 2003 and has 30 years of experience in the global mining and petroleum industry, spanning operational, commercial, safety, technology and marketing roles.

Golden Predator Mining Corp. announced Michael “Mike” Maslowski started on December 2 as COO. He will lead the mine development team and is charged with advancing the Brewery Creek mine, located near Dawson City in Canada’s Yukon, through development toward planned operations. He previously served as COO of Golden Predator from 2011 to 2014.

Ben Wesselly has been appointed general manager of KCGM. Wesselly has been in the mining and metal processing industry for more than 30 years, joining Newmont Goldcorp as mine optimization manager at the Merian mine in Surname in July 2017. He moved to the Boddington gold mine as senior manager mining in December 2017.

VMAC Resources Inc. announced changes to the board of directors. Terry MacGibbon will retire as executive chairman and step down from the board. Concurrently, Andrew Adams will assume the role of independent chairman of the board. Dr. Ross Bhappu, a senior partner of Resource Capital Funds, will join the board as an RCF Board nominee and João Carrêlo will concurrently step down as an RCF independent board nominee. Prior to joining RCF in 2001, he was president of a development-stage copper company, director of business development at Newmont Mining Corp., and served in various technical and financial roles at Cyprus Minerals Co.

Intrepid Potash Inc. appointed Brian Stone as COO and Kyle Smith as general counsel-land, minerals, water, oilfield solutions and government affairs. Stone has spent 34 years in all phases of the oil and gas industry, most recently as COO for Hupecol Operating Co. Prior to joining Hupecol, Stone was employed by J.M. Huber Corp., initially as vice president of energy marketing and later as chief risk officer.

Dacian Gold Ltd. announced the following board and management changes. Executive Chairman and CEO Rohan Williams will retire from the board and will resign as CEO. The board appointed Leigh Junk as the new managing director and CEO. Most recently, he was managing director of Dacian Gold until its merger with Silver Lake Resources Ltd. in April 2019. Ian Cochrane, presently a non-executive director of Dacian Gold, was appointed non-executive chairman.

Metals X Ltd. announced that Patrick O’Connor has been elected nonexecutive chairman. O’Connor was appointed as a nonexecutive director in October. Chairman Simon Heggen has resigned as a director of the company. Damien Marantelli, managing director, has resigned as a director, but will remain for a period of transition as CEO reporting to the board. Yimin Zhang, nonexecutive director has indicated his intention to retire. Zhang is the nominee director of Jinchuan Group Ltd. Brett Smith is appointed as a nonexecutive director of the company. Smith was proposed as a director by APAC Resources Ltd. Smith is currently executive director of Dragon Mining Ltd., executive director of APAC Resources Ltd. and none executive director of Tanami Gold NL and Prodigy Gold NL.

Sean Dessureault began a new position as vice president of technology and innovation at The Mosaic Co.

Centaurus Metals announced a series of new senior appointments centered on the recently acquired Jaguar nickel sulphide project in northern Brazil. John Westdorp has been appointed as CFO and will also transition to the role of company secretary when Paul Bridson steps down in early 2020. Westdorp was previously CFO and company secretary of Centaurus between 2012 and 2015, and has since held the role of CFO and interim CEO of MZI Resources Ltd. Roger Fitzhardinge has been appointed as operations manager—nickel. Fitzhardinge is a geologist with 20 years’ experience in the exploration and mining industry, including almost 10 years with Centaurus, where he was originally appointed as senior geologist and subsequently as exploration manager. John Knothe has been engaged as principal metallurgist. Most recently, he spent almost 10 years with midtier copper producer Sandfire Resources, where he held the roles of senior project/process engineer and subsequently principal metallurgist. Grant “Rocky” Osborne has been engaged as principal geoscientist. Osborne has more than 40 years of experience in international mineral exploration and underground mining, with particular expertise in nickel and gold. Osborne has worked with the Mitchell River Group as chief geologist for Albidon Ltd. and Mirabela Nickel Ltd.

The U.S. Senate voted to confirm Aurelia Skipwith as director of the U.S. Fish and Wildlife Service with a bipartisan vote of 52-39. Skipwith has served as deputy assistant secretary for Fish and Wildlife and Parks at the Department of the Interior since April 19, 2017.

ARAMINE appointed Serge Pacodi as country manager, Burkina Faso. Pacodi will lead the teams of Aramine Burkina, the subsidiary representing the brands Atlas Copco, Epiroc, Normet and BTI. In 2017, Pacodi worked as managing director for a multibrand automobile distributor.
2020 March 1 – 4
Metro Toronto Convention Centre
Toronto, Canada

REGISTER AT pdac.ca/convention
Purchase an All Access Pass and enjoy unlimited programming, networking events & more!

EXPAND YOUR NETWORK
25,000+ attendees from 132 countries

GAIN INSIGHTS FROM INDUSTRY EXPERTS
780+ speakers

ACCESS TO CAPITAL
2,500+ investors

PROMOTE YOUR BUSINESS
1,100+ exhibitors
Fruta del Norte Ships Concentrate

The Fruta del Norte mine exported its first shipment of gold concentrate from the Port of Guayaquil, in Ecuador, to the European market. The cargo that sailed on December 8 amounted to 177.9 tons of the ore. Production of this concentrate started on November 15.

The gold was transported from the mining company in eight sealed containers, 22 tons each. The cargo was escorted by armed security units all the way to the Port of Guayaquil, where it was stored in a guarded area, and then loaded on the ship.

Minister of Energy and Non-Renewable Natural Resources José Agusto said that 2019 was key for the Ecuadorian mining sector. “With the first export of Fruta del Norte, a responsibly managed mining activity is consolidated, an activity that complies with all current legal regulations, promotes the development of its communities and generates resources for the country,” he said. “This mine estimates export revenues for $7.89 billion between 2019 and 2034.”

The vehicles transporting the gold concentrate from the Fruta del Norte mine are covered by an insurance policy, are monitored by GPS systems and are driven by qualified drivers.

During 2019, three daily trucks with 22 tons each will leave the Fruta del Norte mine toward the Port of Guayaquil. This amount will increase every year, until reaching its maximum production within the next three years.

The Fruta del Norte mine — opened on November 14 — will have an estimated life span of 15 years and will annually produce 310,000 ounces (oz) of gold and 400,000 oz of silver. A total of $2.7 billion was invested for the mine development.

**Anglo Receives License for Minas-Rio Tailings Facility**

Anglo American has received the next phase of its operating license for its Minas-Rio tailings facility in Brazil, following the work to raise the dam as part of the Step 3 license area of the mine, the company said. The regulatory authorities in Brazil granted the installation license for this work in January 2018 and the construction work was completed in August 2019.

“This is an important milestone for our Minas-Rio iron ore operation in Brazil toward reaching its full potential,” said Seamus French, CEO of Bulk Commodities at Anglo American.

French added that Minas-Rio expected to produce 23 million metric tons (mt) in 2019, with an FOB unit cost of about $24/mt.

The Minas-Rio tailings dam uses a downstream construction design and is an embankment dam structure, built using compacted imported earth-fill material, with carefully selected granular materials for the drainage and filter zones. Tailings are not used to build the dam, and instead construction materials are placed in controlled layers. French explained this is a conservative and high-quality design for a tailings dam, being designed and built as a water-retaining type of dam.

**PFS Supports Argonaut’s Cerro del Gallo Project**

Argonaut Gold has reported the results of a positive prefeasibility study (PFS) of its 100% owned Cerro del Gallo project 30 kilometers (km) east of the city of Guanajuato, Mexico. The study describes an open-pit, heap-leach project that would produce an average of about 64,000 ounces per year (oz/y) of gold, 1.3 million oz/y of silver, and 2,400 metric tons per year (mt/y) of copper over a mine life of 15.5 years.

Preproduction capital costs are estimated at $134 million. Construction time is estimated at 18 months. Estimated all-in sustaining costs are $597/oz of gold sold. The after-tax pay-back period is estimated at 4.5 years.

Cerro de Gallo ore will be mined by truck-and-shovel, open-pit mining methods at a rate of 6 million mt/y, fine crushed using a system incorporating cone and high-pressure grinding roll crushers, agglomerated with cement, and conveyor stacked on the heap leach pad. Ore will be leached with a dilute cyanide solution at a high solution application rate for the first 40 days and a lower application rate for the remaining 80 days for a total leach cycle of 120 days.

The gold, silver, and copper bearing solution will be collected in a pregnant solution pond and pumped to an SART plant. Pregnant solution will be acidified with sulphuric acid, and copper and silver will be precipitated as sulphides by the addition of sodium hydrosulphide. The precipitate will be thickened and filtered to produce a copper-silver filter cake for shipment to a smelter.

The copper-stripped barren solution from the SART plant will then be processed in a carbon ADR plant to recover gold. The

(Continued on p. 19)
Kirkland Lake Gold has announced new high-grade results from ongoing drilling into the Robbin’s Hill resource at its Fosterville mine in Victoria, Australia. The results include high-grade intercepts containing visible gold, according to the company. The reported drill results are from 66 holes totaling 36,428 m that targeted extension and infill of the Robbin’s Hill mineral resources previously reported in December 2018.

Kirkland Lake President and CEO Tony Makuch commented, “For a long time, we’ve been saying that there could be more Fostervilles at Fosterville, and, with today’s results, Robbin’s Hill has clearly emerged as a second potential mining front to provide feed to our Fosterville mill. Based on current drilling, we have already identified a large mineralized system at Robbin’s Hill that we expect will support substantially higher levels of mineral resources and that remains open at depth and along strike.

“Most of our drilling has targeted areas 650 m from surface and higher. The level of visible gold in quartz that we’ve intersected in this area compares favorably to levels seen at the existing Fosterville mine at similar elevations. The presence of visible gold in quartz and the 500-m down-plunge extension of Robbin’s Hill mineralization included in today’s results highlight the potential for future discoveries of high-grade, visible gold-bearing zones at depth similar to Swan and Eagle at Fosterville’s Lower Phoenix system. Work is continuing at Robbin’s Hill, with five surface drill rigs on site and plans currently being finalized for future underground development and drilling.”

In addition to drilling and other exploration techniques, Kirkland Lake is currently performing a 3D seismic survey covering approximately 6 km² in the north part of the Fosterville mining license. The geophysical survey is the first of its kind to be undertaken in Victoria for gold exploration and will provide a high-resolution 3D dataset to a depth of more than 1 km. The company is optimistic that results of this detailed survey will assist in the definition of structural features and mineralized corridors that will aid the future exploration and development of the Robbin’s Hill area.

Lynas Selects Kalgoorlie for Rare Earths Processing Plant

Lynas Corp. has selected Kalgoorlie, Western Australia, as the location for its new rare earths cracking and leaching plant (See E&MJ, October 2019, p. 4). Kalgoorlie was selected from the two short-listed locations in Western Australia’s Goldfields region following extensive due diligence. The city provides close proximity to Lynas’s rare earths mine at Mt Weld, as well as a skilled workforce and a rich history in the mining and processing industries.

Lynas produces rare earths concentrate at the Mt Weld mine and flotation concentrator 30 kilometers south of Laverton, Western Australia. The plant is designed to process 240,000 metric tons per year (mt/y) of ore and produce up to 66,000 mt/y of concentrate containing 26,500 mtpy of rare earth oxides. The concentrator was commissioned in May 2011 and has been exporting concentrate to Lynas processing operations in Malaysia since late 2012.

Lynas signed an option to sublease an industrial-zoned property from the city of Kalgoorlie-Boulder. The terms are being finalized. The signing of the option follows Lynas signing a memorandum of understanding with Kalgoorlie-Boulder announced in early September.

The Kalgoorlie cracking and leaching plant will upgrade Mt Weld concentrate that is currently exported to Malaysia. It is a further step toward delivering on the Australian federal government’s “Critical Minerals Strategy” and the government of Western Australia’s objective of developing more downstream processing within the state. Lynas will also explore opportunities for the next stage of processing (upstream solvent extraction) in Western Australia.

Alien Metals Acquiring Past-producing Silver Mine

Alien Metals Ltd. has entered into a conditional agreement to acquire a 100% interest in the former-producing Elizabeth Hill silver project in Western Australia from Karratha Metals Group. The project was mined from 1998 to 2000, extracting ore from a small but very high-grade silver deposit. Mine production totaled approximately 16,800 metric tons (mt) of ore grading 2,195 grams/mt silver, containing 1.17 million ounces (oz) of silver, including some very large specimens of native silver.

The Elizabeth Hill project is located about 40 kilometers (km) from the deep-water port at Dampier, Western Australia, and 8 km from rail infrastructure. Grid power and groundwater are available on site. Native silver and lesser amounts of silver sulphide minerals occur as both fine and coarse grains within a coarse-grained calcite vein stockwork. Historic exploration totaled 50,000 meters (m) in 470 holes.
Barrick Sells Interest in Massawa Project

Barrick Gold Corp. has reached an agreement to sell its aggregate 90% interest in the Massawa project in Senegal to Teranga Gold Corp. for a total consideration of up to $430 million. Teranga’s flagship Sabodala gold mine in Senegal is located adjacent to the Massawa project, creating the opportunity for significant capital and operating synergies.

The agreement includes an up-front payment of $380 million, comprised of more than 20.7 million Teranga common shares with an aggregate value of approximately $80 million, and a cash payment of approximately $300 million, plus a contingent payment of up to $50 million, which is based on the average gold price for the three-year period immediately following closing.

The contingent payment is payable three years following closing.

Barrick will receive 92.5% of the total purchase price for its interest in the Massawa project, with the balance to be received by Barrick’s local Senegalese partner for its minority interest. On a pro forma basis, Barrick will hold 19.2 million Teranga common shares, representing approximately 11.45% of Teranga’s issued and outstanding common shares on closing.

Barrick will have the right to nominate one Teranga director for as long as it retains at least a 10% equity interest in Teranga.

Barrick President and Chief Executive Mark Bristow said the group had been pursuing the best means of bringing Massawa — discovered by its legacy company Randgold Resources 10 years ago — to account for the full benefit of all stakeholders. The agreement with Teranga, which will realize the full value of this asset and create a substantial new West African gold mining company with significant African ownership, is the outcome of this process.

The transaction is expected to close in the first quarter of 2020 and is subject to receipt of the Massawa exploitation license and residual exploration license from the government of Senegal, certain other acknowledgments from the government of Senegal and other customary closing conditions.

Redeveloped Obuasi Mine Pours First Gold

AngloGold Ashanti has poured the first gold at its redeveloped Obuasi gold mine in Ghana. Mining was suspended at Obuasi five years ago. The redevelopment project is targeting access to the property’s 30-million-ounce (oz) orebody over the next two decades and beyond.

The first phase of construction for Obuasi redevelopment was completed on time and on budget over the past 18 months and included refurbishment of an existing plant, construction of new infrastructure, and underground development in line with a new mine plan. Following ramp-up, mining is planned at a rate of 2,000 metric tons per day (mt/d) during 2020, climbing to 4,000 mt/d by year-end.

Gold production is forecast to average 350,000 oz per year (oz/y) to 400,000 oz/y for the first 10 years and above 400,000 oz/y over the life of the mine at all-in sustaining costs of around $800/oz.

AngloGold Ashanti CEO Kelvin Dushnisky said, “Producing first gold on budget and on a tight schedule is a significant achievement for the company, for the community at Obuasi, and for Ghana as a whole.”

Underground mine development is ongoing, with deepening of the Obuasi Deeps decline and access to the KRS shaft on schedule for mid-2020. Construction of new plant and infrastructure will continue throughout 2020. The initial project capital for Obuasi redevelopment remains in the range of $495 million to $545 million to be spent by the end of 2020.

AngloGold Ashanti is working closely with government and community stakeholders to ensure that the Obuasi mine is developed sustainably, fueling growth for Ghana and benefitting the communities around the mine. A committee, including local stakeholders and regulators, has been created to track execution of the reclamation of the mine site, and the mine will be contributing $2/oz of gold produced to a Community Trust Fund over its mine life to facilitate development projects in the local area.

The redevelopment project has placed a premium on local content, with 80% of the capital thus far spent in-country. Ghanaian companies have been given preference in the procurement of goods and services, from the large-value underground mining contract all the way to catering and security contracts. Employment has also prioritized Ghanaians from the immediate area around the mine wherever possible.
India Becomes a Net Copper Importer

By Ajoy K. Das

The closure of Vedanta Ltd.’s copper smelter in the southern state of Tamil Nadu has wiped off about 46% of availability of the base metal in the domestic market, turning India into a net importer of copper after 18 years.

Vedanta Ltd.’s Sterlite Copper Plant located at Tuticorin was closed down by the government of the southern Indian state of Tamil Nadu in May 2018 when six people were killed when the police opened fire on a local population protesting the pollution caused by the smelter.

The Tamil Nadu government ordered a “permanent closure” of the plant in response to the killings and protests over the pollution. Over the past year, there have been several attempts by the Vedanta Group, the principal promoters of Sterlite Copper to reopen the plant, but the process has been in a legal logjam since last year.

According to government data, Indian refined copper production during 2013-2014 and 2017-2018 recorded a compounded annual growth rate (CAGR) of 9.6%. But following the closure of Vedanta’s Sterlite Copper Plant with a capacity of 400,000 metric tons per year (mt/y) of refined copper and accounting for 40% of domestic supply of the metal, total output of copper in India was down 46% during fiscal year 2018-2019.

The shortage situation was further aggravated by a fall in production from Hindalco Industries and state-run Hindustan Copper Ltd. (HCL) during the year owing to scheduled plant shutdowns. The other two primary domestic copper producers accounted for a combined 800,000 mt of domestic supplies of copper per year.

Government data indicates that India imported about $1.97 billion worth of copper cathodes primarily from Congo, Singapore, Chile, Tanzania and South Africa during fiscal year 2018-2019.

In the first six months of the current fiscal year 2019-2020, the country has already imported 70,000 mt of copper cathodes at an estimated value of $447 million.

In sharp contrast, India has exported 378,000 mt of copper cathodes in 2017-2018 which plunged to a mere 48,000 mt of the estimated value of $300 million in 2018-2019.

During the first six months of the current fiscal year, Indian exports of copper cathodes is estimated at 7,000 mt.

ArcelorMittal, Nippon Steel Complete Essar Acquisition

ArcelorMittal has completed the acquisition of Essar Steel India Ltd., and simultaneously established a joint venture with Nippon Steel Corp., called ArcelorMittal Nippon Steel India Ltd. (AM/NS India), which will own and operate Essar. ArcelorMittal holds 60% of AM/NS India, with Nippon Steel holding the balance.

“The acquisition of Essar Steel is an important strategic step for ArcelorMittal,” said Lakshmi Mittal, chairman and CEO of ArcelorMittal. “India has long been identified as an attractive market for our company and we have been looking at suitable opportunities to build a meaningful production presence in the country for more than a decade.”

Mittal said Essar has sizeable, profitable, well-located operations and the potential for long-term growth for the Indian economy is well-known.

“We are also delighted to be embarking on this together with Nippon Steel, with whom we have a trusted, long-term relationship,” Mittal said. “Our combined strengths and technology will bring many new opportunities, which will allow us to make a positive contribution to India’s target to grow steelmaking capacity to 300 million metric ton per year (mt/y) by 2030, and for its manufacturing sector more broadly.”

AM/NS India’s current level of annualized crude steel production is approximately 7.5 million mt. It also has iron ore pellet facilities in the east of India, with current annual capacity of 14 million mt/y.

Mongolia Approves Resolution on Oyu Tolgoi

Rio Tinto reported the Mongolian Parliament unanimously approved a resolution that instructs the government to look for ways to improve the implementation of the Investment Agreement of 2009, the Amended & Restated Shareholder Agreement of 2011 and the Underground Mine Development & Financing Plan of 2015. The passing of this resolution reconfirms the validity of all the investment agreements between the government of Mongolia, Rio Tinto and Turquoise Hill Resources.

This brings to a close an 18-month review by the Parliamentary Working Group of Oyu Tolgoi and the investment agreements governing the business, according to Rio Tinto.

The resolution includes exploring options to look at the Mongolian government’s equity share in Oyu Tolgoi; a redefinition of the reserve report and updated feasibility report; a renewal of the environmental and water assessments; and further capability development within the team, which represents the Mongolian party.

Alamos Suspends Activities in Aegean Region

Alamos Gold Inc. reported that it has suspended all construction activities on its Kirazli project pending the renewal of its Turkish mining concessions which expired on October 13, 2019. Although the mining concessions have not been revoked and can be renewed following this expiration date, no further construction activities can be completed until the concessions have been renewed. The company has met all the regulatory requirements and conditions for the concessions to be renewed and reasonably expected the renewal by the expiration date, according to Alamos Gold. Local communities to the Kirazli project remain supportive. The company is working with the Turkish Department of Energy and Natural Resources on securing the renewal of the mining concessions, which will allow for a resumption of construction activities. The renewal is required from the same government department that granted the Operating Permit for Kirazli in March.

Since 2010, Alamos has been working with the various government ministries and local communities as part of a multi-year environmental review and community consultation process. The company was granted approval of all the major permits needed to build Kirazli including the Environmental Impact Assessment, forestry permits, GSM and operating permits.

Given the uncertainty around the timing of the concession renewal, initial production from Kirazli has been delayed from previous guidance of late 2020.
Newcrest Mining has reported additional high-grade results from the Havieron gold exploration project 45 kilometers (km) east of the company’s Telfer gold mine in Western Australia. The project is operated by Newcrest under a farm-in agreement with Greatland Gold. The project is centered on a deep magnetic anomaly overlain by more than 420 meters (m) of post-mineral cover. Newcrest can earn up to a 70% joint-venture interest in the project through total exploration expenditures of $65 million over a six-year period.

Recent drill intercepts from separate holes at Havieron have included 14.6 m grading 9.1 grams/metric ton gold and 0.48% copper from 705 m downhole, 13 m grading 13 g/mt gold and 1.1% copper from 770 m, 21 m grading 10 g/mt gold and 0.74% copper from 665 m, and 39 m grading 6.5 g/mt gold and 0.40% copper from 764 m, including 10.6 m grading 22 g/mt gold and 1.3% copper from 764.9 m.

Drilling is ongoing at Havieron, with six drill rigs currently turning at the project. To date, drilling at the Havieron project has defined a series of higher-grade zones within a broad envelope of mineralization and has recently extended the footprint of the high-grade mineralization 100 m to the north. The Newcrest announcement cautions that although results to date are highly encouraging, the project is still at an early stage. Infill and extension drilling is ongoing to define geometric relationships and mineral continuity within the footprint of the magnetic anomaly. Interpretation of results suggests the system is open to the north and at depth.

Assuming Newcrest completes its 70% farm-in, the company may acquire an additional 5% interest in Havieron at the end of the farm-in period at fair market value. During the farm-in period, the company has a first right of refusal over the remainder of Greatland Gold’s Paterson project.

The farm-in agreement includes tolling principles reflecting the intention of the parties that, subject to a successful exploration program and feasibility study, the resulting joint-venture ore will be processed at Telfer.

The Telfer mine produced 452,000 oz of gold during Newcrest’s 2019 fiscal year. (www.newcrest.com)

SilverCrest Metals has reported additional drill results from its previously mined Las Chispas property in Sonora, Mexico. The current drill program on the Las Chispas and Giovanni veins is designed to expand high-grade precious metal mineralization by stepping out from historic underground workings along the down plunging mineral-
ized trend toward intact and previously unmined areas. A newly defined high-grade zone named Area 118 now measures 300 m along strike and 125 meters (m) in height across 1.6 m grading 16.54 grams/metric ton gold and 1,837.3 g/mt silver.

SilverCrest currently has 17 core drills operating at Las Chispas, 16 surface and one underground. Twelve rigs are currently completing in-fill and known vein expansion holes in the project’s Babicanora area, and four rigs are working on new vein targets in the Las Chispas area.

Historically, the Las Chispas vein had the largest recorded production in the district, with approximately 40 million ounces (oz) of silver and 200,000 oz to 300,000 oz of gold. Historic grade from various public domain references is estimated at 15 g/mt for gold and 1,700 g/mt for silver. (www.silvercrestmetals.com)

Lion Ore Metals has encountered multiple high-grade gold intercepts in its first deep diamond drill hole at its Tuvatu alkaline gold deposit in Fiji. The first of a series of four deep diamond drill holes, oriented eastward at an inclination of 55° and drilled to a depth of 536.9 m, encountered high-grade gold mineralization at the bottom of the current delineated resource. Of particular note is a 4.29-m interval of 33.22 g/mt gold starting at 422.53 m down hole (true width estimated to be 2.5 m).

This interval, fully 70 m below the current resource, is comprised of hydrothermal breccia unlike any mineralization previously observed at Tuvatu, but closely resembling that seen in some lodes at the Vatukoula gold mine approximately 40 km to the northeast. Included in this interval is a 0.31-m interval of 322 g/mt gold beginning at 423.41 m down hole. Lion One believes this intercept is highly significant and suggests the mineralizing system is evolving with depth, perhaps an indication of further high-grade mineralization below. In this area, several lode structures appear to be converging, potentially forming a root feeder. (lionoremetals.com)

Nord Gold has reported encouraging results from the 2019 drilling program on the Vickers gold deposit at its the Pistol Bay project on the west coast of Hudson Bay, Nunavut, Canada. The company completed a diamond drilling program consisting of 10 holes totaling 4,608 m during the summer of 2019 to test extension of high-grade mineralization beyond the current resource. The program targeted the southward and westward continuations of the flat-lying, high-grade mineralization beyond its previously modeled limits.

The results were compelling. All of the 2019 drill holes confirmed the continuation of the high-grade mineralization at Vickers, intersecting grades and widths potentially suitable for underground mining. Six drill holes extended the gold mineralization laterally to a post-mineral dyke. Four drill holes demonstrated that the mineralization steepens and continues at least 200 m southwestward beyond the dyke.

SRK Consulting has been contracted to update open-pit resources and provide an evaluation of the underground resource potential based on the 2019 exploration campaign results. Based on these studies, Nord Gold intends to implement a further drilling program in 2020 to better define the Vickers deposit and further increase the potential for underground mining at Pistol Bay. (www.nordgold.com)
South Africa Comes to Standstill With Eskom’s Load Shedding

By Gavin du Venage, South African Editor

Some of the largest mining operations around South Africa have ground to a halt as the country once again undergoes rolling electricity blackouts.

In late November, the country’s state-owned energy utility warned it could not guarantee electricity supplies, and began “load shedding,” taking parts of the national grid offline. In December, it implemented “Stage 6” electricity cuts — about 6,000 megawatts (MW) of production shed, the first time ever in Eskom’s history. Previous cuts had only gone to Stage 4 at maximum, or 4,000 MW.

Mining in particular is an energy intensive industry, especially in the gold and platinum regions in the north, where much of the activity takes place underground. Operations need to pump water to keep operations from flooding, as well as provide hoists to transport men and materials to and from work sites.

“Underground mines are far more seriously affected,” said Alan Fine, spokesman for the Minerals Council of South Africa. “In fact, for most mines, processing facilities will need to be curtailed quite substantially, if not totally.”

Safety is compromised and few mines have the necessary backup generation capacity, since their power needs are close to those of a small city.

Eskom, meanwhile, also appealed to energy intensive users to reduce operations.

Petra Diamonds said it had halted operations at three of its mines — Cullinan, Finsch and Koffiefontein — in response to Eskom’s request.

Harmony Gold also announced it had suspended nightshift operations.

Anglo American Platinum, meanwhile, issued a shareholder notice ahead of a briefing to investors warning that production could be impacted by power outages. Sibanye-Stillwater, which operates some of South Africa’s oldest gold mines, also said it would cut production.

Previously, mining companies have noted that electricity is one of their largest costs, making up to one-third of their operating expenses in South Africa. Eskom for its part is struggling with an aging fleet of coal plants that supply more than 90% of the country’s electricity.

Two mega coal stations in the northern part of the country are still partially complete after work began in 2010. Each plant will have a capacity of 4,800 MW and consume 15 million tons of coal annually.

These were intended to replace the older coal plants mostly in the Mpumalanga province. Years of delay, however, mean older, increasingly unreliable coal stations are kept chugging along.

Apart from mining operations, the power cuts were also hurting other critical systems, said Minerals Council Chief Economist Henk Langenhoven. “We have logistical problems like the unavailability of harbor and rail capacity,” he noted. Crucially, smelters that produced ore had to be shut down or risk permanent damage if slag cooled and hardened in their crucibles.

“The smelters are the big users and the first to be asked to curtail consumption,” Langenhoven said.

The government has said it wants to continue developing coal mines, as the country has around 50 billion tons in the ground, enough to last for the next two centuries at least, according to Mineral Council figures.

The coal mining industry itself, however, is under pressure from the government to reduce prices at which it sells to Eskom. Public Enterprises Minister Pravin Gordhan, under whose aegis Eskom falls, told parliament in December talks had begun with producers.

“We have got to lower the price of coal,” Gordhan said. “We are talking to coal suppliers to make sure they contribute; they have to share the burden.”

He said Eskom was returning to the practice of cost-plus mines, in which power plants rely on mines located next to them at preferential prices.

Under the administration of former President Jacob Zuma, Eskom had signed deals with politically connected businessmen in a corruption scandal now unfolding in a series of public hearings. These businessmen sold coal that required long distance haulage, often by road.

In the meantime, the mining industry can expect little relief from power cuts in the foreseeable future. Eskom has warned that although it has a plan in place to refurbish older plants, for the next two years at least, companies must work-load shedding into their planning.

The Duvha coal-fired power plant in Witbank, South Africa, has six 600-MW units.
Pan American Has Major New Deposit at La Colorada

Pan American Silver has announced an initial mineral resource estimate for the large polymetallic deposit discovered in 2018 at the company’s La Colorada mine in Zacatecas, Mexico. The initial inferred mineral resource totals 72.5 million metric tons (mt), averaging 44 grams/mt silver, 3.2 million mt of zinc, 1.5 million mt of lead, and 121,000 mt of copper. The majority of the mineralization is contained within a larger polymetallic mineralized skarn covering an area measuring 500 meters (m) by 600 m. The deposit, as currently defined, is located between 600 m to 1,700 m below surface and east of the current La Colorada underground mine workings.

Initial laboratory bench-scale metallurgical testing of individual diamond drill core composite samples indicates encouraging selective polymetallic flotation recoveries generating high-quality, silver-rich copper, lead, and zinc mineral concentrates.

Pan American President and CEO Michael Steinmann commented, “This initial resource estimate is a very exciting development for Pan American Silver and our La Colorada operation. The substantial size and grades point to a world-class deposit, discovered with our near-site exploration program.

The company plans to invest $10 million in 2020 to drill 44,000 m at the deposit, focusing on infill and exploration drilling to further define, expand and add confidence to the inferred resource.

Sixty-five diamond drill holes having a total length of 54,000 meters (m) were used for the geological interpretation and inferred resource estimate.

Metal contents in the deposit are estimated at 102 million ounces (oz) of silver, 3.2 million mt of zinc, 1.5 million mt of lead, and 121,000 mt of copper. The majority of the mineralization is contained within a larger polymetallic mineralized skarn covering an area measuring 500 meters (m) by 600 m. The deposit, as currently defined, is located between 600 m to 1,700 m below surface and east of the current La Colorada underground mine workings.

Initial laboratory bench-scale metallurgical testing of individual diamond drill core composite samples indicates encouraging selective polymetallic flotation recoveries generating high-quality, silver-rich copper, lead, and zinc mineral concentrates.
As the new year begins, 2020 looks to be another good year for project activity. Mining firms, especially publicly traded ones, spent more in 2019 than in 2018 for both organic growth and mergers and acquisitions, marking the second year of increased spending after hitting the bottom of the cycle in 2017. That trend is expected to continue in 2020 as companies increase spending nominally or normalize spending near 2019 levels. An analysis of the capital guidance of six of the top mining companies (Rio Tinto, Vale, BHP Billiton, Glencore, Barrick Gold and Newmont Goldcorp) shows a combined 10% increase in planned capital expenditures for 2020.

Globally, Industrial Info Resources is tracking nearly 12,000 mining projects representing total investment value of $1.2 trillion as part of its Global Market Intelligence (GMI) Platform (See Map 1). These projects involve capital expenditures ranging from grassroot mines to in-plant capital at existing operational mines and processing. This includes expansions, additions, and retrofits of equipment at mining assets and related infrastructure. Projects included in the analysis are tracked from the exploration stage through planning, engineering and construction.

A good way to measure the health of mining project activity is to analyze projects in the construction stage. Compared with last year at this time, construction activity is up 17%, based on the total investment value (TIV) of projects. Currently, more than $209 billion worth of mining projects are under construction worldwide. Construction activity is up in all market regions with the exception of Africa, Middle East and Southeast Asia. Of note are increases in Australia, India and Russia.

Mining companies continue to develop new mines, but at a slower pace. More attention is being paid to optimizing and expanding existing assets. Grassroot projects and unit additions are being developed to replace depleting capacity from existing mines in order to keep up with demand, which is growing due to urbanization, electrification, increased usage of renewable energy sources, and a host of emerging technologies, such as electric vehicles and battery storage that require greater and more diverse metals and metal compounds. Many companies are developing pilot plants to test new process technology. Industrial Info is tracking 56 mining projects globally that are developing processes through pilot plants prior to construction of full-scale operations.

The biggest challenges to mining project development going forward include rising costs associated with social responsibility, environmental stewardship, water resources, raw materials, energy and labor. Attention is being given to Industry 4.0 and harnessing the Industrial Internet of Things (IIoT), which utilizes smart computers to analyze big data in order to identify areas of improvement in the mining process. Automation of mining equipment, comminution and material-handling systems will continue to drive cost and efficiency improvements at mines and processing plants.

Golden Years

The price of gold reached a six-year high in 2019 and threatened to reach $1,600 per ounce (oz) before receding to the $1,500/oz range by the end of the year. Gold prices were up nearly 50% since hitting a low at the end of 2016. The shaky economic outlook, exacerbated by Brexit and the U.S.-China trade negotiations, is prompting many investors to buy gold as a safe haven. Gold miners want to produce as much gold as possible during this high-price environment, which is putting pressure on gold mining projects. Canada, Indonesia, Papua New Guinea, Mexico and Australia are important countries for gold mine development over the next two years. Several important mergers and acquisitions occurred in 2019, the Barrick-Newmont joint venture being the most notable.

In the U.S. and Canada, gold mining projects account for about 20% of what is scheduled to begin construction in 2020. There also is a focus on critical minerals, such as rare earths and battery metals such as lithium.

In the U.S., government support for mining in the form of executive orders, such as for critical minerals development.
or in the form of regulatory changes, have aided the industry, but in spite of this, permitting continues to be a deterrent to mining project development in the U.S. A prime example of this is Hudbay Minerals’ $1.9 billion Rosemont copper project in Arizona. The U.S. Army Corps of Engineers granted approval early in 2019 after a 2017 approval was received from the U.S. Forestry Service. In 2019, the company was spending money and ramping up preconstruction activity with the goal of starting work during the third quarter of 2019, but on July 31, a U.S. district judge ruled against the project, overturning previous approvals and bringing the project’s construction to a halt. Hudbay Minerals is appealing to a higher court. The decision could have national implications regarding the development of mining projects on federal lands. The project has been studied and litigated for more than 23 years.

**Coal Quandary**

Coal presents an interesting dichotomy. Global growth is occurring, especially in Asia and Africa, while declining usage due to decarbonization and environmental regulations is happening in North America and Europe. Coal accounts for 38% of global electricity generation. New coal-fired generation capacity is coming online mainly in Asian countries, and China, Australia, India, Mongolia, Russia and South Africa lead the world in coal-mining projects.

The U.S. Energy Information Administration (EIA) forecasts that the share of U.S. generation from coal will average 22% in 2020, down from 28% in 2018. U.S. power generators retired 13 gigawatts (GW) of coal-fired generation in 2018. An additional 17 GW are scheduled to be retired by 2025. Generation capacity is mostly being replaced with natural gas and renewables. Coal exports were down about 15%-20% in 2019. U.S. coal production for both thermal and metallurgical is expected to drop by 9%-10%. Nevertheless, there is $2 billion in planned capital spending for coal mining in the U.S. in 2020. Much of the capital expenditure planned is going toward cleanup and closure projects, life extensions, expansions and replacing outdated mining equipment.

New innovations and technology for alternative uses for coal are being developed. For example, Elixsys Inc. hopes to partner with a utility company and begin construction on a plant that is able to extract value products from coal combustion waste. Arq Inc., with partner Peabody, plans to bring a waste-coal-to-powder processing plant online in 2020, with plans for more locations over the next five years. Omnis Mineral Technologies teamed up with CONSOL Energy using Hendricks Resources technology to convert waste coal into clean-carbon fuel pellets and mineral product fertilizer.

**Latin America**

In Latin America, the mining sector is slowly improving compared with previous years. Some mining investments that were placed on hold have been reactivated in countries like Chile and Peru, especially for copper mining projects. The price of copper fell as low as $2.50 per pound (lb) during 2019. By year end, it was approaching $2.80/lb. If it would eclipse $3/lb in 2020 that marks a high not seen since 2014. Strong demand fundamentals and disruptions in supply due to resource nationalism and mine strikes in South America boosted copper prices, but ample capacity has been able to keep up with supply. A long-term supply deficit is expected, causing mining firms to invest in new copper capacity, especially in the Americas.

In Brazil, thanks to China’s growing demand for iron ore, some multimillion-dollar investments have been reactivated. The Brazilian market was heavily impacted in the aftermath of Vale’s Brumadinho dam disaster, which curtailed substantial iron ore exports. The Brazilian government banned upstream tailings dams as a result. Vale has committed billions over the next five years into new dry stacking technology and redesign/strengthening of existing dams.

Other Latin American countries are suffering due to geopolitical and economic issues. Argentina is in an economic crisis. The Argentinean peso has lost significant value and mining investments are paralyzed due to uncertainty, lack of economic stability and a lack of clear mining policies.

In Mexico, the mining sector suffered a recession due to mining policies imposed by the new government. Many investments have been halted as a result of economic uncertainties. The new USMCA trade agreement should help alleviate some of the uncertainty.

**Europe**

A mature market for mining, Europe’s decarbonizing efforts are resulting in a shrinking coal market. Nevertheless, coal is the second-largest market for mining project activity in Europe after copper. Poland, Russia, Ukraine, Germany, Czech Republic, Romania and U.K. are the top countries for coal mining project spending.

In Europe, Russia represents about 35% of the market, with projects reaching the construction stage doubling over the past year currently representing $10.2 billion. Russia is seeing an uptick in coal project activity as it looks to take advantage of export logistics to neighboring China.

For copper, there are 148 projects totaling $25.7 billion, but very few are reaching the construction stage due to permitting and financing delays.
Africa
Growing demand for metals and minerals in Asia is driving investment in mining projects in Africa. South Africa, Guinea, Tanzania, Mozambique, Botswana, Zimbabwe and Congo are the main countries for investments in 2020. Leading commodities for mining project development in Africa are gold, coal and copper as well as platinum, bauxite, mineral sands, rare earths and tin.

However great the potential of Africa’s natural resources, challenges remain a deterrent to mining activity, as geopolitical and local social unrest continue to impact African mining operations in some countries. Rio Tinto recently restarted operations and construction activity at Richards Bay Minerals in South Africa. Criminal activity is jeopardizing operations and construction of the $463 million Zulti South heavy mineral sands mine.

China
Chinese growth has slowed due to ongoing trade negotiations with the U.S., but remains strong at around 6% GDP growth. In 2020, China will accelerate its economic restructuring for the steel, cement, aluminium and non-ferrous metal industries to speed up capacity replacement and optimization processes, eliminating excess capacity and outdated capacity. China’s mining sector experienced rapid growth in 2019, but investments in coal mining projects are expected to slow as the growth is mainly driven by the resumption of projects that were previously put on hold.

China is developing a whopping 271 grassroots upstream and downstream aluminium projects. This includes 16 new bauxite mines, which will add almost 22 million metric tons per year (mt/y) of bauxite mining capacity; 14 alumina refineries totaling 30 million mt/y of capacity; 10 new primary aluminium smelters totaling about 2.5 million mt/y of primary capacity, six of which are currently under construction scheduled to come online in the next one to two years; and 69 secondary smelters ($2.2 billion) totaling about 3.3 million mt/y of new secondary capacity.

Southeast Asia
Southeast Asia is expected to experience continuing headwinds in 2020 due to the effects of U.S.-China trade, resource nationalism and protectionism in some countries and a growing steel production overcapacity in the region.

Resource-rich countries like Indonesia and the Philippines are expected to continue their campaigns to increase taxes and revenue from natural resources and further boost environmental measures in mining, especially in direct-shipping ore (DSO) projects. Indonesia reinstated its ban on nickel ore exports beginning next year, and the Philippines has suspended multiple nickel DSO mines indefinitely as it conducts environmental audits.

The raw mineral export ban in Indonesia five years ago, Law No. 4 of 2009 concerning mineral and coal, has promoted about 15 new smelter projects, which are operational or in commissioning, in 2020. The Indonesian government expects further mineral processing projects to support local miners as Chinese and other foreign investors, with local owners, invest in smelter projects in the provinces of Sulawesi, Kalimantan, Sumatra and Papua.

Indonesia Ministry of Energy and Mineral Resources intended to increase nickel production and maintain ore reserves by implementing its latest regulation, No. 11 of 2019, which will stop nickel ore exports beginning 2020 and strengthen nickel prices and sales in the country.

India
In India, coal production is expected to increase by 6%-7% during 2020. Production will improve on account of miners focusing on surface mining instead of underground mining. Coal production grew by 7.3% to 739.4 million mt during 2019, versus 2.6% growth in 2018.

Oceania
Coal and iron ore, two of Australia’s most important mined commodities, were particularly hit in the recessionary years. The oversupply in steel markets and the shutting down of surplus steel-making capacity has impacted Australian exports and prices. Nevertheless, Australian mining firms are pushing ahead with iron ore mine expansions, and the recent start of construction at Adani’s Carmichael coal mining project in Queensland has driven construction activity up for the metals and minerals industry. Activity has almost doubled over the last 12 months, increasing from $6 billion to $11.9 billion currently. Uncertainties still prevail into 2020 — average thermal coal prices are expected to remain subdued as the power market continues to shift away from coal-fired generation — this has impacted new grassroots coal mines and some major expansion projects are curtailed.

Mining project activity in 2020 will continue to grow at, or moderately above, 2019 levels. Activity is driven by increasing demand for metals and minerals from existing consumers such as infrastructure construction, and new consumers such as electrical vehicle and battery applications. Challenges to reduce costs, meet ever-increasing environmental and social standards, manage resources, and navigate geopolitical issues, will continue to mold the next generation of projects.

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donlin</td>
<td>USA</td>
<td>Permitting</td>
<td>OP</td>
<td>Au</td>
<td>Barrick, NovaGold Resources</td>
<td>6,700</td>
</tr>
<tr>
<td>Norte Abierto</td>
<td>Chile</td>
<td>Prefeasibility</td>
<td>OP, Ag</td>
<td>Au, Ag</td>
<td>Barrick, NewmontGoldcorp</td>
<td>6,000</td>
</tr>
<tr>
<td>KSM</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP, UG</td>
<td>Au, Cu</td>
<td>Seabridge Gold</td>
<td>5,500</td>
</tr>
<tr>
<td>Galore Creek</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP, Ag</td>
<td>Au, Ag</td>
<td>Newmont, Teck</td>
<td>5,208</td>
</tr>
<tr>
<td>Wafi-Golpu</td>
<td>Papua New Guinea</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Au, Cu, Ag</td>
<td>Newcrest, Harmony</td>
<td>2,800</td>
</tr>
<tr>
<td>Detour Lake LOM</td>
<td>Canada</td>
<td>Construction</td>
<td>OP</td>
<td>Au</td>
<td>Kirkland Lake</td>
<td>2,500</td>
</tr>
<tr>
<td>Sukhoi Log</td>
<td>Russia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Polyus</td>
<td>2,500</td>
</tr>
<tr>
<td>Rosia Montana</td>
<td>Romania</td>
<td>Permitting</td>
<td>OP, Ag</td>
<td>Au, Ag</td>
<td>Gabriel Resources, Gov’t.</td>
<td>1,970</td>
</tr>
<tr>
<td>Metales</td>
<td>Mexico</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Au, Ag</td>
<td>Chesapeake Gold</td>
<td>1,910</td>
</tr>
<tr>
<td>Livengood</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>International Tower Hill</td>
<td>1,840</td>
</tr>
<tr>
<td>Courageous Lake</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Seabridge Gold</td>
<td>1,520</td>
</tr>
<tr>
<td>Cité</td>
<td>Canada</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Iamgold</td>
<td>1,147</td>
</tr>
<tr>
<td>Bystroiskoye</td>
<td>Russia</td>
<td>Feasibility</td>
<td>OP, Au, Cu</td>
<td>Nornickel</td>
<td></td>
<td>1,100</td>
</tr>
<tr>
<td>Century</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>NewmontGoldcorp</td>
<td>1,050</td>
</tr>
<tr>
<td>Goldrush</td>
<td>USA</td>
<td>Construction</td>
<td>UG</td>
<td>Au</td>
<td>Nevada Gold Mines JV</td>
<td>1,000</td>
</tr>
<tr>
<td>Pueblo Viejo</td>
<td>Dominican Republic</td>
<td>Feasibility</td>
<td>Plant</td>
<td>Expansion</td>
<td>Au</td>
<td>1,000</td>
</tr>
<tr>
<td>Stibnite</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Midas Gold</td>
<td>970</td>
</tr>
<tr>
<td>Mansourah - Massarah</td>
<td>Saudi Arabia</td>
<td>Construction</td>
<td>OP</td>
<td>Au</td>
<td>Saudi Arabian Mining</td>
<td>880</td>
</tr>
<tr>
<td>Salares Norte</td>
<td>Chile</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Gold Fields</td>
<td>834</td>
</tr>
<tr>
<td>Cangrejos</td>
<td>Ecuador</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Lumina Gold</td>
<td>831</td>
</tr>
<tr>
<td>Mount Todd</td>
<td>Australia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Vista Gold</td>
<td>826</td>
</tr>
<tr>
<td>Springpole</td>
<td>Canada</td>
<td>PEA</td>
<td>OP, Au, Ag</td>
<td>First Mining Gold</td>
<td></td>
<td>809</td>
</tr>
<tr>
<td>Horne 5</td>
<td>Canada</td>
<td>Feasibility</td>
<td>UG</td>
<td>Au</td>
<td>Falco Resources</td>
<td>802</td>
</tr>
<tr>
<td>Tanami</td>
<td>Australia</td>
<td>Expansion</td>
<td>UG</td>
<td>Au</td>
<td>NewmontGoldcorp</td>
<td>809</td>
</tr>
<tr>
<td>Obuasi</td>
<td>Ghana</td>
<td>Construction</td>
<td>UG</td>
<td>Au</td>
<td>AngloGold Ashanti</td>
<td>545</td>
</tr>
<tr>
<td>Chulbatkan</td>
<td>Russia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Kinross Gold</td>
<td>500</td>
</tr>
<tr>
<td>Media Luna</td>
<td>Mexico</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Torex Gold</td>
<td>482</td>
</tr>
<tr>
<td>Amursk POX-2</td>
<td>Russia</td>
<td>Feasibility</td>
<td>Plant</td>
<td>Au</td>
<td>Polymetal Intl.</td>
<td>431</td>
</tr>
<tr>
<td>Massawa</td>
<td>Senegal</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Teranga Gold</td>
<td>412</td>
</tr>
<tr>
<td>Lac Windfall</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Au</td>
<td>Osisko</td>
<td>397</td>
</tr>
<tr>
<td>Montagne d’Or</td>
<td>French Guiana</td>
<td>Permitting</td>
<td>OP/Complex</td>
<td>Au</td>
<td>Nordgold, Columbus Gold</td>
<td>361</td>
</tr>
<tr>
<td>Valentine Lake</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Marathon Gold</td>
<td>355</td>
</tr>
<tr>
<td>Wasamac</td>
<td>Canada</td>
<td>Feasibility</td>
<td>UG</td>
<td>Au</td>
<td>Monarques Gold</td>
<td>353</td>
</tr>
<tr>
<td>Castle Mountain Phase 1</td>
<td>USA</td>
<td>Construction</td>
<td>OP, HL</td>
<td>Au</td>
<td>Equinix Gold</td>
<td>347</td>
</tr>
<tr>
<td>Block 14</td>
<td>Sudan</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Orca Gold, Gov’t.</td>
<td>328</td>
</tr>
<tr>
<td>Turquoise Ridge</td>
<td>USA</td>
<td>Construction</td>
<td>UG Expansion</td>
<td>Au</td>
<td>Nevada Gold Mines JV</td>
<td>325</td>
</tr>
<tr>
<td>Macassa Phase 1 and 2</td>
<td>Canada</td>
<td>Feasibility</td>
<td>UG Expansion</td>
<td>Au</td>
<td>Kirkland Lake</td>
<td>320</td>
</tr>
<tr>
<td>Moose River</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>St. Barbara</td>
<td>319</td>
</tr>
<tr>
<td>Coffee</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>NewmontGoldcorp</td>
<td>317</td>
</tr>
<tr>
<td>Volta Grande</td>
<td>Brazil</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Belo Sun</td>
<td>298</td>
</tr>
<tr>
<td>Spanish Mountain</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP, Au, Cu</td>
<td>Spanish Mountain</td>
<td></td>
<td>273</td>
</tr>
<tr>
<td>Hod Maden</td>
<td>Turkey</td>
<td>Feasibility</td>
<td>UG</td>
<td>Au, Cu</td>
<td>Sandstorm Gold</td>
<td>272</td>
</tr>
<tr>
<td>Yaouré</td>
<td>Cote d’Ivoire</td>
<td>Construction</td>
<td>OP</td>
<td>Au</td>
<td>Perseus Mining</td>
<td>265</td>
</tr>
<tr>
<td>Boto</td>
<td>Senegal</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Iamgold</td>
<td>254</td>
</tr>
<tr>
<td>Bomboré</td>
<td>Burkina Faso</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Orezone Gold</td>
<td>250</td>
</tr>
<tr>
<td>Prognoz</td>
<td>Russia</td>
<td>Prefeasibility</td>
<td>OP/UG</td>
<td>Au</td>
<td>Polymetal Intl.</td>
<td>249</td>
</tr>
<tr>
<td>Nezelda</td>
<td>Russia</td>
<td>Construction</td>
<td>OP, UG</td>
<td>Au</td>
<td>Polymetal Intl.</td>
<td>249</td>
</tr>
<tr>
<td>Eskay Creek</td>
<td>Canada</td>
<td>PEA</td>
<td>OP, Ag</td>
<td>Au</td>
<td>Skeena Resources</td>
<td>233</td>
</tr>
<tr>
<td>Kekura</td>
<td>Siberia</td>
<td>Construction</td>
<td>OP, UG</td>
<td>Au</td>
<td>Highland Gold</td>
<td>229</td>
</tr>
<tr>
<td>Cerro Blanco</td>
<td>Guatemala</td>
<td>Feasibility</td>
<td>UG</td>
<td>Au, Ag</td>
<td>Bluestone Resources</td>
<td>196</td>
</tr>
<tr>
<td>Dark Stan/Pinion</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Au</td>
<td>Gold Standard</td>
<td>194</td>
</tr>
<tr>
<td>Los Filos Bermejal</td>
<td>Mexico</td>
<td>Feasibility</td>
<td>UG</td>
<td>Au</td>
<td>Leagold</td>
<td>180</td>
</tr>
<tr>
<td>Ixtaca</td>
<td>Mexico</td>
<td>Feasibility</td>
<td>OP/Complex</td>
<td>Au, Ag</td>
<td>Almaden</td>
<td>174</td>
</tr>
<tr>
<td>Fekola</td>
<td>Burkina Faso</td>
<td>Expansion</td>
<td>OP</td>
<td>Au</td>
<td>B2Gold</td>
<td>173</td>
</tr>
<tr>
<td>DeLamar</td>
<td>USA</td>
<td>PEA</td>
<td>OP, Au, Ag</td>
<td>Integra Resources</td>
<td></td>
<td>161</td>
</tr>
<tr>
<td>Tasiast 24K</td>
<td>Mauritania</td>
<td>Expansion</td>
<td>OP</td>
<td>Au</td>
<td>Kinross Gold</td>
<td>150</td>
</tr>
<tr>
<td>Camino Rojo</td>
<td>Mexico</td>
<td>Feasibility</td>
<td>OP</td>
<td>Au</td>
<td>Orla Mining</td>
<td>123</td>
</tr>
<tr>
<td>Essakane</td>
<td>Burkina Faso</td>
<td>Feasibility</td>
<td>HP L</td>
<td>Au</td>
<td>Iamgold</td>
<td>115</td>
</tr>
<tr>
<td><strong>COPPER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Cu, Mo</td>
<td>Rio Tinto, BHP</td>
<td>6,000</td>
</tr>
<tr>
<td>Tampakan</td>
<td>Philippines</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Au</td>
<td>Sagittarius</td>
<td>5,900</td>
</tr>
<tr>
<td>Baimskaya</td>
<td>Russia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Au</td>
<td>KAZ Minerals</td>
<td>5,500</td>
</tr>
<tr>
<td>Oyu Tolgoi</td>
<td>Mongolia</td>
<td>Expansion/constr</td>
<td>UG</td>
<td>Cu, Au</td>
<td>Rio Tinto, Gov’t. of Mongolia</td>
<td>5,300</td>
</tr>
<tr>
<td>Project Name</td>
<td>Location</td>
<td>Status</td>
<td>Type</td>
<td>Products</td>
<td>Owner</td>
<td>Project Cost (US$M)**</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>---------------</td>
<td>--------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Quellaveco</td>
<td>Peru</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Mo</td>
<td>Anglo American, Mitsubishi</td>
<td>5,300</td>
</tr>
<tr>
<td>Quebrada Blanca Phase 2</td>
<td>Chile</td>
<td>Construction</td>
<td>OP, Conc</td>
<td>Cu</td>
<td>Teck, Sumitomo</td>
<td>4,800</td>
</tr>
<tr>
<td>Chiquicamata</td>
<td>Chile</td>
<td>Expansion/constr</td>
<td>OP, UG</td>
<td>Cu, Mo</td>
<td>Codelco</td>
<td>4,700</td>
</tr>
<tr>
<td>Pebble</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Au</td>
<td>Northern Dynasty</td>
<td>4,500</td>
</tr>
<tr>
<td>El Teniente</td>
<td>Chile</td>
<td>Expansion/constr</td>
<td>UG</td>
<td>Cu, Mo</td>
<td>Codelco</td>
<td>3,900</td>
</tr>
<tr>
<td>Frieda River</td>
<td>PNG</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Au</td>
<td>PanAust, Highlands Pacific</td>
<td>3,600</td>
</tr>
<tr>
<td>NuevaUnion</td>
<td>Chile</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Au</td>
<td>NewmontGoldcorp, Teck</td>
<td>3,500</td>
</tr>
<tr>
<td>Spence Growth Option</td>
<td>Chile</td>
<td>Construction</td>
<td>Plant</td>
<td>Cu, Mo</td>
<td>BHP</td>
<td>3,300</td>
</tr>
<tr>
<td>Schaft Creek</td>
<td>Canada</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Au</td>
<td>Teck, Copper Fox</td>
<td>3,256</td>
</tr>
<tr>
<td>Collahuasi</td>
<td>Chile</td>
<td>Expansion</td>
<td>OP</td>
<td>Cu, Mo</td>
<td>Anglo American, Glencore</td>
<td>3,200</td>
</tr>
<tr>
<td>Constellation</td>
<td>Chile, Argentina</td>
<td>Prefeasibility</td>
<td>OP, UG</td>
<td>Cu, Au</td>
<td>NGE Resources</td>
<td>3,080</td>
</tr>
<tr>
<td>El Pachón</td>
<td>Argentina</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Mo</td>
<td>Glencore</td>
<td>3,000</td>
</tr>
<tr>
<td>Mes Aynak</td>
<td>Afghanistan</td>
<td>Reopen/prefeasibility</td>
<td>OP</td>
<td>Cu</td>
<td>MCC, Jiangxi Copper</td>
<td>2,890</td>
</tr>
<tr>
<td>CuMo</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Mo</td>
<td>American CuMo</td>
<td>2,800</td>
</tr>
<tr>
<td>Alpala</td>
<td>Ecuador</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Au, Ag</td>
<td>SolGold</td>
<td>2,800</td>
</tr>
<tr>
<td>Centinela Phase 2</td>
<td>Chile</td>
<td>Expansion/prefeasibility</td>
<td>OP</td>
<td>Cu</td>
<td>Antofagasta Minerals</td>
<td>2,700</td>
</tr>
<tr>
<td>Michiquillay</td>
<td>Peru</td>
<td>Feasibility/Planning</td>
<td>OP</td>
<td>Cu, Mo</td>
<td>Southern Copper</td>
<td>2,500</td>
</tr>
<tr>
<td>Los Azules</td>
<td>Argentina</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Mo</td>
<td>McEwen</td>
<td>2,400</td>
</tr>
<tr>
<td>Agua Rica-Alumbrera</td>
<td>Canada</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Au</td>
<td>Casino Mining</td>
<td>2,150</td>
</tr>
<tr>
<td>Casino</td>
<td>Australia</td>
<td>Plant Expansion</td>
<td>Cu</td>
<td></td>
<td>BHP</td>
<td>2,100</td>
</tr>
<tr>
<td>Olympic Dam BFX</td>
<td>Australia</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu</td>
<td>Yamana, Glencore</td>
<td>1,900</td>
</tr>
<tr>
<td>Rosemont</td>
<td>USA</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu</td>
<td>Los Andes Copper</td>
<td>1,650</td>
</tr>
<tr>
<td>Vizcachitas</td>
<td>Chile</td>
<td>PEA</td>
<td>OP</td>
<td>Cu</td>
<td>Rio Tinto</td>
<td>1,600</td>
</tr>
<tr>
<td>La Granja</td>
<td>Peru</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu</td>
<td>Minsur</td>
<td>1,600</td>
</tr>
<tr>
<td>Mina Justa</td>
<td>Peru</td>
<td>Construction</td>
<td>OP</td>
<td>Cu</td>
<td>Minsur</td>
<td>1,600</td>
</tr>
<tr>
<td>NorthMet Phase 1</td>
<td>USA</td>
<td>Permitting</td>
<td>OP/Complex</td>
<td>Cu, Ni, PGM, Co</td>
<td>Polyem</td>
<td>1,600</td>
</tr>
<tr>
<td>Santo Domingo</td>
<td>Chile</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Fe</td>
<td>Capstone, KORES</td>
<td>1,510</td>
</tr>
<tr>
<td>Kencneccott LOM</td>
<td>USA</td>
<td>Construction</td>
<td>OP</td>
<td>Cu</td>
<td>Rio Tinto</td>
<td>1,500</td>
</tr>
<tr>
<td>Andina</td>
<td>Chile</td>
<td>Expansion/constr</td>
<td>OP, UG</td>
<td>Cu, Mo</td>
<td>Codelco</td>
<td>1,400</td>
</tr>
<tr>
<td>Ann Mason</td>
<td>USA</td>
<td>PEA</td>
<td>OP</td>
<td>Cu, Mo</td>
<td>Hudbay Minerals</td>
<td>1,350</td>
</tr>
<tr>
<td>Udokan</td>
<td>Russia</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu, Ag</td>
<td>Baikal Mining</td>
<td>1,300</td>
</tr>
<tr>
<td>Los Pelambres</td>
<td>Chile</td>
<td>Expansion</td>
<td>OP</td>
<td>Cu</td>
<td>Antofagasta Minerals</td>
<td>1,300</td>
</tr>
<tr>
<td>Aktoq</td>
<td>Kazakhstan</td>
<td>Expansion</td>
<td>OP</td>
<td>Cu, Au</td>
<td>KAZ Minerals</td>
<td>1,200</td>
</tr>
<tr>
<td>Lone Star</td>
<td>USA</td>
<td>Construction</td>
<td>OP</td>
<td>Cu</td>
<td>Freeport-McMoRan</td>
<td>850</td>
</tr>
<tr>
<td>Fili del Sol</td>
<td>Chile</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu</td>
<td>Fino Mining</td>
<td>792</td>
</tr>
<tr>
<td>Arctic</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Zn, Pb</td>
<td>Trilogy Metals</td>
<td>780</td>
</tr>
<tr>
<td>Carrapateena Phase 2</td>
<td>Australia</td>
<td>Construction</td>
<td>UG</td>
<td>Cu, Au</td>
<td>OZ Minerals</td>
<td>647</td>
</tr>
<tr>
<td>Timok Phase 1</td>
<td>Serbia</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Cu, Au</td>
<td>Nevsun Resources</td>
<td>630</td>
</tr>
<tr>
<td>Nchanga</td>
<td>Zambia</td>
<td>Construction</td>
<td>Refinery</td>
<td>Cu</td>
<td>Vedanta Resources</td>
<td>600</td>
</tr>
<tr>
<td>White Pine North</td>
<td>USA</td>
<td>PEA</td>
<td>UG</td>
<td>Cu, Ag</td>
<td>Highland Copper</td>
<td>457</td>
</tr>
<tr>
<td>Antamina LOM</td>
<td>Peru</td>
<td>Permitting</td>
<td>OP</td>
<td>Cu</td>
<td>BHP, Glencore, Teck, Mitsubishi</td>
<td>390</td>
</tr>
<tr>
<td>Eva</td>
<td>Australia</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu</td>
<td>Copper Mtn. Mining</td>
<td>350</td>
</tr>
<tr>
<td>Hillside</td>
<td>Australia</td>
<td>Feasibility</td>
<td>OP</td>
<td>Cu</td>
<td>Rex Minerals</td>
<td>338</td>
</tr>
<tr>
<td>Cobre Panama</td>
<td>Panama</td>
<td>Construction</td>
<td>OP</td>
<td>Cu, Au</td>
<td>First Quantum</td>
<td>327</td>
</tr>
<tr>
<td>Gediktepe</td>
<td>Turkey</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Cu, Zn, Au, Ag</td>
<td>Alacer Gold</td>
<td>246</td>
</tr>
<tr>
<td>Copperwood</td>
<td>USA</td>
<td>Feasibility</td>
<td>UG</td>
<td>Cu</td>
<td>Highland Copper</td>
<td>245</td>
</tr>
<tr>
<td>E26 Lift I North</td>
<td>Australia</td>
<td>Construction</td>
<td>UG</td>
<td>Cu</td>
<td>China Molybdenum, Sumitomo</td>
<td>200</td>
</tr>
<tr>
<td>Pumpkin Hollow</td>
<td>USA</td>
<td>Construction</td>
<td>UG</td>
<td>Cu</td>
<td>Nevada Copper</td>
<td>197</td>
</tr>
</tbody>
</table>

**IRON ORE**

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simandou Phase 1 and 2</td>
<td>Guinea</td>
<td>Feasibility</td>
<td>OP</td>
<td>Fe</td>
<td>SMB Consortium</td>
<td>15,000</td>
</tr>
<tr>
<td>Simandou North</td>
<td>Guinea</td>
<td>Feasibility</td>
<td>OP</td>
<td>Fe</td>
<td>Rio Tinto, Chinalco, Gov't.</td>
<td>10,000</td>
</tr>
<tr>
<td>Jack Hills</td>
<td>Australia</td>
<td>Expansion/susp</td>
<td>OP</td>
<td>Fe</td>
<td>Sinosteel</td>
<td>6,860</td>
</tr>
<tr>
<td>Mbalam-Nabeba</td>
<td>Cameroon/D R Congo</td>
<td>Feasibility/susp</td>
<td>OP</td>
<td>Fe</td>
<td>Sundance Resources, AustSino</td>
<td>4,986</td>
</tr>
<tr>
<td>Balmermal South</td>
<td>Australia</td>
<td>Feasibility</td>
<td>OP</td>
<td>Fe</td>
<td>Mineralogy</td>
<td>3,966</td>
</tr>
<tr>
<td>South Flank</td>
<td>Australia</td>
<td>Construction</td>
<td>OP</td>
<td>Fe</td>
<td>BHP</td>
<td>3,400</td>
</tr>
<tr>
<td>Extension Hill</td>
<td>Australia</td>
<td>Feasibility/susp</td>
<td>OP</td>
<td>Fe</td>
<td>Asia Iron Australia</td>
<td>3,053</td>
</tr>
<tr>
<td>Southdown</td>
<td>Australia</td>
<td>Feasibility/susp</td>
<td>OP</td>
<td>Fe</td>
<td>Grange Resources, SRT</td>
<td>2,936</td>
</tr>
<tr>
<td>Koodaideri</td>
<td>Australia</td>
<td>Construction</td>
<td>OP</td>
<td>Fe</td>
<td>Rio Tinto</td>
<td>2,600</td>
</tr>
<tr>
<td>Iron Bridge Magnetite Phase 2</td>
<td>Australia</td>
<td>Construction</td>
<td>OP/Complex</td>
<td>Fe</td>
<td>FMG Magnetite, Formosa Steel</td>
<td>2,600</td>
</tr>
<tr>
<td>Zananga Phase 1</td>
<td>Republic of Congo</td>
<td>Feasibility</td>
<td>OP</td>
<td>Fe</td>
<td>Glencore, Zanaga Iron</td>
<td>2,200</td>
</tr>
<tr>
<td>Robe Valley</td>
<td>Australia</td>
<td>Construction</td>
<td>OP</td>
<td>Fe</td>
<td>Rio Tinto, Mitsui, Nippon Stl</td>
<td>1,550</td>
</tr>
<tr>
<td>Hawsons</td>
<td>Australia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Fe</td>
<td>Carpentaria, Pure Metals</td>
<td>1,401</td>
</tr>
<tr>
<td>Razorback</td>
<td>Australia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Fe</td>
<td>Magnete Mines</td>
<td>1,200</td>
</tr>
<tr>
<td>West Angelas</td>
<td>Australia</td>
<td>Construction</td>
<td>OP</td>
<td>Fe</td>
<td>Rio Tinto, Mitsui, Nippon Stl</td>
<td>579</td>
</tr>
</tbody>
</table>
## Project Survey 2020

### Nickel

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shymansivske</td>
<td>Ukraine</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Fe</td>
<td>Black Iron</td>
<td>436</td>
</tr>
<tr>
<td>KeMag/LabMag</td>
<td>Canada</td>
<td>Feasibility</td>
<td>OP</td>
<td>Fe</td>
<td>New Millennium, Tata Steel</td>
<td>311</td>
</tr>
<tr>
<td>Queens Valley</td>
<td>Australia</td>
<td>Construction</td>
<td>OP</td>
<td>Fe</td>
<td>Fortescue</td>
<td>287</td>
</tr>
<tr>
<td>Wingellina</td>
<td>Australia</td>
<td>Feasibility</td>
<td>OP</td>
<td>Ni, Co</td>
<td>Metals X</td>
<td>2,500</td>
</tr>
<tr>
<td>Skalisty</td>
<td>Russia</td>
<td>Construction</td>
<td>UG</td>
<td>Ni, Cu, PGM</td>
<td>Nornickel</td>
<td>2,200</td>
</tr>
<tr>
<td>Nonoc</td>
<td>Philippines</td>
<td>Feasibility</td>
<td>OP</td>
<td>Ni, Co</td>
<td>Top Frontier</td>
<td>1,500</td>
</tr>
<tr>
<td>Ramu</td>
<td>Philippines</td>
<td>Expansion/Delayed</td>
<td>OP</td>
<td>Ni, Co</td>
<td>Met. Corp. of China</td>
<td>1,500</td>
</tr>
<tr>
<td>Decar</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Ni, Fe</td>
<td>FPX Nickel</td>
<td>1,384</td>
</tr>
<tr>
<td>Rönnbäcken</td>
<td>Sweden</td>
<td>Feasibility/Susp</td>
<td>OP</td>
<td>Ni, Co</td>
<td>Archelon</td>
<td>1,260</td>
</tr>
<tr>
<td>Dumont</td>
<td>Canada</td>
<td>Feasibility</td>
<td>OP</td>
<td>Ni, Co</td>
<td>Royal Nickel, Waterton</td>
<td>1,200</td>
</tr>
<tr>
<td>Vermelho</td>
<td>Brazil</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Ni</td>
<td>Horizonte Minerals</td>
<td>652</td>
</tr>
<tr>
<td>Eagle’s Nest</td>
<td>Canada</td>
<td>Feasibility</td>
<td>UG</td>
<td>Ni, Cu, PGE</td>
<td>Noront</td>
<td>609</td>
</tr>
<tr>
<td>Araguaia</td>
<td>Brazil</td>
<td>Feasibility</td>
<td>OP</td>
<td>Ni</td>
<td>Horizonte Minerals</td>
<td>443</td>
</tr>
<tr>
<td>Mt. Thirsty</td>
<td>Australia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Ni, Co</td>
<td>Barrra Res., Conico</td>
<td>149</td>
</tr>
</tbody>
</table>

### Silver

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitonilla</td>
<td>Mexico</td>
<td>Feasibility</td>
<td>OP, UG</td>
<td>Ag</td>
<td>SSR Mining</td>
<td>741</td>
</tr>
<tr>
<td>Corani</td>
<td>Peru</td>
<td>Feasibility</td>
<td>OP</td>
<td>Ag, Pb</td>
<td>Bear Creek Mining</td>
<td>579</td>
</tr>
<tr>
<td>Hermosa</td>
<td>USA</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Ag</td>
<td>South32</td>
<td>519</td>
</tr>
<tr>
<td>Juanicipio</td>
<td>Mexico</td>
<td>Construction</td>
<td>UG</td>
<td>Ag, Au</td>
<td>MAG Silver</td>
<td>395</td>
</tr>
<tr>
<td>Bawdwin</td>
<td>Myanmar</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Ag, Pb, Zn</td>
<td>Myanmar Metals</td>
<td>267</td>
</tr>
<tr>
<td>Kutcho</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Ag, Au</td>
<td>Desert Star</td>
<td>168</td>
</tr>
<tr>
<td>Cusi</td>
<td>Mexico</td>
<td>Expansion</td>
<td>UG</td>
<td>Ag</td>
<td>Sierra Metals</td>
<td>104</td>
</tr>
</tbody>
</table>

### PGM

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Cluster</td>
<td>Russia</td>
<td>Construction</td>
<td>OP/UG/Conc. Exp</td>
<td>PGM</td>
<td>Nornickel</td>
<td>1,400</td>
</tr>
<tr>
<td>Waterberg</td>
<td>South Africa</td>
<td>Feasibility</td>
<td>UG</td>
<td>PGM (4E)</td>
<td>Platinum Group Metals</td>
<td>874</td>
</tr>
<tr>
<td>Garatau</td>
<td>South Africa</td>
<td>Feasibility</td>
<td>UG</td>
<td>Pt, Pd</td>
<td>Nkwe Platinum</td>
<td>659</td>
</tr>
<tr>
<td>Lac des Iles</td>
<td>Canada</td>
<td>Feasibility/Expansion</td>
<td>UG</td>
<td>Ag</td>
<td>Impala Canada</td>
<td>142</td>
</tr>
</tbody>
</table>

### Diamonds

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venetia</td>
<td>South Africa</td>
<td>Expansion/construction</td>
<td>UG</td>
<td>Dia</td>
<td>DBCM</td>
<td>2,100</td>
</tr>
<tr>
<td>Jwaneng Cut-9</td>
<td>Botswana</td>
<td>Construction</td>
<td>OP</td>
<td>Dia</td>
<td>Debswana</td>
<td>2,000</td>
</tr>
<tr>
<td>Star-Orian</td>
<td>Canada</td>
<td>PEA</td>
<td>OP</td>
<td>Dia</td>
<td>Star Diamond</td>
<td>1,410</td>
</tr>
<tr>
<td>Ekati Fox Deep</td>
<td>Canada</td>
<td>Expansion/planning</td>
<td>UG</td>
<td>Dia</td>
<td>Dominion Diamond</td>
<td>628</td>
</tr>
<tr>
<td>Karowe</td>
<td>Botswana</td>
<td>Feasibility</td>
<td>UG</td>
<td>Dia</td>
<td>Lucara</td>
<td>514</td>
</tr>
<tr>
<td>Chilediak</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>Dia</td>
<td>De Beers</td>
<td>435</td>
</tr>
<tr>
<td>Aikhai</td>
<td>Russia</td>
<td>Construction</td>
<td>UG</td>
<td>Dia</td>
<td>Alrosa</td>
<td>150</td>
</tr>
</tbody>
</table>

### Zinc/Lead

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Izok Corridor</td>
<td>Canada</td>
<td>Feasibility</td>
<td>OP</td>
<td>Zn, Cu</td>
<td>MMG Ltd.</td>
<td>2,500</td>
</tr>
<tr>
<td>Admiral Bay</td>
<td>Australia</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Zn, Pb</td>
<td>Metallicity</td>
<td>837</td>
</tr>
<tr>
<td>Citroen</td>
<td>Greenland</td>
<td>Feasibility</td>
<td>UG</td>
<td>Zn, Pb</td>
<td>Ironbark, NyStar</td>
<td>514</td>
</tr>
<tr>
<td>Hilarion</td>
<td>Peru</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>Zn, Pb</td>
<td>Nexa Resources</td>
<td>500</td>
</tr>
<tr>
<td>Tala Hamza</td>
<td>Algeria</td>
<td>Feasibility</td>
<td>UG</td>
<td>Zn, Pb</td>
<td>Terramin, ENOF</td>
<td>413</td>
</tr>
<tr>
<td>Macmillan Pass</td>
<td>Canada</td>
<td>PEA</td>
<td>OP</td>
<td>Zn, Pb</td>
<td>Fireweed Zinc</td>
<td>308</td>
</tr>
<tr>
<td>Back Forty</td>
<td>USA</td>
<td>Permitting</td>
<td>OP</td>
<td>Zn, Au, Cu, Pb</td>
<td>Aquila Resources</td>
<td>294</td>
</tr>
<tr>
<td>Palmer</td>
<td>USA</td>
<td>PEA</td>
<td>UG</td>
<td>Zn, Cu, Au, Ag</td>
<td>Constantine, Dowa Metals</td>
<td>278</td>
</tr>
<tr>
<td>Prieska</td>
<td>South Africa</td>
<td>Feasibility</td>
<td>UG</td>
<td>Zn, Cu,</td>
<td>Orion</td>
<td>267</td>
</tr>
<tr>
<td>Ayawilca</td>
<td>Peru</td>
<td>PEA</td>
<td>UG</td>
<td>Zn, Ag, Pb</td>
<td>Tinka Resources</td>
<td>262</td>
</tr>
<tr>
<td>Prairie Creek</td>
<td>Canada</td>
<td>Permitting</td>
<td>UG</td>
<td>Zn, Pb, Ag</td>
<td>NorZinc</td>
<td>253</td>
</tr>
<tr>
<td>Abra</td>
<td>Australia</td>
<td>Construction</td>
<td>UG</td>
<td>Pb, Ag</td>
<td>Galena Mining</td>
<td>116</td>
</tr>
</tbody>
</table>

### Uranium

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Status</th>
<th>Type</th>
<th>Products</th>
<th>Owner</th>
<th>Project Cost (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viken</td>
<td>Sweden</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>U, V</td>
<td>EU Energy</td>
<td>1,230</td>
</tr>
<tr>
<td>Patterson Lake South</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP/UG</td>
<td>U</td>
<td>Fission Uranium</td>
<td>1,132</td>
</tr>
<tr>
<td>Michelin</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>OP, UG</td>
<td>U</td>
<td>Paladin Energy</td>
<td>994</td>
</tr>
<tr>
<td>Arrow</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>U</td>
<td>NexGen</td>
<td>952</td>
</tr>
<tr>
<td>Etango</td>
<td>Namibia</td>
<td>Feasibility</td>
<td>OP</td>
<td>U</td>
<td>Bannerman Resources</td>
<td>793</td>
</tr>
<tr>
<td>Kvanefjeld</td>
<td>Greenland</td>
<td>Feasibility</td>
<td>OP</td>
<td>U, RED</td>
<td>Greenland Minerals &amp; Energy</td>
<td>505</td>
</tr>
<tr>
<td>Norasa</td>
<td>Namibia</td>
<td>Feasibility</td>
<td>OP</td>
<td>U</td>
<td>Forsys Metals</td>
<td>433</td>
</tr>
<tr>
<td>Wheeler River</td>
<td>Canada</td>
<td>Prefeasibility</td>
<td>UG</td>
<td>U</td>
<td>Denison, Cameco, JCU</td>
<td>322</td>
</tr>
<tr>
<td>Mulga Rock</td>
<td>Australia</td>
<td>Feasibility</td>
<td>OP</td>
<td>U</td>
<td>Vimy Resources</td>
<td>311</td>
</tr>
<tr>
<td>Wiluna</td>
<td>Australia</td>
<td>Prefeasibility</td>
<td>OP</td>
<td>U</td>
<td>Toro Energy</td>
<td>220</td>
</tr>
</tbody>
</table>

* Information listed above has been compiled from available public sources, including corporate reports and presentations, press releases and regulatory filings. E&MJ and its publisher, Mining Media International, assume no responsibility for errors, omissions or suitability for purpose.

** Original capital cost estimate is shown in most cases; mature projects may show updated late-stage capital estimate.
Haile Gold Mine

OceanaGold makes major capex investments in South Carolina gold mine and mill

By Jesse Morton, Technical Writer

A significant investment in the Haile processing plant is expected to improve capacity by 40% and increase gold recovery rates to the mid-80% range.

For OceanaGold’s Haile Gold Operation, the numbers from the last two years reveal a major milestone was hit in the second and third quarters of 2018 that launched a trend that continues today.

In Q1 2018, the total ore milled was down 12% from the average for 2017. Then it spiked. In Q2, it was up more than 8% over the 2017 average. It never retreated. The average total ore milled for H2 2018 through Q3 2019 was up a whopping 26% over the average for 2017.

The numbers also reveal that upward trend in ore milled resulted from substantial planned investments. Going by total sustaining and non-sustaining expenditure numbers, Haile went from being the company’s least expensive mine in 2017 to being its most expensive mine in 2018. In 2018, Haile accounted for 40% of what the company refers to as growth capital, with the rest divided between the company’s other three mines.

The numbers show that the mine is trending differently than the plant. In 2018, the company reported that total ore mined at Haile in Q3 dipped below the average for 2017. Afterward, it climbed steadily, but didn’t reach the 2017 average.

Significantly, in Q3 2018, the operation for the first time milled as much ore as it mined, and then, starting in Q4, it milled more than it mined. For the duration of 2019, the mill at Haile outpaced the mine, a trend and a challenge that the executive manager at the mine, James Whittaker, said the mine was eager to field. “There was a specific debottlenecking investment plan to take the plant from 3.5 million metric tons per year (mt/y) up to 4 million mt/y. That is the process that we have been going through this past year,” he said. “Right now, the plant is hitting all their targets, and the mine is chasing the plant.”

The plant has benefited from a long-planned expansion program that has spanned more than two years, has seen the installation of top tier solutions, is expected to increase annual throughput by more than 40% over the 2017 average, and will provide a recovery rate in the mid-80% range.

With the construction of the final addition to the plant calendared for completion in Q4 2019, the wind-down of the plant expansion project amounts to a “major milestone” for the mine-site, which started commercial production in Q3 2017, Whittaker said. “We have already hit record months in the plant,” he said. “We are well-positioned to beat our original budget and our forecasts on mill throughput.”

According to quarterly reports, the mine faced challenges in late 2018 and intermittently through 2019. Hurricane-level rainstorms, slow development of dewatering efforts, and limited access to higher grades impacted numbers for the period. Those numbers shouldn’t remain down for long as water management and mining rates improve, Whittaker said.

With the capacity of the mill almost optimized, the company is rolling out the plan to enable the mine to catch up. OceanaGold and Haile invited E&MJ to the site to demo the new plant and to showcase pieces of the effort to upscale the mining ops. What was revealed was easily one of the better equipped, more innovative operations in the U.S. and the world. What was also revealed are the challenges of running an open-pit mine in subtropical South Carolina, USA, far away from any other large-scale gold mining operations, in a tight labor market that is generally unaccustomed to the demands of continuous operations.

Mill Expansion Project

Ultimately a total investment of roughly $50 million will have gone to debottlenecking the mill, Whittaker told E&MJ. Per the 2017 technical report, the optimized mill was to be “on stream in 2021 at 10,959 mt/d.”

Most of the adjustments, additions and upgrades were envisioned as early as the planning stages of the mine, with some launching in the initial ramp up of operations. “There has been constant construction in the plant since it started,” Whittaker said.

Such an expansion program is standard for the industry, Curtis Cadwell, director of operations, Haile Gold Operations, said. “You start out at some set tonnage, and then add equipment and ramp up.”

And nothing about the geology mandated particularly unique equipment or processes, Whittaker said. “It is really a standard circuit: a primary jaw crusher, SAG and ball milling circuit, froth flotation with carbin in leach (CIL) and stripping circuit.”

Nonetheless, the upgrades and additions were numerous, were partly driven by discoveries about the geology made in the ramp up, and were executed incrementally and with substantial overlap. The attempt was to debottleneck without impeding plant operations while doing it.

With only one rebuild left to commission, Whittaker said the attempt has been successful. “The original primary grind-
ing circuit seemed to have a lot of capacity,” Whittaker said. “Then you go to the next logical question, how can I increase the throughput of this total site?” he said. “The bottlenecks were identified. The capital was raised during last year’s process and then it was slowly but surely executed.”

The first bottleneck resolved in 2018 centered on oversize coming from the original primary crusher, new secondary crushers and the stockpile. From the stockpile, the feed went to a SAG mill and onto a screen. An influx of oversize resulting from mining harder ore at the main pit, Red Hill, developed, was anticipated in the planning stages of the plant. The need for the pebble crusher was described as a “key weakness in the design and plans” in a 2017 technical paper on the mine.

In 2018, a pebble crusher was installed to crush “the oversize down to 0.25 in. and put it back in the SAG mill,” Jason Garrick, process control engineer, Haile Gold Operation, said.

The underflow from the SAG mill goes to primary and secondary cyclones.

The underflow from the cyclones now goes to a new flash flotation cell. Ore from Haile was tested for flash flotation as early as 2010. According to the technical report, flash flotation “was shown to recover 62% to 66% of the gold in two minutes of flotation time.”

Cadwell said the flash float unit was not part of the original design, but was injected into the plan and stowed on site before plant startup.

Whittaker described it as a small, high-performance unit. “It enables you to offload concentrate very quickly and allows the rest of the flotation cells to work more efficiently.”

Garrick said OceanaGold added it because this process model is known at a couple of the company’s other sites where it performs well. “Flash float will float just as much as the four rougher float cells. They doubled our capacity at being able to float concentrate.”

Feed from the flash float cell goes to four rougher float cells. From there, the concentrate originally went to stirred media de-tritors (SMDs), which are now used for backup. Instead, it now goes into a new regrinding circuit, comprised of a tower mill and an IsaMill.

Installed in H2 2018 and Q1 2019, and commissioned in Q2 2019, the tower mill grinding circuit, as planned out in 2017, operates in reverse closed circuit with its own hydrocyclone cluster.

“We’ve set the circuits up so that the feed to the tower mill comes from the surge tank, and the discharge from the tower mill goes back to the cyclone feed box and back through the cyclones,” Garrick said. “It is in a constant sizing. Only the right size goes to the IsaMill. The target here is roughly 20 microns. We’ve been achieving between 20 and 35.”

Overflow goes to the cyclones. Underflow goes to the IsaMill if it is available. If unavailable, it drops to a discharge box and is close-circuited in the cyclones for further sizing until the IsaMill is available. “It is very sensitive with densities, but when you get it balanced, it works well,” Garrick said.

Once sized below 20 microns, the feed goes to a regrind discharge box and on to the pre-aeration thickener. “The original pre-aeration thickener was too small for the original design,” Garrick said. Currently, the mill runs two pumps “almost wide open to keep up with the concentrate going through it,” he said. “We are getting a new one built now.”

The plans for the addition were summarized in the technical report. “Oxygen will be added to the slurry using a closed circuit, pumped flow, high-shear oxygenation device to enhance passivation of reactive metal sulphide mineral surfaces.”

Design and concrete work for the new thickener was completed in Q3 2019, with construction completion and commissioning calendared for year-end 2019, the company reported.

The new pre-aeration tank will oxidize the concentrate before it goes to the first leach tank, Garrick said. “We’ve done quite a few pH studies for the pre-aeration and we’re looking at a goldilocks scenario that will improve oxidation and also will improve leaching,” he said. “We haven’t quite put our foot down on whether we are going to do it or not because we haven’t seen enough testing to come back to say that it is worth it. It looks like what we are doing now is probably the best.”

From the pre-aeration thickener, the concentrate moves to the Concentrate CIL Tanks 1 through 8. Historically, it spent up to 24 hours in CIL 1. “From CIL 2 to 8 was another 24 hours,” Garrick said. “With the increased throughput, we are down to a total of 24 to 28 hours total in the CIL circuit. We still get most of our leaching in eight hours in Tank 1.”

For the CIL tanks, the mill recently deployed a carbon scout, which samples and measures activated carbon densities online. “We are going to use that as part of our automation process here in the future for carbon movement so that we can make sure that we’ve got enough carbon, so we don’t have any solution loss,” Garrick said.

Automation means a “fuzzy logic predictive mill control system,” Whittaker said.

The mill also recently installed a mercury capture system downstream of the carbon regeneration kiln. “Somewhere in the ore, somewhere in the process we are picking up mercury. We don’t know where,” Garrick said. “It is real low concentrations, but it is enough to raise concern. To stay in permit compliance we’ve added that system just to make sure that we’re not emitting anything.”

The carbon is pulled from CIL Tank 1 and moved through an acid wash and on to a strip vessel, which brings it up to pressure and temperature. “On average, we run at temperature for four hours,” Garrick said. “That will strip all the gold off the carbon. Then we will move it to the kiln.”

The carbon goes through the regenerating kiln and then back into CIL.

For more than a year, the Haile mine has been chasing the mill.
The thickener underflow slurry moves through a series of de-
s-truct tanks, one of which is new. “To increase throughput, we
had to increase residence on the back end so that we’ve got
enough time to destroy the cyanide,” Garrick said. “We are still
in commissioning.” Commissioning was calendared for comple-
tion in Q4 2019, the company reported.

The 2017 technical report listed nine expected post-startup
additions to the plant. Whittaker said additional debottlenecking
measures included upgrades and upcales to the pumps and
lines. “What we found very quickly is some of the pumps, lines
and auxiliary equipment around the grinding circuit were hold-
ning back capacity,” he said. “All of this year, there have been a
lot of these types of small investment projects.”

Garrick said the constant construction has added a layer of re-
sponsibility and complexity to the routine operations of the mill.
“It has been one thing after another after another,” he added.

Whittaker agreed. “It makes it hard to operate.” Being at the
far end of the expansion program allows the plant to phase into
optimization and continuous improvement programs. “It will be
nice to get out of the expansion and construction business and
get into the efficiency business,” he said. “That is what we are
getting to very quickly.”

For Q4 2019, the company calendared optimizing the re-
grinding circuit, which would allow the plant to “maintain
steady-state grind sizes and recoveries” and achieve a through-
put rate up 40% year over year.

That rate, while representing a major milestone for the opera-
tion, presents challenges to a mine that has otherwise struggled
to hit its numbers this year.

Upscaling the Mine

According to the mine’s technical report, Haile consists of 11
named gold deposits within a 3.5-km x 1-km area. Once com-
pleted, the pit will span 2.5 km from east to west, 1.25 km from
north to south, and to a depth of 370 m. To get there, the plan
is to work eight historic pits, some of which date back more
than a century. Three will become pit lakes. Ultimately, the mine
will graduate to an underground operation, which is still in the
permitting phases.

Currently, the mine looks like a couple of quarries side by
side. The main pit, Red Hill, was being fast tracked in Q1
2019. There the sediment layers include purple and white
bands of cerussites and red and orange clays. A smudge of
black basalt defines a contour of the tallest ridge, roughly 150
m above sea level.

At a shovel roughly 50 m beneath it, a Caterpillar 777, one
of a dozen in the fleet, pulls away. For it, the cycle time from
the tip site and back is short. The road out climbs maybe 25
m. “We’re not real deep here. We’re just barely to the horizon,”
Cadwell said. “Here you don’t see a lot of real competent rock
yet.” Yet is the key word.

Equipped with Cat’s GNSS-based MineStar Fleet tech, the
hauler is roughly equidistant from those in front of and behind
it. It crests a hill, descends and disappears. Its usage in Red Hill
is almost at an end.

With the plant expansion program nearing completion, a new
fleet is coming online to move the additional ore. Haile is de-
ploying 15 new 180-mt Komatsu 730E-10 electric haulers, a
PC3000 excavator and a PC4000 hydraulic shovel.

Cadwell said the original plan contemplated graduating
from the 777s. “A 777 is not a high-duty truck,” he said. “We
always knew we were going to go from 100-ton trucks to some-
thing bigger.”

Decision time hit at year-end 2018. The idea was to adopt
haulers in the 150- to 200-mt range, Cadwell said. “You do the
evaluation. You do total cost of ownership. That is the cost of the
machine. The cost to run it. The cost to maintain it over a 60,000-
hour life,” he said. “You say at 60,000 hours, I’m going to replace
all these parts, everything else. What is the total cost of ownership
over the total tons I am going to move with that machine?”

Other factors include vendor support and ease of maintenance.

“With the Komatsu electric drive truck, the wheel motors bolt
on and then you connect cables to them,” Cadwell said. “You’ve
got a diesel motor, a generator, and cables running from that
generator to the two-wheel motors on the back end.”

Thus, it is simpler to maintain than a mechanical drive truck
“where you’ve got final drive differentials, you’ve got a lot of
fluids, and other things,” Cadwell said. “The other thing is on
rough surfaces, with an electric drive truck, the engine doesn’t
feel the road like a mechanical drive truck does because it is just
electrons moving from the generator to the wheels.”

On a mechanical drive, the entire drive train up to the engine
can be damaged in a single incident, Cadwell said. “On an elec-
tric drive truck, if you have an incident with one of the wheel
motors, you take it off and put on another one and that is kind of
the end of it,” he said. “It is very a very simple maintenance model.”

Whittaker agreed. “You don’t have the linkage,” he said. “So
the road conditions can be less forgiving.”

Part of the decision to go to the electric drive haulers was
diesel costs, Sam Murphy, group commercial manager, Haile
Gold Operation, OceanaGold, said. Yet the big picture was more
complex, he said. “Total burn rates are very similar between Cat
and KOM via various offsetting factors.”

Komatsu leadership told E&MJ the standard 730E-10 features
the company’s Fuel Saver Technology. “We have seen fuel reduc-
tion of 5% or more by utilizing Fuel Saver II combined with Tier 4
Technology,” Brian Yureskes, director, sales and business develop-
ment, Komatsu, said. “In addition to fuel economy, components
are designed more durable and less complicated for longer life expectancy and ease of maintenance to reduce replacement parts cost and maintenance downtime,” he said. “The total cost of ownership advantage of the 730E-10 is the result of intense product testing to ensure robust product quality, customer feedback on service and performance, and a complete understanding of the major cost drivers faced by mining operations today.”

Ultimately, the primary factors in the decision were the initial capital costs and projected operating costs, Whittaker said. It hinged on long-term projections of both, he said. “As the mine gets deeper, the haulage cycle times and the uphill climb gets longer,” he said. “OceanaGold keeps the view on the long game and so a lot of the decisions are not made on a quarter-to-quarter basis.”

It was not an easy decision, Cadwell said. “It was close,” he said. “Dollar-wise it was pretty even.”

Whittaker said the discussion of whether to go with hydraulic or rope shovels was similar. “When you look 10 years down the road, which one actually works better?” he said. “What is the fit for purpose for this type of mine and which gives you the better long-term cost structure?”

Within earshot of Red Hill is the laydown yard, where the new haulers and shovels are being built. Part of the original mine plan, it is a couple acres of leveled hilltop. In one corner, an arching tent referred to as a temporary maintenance facility provides shelter from the mist. Covered with plastic and scattered strategically are various parts and components. A half-built 730E occupies the center. Behind it, the second PC4000 takes shape.

By mid-October 2019, nine 730E haulers were complete. The remaining six were expected to be completed by May. The project has continued apace despite the Lowland summer weather. “As long as these guys have space and you don’t have lightning, they are fine,” Whittaker said.

The big issues thus far have related to logistics, he said. “These parts come from different places in the U.S., from different ports,” Whittaker said. “Different states have different logistics,” he said. “We are on top of it now, but at first it was a bit of a surprise. One state would have one way of looking at it and another would have another.”
Each state would have its own limits on width of loads. One solution was to, for example, cut the truck boxes in half. “It has been kind of unique here, getting truck parts in pieces,” Whittaker said. In other countries, he said, the norm would be for it to be brought in complete on the back of a large flat deck. “We are basically bringing them in in small parts and putting them together,” he added.

The fleet was purchased from Linder Industrial Machinery, in Columbia, South Carolina. Handling the logistics and building the units was farmed out to J.P. Technical Services Inc. of Kentucky.

Leadership at the latter told E&MJ the project plan, site and management is perhaps the best it has seen. “I’ve got 34 years of mining experience and I would put theirs at the top of the ladder in terms of how the job is laid out,” Jonathan Pruitt, owner, J.P. Tech Services, said.

Being currently ahead of schedule is due to Komatsu, Linder, Haile and J.P. Tech communicating and coordinating effectively, Pruitt said. “The three parties working together has been very beneficial in the productivity and the safety record we’ve achieved, communication is key,” Pruitt added.

However, most critical to the success of the project was “having one vendor in control of the transportation, the assembly, the welding, the lifting, negated having so many different possible problems,” he said. “Our company has worked hard at achieving these goals.”

Pruitt said the biggest challenge is balancing employee personal time with productivity at a seven-day-per-week jobsite. “On a job of this scope and size, if you don’t balance manpower, personal time, and productivity carefully, you could have men getting burned out or injured due to fatigue,” he said. “We met the challenge by putting teams in place, a red team and a blue team, and we worked a six-four rotation with 11-hour shifts. They work six and they are off four.”

Finding that balance “was a small learning curve for us and we’ve adapted and done well,” he said.

Whittaker said that with each new hauler build, the teams involved discover “a few more things about signals, cables and connections.” That knowledge is then leveraged with the next build. “The only thing I can assure you is we are getting better at building them,” he said. “Each is built more efficiently than the last.”

The mine is considering deploying teleremote drills in H1 2020, including the Sandvik DR410i rotary drill. The model is calendared to be released to the market in Q1 2020. Sandvik leadership told E&MJ the rig will provide best-in-class machine efficiency and hole quality. “The automation-capable, midsize drill will provide a powerful, productive solution for their blast hole drilling needs,” said Matt Chorley, vice president, global product management and sales, Rotary Drill Division, Sandvik Mining and Rock Technology.

Until then, the focus is maximum productivity with the resources available, including the human resources.

**Staffing Innovations**

The upscaling projects at Haile pushed the company to add staff. The resulting effort was two-pronged. The company took measures to retain people and recruit. To lower turnover rate, the mine modified its shift schedules.

In the first couple of years, the mine ran a seven-by-seven rotation. The worker would be on seven days and then off seven days. “That is effective when you have a camp operation and you need to move people over large distances,” Whittaker said. “But most of our people are local, within a short drive from the mine. Almost everybody here lives within almost an hour from the site.”

The rotation schedule was highly unpopular. “People just couldn’t handle the long schedule,” Whittaker said. “It was something that was not very normal here to say you are going to
work seven days, 12 hours per day, and then you get seven off. Locally, it just didn’t fit.”

In Q1 2019, the mine switched to four-by-four and four-by-five schemes. “So, shorter schedules, more rotation,” Whittaker said. “That went over really well. That immediately started to drop the turnover rate.”

Cadwell described the new rotation scheme as more balanced. “It is even time,” he said. “In a 36-day cycle, you work 18 and you are off 18, but it is five and four and you go nights for half the time and days for the other half.”

To add staff, the mine recruited in coal country, Cadwell said. “The tight labor market is a challenge,” he said. “Coal mining has been good because we’ve been able to pick up coal miners. That works well on the mine side because you can find experienced people from coal mines.”

Finding skilled personnel for the plant is a different story. “Gold mining is pretty hot right now” and so experienced plant workers are hard to come by, Cadwell said. “We’ve done career fairs in the West, in Nevada, Arizona and Wyoming.”

The plant therefore employs more locals who have prior experience in the power space. “Maintaining a power plant, operating a power plant, when compared to operating a gold processing plant, you get enough similarities that it transfers alright,” Cadwell said. “But we spend a lot of time training.”

In Q1 2019, the operation was onboarding as many as 15 new hires per week, Whittaker said. At the time, turnover at the mine was close to 40% and 30% at the plant. Since then it has leveled out, Cadwell said. “It seems like we are headed toward 20%, which is pretty healthy.”

The new Komatsu fleet requires the mine to bring on experts who are increasingly hard to find, Whittaker said. “There is a serious shortage in the eastern U.S. of heavy-duty mechanics who have even seen this type of equipment,” he said. “The issue about finding good talented mechanical electrical technicians to work on this class of equipment has been a challenge, and will continue to be a challenge.”

Finding and training them may be difficult, but keeping them shouldn’t be, Whittaker said. “Haile offers a unique combination of professional and lifestyle opportunities. Located between the sea and the mountains, it offers great choices in both city and country living,” he said. “It is extremely hard to find a project of this caliber, with varied mining and technological challenges, in a great lifestyle setting.”
Battery-electric Vehicles: Brightening the Mining Industry’s Future

E&MJ looks at some of the collaborative projects driving BEV development and adoption, and mulls over the technology’s place in the future of the mining sector

By Carly Leonida, European Editor

Battery electric vehicles are a hot topic in mining at the moment.

From German manufacturer Kuhn Schweitz’s fully electric 120-metric-ton (mt) dump truck, which recently demoed at a limestone operation in Switzerland, to Anglo American’s mission to convert a 300-mt truck to run on renewable energy using hydrogen fuel cells. These developments are barely out of the news.

And then there’s the underground market where orders for battery electric LHDs, loaders and drill rigs seem to be announced almost daily.

One could easily get carried away with all the hype. It is, after all, an exciting time to be working in the mining industry. The rate of technological development and uptake is probably faster right now than at any other point in the sector’s history, and the machines that are starting to come through are, quite frankly, amazing.

It would have been easy to produce another article listing all the BEV deliveries and equipment launches from 2019. However, what is far more interesting, and valuable, is context.

BEVs are much more than just a talking point, and they serve a greater purpose than eliminating diesel from mine sites. They are a tool that will help mining companies tackle one of the biggest operational and business challenges they face going forward: sustainability in the age of climate change.

The Power of Collaboration

In a bid to put some color around the topic of BEVs and their role within the industry, E&MJ turned to the International Council on Mining and Metals (ICMM). The organization launched its Innovation for Cleaner, Safer Vehicles (ICSV) initiative in 2018. The program held its first roundtable the same year and has spent the time since building working groups and whitepapers to guide its participants on their journey to next-generation mining vehicles.

There are a few sustainability initiatives within the industry at present that bring together mining companies, vendors and research institutions to drive innovation and speed the adoption of new equipment, including BEVs. But what makes ICSV stand out is the volume and weight of mining companies involved. It has the support of all 27 ICMM council members, as well as 16 (currently) mining equipment suppliers who collaborate in a non-competitive space to accelerate the development of new mine vehicles.

The program is also CEO-led. The ICSV advisory group comprises six representatives, three from ICMM member companies including: BHP’s Mike Henry, Anglo American’s Mark Cutifani, Gold Fields’ Nick Holland and, from participating equipment suppliers, Caterpillar’s Denise Johnson, Max Moriyama of Komatsu and Sandvik’s Henrik Ager.

Sarah Bell, director health, safety and product stewardship at the ICMM, leads the initiative, and E&MJ caught up with her in December to talk all things BEV.

“This program is key to enabling a sustainable future for us all,” she told me. “It means that we are committed to strengthening both the social and environmental performance of the mining and metals industry, to deliver the materials essential for human progress in a responsible way.

“The ICSV program was created to address three of the most critical safety, health and environment performance issues on our mission toward zero harm and contributing toward decarbonization.”

Those aims are to introduce greenhouse gas (GHG) emission-free surface mining vehicles by 2040, minimize the operational impact of diesel emissions by 2025, and make collision avoidance technology available to all mining companies by 2025.

“Fundamentally, this is a change leadership program,” explained Bell. “Firstly, our members recognize that climate change is a critical global challenge. We all have a responsibility to reduce GHG emissions. But our sustainability strategies go beyond the climate crisis. We are addressing safety, health and environmental performance in a coherent framework. This is about moving mining to the next stage of the journey. The ICSV program is central to realising this vision.”
emissions. Large mining equipment currently makes up around 30-50% (and up to 80%) of the scope 1 emissions at a mine. Access to ore is getting more difficult in mature operations — deposits are becoming deeper and grades are declining — requiring more trucks and longer hauling distances for mining vehicles.

“Secondly, almost all underground mine equipment is diesel-powered. The World Health Organization has classified diesel particulate matter (DPM) as a carcinogen and exposure to elevated DPM emissions, particularly in underground mining operations, has been linked to negative health effects. One of the interesting points on the technologies to control DPM exposure is that quite a lot of solutions are already available and mining companies are seeing significant DPM reductions through improved maintenance programs. The issue is increasing awareness about existing technologies and getting them implemented across the industry.

“Thirdly, transport and mobile equipment accidents accounted for 30% of fatalities at ICMM-operated mines in 2018. They were the highest cause of fatalities at our member operations. Safe working conditions are a fundamental human right and we are committed to reducing operational fatalities to zero.”

ICSV recognizes that mining companies can’t achieve these outcomes alone, but by working with industry partners, they have an opportunity to succeed.

“This is where the convening power of ICMM matters,” Bell said. “Because our membership offers a critical mass for change. Our membership makes up around 30% of the total metals market. And if you break that down further, our membership makes up approximately: 46% of copper; 27% of gold; and 42% of iron ore produced globally. The signals that can be sent through this program are strong.”

Of course, ICSV won’t just benefit member companies. By speeding up development and adoption of next-generation mining vehicles, all mines will gain access to better, more cost-competitive vehicles, regardless of their size, stage of life or commodity.

BEVs: One Solution Among Many
So, where do BEVs come into this?

Bell was clear: “The ICSV program focuses on convening the participants, motivating action and promoting outcomes. It does not work on specific solutions as we recognize that there will be more than one — our role is to champion innovation. The program focuses on aligning the group on the direction of travel that needs to be taken to meet the ambitions set.

“That said, BEVs are definitely one of the options on the table to achieve the program’s GHG ambition. As the industry continues to increase the pace of thinking around how to develop new batteries with higher energy density and lower cost, that will make BEVs more competitive in the mining industry, but we acknowledge it’s not the only solution to reflect the industry’s broader needs in the future.”

Bell makes a good point. It’s very easy to forget that BEVs are not a silver bullet. Alone, they will not reduce GHG and DPM emissions far enough to make a significant impact on global industrial reduction targets. They are also not a one-size-fits-all solution. Some mines simply won’t be suitable condition-wise for BEVs and some mines, particularly those that have been operational for some time, won’t be able to afford a new fleet.

Also, when it comes to surface operations, the technologies required for battery-electric loaders and haul trucks, simply aren’t ready yet.

But the good news is that BEVs are now, in some markets, a viable option for mining companies that are looking to better their sustainability and environmental performance. Other options include hydrogen fuel cells (see box, page 34), tethered electric vehicles, trolley assist and, not forgetting the good old diesel engine; engines equipped with U.S. EPA Tier 4 final-compliant engines are among the cleanest available and offer one of the quickest and easiest ways for mines to drive down their emissions right now. In some studies, self-regenerating particulate filters have proven even more effective than Tier 4 final technologies, providing another option to improve existing equipment.

“As the industry continues to increase its pace of thinking around how to develop new batteries that will make BEVs more competitive in the mining industry, price point is a phrase that the OEMs use a lot,” Bell explained. “That’s been a big pull for them during R&D. You can imagine then that calling all of these groups together really pricks up the ears of the equipment suppliers.”

Underground Revolution
While commercially viable BEVs for surface operations are still a way off yet, the underground side of the mining industry now has multiple equipment options available from various suppliers.

The number of underground operations globally is far outweighed by the number of surface mines, and the financial drivers are currently greater in this area thanks to potential reductions in ventilation. However, success in this market has done something very valuable: it has proven that BEVs can match or exceed the performance of diesel-powered equipment and it has provided confidence. Although the mining industry is becoming better at taking risks and embracing new concepts, there is definitely still a preference of being “second to be first” mainly dictated by the weight of investment.

“The value proposition to adopt zero-emission vehicles in underground mining is quite different, as eliminating exposure of workers to DPM and ventilation cost reductions make for a strong business case, especially in greenfield projects, and we are
Nearly all new underground mines are suitable for BEVs. The challenge lies in implementing the technology at existing operations. (Photo: Newmont Goldcorp)

addressing these issues in the DPM work-stream of the ICSV Program,” Bell told me.

“For surface mines, there are certain market conditions or enabling technologies that we have identified that can accelerate the development and adoption of zero-emission vehicles. For example: access to clean and competitive electricity, autonomous machines and digital capability developed by both OEMs and mining companies.”

When it comes to developing BEVs for surface equipment, power and size are critical variables, but they are not the only ones to consider when thinking about vehicle requirements. Understanding the energy consumption profile of haul trucks is critical, as this will set design conditions of potential solutions including fuel cells/battery sizing, battery chemistry, charging strategies, etc.

In addition, a zero GHG-emission fleet will likely involve some trade-offs in flexibility and mine design, so challenges are not only on the technology development side as mine sites are currently designed with the very flexible characteristics of diesel-fueled fleets in mind.

“We see some early signs based on the first 12 months of the program that suggest that the complexity of the GHG-battery challenge is now better understood and that will motivate development, testing and piloting of new surface battery technologies,” Bell said.

“For example, analysis of the energy consumption profile of haul trucks shows that around 70%-80% of fuel use happens travelling up the ramp. There are successful pilots of trolley assist technology in this area, such as at Boliden in Sweden, so a hybrid solution (trolley/battery) might be able to help tackle the battery size challenge the industry faces.”

Planning for the Future

The ICVS has established three working groups — one for each of the challenges outlined above. Bell mentioned that, in the ICSV GHG focus group, working through the scope of the challenge and analyzing different solutions and pathways has helped to change the collective mindset of the companies involved.

“At the start of 2019, the 2040 target seemed a challenge to pin down, but fast forward to August, and the GHG working group was so energized. Now participants are saying: ‘we can actually make this happen, and here are the frameworks and actions to take inside and outside of this program to make it reality.’

“It’s really exciting to hear that change. Because that, in itself, is a massive barrier to overcome. That means that the equipment suppliers, in my mind, trust the commitment from the collective industry group.”

Many of the OEMs E&MJ has spoken to in the past 12 months have mentioned an increase in the number of inquiries they have had from mining companies around cleaner, safer vehicles and particularly for BEVs. That’s important, because the more inquiries these companies get, the more impetus and funding will be put on developing these types of vehicles and technologies.

Education is another key factor. As mentioned earlier, the majority of mines, both surface and underground are designed with diesel-driven equipment in mind. In order to operate a battery-electric load and haul fleet, mines need to be designed differently, charging stations and ancillary equipment must be allowed for and some haul routes may need to be altered.

However, until these requirements are properly understood within the industry and, until this knowledge is conveyed to the next generation of engineers through higher educational courses and mentoring, new recruits will not be taught how to prop-

Anglo’s Hydrogen-electric Solution

On October 10, Anglo American signed an agreement with energy provider ENGIE to develop a 300-metric-ton haul truck powered by hydrogen fuel cells. The project is part of Anglo American’s FutureSmart Mining sustainability program, and Anglo is working with a number of partners to develop the necessary systems.

The pilot will involve the conversion of a haul truck to run on hydrogen for operation at Mogalakwena in South Africa.

ENGIE will provide the hydrogen generation solutions and Anglo American the truck. The modifications required include replacing the diesel tank with hydrogen tanks and replacing the engine with hydrogen fuel cells and a battery pack. The power module combines fuel cells and a battery that will drive the electric motors on the haul truck. The hydrogen will be provided by the solar power generation capacity at the mine, and the hybrid hydrogen power plant is being developed in-house.

The companies said that “first motion” of the truck is expected in 2020, followed by testing and validation at Mogalakwena. If that is a success, then the technology will be rolled out to other Anglo American open-pit operations.

The prototype is currently being constructed and trials will start in Q2 of 2020, lasting until the end of the year.
erly design for battery-electric equipment. Without this know-how, mines will not be able to get the most from BEV investments.

Likewise, it is all very well OEMs developing new batteries and BEVs, but unless they can provide the appropriate level of support for mines around the associated infrastructure as well, these projects will not deliver their full potential, and there is a danger that mines could become disillusioned with the technology.

“We’ve clearly outlined all these considerations beyond the technology which are enabling conditions,” said Bell. “That, in its own right, is a challenge. And the OEMs know that.”

The First To Be First
There are pockets of growing excellence in the industry when it comes to BEV development and adoption. Northeastern Ontario being the prime example for underground equipment, and Bell pointed to Newmont Goldcorp’s Borden Lake operation as a good example of what can be achieved when mining companies and suppliers work closely.

Newmont Goldcorp is an ICMM member and operates BEV fleets not just at Borden but also at its Musselwhite and Éléonore operations. The company’s experience has proven very valuable as part of the ICSV program.

Maarten Van Koppen, manager for energy and sustainability in North America, talked to E&MJ about the company’s decision to move to battery-electric technology at Borden.

“It was decided to go down this path as it provided the most shareholder value,” he explained. “Design criteria for Borden were largely driven by local stakeholder concerns, which we were able to meet with electric equipment. Company leadership at the time understood that there was risk involved with new technology, which we were able to offset through provincial and federal funding programs.”

The fleet at Borden now boasts 16 battery-electric utility vehicles from MacLean Engineering, including bolters, a block-holer, cassette carriers and scissor lifts.

“From Sandvik, we operate battery-electric jumbos and LH514E scoops. The production drill is expected to arrive on site in early 2020,” Van Koppen said. “In addition, we have Minecat tractors and PMP personnel carriers. Electric haul trucks are under analysis at the moment.

“The scoops are tethered but all other electric equipment is battery-electric. The haul trucks, the production drill and a couple of miscellaneous vehicles still run on diesel, and those are expected to be swapped for electric equipment in the future.”

Van Koppen said that standardizing battery charging and swapping equipment for the mine was relatively straightforward for the procured vehicles.

“We pushed for onboard chargers that connect up to our 1,000-V common jumbo plug,” he explained. “The savings in GHG we expect once fully converted compared to a diesel base case are significant — around 70%-80% — and our operators appreciate the cleaner work environment.

“All mines and projects are different, but virtually all new underground mines would stand to benefit from going electric. For existing mines it’s typically a much harder analysis and it really depends on the characteristics to determine what the fit is.”

Learning From Other Industries
When it comes to BEVs there are industries that are ahead of mining in terms of implementation and advancement. Observation and/or collaboration presents an opportunity for learning, and for the mining industry to potentially leapfrog some of the hurdles that currently stand in its path.

“There is definitely the possibility to learn from other industries, particularly around charging options and super-fast charging. What would that look like in the future in mining?” Bell wondered. “How can all that thinking be transferred to the mining industry? Again, our white papers touch on these kinds of questions.”

She highlighted road freight transportation and the shipping industry as two good examples in terms of technological development, adoption and industry alignment.

For example, in the shipping industry, the International Maritime Organization, through its GreenVoyage-2050 project, is promoting global efforts to demonstrate and test technical solutions for reducing GHG emissions. This enhances knowledge and information sharing to support the ambition to reduce the total annual GHG emissions by at least 50% by 2050.

Another excellent example is Scania’s 2025 Strategy. This ensures the company’s product emissions are in line with what is required by the Paris agreement, reducing CO₂ emissions from its rolling fleet and developing biofuel and electrified buses and trucks to achieve full decarbonization.

Bell emphasized that the ICSV team is very open to new companies joining the program and sharing their ideas, particularly those that can bring valuable experience from other industries.

“We know that the program is benefiting the entire mining industry, not just our members,” she said. “And it remains open to all equipment manufacturers who would like to join. ICMM also hopes that the first adopters, who we’re defining as those that initiate collaborations and join partnerships to test and trial new technologies, and all those that take on the new technologies or equipment in the first instance, will motivate others. Ultimately, this will result in a wider industry shift toward cleaner and safer vehicles.

“Our message would be: if you’re a mining equipment supplier with a solution or if you have some learnings to share, even if you’re not a mining equipment supplier directly, we absolutely want to hear from you.”
In 2020, ICSV will focus more heavily on the promotion and education of its efforts by running regional workshops within key mining jurisdictions. The aim being to extend the reach to the operations level to motivate a broader group of representatives to start a change conversation at their site.

Bell added: “We’ve seen some positive early signs and we hope that that will continue in 2020 as well.”

The Vendor’s Perspective

Two vendors that are helping to drive progress in the BEV market, both individually and as part of the ICSV program, are Sandvik and Epiroc.

Sandvik Load and Haul is currently preparing to deliver its 600th electric loader. The division completed the acquisition of Californian BEV expert, Artisan Vehicle Systems, in February last year, expanding its range of machines and electric-drive train expertise. The company now has three battery-electric trucks and loaders available: a 50-metric-ton (mt) truck (the Z50), a 10 -mt loader (the A10), and a 4-mt loader (the A4), and battery-electric drill rigs.

The trucks and loaders have a “swappable” battery system, which allows for quick recharging, and the Z50 and the A10 have a self-loading battery system that allows swapping without the use of a crane. This minimizes infrastructure requirements and means that swapping can be accomplished in around six minutes.

“The Artisan Business Unit designs and manufactures its own proprietary battery packs, BMS and control hardware/software,” Mats Eriksson, president of Load and Haul division at Sandvik Mining and Rock Technology, said. “We use lithium-ion-phosphate (LiFePO4) as our battery chemistry because it is the safest option for underground mining. LiFePO4 has the lowest volatility of available lithium chemistries, ensuring the battery won’t start a fire underground. Of course, we are open to different chemistries as battery technologies develop rapidly, but because our products are for underground use, we make no compromises on safety.”

Sandvik is also heavily involved with the Global Mining Guidelines (GMG) BEV working group. Another independent organization that is convening expertise from across the globe to advance mine vehicles.

“Artisan has been a core contributing member of the GMG group since the inception of the battery-electric equipment guideline,” Eriksson said proudly. “We are involved in multiple sub-committees responsible for battery design, machine design, safety systems, mine design and performance standards.”

GMG published version two of its Guideline on the Recommended Practices for Battery Electric Vehicles in the Underground in November 2018. The publication has become something of a bible for miners and vendor operating in this field and the group continues to drive excellence in this area.

Eriksson explained his view on mine electrification. “If we look at what electrification means for the mining industry, this is a rare opportunity to combine health, sustainability and cost improvements,” he said. “By improving mine cost structure, you also get benefits such as a healthier working environment and the operation becomes more sustainable.

“Electrification also helps to solve issues around cooling: diesel engines generate a lot of heat but by moving to electric, you can reduce that as well, and cut cooling costs. There are a lot of positives with moving to electric.

“Looking further ahead, there are a lot of unexplored areas in the world. Mining is going to go deeper underground, to more unfriendly environments full of heat and moisture, and it’s only by using electrification that miners will be able to explore these areas cost-effectively.

“BEVs enable opportunities that haven’t made economic sense before. With this technology, and sometimes combined with automation, mining companies will find new opportunities that they never thought were possible.”

Sustainable and Intelligent

Another program that is redefining applications for BEVs and their performance is the Sustainable Intelligent Mining Systems (SIMS) project in Scandinavia. Among its various projects, is Work Package 6 (WP6). This deals specifically with next-generation, diesel-free mobile equipment for underground mines.

Epiroc is one of the project coordinators for SIMS and the company’s Jan Gustafsson acts as project manager for WP6. Gustafsson presented some of the project’s achievements thus far at the Smart Mining Conference in Germany in November, and E&MJ caught up with him afterward to find out more.

“This work package demonstrates BEV use in a mining environment,” Gustafsson explained. “Physically, it will
demonstrate machines and part of the infrastructure needed for battery-powered machines. We are also investigating the benefits of introducing BEVs within underground mines, both from a financial and environmental perspective.”

LTU Luleå University of Technology and Agnico Eagle Finland are also participating, and the demonstrations are currently taking place at Agnico Eagle’s Kittilä gold mine in northern Finland.

Epiroc has designed and built the machines and charging infrastructure.

“Right now, we are running them in production at Kittilä,” said Gustafsson. “The demonstration is not finalized but we definitely see the potential. The machines have been at the mine site since May 2019 when the field trial officially started.

“The overall impression so far is that the machines are performing to expectations and the diesel engine is not missed at all. The machines are still running, and testing is ongoing to collect data for the final evaluation.”

Jari Kolehmainen, production manager at Agnico Eagle Mines, has been quoted as saying: “Operator feedback has been positive, and we are looking forward to expanding our fleet with more electrical equipment in the near future. We are also very excited to be testing a battery-powered mine truck and loader. These tests are giving us the confidence to be a successful early adopter of this new and exciting technology.”

Like Bell, Gustafsson stressed that collaboration has been really important in helping the SIMS team to reach their goals.

“Collaboration is important for us to find the best solutions and to share knowledge and experiences,” he said. “During the development of our new-generation BEVs, Epiroc has collaborated closely with technology suppliers like ABB and Northvolt.

“The internal collaboration within the SIMS project has also been extremely valuable for experience sharing between the different beneficiaries.”

“Collaboration with the mining companies has strengthened the customer perspective, and collaboration with the universities has also added benefits in terms of scientific approach on the evaluation.

Next Generation in Action
Epiroc released its second-generation BEV range in November 2018. Their design is quite different to the first, featuring a new modular battery approach and a new chemistry for reduced power loss.

Gustafsson explained: “The design around the batteries allows us to offer batteries as a service to our customers, moving large CAPEX investments to OPEX. The new batteries are fully compatible with technological advances that are expected to happen in the coming years.”

Swedish battery producer Northvolt supplies Epiroc with batteries for its mining equipment. The companies selected a nickel-manganese-cobalt (NMC) chemistry from within the lithium-ion family based predominantly on two factors: safety and energy density.

“Driving time on the batteries varies depending on the application,” said Gustafsson. “In general, we can say that they last for 3-6 hours. With battery cell development, we expect to see the driving time increase.”

He added that implementing an electric drill rig can be as straightforward as purchasing a machine.

“There is no requirement for infrastructure, but for loaders and mine trucks, charging stations are needed,” Gustafsson explained. “The type of charging station depends on whether the quick charge, charge-in-place method is used or if the normal charge, battery-swap method is used. Both quick charge and normal charge will require some infrastructure: charging room, charger and electrical installation.

“Where they differ is that the quick charge will require larger electrical infrastructure and parking space for the vehicle, whereas the normal charge will require a lifting crane for battery swapping. Optional additional pieces include a monitoring system, smoke detection, fire detection, fire suppression and video surveillance.”

Gustafsson added that, when it comes to BEVs, the most important part that should be standardized is charging of the batteries; mines should not have different chargers for different vehicles.

“BEVs and chargers should be 100% compatible across the board,” he stressed. “This is why Epiroc has decided to use a standard from the automotive industry: CCS 2.0. Other areas where Epiroc has achieved good results with standardization is within our batteries. All of our second-generation batteries use exactly the same components. It is only their number that varies depending on the size of battery required.”

Epiroc has seen serious interest in BEVs from miners on all continents.

“The orders we have booked are testimony to this,” Gustafsson said. “We’ve sold BEVs in Australia, Canada and Finland.”

The demand for battery-driven models is so important that we can hardly keep the pace,” he said. “You can expect product launches in 2020. We also expect component suppliers to start designing components that are made for battery-electric drives, improving performance and efficiency. With so much focus on batteries worldwide, we also expect some great technological advances which will lead to better range and cost reduction.”
Sustainable development will continue to be a growing force within the mining industry, particularly as global pressures drive demand for the metals and minerals that the mining industry provides. Water is a critical component in mining operations, and effective water management has long been a focus for miners as they work to improve water efficiency and reduce environmental impacts.

But the world has a finite amount of freshwater, and under intensifying pressure from rising industrialization, urbanization, a growing global population and climate change, water-associated risks are expected to increase proportionally. It’s no secret that competing demands on water resources can create insecurities if not appropriately addressed and managed.

Recognizing the critical need to address the global water supply, the United Nations has declared the decade spanning 2018-2028 as an International Decade for Action in “Water for Sustainable Development,” and released accompanying sustainable development goals (SDGs) that emphasize sustainable development and integrated water resources management.

The International Council on Mining and Metals (ICMM) has established 10 principles that map against the UN’s SDGs and offer a best-practice framework for sustainable development in the mining sector. ICMM member companies are committed to these 10 principles and are encouraged to transparently report their performance involving water, energy and their environmental and social stewardship.

For example, Anglo American has said it is “ultimately aiming for a future where we’ve created waterless, carbon-neutral mines,” while Rio Tinto has moved toward focusing on site-specific water use targets to meet local needs and conditions. BHP is taking strides to reduce freshwater withdrawals by 15% by fiscal year (FY) 2022 and prioritize integrated water resource management by FY 2030. South32 is taking a holistic approach centered on promoting better water use, effective catchment management and improved water security — and by doing so, has reduced its total FY 2019 water inputs by 6% and improved water efficiency by 3%.

As a significant global consumer of water, the mining industry is responsible for playing an important role when it comes to sustainably managing water resources. As the global mining industry continues to develop new mines to replace reserves and production, the challenges of dealing with lower-grade ores — which require more water to produce equivalent product as higher-grade ores — will challenge the sector to be increasingly innovative as it strives to drive toward more efficient water management, balancing its needs with those of society and the environment.

The Drive for Copper
As the world continues to march toward a more sustainable and energy-efficient future, demand for copper is expected to rise over the next decade. Global population growth, urbanization and the proliferation of electric vehicles (EVs) will increase the demand for copper. And, with sales of EVs expected to rise to 8% of the global fleet by 2035, demand for copper due to EVs alone is estimated to increase by 1.7 million metric tons (mt) by 2027.

Chile is the world’s largest copper producer, providing nearly one-third of the global supply. Copper mining is a pillar of the Chilean economy and is credited with driving economic development there over the last 30 years. According to industry estimates, over the last two decades, copper mining has accounted for an average of 10% of Chile’s gross domestic product (GDP). In comparison, the mining industry as a whole represents 11% of the country’s GDP.

Most of these mines are concentrated in northern Chile, in the Atacama Desert,
one of the driest regions on Earth with an average annual rainfall of about 0.6 in. The terrain is mountainous, high in elevation, and features a complex desert ecosystem.

In this region, increasing drought and decreasing rainfall are driving concerns that Chile will be severely impacted by water shortages over the coming decades. To address this, the Chilean Congress is discussing new amendments to the Water Code that would limit freshwater withdrawals. As a result, the mining industry is facing pressure to decrease its freshwater withdrawals and to use seawater, either through direct seawater flotation or desalination to produce freshwater.

Desalination Offers Long-term Solutions
Desalination offers a sustainable long-term solution. Only 2.5% of the world’s water is freshwater. If all the water on the planet was collected into a one-gallon jug, available freshwater would comprise less than 2 tablespoons.

Even as miners deal with current water scarcity issues, the declining quality of ore is causing additional concern throughout the industry, as miners must use greater amounts of water and energy to process ever-larger amounts of ore. In fact, the Chilean Copper Commission (Cochilco) estimates that higher water intensity in ore processing will more than triple the industry’s seawater consumption by 2029. The group added, “It is important to note that Chile’s copper production matrix is expected to change over the coming years, shifting toward sulfide mineral whose treatment involves the water-intensive flotation process.”

And with nearly half (46%) of the world’s copper coming from ICMM member companies, pressure is mounting as these miners work to adhere to the 10 principles. With this and the potentially changing regulations in mind, Cochilco said that based on current trends, seawater will account for 43% of the water required by the country’s copper mining industry by 2029.

Building Major Desalination Project in Northern Chile
Although the concept of desalination has been around for centuries, modern large-scale desalination has only been around for decades. Adapting the engineering and construction of a conventional desalination plant and pipeline conveyance system to the mining industry’s stringent safety, quality, availability and reliability requirements is essential. These systems must be designed and constructed to provide reliable water supply for the life of mine.

In northern Chile, these technologically advanced desalination plants are built along the coast, the desalinated water is moved through an accompanying conveyance system — a complex system of pipelines and pumping infrastructure — over long distances to the high elevations of the mine site. The resulting brine is released back into the sea through a sophisticated dispersion system designed to reduce brine concentrations to ambient levels efficiently and over the shortest distances possible.

Perhaps no name has aligned itself as a leader in desalination more so than BHP Billiton, which continues to lead the way with its Escondida Water Supply (EWS) project. BHP needed to develop a sustainable long-term water supply solution for its Minera Escondida copper mine, located in the Atacama Desert. The miner decided that desalination provided the best opportunity to improve operations while protecting the environment. By relying on water from the sea, BHP could reduce its freshwater withdrawals, saving those resources for the local communities and area ecosystems.

To deliver desalinated water to the mine site, BHP built and commissioned a technologically advanced desalination plant, conveyance system and associated infrastructure. The desalination plant is located at the port of Coloso, and the desalinated freshwater is pumped over more than 180 km (100 miles) in distance and upward approximately 3,000 m in elevation to the mine.

The conveyance system relies on two 42-in. buried pipelines and four pump stations to deliver up to 2.5 m³ of water per second (m³/s) to the mine. A throughput expansion to the plant is also nearly completed making it the largest desalination plant in the Western Hemisphere. Additionally, the marine intake and outfall used innovative micro-tunneling to install the infrastructure, minimizing disturbances to the delicate marine eco-system and reducing disruptions to the local fishing community.

This allows BHP to rely on desalinated water, reducing its withdrawals from aquifers and offering a more sustainable water solution. As a leader in safety and sustainability, BHP’s success with EWS blazes a new path forward for sustainable mining in northern Chile.

Desalination Cost Levers
Capital efficiency is critical for investments and there are important considerations when designing a major desalination plant and conveyance system. A new copper mine can be a multibillion-dollar investment and infrastructure comprises a significant portion of that capital, particularly when it comes to building a desalination and conveyance system.

The Escondida Water Supply (EWS) project pumps desalinated freshwater more than 180 km (100 miles) to the mine, which sits more than 3,000 m above sea level.
Key cost drivers can be organized into four areas: program, site conditions, community and environmental concerns, and execution strategy.

Under the program category, the class of the facility and the expected design life are major cost levers. There is a significant cost difference between a 20-year facility and a 40-year facility. Other variables include the raw seawater quality, local energy costs, treatment goals (production flowrates, RO recovery, finished water quality, etc.), as well as the technology requirements, including redundancy and availability and pilot studies for pretreatment selection and process optimization. For conveyance systems, local topography and proximity between the desalination plant site and the mine will be major cost levers, as well as the selection of corrosion protection plan for pump station and pipeline materials, which must be weighed against selected finished water quality goals.

Site conditions also present significant cost variables. Many times, sites will be remote and new roadways will need to be installed to access these areas. This is especially true for those sites along conveyance routes where topography and hydraulic drive site selection over ease of access. These remote sites also must consider the challenges associated with travel time for delivery of equipment and materials and time required for operators to commute to a site to respond to disruptions in operations. This frequently results in these sites being completely operated remotely from control stations either at the mine or at the desalination plant, both of which warrant full-time operations staff.

Community and environmental concerns will also impact cost. Working in both the marine environment as well as the terra firma landscape will present different challenges. Miners must comply with restrictions on shoreline work when building out the marine infrastructure (e.g., tunneling vs. open trench), and adhere to all environmental politics and regulations — obtaining the correct permits, mitigating the impact to any local threatened or endangered species, and being considerate of any local fishing communities, which may depend on the local marine ecosystem. Furthermore, daily changes in ocean conditions can be a notable driver on productivities for marine work during construction and regular maintenance periods as periods of high winds and waves can restrict work-at-sea.

Execution strategy, including the commercial approach, can have a major impact on cost. Engineering, Procurement and Construction Management (EPCM), Engineering, Procurement and Construction (EPC), and Build-Own-Operate-Transfer (BOOT) contracts are commonly considered. This selection can impact not only the total installed cost of the project but can also shift costs from capital expenses to operating expenses and vice versa. The project schedule will also dictate cost.

The proper composition of the project delivery team is also critical, using local team members with an understanding of local labor markets and local material supply combined with global expertise in desalination, other treatment systems, and the significant expertise required for complex conveyance systems. Finally, as much of the major desalination equipment will be supplied from global equipment suppliers, an effective sourcing strategy will also be critical.

**Emerging Trends in Mine Water Today**

Miners are studying and implementing multiple alternative options to help ensure long-term water security. The outcomes and adaptations of these ongoing efforts will shape the future of how copper miners source and manage water in northern Chile.

Desalination water supply will become the norm. Large-scale desal will continue to play a role in copper mining in northern Chile, especially in water-stressed areas such as the Atacama, where all greenfield copper projects — and most major existing operations — are planning for a desalinated water supply (or seawater flotation). BHP led the way with their EWS project, and with another desalination plant under construction at Spence, the trajectory has now been set. In fact, at least eight new mining projects are planned around the use of seawater, with four expansions of existing systems.

**Filtered tailings for water reuse.** Huge amounts of water are trapped in tailings, and some miners are investigating using large-scale tailings filter systems to recover water. These systems are being trialed at multiple mines and expect to see more trials and production-scale systems down the road.

**Major water reuse and treatment projects.** Miners all have initiatives to use less water, and water reuse, recovery and recycling initiatives will continue to be a major priority. This includes managing evaporation, controlling contact water, producing higher density tailings, and investing in alternative water treatment technologies beyond reverse osmosis, to name a few. But a critical component of recycling and reuse is managing the levels of contaminants that build up in the process water — as more water is recycled, more treat-
ment is required to maintain the quality of the process water being used.

**Larger-scale water treatment and exchange programs.** Miners are studying their water security options, which can include moving water between basins and water exchange programs with local communities. These programs could involve treating and reinjecting water into basins and aquifer recharging systems, providing new infrastructure for communities to facilitate sharing of water resources and reuse of municipal wastewater.

**Floating solar on water reservoirs.** Installing floating solar arrays on reservoirs offers two major benefits: renewable energy generation and evaporation prevention. Evaporative loss of water is significant in northern Chile, and multiple studies are currently in progress with some small-scale facilities already installed.

**Integration with pumped hydro storage.** An exciting new development is the integration of desalination, pumped hydro storage and renewable energy at grid scale. Combining these technologies together — each proven in their own right — is likely the best way to deliver freshwater while providing renewable energy generation and low-cost energy storage. The topography and solar resources of northern Chile are well-suited for these integrated projects by providing access to both seawater as well as to the higher elevations necessary to situate the upper reservoirs. Coupling seawater pumped hydro storage with renewable energy installations provides an excellent opportunity to lower the operation cost of desalination facilities since the head pressure of the upper reservoir can be used, and today there are multiple studies under way by private developers in multiple locations.

The future of the Chilean copper mining industry is bright, as shifting global trends and rising demand continue to support a robust market. But challenges abound — miners must use greater amounts of water and energy to process lower-grade ore, even as they work to meet increasingly stringent regulatory and sustainability targets. This is causing miners to take additional consideration when building new greenfield projects or investing in mine expansions.

Miners will continue to play a significant role when it comes to sustainably managing water resources in northern Chile. Desalination and the use of seawater will be areas of major investment going forward and will continue to offer new opportunity when it comes to achieving their water security and sustainability objectives.

As the world’s largest producer of copper and a major mining center, Chile can be a true leader in sustainable mining. By embracing innovation and collaboration, miners can drive toward more efficient water management while balancing the needs of the sector with those of society and the environment, helping to define a new future of sustainable mining.

Spenceley is senior vice president of Black & Veatch Mining, where he is responsible for developing new and existing client relationships while leading business development, financial management, engineering, operations and construction. Spenceley has 25 years of experience in mega-project execution, greenfield project development, brownfield expansions, and open-pit and underground mines. He has extensive international experience, having served as an international project director and group executive responsible for global project services for Newmont Mining Corp., and has lived and worked in Chile, Ghana, Canada, Australia, Indonesia and the U.S.
One of the ways mining operations remain competitive is through economies of scale. Similar to other bulk commodities, moving large amounts of rock at the lowest possible cost translates to profits. Productivity in this area remains key, especially with the drilling and blasting programs for open-cast mines.

Through constant innovation, the suppliers that support drilling and blasting operations are improving the products they provide. Digital technologies are reducing the amount of manual data collection traditionally associated with blast planning and execution. It saves time, reduces the likelihood of error and provides feedback on performance.

Increasingly sophisticated software and modeling tools, electronic detonators and advanced initiation systems convert designs into highly predictable blasts, explained Joe Keenan, managing director, BME, one of the largest explosives suppliers. "Electronic detonators allow multiple delays in a single blasthole, so that there is less charge and energy released per detonator," Keenan said. "The intricate timing delivered by these detonators ensures no overlap of individual holes."

As far as the industry's quest to reach best-in-class drill and blast milestones and build further upon them, suppliers can be a great help to miners, Keenan explained. "We operate in a variety of locations and for a range of customers," Keenan said. "We see what works best and we can compare results across sites. It is all part of a vital process of raising the bar for a more efficient and productive mining sector."

Keenan's team at BME recently extended its own world record for the highest number of AXXIS detonators fired in one blast. At the Caval Ridge coal mine in Queensland on November 16, 7,350 AXXIS electronic detonators were successfully fired by the blasting team. The 1,700-m-long blast pattern was loaded over five days, then logged, tested and fired within two days. There were no errors or delays in the execution of the shot. The support provided by BME’s technical team fostered the teamwork environment that allowed the safe detonation of this record blast.

Transition to Electronic Delays

The transition from non-electric to electronic delay detonators (EDDs) in the field of blasting has brought many benefits to mining productivity, but there are plenty of advantages to be gained.

BME Technical Director Tony Rorke highlighted the focus in recent years on the flexibility in blast timing that EDDs allow, and more specifically on the value of longer timing delays.

"When we were first exploring the capability of EDDs, we were impressed by the accuracy that blasting with this technology allowed us," Rorke said. "This accuracy and reliability was a huge step forward, ensuring that there were no out-of-sequence blasts."

When using non-electric initiation systems, there were certain traditional timing conventions that were employed. These were based on the fact that accuracy decreased significantly as the length of the pyrotechnic delay elements increased and that the downlines may be severed (cut-offs) during a blast before the firing signal reaches the detonators thus leading to dangerous misfires.

"To get the detonators to fire in some acceptable sequence, therefore, delay periods were in the past kept as short as possible," he said. "The longer downhole delay has the dominant impact of firing time accuracy, so the risk of out-of-sequence initiation is a function of the in-hole detonator. Keeping this short as possible led to delay periods of between 350 milliseconds (ms) and 550 ms becoming standard for in-hole delays in surface blasting."

The result of these in-hole delays was that surface delays had to be notably shorter, to ensure an adequate "burning front" — so standard delays most commonly used today for surface connections
are 17, 25, 42 and 67 ms. These delay periods are generally suitable for hard rock, but the shorter periods (17 ms and 25 ms) increase the risk of out-of-sequence firing or blast choking, due to the inaccuracy of the longer in-hole periods. However, if the surface delay periods are increased to try and prevent non-sequential firing, there is a greater risk of cable cutoffs caused by short burning fronts.

“None of these problems exist with EDDs,” Rorke said. “Their accuracy allows for short delays with little risk of non-sequential firing. Furthermore, each detonator counts down independently — irrespective of whether the cable attached to it is cut. This means that blast planners can program long delays without worrying about misfires caused by down-line cutoffs.”

This improves the flexibility in timing designs enormously, allowing for complex and effective timing designs. The result is a range of blast outcomes that can effectively change the mining method and significantly reduce costs.

According to Rorke, rock takes around 30 ms to react to the energy of an explosion, depending on geology. This response time has led blasters to lengthen the timing delays in search of better results — and they have been rewarded. Blasting results have improved as the timing delays increase — delivering improvements in a number of areas including ore dilution control, through-seam blasting, underground blasting, trim blasting and drill pattern variation within a blast.

The problem, however, is that the adoption of EDDs is not always followed by any innovation in blasting practice.

“My experience is that — when operations convert from non-electric initiation systems to electronic detonators — there is a reluctance to give up the familiar 17 x 42 ms or 42 x 67 ms combinations, and miners impose these delay periods on EDDs,” he said. “This restricts the benefits of electronics to only the accuracy component and ignores the much more powerful flexibility component.”

Through-seam blasting is another valuable innovation for coal, not used much in South Africa, but successfully employed in the U.S. and Australia. The principle is to separate the charge in the seam and the charge in overburden with an aggregate deck. The charges in the overburden are fired first, followed by the charges in the deck zone a few seconds later. This can only be achieved using EDDs, as the firing of the top layer cuts of the down-lines to the detonators in the layer below.

“A time lag of a few seconds allows the waste to settle back on top of the seam,” he said, “so that when the seam charges fire, the overlying waste effectively blankets and confines the seam portion of the blast and thus prevents heave and dilution.”

Rorke urged mines to actively explore the power of EDDs to achieve timing designs and results that are simply not possible with non-electric initiation systems.

**Digital Fragmentation Measurement Technology**

A new automated rock sizing measurement technology, FRAGTrack, developed by Orica, captures real-time fragmentation measurement data for optimizing drill and blast operations, improving downstream unit productivity, and tracking of operational performance.

“Systematic and automated measurement and analysis of blast fragmentation provides a basis for continuous improvement,” said Raj Mathiravedu, vice president of digital solutions for Orica. “Fragmentation is a critical measure of tracking daily drill and blast performance, optimization of blasting, loading and haulage, and maximizing throughput of material during the processing cycle.”

FRAGTrack delivers accurate and reliable fragmentation measurements on both face-shovels and conveyors. The greater sampling frequency, enabled by the fully autonomous system, provides better insight, allowing for visualization and comparative analysis of multiple sample data sets. It also improves safety benefits by reducing manual sampling methods on the muck pile.

**DetNet Boosts Wits’ Research on Blasting**

A state-of-the-art smart blasting system was officially handed over to the Wits...
Mining Institute (WMI) by electronic blast initiation specialists, DetNet.

The BlastWeb system has been installed in the mock mining operation on the Wits West Campus, and promises to boost both research capacity and learning at the university. DetNet is an industry partner in the WMI’s Sibanye-Stillwater Digital Mining Laboratory (DigiMine). According to WMI director and professor, Fred Cawood, the system will be a vital resource for masters and Ph.D students in mining engineering. Wits School of Mining Engineering is located at the University of the Witwatersrand in Johannesburg, South Africa.

“Blasting and explosives is a very specialized field, and BlastWeb will allow researchers to do a range of tests using the system,” said Cawood. Key research areas that will benefit include: the relationship between blasting and seismicity; optimal rock fracturing using explosives; and safe, controlled blasting practices. He said access to the system gave Wits a significant resource in helping the industry realize its goal of zero harm.

“Electronic blasting from a control room puts distance between mine workers and risk,” he said. “The system also has a powerful analytics element, so workers can ‘inspect’ the quality of the blast from the control room.”

The Blasting Control Unit (BCU) has been installed along the crosscut of the mock tunnel at Wits, with 43 dummy detonators connected to the development end. The system’s hardware and software are installed in the WMI’s DigiMine control room, providing the analytics from each simulated blast. Communication
Dyno Nobel recently released what it calls the next evolution of Differential Energy, the ΔE2 software system. Enabled by an in-truck control panel, DynoLogix, this new software system uses data from outside sources, such as drills, face profiles or other data, which characterizes rock properties to allow targeted placement of energy in the blast hole. The ΔE2 system can also send loading instructions directly to the pump truck control system ensuring boreholes are loaded as designed.

The ΔE2 system can improve shovel dig rates, improve crusher throughput and lower overall drill and blast costs, according to Dyno Nobel. Furthermore, the company said this new system improves operator efficiency by simplifying the loading process and allowing explosives’ energy to be accurately placed in the blasthole, thus reducing oversize and/or fines.

The ΔE2 Pre-Load desktop software, part of the new ΔE2 system, allows users to precisely place energy within the shot and can be used by blasters and engineers to optimize energy placement within each borehole in the shot. The system can import data from multiple sources, including data from the Dyno Nobel mobile suite of applications that can create shot designs, to allow users an easy way to control the loading of a blast. Users can view powder factors that can be changed on the fly, which gives the engineer and blaster the ability to understand explosives usage prior to loading the shot, enabling them to control the actual shot cost.

Dyno Nobel recently conducted a trial shot using its ΔE at a quarry in the Laurentian region of Quebec, Canada. The quarry used a 1070G blend-like product with an average density of 1.2 g/cc, for most of its operation. A pattern of 3.96-x 4.27-m, on 102-mm diameter, 2.1 m stemming, with 0.15 to 0.3 m of subdrill produced satisfactory results with a bench height that varied from 10.7 to 17 m. The quarry, however, wanted to improve the fragmentation by reducing fines and generating more 150- to 500-mm material.

For the purpose of the test, the blast parameters remained constant to compare the performance of bulk emulsion. ΔE was introduced next to the 1070G blend in the same blast. Four different segments of the product, with different densities, were introduced into the boreholes. This reduced the density from 1.2 to 1.14 g/cc.

Following the trial shot, a fragmentation analysis using WipWare tools was conducted to quantify changes, if any, to compare the two products: ΔE vs 1070G blend. Based on numerous photo analyses, Dyno Nobel said that ΔE helped to increase coarser material (150-500 mm) by 3%, while reducing the fines by 1.1%. Furthermore, it was determined the ΔE helped reduce the explosive load per meter of blast hole by 5%.

This article was adapted from a similar article than ran in the December 2019 edition of Coal Age.
Screening solutions

Miners make novel use of screens and media to solve problems

By Carly Leonida, European Editor

Fixing new screen media panels into place. (Photo: Metso)

Screening machines serve a dual purpose: they sort materials by size and they can be used for dewatering applications. Considering the various parameters involved in the design, the size of the screening machine, angle of the deck(s), the frequency of the vibration, the media on the deck itself (polyurethane vs. woven wire), etc., the systems can be configured for many different applications.

Greater awareness of the possibility that screens can offer in process optimization, particularly in preconcentration, is driving interest from mine operators. And interest in digital technologies, as well as features that improve uptime and lower operating costs are strongly influencing R&D. The results are starting to take shape. Miners have been using screening machines in some rather novel applications with a great degree of success. E&MJ reviews two of those applications as well as some of the new products, developments and deliveries announced over the past 12 months.

Customized Media for Bell Creek

Polydeck recently helped Tahoe Resources’ Bell Creek gold mine in Ontario tackle severe blinding on its trash circuit screens. Fibrous blasting material residue was increasing the amount of time crews needed to manually clean the screens. Furthermore, poor dewatering was reducing throughput and increasing energy consumption.

Polydeck screening experts John Griffith and Perry Miller visited the plant several times in order to understand the problem and formulate a solution.

The company began testing some panels that were modified to add flexibility and installed them on the carbon safety screen. The modified panels had some success; however, even more flexibility was needed, so Griffith and Miller decided to create a custom solution.

The new panels would need to meet a wide range of criteria. They needed to be durable enough to last for six months, but flexible enough to impart some secondary motion.

The secondary motion was needed to resist particles of trash from plugging the apertures, while simultaneously preventing the build-up of calcium carbonate on the underside of the panels; a trend that had been observed on virtually every trash and carbon safety screen used at this site. Typically, panels in this application would require daily cleaning, which is inefficient and expensive.

Another criterion was compatibility of fastening, as the panels needed to fit on existing machines with other manufacturer’s modular panels. Above all else, the panel needed to provide adequate dewatering.

Griffith and Miller commissioned two custom Polydex panel designs to address the issues. The modular polyurethane panels have proven themselves in a variety of screening circuits and are well suited for wet applications.

Polyurethane offers the most options, not only in terms of screen openings, but also in the integration of performance enhancing features like dams, restricted flow bars, skid bars and deflectors.

In October 2018, the new Polydex 1- x 1-ft slotted panels with pin fastenings were installed at Bell Creek in rows one through four, and new 1- x 1-ft VR screen panels were installed in rows five and six. The remaining six rows of the screen contained panels manufactured by competitors to draw a comparison in performance.

“The panel’s performance exceeded our best expectations, both in drainage rate and durability. This innovation provides a cost-effective alternative solution to more costly vibrating screen machines and specialty media solutions,” Griffith said.

The Polydex panels exhibited excellent dewatering results with little water proceeding past the last row of Polydeck panels. They allowed for more efficient rinsing of material and increased throughput by 32%. The drain rate increased by more than 2.5 times, screen capacity more than doubled, and the panels eliminated the need for a secondary screen altogether.

While the competitor panels still exhibited blinding, the Polydex panels resisted it, reducing the labor costs associated with maintenance and boosting availability.

Polydeck said that, upon hearing the results, other gold producers have now reached out in a bid to improve their trash screen operations.

Martabe Solves Problems With Screens in Sumatra

FLSmidth’s Ludowici team recently completed a project at PT Agincourt Re-
sources’ Martabe gold mine in Northern Sumatra to improve the life of the mine’s screen media.

Every seven weeks, a shutdown of the SAG mill was scheduled to assess and maintain the steel mill liners and screen media. Yet the metallurgy team at the mine observed that the feed-end blank panel’s mean time to failure was a maximum of four weeks. Depending on the mill discharge grate wear, sometimes only three weeks wear life was achieved.

This meant, even with the original seven-week shutdown frequency, the mill faced unplanned downtime and production loss to allow the feed-end blank panels to be changed. However, the mine’s ultimate goal was to extend the shutdown to 16 weeks. Therefore, changes needed to be made, and the team turned to FLSmidth for help.

At Martabe, the mill discharge is fed on to an FLSmidth BRU 3 x 7.3 horizontal screen. The screen media installed was the FLSmidth LUDODECK P2 modular system and the feed-end had three rows of blank panels for the mill discharge chute to feed onto. The performance of the aperture panels did not need attention. There was no pegging of apertures and wear on the panels, which meant the feed-end screen decks only required changing twice a year and the discharge screen decks just once a year.

The solution was delivered in two stages and involved trials and discussions that spanned several months. Media wear was reduced by combining a section of the already installed LUDODECK P2 modular screen panels with removable rubber wear plates.

This process involved increasing the panel thickness from 1.8 in. to 2.36 in. (46 mm to 60 mm). Then, steel-backed rubber wear pads were bolted to the panels. This increased the overall thickness to 3.39 in. and meant the blank screen panel did not see any wear, allowing for reuse after every shutdown.

The installation of the new solution did not change the original fixing method. Therefore, the panels were fitted by the mine crew on time and without any reported injuries. In addition, future replacements can be assembled offline and fitted quickly when required.

The metallurgy team inspected the feed-end blank panels after two weeks of use and found the panels in very good condition. The panels were inspected again at seven weeks of use and the wear was considered very satisfactory.

**JOEST Updates Flip-Flow OSCILLA**

JOEST celebrated its 100th anniversary in 2019 and, to mark the occasion, the company released an update to its popular Flip-Flow OSCILLA screen.

The OSCILLA is suited to classifying hard-to-screen bulk materials, as well as wet or inhomogeneous materials. The 2019 generation has been optimized even further to minimize maintenance requirements and maximize throughput.

The OSCILLA technology is based on that of a resonant system in which the dynamic screen frame is excited relative to the body of the screen.

The body of the screen is brought into motion by a standard, unbalanced motor, or a single or double drive shaft. As a consequence, the frame moves in a linear motion relative to the screen body. The clamped screen mats are attached to the frame and screen body via crossbars. The relative motion of the two systems causes the mats to stress and relax, similar to the movement of a trampoline. This accelerates the particles by up to 50 G and prevents the mats from clogging.

JOEST said that a big advantage of the OSCILLA is the high flexibility offered through stroke control. The stroke is measured, and a frequency converter applied to enable the relative motion between the frame and screen body to be held at a set value.

The updated OSCILLA has been fitted with what JOEST calls “Vibroblocks.” These are located between the frame and body to absorb the system’s resonant forces. The feature was added at a client’s requests. The company said the Vibroblocks are long lasting, quick to change and minimally sensitive to temperature variations.

The OSCILLA cross members have also been redesigned. These are no longer manufactured individually for each machine type. Instead, they consist of specially developed profiles, which are cut to length and fitted with a standard end-plate. The attachment points for the screen mats are also integrated to eliminate labor intensive alignment and bolting of the individual parts to the cross members.

The new OSCILLA is available in widths from 23.6 in to 94.5 in (600 mm to 2,400 mm) and lengths up to 362 in (9,200 mm), with the option of a single or...
multiple deck configuration. The modular design means that numerous inlets and outlets can be attached without changing the base construction.

**Metso Eyes Market Trends**
The team at Metso has been keeping a close eye on market trends and using these to inform their R&D projects.

Andreas Kanter, product manager, mining screens and feeders, told *E&MJ*: “Condition monitoring has become a common feature as part of the scope of many tenders. In some markets, there’s also a tendency toward larger screens; 4.2-m or 4.3-m-wide screens for instance are standard in Australian mining operations. We don’t see this in many other markets.

“It seems to be a philosophy in Australia based on using less equipment but larger models. Skilled labor is hard to find and many operations are fly-in fly-out, so having less equipment helps reduce maintenance requirements.”

Kanter and his team have also noticed increased interest in the optimization of screening operations. Rather than adding more equipment to boost capacity, many mines are looking to enhance the performance of the machines they already have. This has the dual benefit of keeping capital costs low as well as minimizing the screening footprint within concentrators.

Michael Gyberg, vice president of products for Metso’s Screening Business, explained: “Going back a few years, that wasn’t the main focus. The quickest and easiest way to increase capacity when the market was booming was to add more machines. Now, that capital investment isn’t so readily available, there is more willingness to optimize.”

One way to do this is by using Metso Metrics. This package combines digital monitoring technologies with a customer interface that connects the team to Metso’s performance experts who can help maximize plant operational efficiency.

Kanter explained: “It [Metso Metrics] speeds up first response in case of events, and aids in inspection and shutdown of screens. It enhances the ability of customers to access Metso support.

“We see this in many tenders nowadays. Many customers expect it with the equipment. And for sure, our plans are also to install it on existing installations, too.”

He added: “Screening often becomes a bottleneck when it comes to plant upgrades. Installing a high-performance cone crusher with increased capacity is, in many cases, possible with only little modifications at the foundations.

“But for screens, it’s more challenging, because they demand a lot of space, so we have to optimize. We see many cases where the impact that screening has on crushing circuits has been underestimated.”

**New Screen and Updated Media**
In the past 12 months, Metso has released a new ultrafine screen that can screen wet products down to 50 microns.

“We achieve that by using up to 10 decks,” explained Kanter. “This screen can be used in grinding circuits, instead of cyclones. The advantage is the sharper cut point compared to cyclones in some grinding circuits.”

And how about media?

Gyberg explained: “We are on the verge of launching an updated version of our flagship media product groups. We have developed internally a manufacturing process, which gives us very precise control over aperture design and high panel production capacity.

“We are bringing in high open-area type designs, which haven’t been that common in some markets globally. It’s more a trend in aggregates. This is something which will be coming in the next coming six months.”

Gyberg added that the company also has an important development concerning the North American market.

“In the first quarter of 2020, we will be a full line manufacturer for screening media in North America,” he told *E&MJ*. “In the past, we have imported a lot, but we have done quite a bit of investment there in our plants to enable us to better supply that market.

“In other areas of the world, we already have strong capabilities, and going forward, we’ll be able to make everything from polyurethane to wire-type products on American soil.”

**Derrick Ups SuperStack’s Decks**
In November, Derrick introduced the 8-Deck High-Capacity SuperStack vibratory screen. The company said this offers two to three times the capacity of its predecessor, the 5-deck Stack Sizer.

The eight decks operate in parallel and this, combined with a 30%-35% increase in screening width per deck, delivers a significantly higher production capacity with only a modest increase in footprint. While the 5-Deck Stack Sizer is equivalent to a 5-m x 1.5-m screen, the 1.42-m-wide SuperStack is equivalent to an 11-m x 1.5-m screen.

“The SuperStack is a highly efficient means of achieving major production increases within a comparatively small footprint,” said Todd Burchett, vice president of Derrick’s Mining and Industrial Division.

“Consequently, we expect the SuperStack to fill the need for higher productivity in facilities where space is limited.”

Derrick said the more effective use of screen area and increased capacity results from the front-to-back screen ten-
sioning system that tensions the panel in the direction of flow rather than side to side. In addition to increasing productivity, the system reduces screen panel changing time by 80%-90% compared to side-to-side tensioning.

Derrick’s Polyweb urethane screen panels with 150- or 180-micron slotted openings are available for the SuperStack, and an optional re-pulp spray system introduces free water into replaceable rubber wash troughs to help reduce material pass through screen openings. All screen frames are coated with abrasion-resistant urethane for extended service.

Dual oversize launders (one per side) and a single undersize launder eliminate the need for a large hopper, minimizing height requirements. Each feeder has a removable front cover to facilitate maintenance and debris removal. Custom-designed inlet pipe configurations are available if required to meet equipment layout requirements.

The Flo-Divider, which equalizes flow from the feed source to each deck, is also available in a number of discharge outlet configurations, from two-way to 16-way.

Dual vibratory motors are positioned directly over the upper screen frame to deliver linear vibratory motion to all eight screen decks. The motors have an internal oil lubrication system that removes the need for a separate lubrication system, while providing long-term, maintenance-free operation and less noise.

**SuperStack Boosts Russian Iron-ore Production**

Derrick also announced the delivery of SuperStack equipment, including an 8-Deck SuperStack, to Metalloinvest’s Mikhailovsky GOK iron-ore beneficiation plant in the Kursk region of Russia in October.

The agreement was signed with Thrane Teknik in September to supply Derrick equipment for the second stage of the project. The companies have been working together since 2005 when Derrick technology was introduced at four sections of the old beneficiation plant. The design, supply and installation of the equipment, adjustments and commissioning took place in just one year.

As a result of the successful first stage implementation, the fine screening section is projected to produce more than 3.7 million metric tons (mt) of iron-ore concentrate, with iron content increasing to 67% compared to the previous 65.1%.

The second stage of the project will see construction of a new building for beneficiation, and the plant is expected to produce 16.9 million mt of concentrate with an iron content of 68.7% by 2022.

Nizam Efendiev, First Deputy CEO and sales director at Metalloinvest, commented on the deal: “The introduction of Derrick fine screening technology is an important part of the comprehensive program to improve iron-ore products at Mikhailovsky GOK.

“Improvements in the quality of concentrate will enable the enterprise to produce premium-quality pellets in line with international standards. The enterprise will also reduce its impact on the environment and will increase production efficiency.”

**Haver & Boecker Niagara: New Name and New Products**

Haver & Boecker announced a big change in April at the bauma 2019 tradeshow in Germany. The company has established a new brand called Haver & Boecker Niagara, which combines the engineering expertise and product portfolios of its three mineral processing locations in Brazil, Canada and Germany.

In the past, the three locations acted individually for their respective regions and territories, but the company said the new brand will allow customers across the globe to benefit from shared innovations, more in-depth consultations, greater parts availability and better delivery times.

“Niagara now stands for a new, global drive in processing technology,” said Adrian Gamburgo, director of corporate business development at Haver & Boecker OHG. “These three Niagara locations will join forces and, together, focus on developing innovations in screening, washing and pelletizing technology, as well as increasing their regional service reach.”

At the event, the company also launched a number of new products including the Ty-Max screen media. This polyurethane media is suitable for wet or dry screening applications and is created using open-cast technology. The media permanently hardens when cured allowing it to maintain its chemical properties and resist wear and tear.

Haver & Boecker Niagara said the polyurethane lasts much longer than wire cloth and handles direct feed better, maximizing productivity by reducing changeouts. Ty-Max features an internal wire grid as thick as 3/8-in. (9.5 mm) to reinforce the screen — something modular polyurethane products do not offer.

Tensionable hooks come standard with Ty-Max sections, eliminating the need for deck conversions, which can cost thousands of dollars. Typically, a switch from a woven wire cloth, which requires a cambered deck, to a polyurethane modular product requires a deck conversion costing anywhere from $5,000 to $15,000. However, Ty-Max is hooked for a cambered deck to eliminate the need for conversion.

Ty-Max features square or slotted tapered openings to release near-sized material. The top of each opening is narrower than the bottom, helping prevent pegging.

Several Ty-Max options are available to fit different applications. Standard Ty-Max sections have bar rail spacing up to 12 in. (304.8 mm), while heavy-duty Ty-Max handles higher impact applications and deep bed depths on vibrating screens with bar rail spacing up to 16 in. (406.4 mm). The heavy-duty sections feature thicker wire reinforcements for withstanding large top sizes and heavy material. Finally, Dual Durometer Ty-Max features a top layer that is softer than the bottom to alleviate pegging.

Haver & Boecker Niagara also launched the N-Class vibrating screen, which can handle up to 5,000 mt/h of material scalping and classifying duties, and various other mining applications.

The N-Class features one to three screen decks and a single-eccentric shaft design that’s supported by four high-performance, double-spherical roller bearings. It is balanced to minimize dynamic loads transferred into the structure, allowing multiple screens to be placed side by side in the same building.

Haver & Boecker Niagara said the N-Class maximizes screening efficiency and virtually eliminates blinding and pegging by providing consistent G-force in all operational modes, regardless of load consistency. A heavy-duty body handles heavy loads in applications with extreme material sizes up to 80 x 40 x 40 in. (2,032 x 1,016 x 1,016 mm).

The screens also offer a self-cleaning action to minimize common problems encountered with traditional grizzly feeders. And each N-Class comes equipped with the aforementioned Ty-Rail System.
When Old Beats New

 Suppliers say reman exchange programs are on the rise primarily because the products are superior

By Jesse Morton, Technical Writer

All the suppliers that spoke to E&MJ about their reman exchange programs unabashedly declared reman parts outperform new. On the surface, the assertion seemed outrageous. How could old outdo new? Yet, they all had different explanations that satisfied that view. That is partly why they are all growing their programs due to popular demand. A glance at the latest news on the topic reveals more about the basis of that demand and why reman exchange programs could be ascendant for a while.

Liebherr recently establishes a new remanufacturing facility in Panama to support a fleet of trucks at the Cobre Panama mine as well as other mining equipment operating throughout Central America.

As-new Quality, at a Lower Price

Liebherr told E&MJ it began construction this month on a reman facility in Panama City, Panama. The facility, one of 12 in the company’s reman network, will feature 1,500 m² of production space, is expected to cost roughly $10 million, and is calendared for completion in early 2021, Jeff Rounds, general manager, global remanufacturing and service component production, Liebherr-Mining Equipment SAS, said.

The new facility will enable the company to fully support a fleet of ultra-class haulers delivered over the course of the last two years to First Quantum Minerals’ Cobre Panama project.

That the project deployed 38 new 400-ton haulers necessitated the facility, Rounds said. “When you supply that number of machines in a relatively short period of time, you then are faced with a unique challenge that all of the machines’ components will come due for overhaul or reman in very close sequencing.”

The new reman facility will complement Liebherr Panama S.A.’s Panamerica Corporate Center administrative office, workshop and parts warehouse in the country’s special economic zone. It will enable the company to convert its Liebherr Colombia SAS reman facility in Barranquilla to a parts warehousing facility.

“It is basically replacing a facility that is a very small one,” Rounds said.

The new facility will be certified to Liebherr guidelines and standards, Round said. “All of those 12 facilities have online access to the latest factory documentation, approved remanufacturing specifications, and access to the complete range of Liebherr genuine parts. All of those operators in the network are certified to one group of unified standards,” he said. “Our philosophy is if we all share the same documentation as the OEM, and we test in the same way with the same equipment that the OEMs use, and we have the same training across the board, we should have likewise a similar and measurable quality output.”

The development is important for both the company and the country, Rounds said. Mining “is the first industry outside the Panama Canal for the Panamanian government and the people there,” he said. “It is very exciting.”

Separately, in Q4 2019, the company commissioned a diesel engine remanufacturing capability at its reman facility in Springs, Gauteng, South Africa. The development doubled the size of the production space at the facility, increased staff there by 10, and was calendared for commissioning for late January.

“We knocked down walls,” Rounds said. “We repurposed space that was otherwise previously used for nonproductive activities, and we installed an engine dyno testing system.”

With that system, the facility, which previously offered component repairs services, “can now do the full process,” Rounds said. “It will allow us to repair and remanufacture mining diesel engines to the same test protocols that are done today in Europe in new-build production.”

It will enable the facility to bring existing engines to as-new or better-than-new condition. “We are consistently focused on measuring that metric,” Rounds said. “We analyze the component lifetime of new and we compare it to the lifetime achieved of the reman, and we study the reliability of both, and we are able to consistently identify where we are able to exceed the lifetime of the new component.”

Hypothetically, a reman part or component might outperform a new one because it features, for example, a new coating technology, a new type of sensor system, or because it has benefited from a technical
design revision, Rounds said. “Because we have lots of cores and we are opening them every day, we also have the opportunity to introduce those technical updates in an accelerated manner compared to the serial production for the machines,” he said. “Our value proposition is centered around providing as-new quality and performance at a fraction of the price of new.”

Customers can leverage Liebherr’s reman offerings by either buying individual reman parts from the company as needed or by joining its reman parts exchange program.

In the case of the former, the customer can obtain parts sometimes for a fraction of the cost of buying new. “When we talk about basic scope of repair, that can be as low as 10% of new,” Rounds said. The downside is the price can vary as can the lead time.

With the exchange program, Liebherr owns the exchange inventory. “The customer owns the component that is on the machine. And the title is transferred when they exchange the broken core for the exchange component,” Rounds said.

In the exchange program, the customer pays a preset price on reman parts and components and gets same-day service on them. The price can range between 50% and 60% of new, Rounds said.

The set price helps ensure “you don’t have any variance in your maintenance budget,” he said.

In the exchange program, Liebherr effectively manages the inventory, Rounds said. It puts people on the mine site regularly to track plans and stay atop developments.

“We spend a lot of energy trying to understand on a continuous basis the maintenance plans our customers have for those ultra-class machines so that we can ensure that we have the materials and the capacity at the time that the customer needs the service,” Rounds said. “We offer services like machine inspections where we have technicians on the ground. They go to the machine. They understand what is happening with it, in particular the hours accumulated on all of the different components that are installed and then make recommendations based on those observations.”

Rounds said the company had a customer that was managing their maintenance via a third party that was able to reduce costs up front. “They then later encountered premature failures on some components,” Rounds said. “What we did was through the exchange program, we set up a way in which they could exchange components but at a variable price,” he said. “They still had the opportunity to win the lowest price when, at this particular time, the budget climate was very tight, and out of that came the business back to Liebherr while at the same time the reliability and the performance of those machines in that mine increased.”

Being that one out of every two Liebherr components sold is a reman, such hybrid programs are not uncommon. “We have some that will do both, depending on the cost of a given component and the size of a machine,” Rounds said. “Our mission is to offer the complete range of services, so whether you exchange or whether you repair, we want you to come to us for the genuine parts, for the quality, and we can provide the same testing whether they own the component core or Liebherr does.”

**Growing Selection, Nimble Supply Chain**

Epiroc reported it expanded its reman offering portfolio in North America and streamlined its reman product supply chain.

The program recently added eight air compressor air ends for the company’s midrange surface drills. “We had a gap in that,” Matt Cadnum, national sales and operations manager, mining service division, Epiroc USA, said. “We always had the remanufactured components for our large blasthole drills, but we never had reman offerings for the midrange. We are also expanding to include some final drive components for the large machines.”

Those additions and others bring to 87 the total number of reman components offered by the program.

Cadnum said the development was customer driven. “We have been very successful in the marketplace over the last few years. The populations are substantially higher in the last five to 10 years and now those components are requiring some replacement and the reman offers are so much more economical,” he said. “So, it is more about customer demand that we have met.”

Additionally, the company recently launched an effort to better coordinate the reman centers in North America to maximize the availability of reman products to customers there. “We’ve changed a bit,” Cadnum said. “We’re offering those reman capabilities via our global distribution network on more of a continental scale in North America. But it is also moving toward a global scale without having to reinvent those programs in the different markets.”

Part of that includes supplying the company’s Texas distribution center with reman components from its Tucson, Arizona, reman facility.

By streamlining the supply chain, the exchange process is simplified. “It flows with the spare parts, and there is a very robust, nimble process for the return of those components, as well, to be re-managed again,” Cadnum said.

The desired effect is customers in North America and elsewhere should have
improved access to OEM reman components, he said.

For some customers, that could mean “tremendous” cost savings, Cadnum said. “It is a very cost-advantageous option,” he said. “It is essentially 70% of new with the exact same quality and the exact same warranty as a new component.”

Reman components meet stricter standards than, and sometimes outperform, new equivalents. “We’ve developed and adjusted our processes that gives better longevity on the remanufactured item,” Cadnum said. “We put a little more cost into the testing and checking and double checking. We’ll test a component for an hour, whereas a new component might be tested for five minutes.”

If a reman part doesn’t meet specs, “we dig into it and make sure it is right, and if it is not, we replace it with one that is,” Cadnum said.

And the numbers prove the superior performance of reman components. “We track it,” he said. “We track warranty costs on new components. We track warranty costs on reman components. Our reman warranty costs are lower.”

The company offers consultative services to miners interested in the exchange program. “We have product sales and support specialists that will go in, work with the mining planners and maintenance personnel and help identify what we have available as reman and do a calculation to show them what their savings are going to be and when they should replace those components,” Cadnum said.

Epiroc says the costs for reman parts are roughly 70% of new with the exact same quality and warranty as a new component.

“We work with their maintenance area and their planners to ensure we identify timeliness of when to replace those components and plan accordingly to make sure we have availability and even the service to install those components.”

The program is primarily leveraged by customers deploying Epiroc’s Pit Vipers and DML blasthole drill rigs. Typically the customer trades out a used component for a reman equivalent. “We will take that core back and provide a remanufactured one right away,” Cadnum said. “For the customers that we serve, we are there doing maintenance and service on the Epiroc equipment as it is. The planned replacement of reman components is part of our job, part of what we do every day.”

Among other things, the program allows a customer to adopt and trial Epiroc equipment at reduced costs. “We will do full-service agreements on the sale of new or existing machines,” Cadnum said.

But, ultimately, the program’s main offerings are cost savings and increased machine availability for customers deploying multiple Epiroc machines, Cadnum said.

“We can really help control that cost of ownership and understand what it is going to be at the frontside so they don’t have any surprises,” he said.

“We link that to availability,” Cadnum said. “It is all about that collaboration and planning together and providing the services and components that keep those machines up and running and keep their mines moving in a very viable manner.”

Swift Turnaround Time, Customizable Program

FLANDERS reported customer feedback on its new exchange program for electric haul truck components has been overwhelmingly positive.

The program allows customers to “have spare component coverage while reducing mine inventory and the associated costs,” Mike Casson, global business development manager, surface mining, FLANDERS, said.

The program’s haul truck parts portfolio includes, but isn’t limited to, wheel motors, alternators, and grid blower motors for 830E and 930E trucks. The main offering, however, is “the unmatched quality of FLANDERS rebuilds and the inherent longevity of life when put into service,” Casson said. “Because we have been fortunate to have earned a leading market share in the surface mining market for many years, we have been able to see an extensive variety of failure modes to which we have applied root cause failure analysis and developed numerous upgrades in processes, materials, and re-designs to correct any weak points in a given type of motor,” he said.

“This allows us to provide the longest
warranties in the industry, which unlike many are non-prorated.”

One example of that quality is a Marion 8750 dragline repaired as a premium rebuild in summer 2000 that is still operating after more than 100,000 hours, Casson said. “The last time I was personally on that dragline was about two months ago,” he said. “The motor still looks great with absolutely no indication of necessary repair or replacement in the foreseeable future.”

Casson said the dragline illustrates how FLANDERS exchange program reman parts “always equal or exceed the performance and longevity of most new parts.” Which is to say over the long run, reman parts present substantial cost savings.

“Alternatively, saving dimes with low-bid, low-quality suppliers or in doing half-measure repairs can often result in wasting dollars,” Casson said. “One example of this I have seen in particular is where a mine chose to do cheap, minimum motor repairs thinking they were saving costs, but then ended up changing the same motor out three or four times over a 10-year period,” he said. “In the end, they spent many more total repair dollars than if they had done it right the first time and that additional cost does not even include the downtime and inherent risks involved with changing the unit out multiple times. Doing it right the first time is almost always the most cost-effective path.”

With the FLANDERS exchange program, turnaround time to repair a failed unit is negligible, Casson said. “When a unit does fail in-service, a FLANDERS owned replacement unit is immediately installed,” he said.

The failed unit then undergoes tests to see what it needs to get it back up to specifications. “After a repair workscope is approved by the customer, repairs are completed,” Casson said, “and the exchange unit is returned to FLANDERS inventory until needed.”

And that process is viable when a customer wants to do numerous repairs simultaneously, he said. “FLANDERS currently holds more than 500 individual components in our rotating equipment exchange program,” Casson said. “For example, if a customer wanted to rebuild all eight hoist motors on a Bucyrus 2570 during an outage, we can provide eight complete units from our inventory, above and beyond any individual FLANDERS spares that are normally dedicated to that customer.”

Inventory is accessed through a dozen hubs located in most mining regions. “Transportation times are minimal due to that local support,” Casson said.

Customers located in remote areas can negotiate an arrangement with the company to maximize parts availability and machine uptime. For example, in one instance, FLANDERS situated a customer such that they had duplicate sets of parts. “Whenever a unit is needed on-site, the spare stored in the mine warehouse is installed and they advise us of the change-out,” Casson said. “We then ship a second spare unit to the site while the failed unit is shipped to one of our regional service centers.”

The program has no core fee or flat rate consignment costs. “We set up our exchange program with mutually agreed upon pricing where the customer only pays for required repairs to get the unit back within mutually agreed upon specifications,” Casson said.

The company offers a similar program for underground mining machines.
The Evolving Role of Communications for the Digital Mine

By Gary Conway

There is a big shift happening in mining around digital automation. Miners have always used machines to boost their productivity, but until recently, digital technologies have played a more limited role. Autonomous vehicles, artificial intelligence and machine learning are combining to create a new Industry 4.0 approach to mining.

Driving the adoption of these digital technologies is the need for continuous improvement in safety, productivity and efficiency. The result has been an unprecedented demand for automating and optimizing all aspects of open pit and underground mining operations.

While the industry has focused on these Industry 4.0 technologies, new industrial wireless communications systems such as 4.9G/LTE and 5G will also play a critical role in enabling these digital technologies and are transforming the way mining views the strategic importance of digital communications.

LTE or 4.9G is the last iteration in the 4G standard before the world moves to 5G, which will roll out in several releases over the next four to five years. These technologies provide performance enhancements over older technologies, such as Wi-Fi and Wi-Max, offering Ethernet-like bandwidth, low latency and security characteristics, all delivered wirelessly, with full support for mobile applications.

Reflecting this high level of performance, mining solution providers like Komatsu and Sandvik are embracing 4.9G/LTE and 5G by ensuring that their equipment and applications run seamlessly on these networks. For instance, Komatsu autonomous ore haulers have been making news over the last few years at some of the bigger surface mining operations worldwide, and private wireless networks are playing a crucial role in making that possible.

Whereas previously, 4.9G/LTE spectrum was only available for mobile network operators, governments are recognizing the strategic importance of these new communications standards by releasing spectrum for 4.9G/LTE and 5G that will be reserved for the use of private networks such as those operated by mines. There are also new forms of LTE (e.g., MulteFire) that can operate in unlicensed spectrum.

The arrival of new, industrial-strength wireless communications based on 4.9G/LTE and 5G should be causing mines to rethink their overall approach to digital communications at the mine site. Over time, they will begin to see communications, and especially wireless communications, as a strategic enabler for the automated mine of the future.

This will represent a change in the normal attitude of miners toward communications technologies. Mining is unlike many businesses where, typically, IT is responsible for the enterprise network and drives the corporate approach to in-
ternet and communications technology (ICT). In mining, the choice of communications technologies is driven by the operations technology teams (OT). They tend to focus on the point solution or application and choose the appropriate communications technology for the job.

Given the rapid evolution of communications technologies over the last few decades, it has certainly made more sense to go with the best of breed technology du jour, then try to standardize on one. However, with the communications field converging very quickly on a single approach to industrial communications, it is time to think more strategically about communications. A 4.9G/LTE network today, which will seamlessly evolve to 5G in the next few years, is actually an investment in a digital transformation platform.

The problem with choosing communications systems based on a point solution or single use case is that OT has, in many cases, inadvertently created a hodge-podge of different, purpose-built networks to support the various applications. As they embrace mine-wide digital transformation, this patchwork of networks will prove to be both a liability and a missed opportunity.

On the operations cost side, managing, updating, troubleshooting and securing multiple networks makes for more work than necessary. It also leads to complexity, which is one of the biggest enemies of predictability, by multiplying the possible points of failure. Running all applications on a single LTE network reduces that complexity and improves operational continuity — and end-to-end security.

In terms of lost opportunities, a hodge-podge of different networks also makes it more difficult to share data between applications. One of the principal advantages of digital transformation is that analytics programs can process, filter and sort through reams of logged data to identify things that humans might miss. Sometimes data from one application can be correlated with data from another for unique insights. These might lead, for instance, to workflow optimization or more accurately predict the time-to-failure of key assets.

Pulling all this data together is much simpler when the majority of applications share the same connectivity platform. Having a total digital picture of the mine’s operations enables analytics software to fully understand the system-level risks and their impact on the bottom line. They can red flag operational and maintenance priorities, whether they concern environmental hazards, worker safety or possible points of asset failure. The key to this level of digital integration is having a single digital communications system that supports all possible applications.

The beauty of 4.9G/LTE today, and 5G tomorrow, is they have been designed for industrial applications. They have support for low-power IoT sensors and devices. They have been engineered to deliver extremely low latencies (the round-trip time for data), which is required by automation. And they are highly secure. In more than a decade of use, no public LTE network has been breached. LTE networks have been tested thoroughly by public safety authorities and are being deployed for next-generation national emergency services networks with full support for push-to-talk and push-to-video private radio services.

As mines pursue digital transformation applications, they often start with a single use case, such as autonomous ore trucks or remote-controlled drill/blast machines. This leads them to install private 4.9G/LTE networks because of the need to support mobility, high bandwidth for on-board video, and low latencies for immediate response to sensor input. Once the business case is made for installing the private wireless network, however, it becomes obvious that other use cases can be supported.

Over time, the mine naturally migrates other applications on to the 4.9G/LTE network. They can replace the TETRA or P25 radio network. It can support remote video surveillance and cameras on moving machinery, digital personal protection equipment, geo-fencing, environmental sensors, equipment monitoring, remotely operated trains, and the list goes on. As the applications add up, costs go down and the opportunities for digital transformation multiply.

Somewhere in this process, the attitude shifts from communications as simply a part of a point solution, to communications as a strategic enabler of digital transformation. Over time, 4.9G/LTE and, in the very near future, 5G will replace most existing communications technologies currently employed by mines and prove to be one of the key technologies in creating the digital mine of the future.

Gary Conway is global head of mining business at Nokia.

QueLLavaco Relies on Immersive for Operator Training

Located in the Moquegua region in the south of Peru, Quellaveco is one of the world’s largest undeveloped copper deposits. Scheduled by owner Anglo American to begin production in 2022, the mine’s overall plan includes eventual transition to autonomous haulage systems.

The new mine will begin autonomous haulage operations once operators are proficient in how to interact with the autonomous environment. To prepare the workforce for this greenfield operation, Anglo American has invested in simulators and learning systems from Immersive Technologies. Immersive Technologies plans to support Quellaveco throughout the training process, using blended learning systems, simulation and human performance analytics.

According to Immersive, use of its solutions at Quellaveco will expedite training to provide sufficient operators for both manned and autonomous mining operations while reducing risks associated with ramp-up to full commercial operations. The transitional period to bring the complete fleet of autonomous trucks into operation will require specific sets of skills and new roles. Human error has a significant impact on autonomous haulage system productivity. The systems being supplied to Quellaveco, according to Immersive Technologies, have been demonstrated to provide a method to build the required skills and decrease human error in the use of autonomous haulage systems.

“Operators will be involved in every stage of the transition. Immersive Technologies simulators would support this process by providing multiple simulation training solutions to generate multifunctional operators in a safe and controlled environment while being efficient,” said Bryce Mancell, technology and systems engineering superintendent, mining and technology at Anglo American.
Komatsu’s Dawes to Chair MINExpo INTERNATIONAL 2020

The National Mining Association (NMA) announced that Jeffrey Dawes of Komatsu will chair MINExpo INTERNATIONAL 2020. A longtime leader within Komatsu and the industry, Dawes is vice president of Komatsu’s Global Mining Business Division, and president and CEO of Milwaukee, Wisconsin-based Komatsu Mining Corp.

Held every four years and sponsored by the NMA, MINExpo INTERNATIONAL is the world’s largest and most comprehensive global mining event, bringing together industry leaders who are ready to purchase the latest equipment and services, explore innovative new technologies, meet face-to-face with suppliers, and make valuable new connections.

“As an honored and excited to be chairing the 2020 show. What an exciting time for our industry and a great moment to gather as one to reveal the future of mining and the latest tools and technologies to meet the world’s demand for essential minerals,” said Dawes. “NMA is a strong and steadfast representative of our industry and has made this event a continued source of inspiration, innovation and excitement. We’re looking forward to a fantastic show together.”

Born in Australia, Dawes studied metallurgy at the Western Australian School of Mines in Kalgoorlie and completed a doctorate at the Julius Krutschnitt Mineral Research Center at the University of Queensland. He began his career as a mining consultant, and worked for several mining companies in different capacities before joining Komatsu in 1998.

“As the leader of a company that represents nearly a century of manufacturing excellence, which consistently advances and showcases our industry’s best technologies, I can’t think of a better chair for MINExpo 2020 than Jeff,” said Rich Nolan, NMA president and CEO. “Next year’s MINExpo will bring together more than 40,000 attendees — both those who have been in the industry for decades and those who are just beginning their mining careers, representing domestic and international operations and all phases of mining. With its strong domestic foundation in the U.S., but extensive global footprint, Komatsu is an ideal partner for 2020.”

MINExpo INTERNATIONAL covers the entire industry — exploration, mine development, open pit, underground mining, processing, safety, environmental improvement and more. MINExpo 2020 will take place September 28-30 at the Las Vegas Convention Center.

Glencore Coal Oz Contracts H-E Parts

Glencore Coal Assets Australia Pty Ltd. awarded a one-year supply agreement to H-E Parts International to supply and overhaul new and service exchanged radiators for the former’s mobile equipment fleet across 24 mine sites in Australia. The contract can be extended based on performance.

H-E Parts Mining Solutions Cooling Division branches will manage the contract. The fleets have various styles of independent radiators and complete modular nose cones, which include the radiator, fan and motor and charge air cooler as a complete assembly.

Leadership at H-E Parts said the viability of the company’s COR Cooling product, now a market leader, helped the company get the contract. “Further, the ability to supply application-specific cooling systems to our mining and industrial customers working in some of the toughest conditions in the world, demonstrated the engineering and quality prowess of H-E Parts,” Ashley Hams, vice president, mining solutions, H-E Parts, said.

Separately, H-E Parts announced the acquisition of Aligo Engineering, which occurred in late 2018. The announcement was delayed until the completion of a new facility.

H-E Parts said the acquisition will add to its capabilities in-house machining by Aligo to provide a cost-effective solution for the West Australia market.

The new facility has 100-metric ton (mt) lifting capacity, a vertical lathe that can swing up to 8 m in diameter, a horizontal lathe that can turn up to 11 m in length, and multiple nine-axis floor borers for milling work.

DeBeers UG Mine Gets Metso Crushers

De Beers’ Venetia mine in Limpopo Province, South Africa, tapped Metso for two primary jaw crushers and several feeders to be installed underground.

The mine selected the Nordberg C Series jaw crusher range due to it ability to be disassembled and reassembled for easy transportation and installation. The Metso apron feeders will be used for ores that are wet, sticky, dry or even frozen.

The Venetia mine is reported to produce an output of about 4 million carats, making it one of South Africa’s mineral resource flagships. Initially, the Venetia mine was designed as an open-pit operation. In 2013, an underground extension project commenced with plans to start producing carats in 2022, climbing to full production in 2025 and extending the mine life to 2046.

Kiruna UG gets Big Sandvik Electric Loader

Sandvik reported a LH625iE electric loader, with a 9.5-m³ bucket and a 25,000-kg payload capacity, will be deployed at LKAB’s Kiruna underground iron ore mine in Sweden.
Leadership at Kiruna said the miner and the supplier have a relationship dating back two decades, which is the context for the adoption and deployment of the loader. “We are satisfied with the loaders delivered from Sandvik,” Michael Palo, senior vice president, northern division, LKAB, said. “We have had a long and good collaboration and look forward to a good continuation.”

The unit belongs to Sandvik’s i-series and features the Sandvik Intelligent Control System and My Sandvik Digital Services Knowledge Box as standard, and can be fitted with the company’s AutoMine and OptiMine solutions. It has an IE4 classified energy-efficient motor.

**2 Miners Contract Drone Services Supplier**

Two global mining operations separately contracted Woolpert for aerial mapping and surveying via manned and unmanned aircraft systems, the latter reported.

The imagery collected will assist in volumetric calculations, provide digital terrain information for autonomous hauling trucks, enable change-detection analysis, validate the locations of drill holes for blasting, and will provide a safer, more frequent and accurate accounting of mining progress, Woolpert reported.

Leadership at Woolpert said the ability to deploy UAS, both on scheduled flights and in response to immediate needs, aligns with the operational needs of the mines. “It’s all about identifying issues and marrying them with the right technologies to produce solutions,” Aaron Lawrence, program director, Woolpert, said. “UAS is the right technology to cost-effectively manage a mining operation.”

**Siemens and Qualcomm Test 5G Network**

Siemens reported it coordinated with Qualcomm Technologies to implement the first private 5G standalone network in an industrial environment on the 3.7-3.8 GHz band.

Siemens provided the industrial test conditions and end devices, to include Simatic control systems and IO devices. Qualcomm provided the 5G test network and test equipment. The network was installed in Siemens’ Automotive Showroom and Test Center in Nuremberg.

Siemens leadership said the coordination between the companies would help both develop wireless network solutions for industry. “Industrial 5G is the gateway to an all-encompassing, wireless network for production, maintenance, and logistics,” Eckard Eberle, CEO, process automation, Siemens, said. “High data rates, ultra-reliable transmission, and extremely low latencies will allow significant increases in efficiency and flexibility in industrial added value.”

**North Shore Acquires Ford Steel**

North Shore Steel, based in Houston, Texas, USA, acquired Ford Steel in early December. The latter will keep its name and continue operating in its current locations in St. Louis, Missouri, and Elko, Nevada, USA.

Leadership at North Shore Steel described the move as strategic. Ford Steel leadership described it as a great fit for both companies. “Ford Steel can now offer more extensive processing capabilities and a full complement of structural steel products to our customers,” Tony Morrison, general manager, Ford Steel, said.

Ford Steel was founded in St. Louis in 1945 and specializes in abrasion and impact resistant plate, bar, and other steel products and services.

**Glencore Tech Develops Russian Mine**

Glencore Technologies reported progress on a contract to develop Ozernoye’s lead-zinc mine and concentrator in Buryatia, Russia, near the Sosnovo-Ozerskoye regional center.

The company reported that in September it worked with Hatch, AMC and Ozernoye to finish a geotechnical drilling program, test work and analysis. The camp was recommissioned, and the company began clearing the site for construction. Capital mine development launched, drill and blast works provided structural materials, and stripping began, Glencore Technologies reported.

The ore mineralogy at the site was described by the company as “remarkably similar” to that of its McArthur River project, which 25 years ago prompted the invention of the IsaMill ultra-fine grinding technology.

Major construction of the plant’s facilities is planned for 2020 to 2022. The company plans to reach design capacity of 8 million metric tons per year in 2024.

**Epiroc Sells Handheld Drilling Business**

Epiroc completed the sale of its handheld drilling consumables manufacturing facility in Ockelbo, Sweden.

The company sold the facility and the business to an affiliate of Monark AS, a rock drilling tools manufacturer based in Hof, Norway. The new owner will continue to supply Epiroc with products, mainly rods for handheld drilling.

The facility was part of Epiroc’s rock drilling tools division. The 40 employees there were offered to continue working there for the new owner.
Resolute Mining Ltd. announced in December that repairs to the sulphide roaster at the company’s Syama gold mine in Mali were completed within the scheduled timeline, on budget, which was initially estimated at $5 million, and without any recordable safety incidents, according to the company. The sulphide roaster was taken offline in early October after a crack was detected in the main external shell. At the time of the most recent announcement, the company said that reheating of the roaster had started prior to recommencement of normal roaster operations and concentrate feed was expected to commence in approximately 5 days.

The roaster repair involved completely replating the crack on the main roaster body by cutting and welding new 10-mm steel plate. An additional crack in the primary cyclone and two minor cracks on the main roaster body were also replated during the repair program. A 10-mm steel plate exoskeleton, insulation and cladding were installed over the repaired section.

The repair program also included extensive refurbishment to the roaster and new installations. During the repair program, a new secondary cone crusher was installed to the sulphide crusher circuit as well as chute improvements, relining of the sulphide primary mill, refurbishment of the sulphide grinding circuit, refurbishment of the flotation circuit, process flow improvements in the calcine regrind circuit, replacement of concentrator thickeners and carbon leach tank refurbishments. The company said these refurbishments, in addition to completion of the roaster repairs, create an opportunity for it to reschedule the major biennial roaster shutdown previously scheduled for May. Following reheating of the roaster, operational performance will be monitored to determine if the roaster shutdown can be deferred until January 2021.

In a November announcement, Resolute said roaster downtime was expected to provide the opportunity to accumulate more than 300,000 metric tons (mt) of available underground ore on the run-of-mine pad. This stockpile, according to the company, provided it with confidence that the mine will be able to achieve nameplate capacity of 2.4 million metric tons per year (mt/y) on a consistent and ongoing basis from January onward.

A total of 127,344 man-hours were expended on the roaster repair program with a peak workforce of 200 personnel from 22 countries. The program required five cranes, 21 welding machines, seven items of heavy mobile plant, 64 procurement packages, 19 construction packages, 12 services packages, 25 mt of boiler plate, 45 mt of scaffold, 60 mt of refractory, 27 air cargo packages, and two dedicated cargo aircraft.
Switching to Hybrid Power
The company also announced in December that Aggreko, a leading provider of mobile modular power, temperature control and energy services, signed a 16-year contract to deliver a new hybrid power plant for the Syama complex. Aggreko will install, operate and maintain a 40-megawatt (MW) thermal power plant and a 10-MW battery storage system, with a further 20 MW of solar power planned in 2023. Work on the power plant was due to start immediately, with the first delivery of power being targeted for Q3 2020.

The new hybrid power solution, which will be administered through a Power Supply Agreement (PSA), reduces Syama’s power costs by an estimated 40%. Once all the renewable power sources are fully installed, it will also reduce carbon emissions by approximately 20%, according to the company.

Installation of the new power plant will be delivered in a two-stage approach:
Phase 1 – Installation of three Wärtsilä Modular Blocks, based on Wärtsilä 32 engines providing a total of 30 MW of power, next to the existing power station and 10-MW Aggreko Y.Cube battery storage system for spinning reserve displacement in 2020.
Phase 2 – Installation of one additional 10-MW Wärtsilä Modular Block in 2022 and 20 MW of solar power in 2023. Once the solar system is installed, the batteries will also smooth out fluctuations in the solar power output to facilitate integration into the hybrid system.

The initial site infrastructure layout will include space to accommodate a fifth 10-MW Wärtsilä Modular Block, enabling the mine to add additional power capacity if needed in the future to support growth or expansion plans.

Aggreko has been providing rental power solutions at Syama since 2015, and its rental units have been the primary source of power at the mine since August.

The thermal element of the project is being implemented in partnership with Wärtsilä, using its new Modular Block technology and design. The project marks one of Wärtsilä’s first sales of its pioneering new product, and Aggreko’s first contract to deliver it.

According to Wärtsilä’s product literature, the Modular Block concept comprises a pre-fabricated, modularly configured and expandable enclosure. It incorporates proven high-efficiency medium-speed engine technology and is able to handle a mine’s unique power demands including large electric motor starts. It also provides a viable opportunity to use power from renewable sources, such as wind and solar.

Wärtsilä said the Modular Block concept includes most of the process equipment needed for converting a simple generating set into a compact power station. Its pre-fabricated, modular design means it can be quickly and easily installed in just a few weeks. Similarly, it can be disassembled and re-installed at an alternative location should it be necessary, or expanded with additional modular blocks to adapt the power supply should the mine capacity increase. Incremental expansion allows the investment costs to be cascaded accordingly. The hybrid plant can also be operated and monitored remotely, in effect becoming an integral part of a digitalized mining operation.
Sandvik reported it will launch its first Stage V underground loaders for hard rock applications. The base engine and selective catalytic reduction purifier are proven Volvo Penta technology, enhanced with a ceramic diesel particle filter.

The engine features passive regeneration of the diesel particulate filter and a modulating engine brake. With the former, soot is burned off the filter during normal operation. The latter enables the operator to adjust the engine braking power, allows better control of vehicle speed downhill, and minimizes brake and transmission overheating and brake wear, the company reported. The filter and engine brake contribute to equipment uptime, Sandvik reported.

The Stage V loaders are capable of operating with up to 3% reduced fuel consumption compared to the lower stages, the company reported.

Sandvik also released AutoMine Access API, which the company described as the industry’s first interoperability platform for autonomous underground loaders and trucks. The solution gives mines the ability to connect non-Sandvik equipment to Automine.

Sandvik reported the development as a step in its journey to drive a digital ecosystem that makes mining smarter, safer and more productive.

Separately, Sandvik announced a new transmission for its flagship TH663i (66 mt) and TH551i (55 mt) trucks. The new eight-gear transmission should enable the truck to up productivity with shorter cycle times, Sandvik reported. The previous transmission had six gears.

The drill will feature a Cummins engine, a GHH-Rand air compressor, Kawasaki hydraulic pumps, a Doosan undercarriage, and a YH-135 drifter. It has no onboard computers and is described by the company as a simple system to operate, maintain and troubleshoot.

The company also announced an upgraded JD-800E-II rig that features an enclosed cabin, heating and air conditioning, and a Tier IV final engine. The 800 series is offered with a range of options.

Self-priming Solids Pump Handles 3-in Spheres
Veriflo Pump Co. released its Series 2100 Trash- and Solids-Handling Self-Priming Pumps, with capacities to 1,300 gallons per minute, heads to 112 ft, and availability in 3-in., 4-in. and 6-in sizes.

Capable of handling solids with up to 3-in.-diameter spheres, the suction lifts to 25 ft.

The series has easy access to remove the impeller and debris. It features an
oversized tapered bore, a self-flushing seal chamber, and an optional external flush, which the company described as an industry-first.

Back pullout design with external impeller adjustment, plus a replaceable case wearplate allows for continuous high efficiency performance, Veriflo reported. Standard construction is all iron and all CD4MCu.

**www.veriflowpump.com**

### Mobile Apps for Accessing Plant Data

FLSmidth launched a new generation of site management information systems to include SiteConnect Mobile Insights App, ECS/PlantDataManagement, and ECS/UptimeGo. The mobile and web app solutions allow customers to access and use performance data outside of the control room on a smartphone or laptop, the company reported.

SiteConnect Mobile Insights App delivers insights on the go, with on-demand equipment and plant performance and health data. ECS/PlantDataManagement is a browser-based system that integrates all process and quality information islands, making critical real-time plant data available to operational management and executive personnel, FLSmidth reported. ECS/UptimeGo is a downtime analysis tool that helps in identifying issues that interrupt operations.

**www.flsmidth.com**

### Injection Solutions Stabilize Rock

Avanti International released the AV-500 Epoxy line, a range of injection solutions that stabilize soils and rock, restore structural integrity, stop leaks, and control groundwater. The AV-502 Series was developed for structural concrete repair by crack injection, gravity feed or patching. The two-component AV-522 was designed for anchoring/bonding applications.

**www.avantigrout.com**

### Graphene-enhanced Boots

First Graphene Ltd. reported successful prototype trials with Steel Blue of graphene-enhanced boots. The boots were manufactured using First Graphene’s PureGRAPH 10 graphene powder, which are non-aggregated, uniform-sized nanoplatelets. The powder was dispersed evenly in thermoplastic polyurethane masterbatches to create the soles of the boots.

**www.firstgraphene.net**

### Optimizable DTH Hammers

Epiroc introduced the COP M-series down-the-hole hammers to the U.S. market. The company reported the range has bits designed with a unique solid shank that enhances durability and energy transfer for penetration rate.

Featuring a lighter and more compact design, the hammers are safer and easier to handle, Epiroc reported. With the simple change of an internal component, they can quickly be optimized for different air compressor pressures and volumes. That creates flexibility for mining companies running rigs with different air packages and allows the most efficient use of airflow at different altitudes, the company reported.

The hammers are available in three sizes: 6 in., 7 in. and 8 in.

**www.epiroc.com**

---

**Protect your mining chains from wear!**

In extreme heavy-duty applications, chain wear and elongation are likely to happen. Get a chain that has a special coating that protects the chain from corrosion and increases fatigue strength. TitanXL is a chain that has specific pin coating specifically formulated for extended wear in harsh engineering chain applications such as conveying and elevating applications.

---

**www.us-tsubaki.com**

---

**Powerscreen Brings Back Phoenix 3300**

Powerscreen reported it is bringing back the Phoenix range of trommel machines, to include the 3300, which previously has been used in reclamation projects. The screens are designed to provide fuel efficiency and low operating costs while reducing emissions and noise levels, the company reported. The Phoenix 3300 features the largest screen area in the range, a 180° swivel fines convey, a 5.8-m discharge, and a four-wheel-drive system. Options include a heavy-duty tipping grid or double-deck vibrating grid.

**www.powerscreen.com**

---

**US Tsubaki**

Toll free: 800.323.7790
Phone: 847.459.9500
Email: sales@ustsubaki.com
Web: www.ustsubaki.com
CONSULTANTS & SERVICES

Your Classified Ad Here
1 column x 3” space
Color: $510
Black & White: $360
Contact your Sales Rep to Book a Space Today

srk.com
Consulting services from exploration through to mine closure

Engineering Expertise for Potash Projects Worldwide
Schlumberger Inc offers productivity solutions, project and outage management, and feasibility study reviews of evaporite deposits.
Contact: michael@schlumberger.com

Your Classified Ad Here
1 column x 2” space
Color: $340
Black & White: $240
Contact your Sales Rep to Book a Space Today

Freelance Writers
Engineering and Mining Journal is looking for remote freelance writers who can create quality content for the magazine. Knowledge of mining and mineral processing industries is preferred. We are especially interested in writers residing in Indonesia, Australia and China, but are open to writers in other parts of the world as well. You will be contributing news and feature articles to the magazine.

If interested, please send your resume and at least two writing samples to Jennifer Jensen, associate editor, at jjensen@mining-media.com.

 visceral
to

 How Simple Thread Can Become the Fabric of a Nation.
Celebrating More Than 123 Years.
1-800-RED-CROSS
www.redcross.org

Your Classified Ad Here
1 column x 1” space
Color: $170 • Black & White: $120
Contact your Sales Rep to Book a Space Today

Visit www.e-mj.com for more information

For Advertising, Contact Your International Sales Representatives:

Midwest/Eastern U.S. & Canada
Victor W. Matteucci
Tel: +1 440-725-7565
vmatteucci@mining-media.com

Western U.S., Canada & Australia
Frank Strazzulla
Tel: +1 949-459-1767
fstrazzulla@mining-media.com

Germany, Austria & Switzerland
Gerd D. Strassmann
Tel: +49 202 28 14 64 83
info@strassmann-media.de

Scandinavia, U.K. & European
Colm Barry
Tel: +46 (0) 736 334670
colm.barry@telia.com

Japan
Masao Ishiguro
Tel: +81 (3) 3719-0775
ma.ishiguro@w9.dion.ne.jp

MINING MEDIA INTERNATIONAL
<table>
<thead>
<tr>
<th>Company/Event</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Blast Inc</td>
<td>57</td>
</tr>
<tr>
<td>Artisan Vehicles</td>
<td>IFC</td>
</tr>
<tr>
<td>BME (Division of the OMINA Group Pty Ltd)</td>
<td>29</td>
</tr>
<tr>
<td>Bosch Rexroth</td>
<td>41</td>
</tr>
<tr>
<td>Brunner &amp; Lay</td>
<td>31</td>
</tr>
<tr>
<td>Epiroc</td>
<td>9</td>
</tr>
<tr>
<td>Expomin 2020</td>
<td>44</td>
</tr>
<tr>
<td>FLSmidth</td>
<td>7</td>
</tr>
<tr>
<td>Haulage &amp; Loading 2021</td>
<td>45</td>
</tr>
<tr>
<td>Hilliard Corp</td>
<td>16</td>
</tr>
<tr>
<td>Jennmar Corp</td>
<td>IBC</td>
</tr>
<tr>
<td>Mining Media Int’l - Social Media</td>
<td>53</td>
</tr>
<tr>
<td>Normet</td>
<td>17</td>
</tr>
<tr>
<td>PDAC 2020 (Prospectors &amp; Developers Assoc. of Canada)</td>
<td>11</td>
</tr>
<tr>
<td>Polydeck Screen Corp</td>
<td>BC</td>
</tr>
<tr>
<td>U.S. Tsubaki</td>
<td>61</td>
</tr>
<tr>
<td>Varel Mining and Industrial</td>
<td>3</td>
</tr>
<tr>
<td>World Mining Equipment (WME)</td>
<td>63</td>
</tr>
</tbody>
</table>

**World Mining Equipment**

The online directory of equipment, products and services for the global mining industry

**The World Mining Equipment Directory:**
- Search by product.
- Search by company.
- Cross reference with country.
- Live links to suppliers.

**Have you seen the mining industry’s VIDEO HUB?**

wme.com
The prices for metals dipped during 2019, but they finished strong for the most part. Base metals began to claw back lost ground at the end of the year when it seemed that the U.S. and China were working toward a trade agreement. With all of 2019’s strange political underpinnings — Latin American protests, Trump tweets and off-again, on-again Brexit — metals markets have become desensitized to the noise and simply plod along. Fundamentals more than speculation now drive the market.

Comparing where metal markets stand today to the same point four years ago, one can identify some trends. All the precious metals are considerably higher than they were four years ago. Iron ore is also noticeably higher. Non-ferrous base metals on the other hand are a mixed bag. Viewing the market in this context, however, unfairly eliminates the swings that day traders live and die by.

Gold is a sign of the times and today’s price level is more fear-based than demand-based. No one in 2016 could have predicted palladium’s meteoric rise. In retrospect, however, it seems logical. One could argue that iron ore prices and base metal prices have benefited from unintended consequences that limited supply, such as environmental disasters in Brazil, labor issues in Chile, nationalization in Indonesia and increased costs in South Africa.

No one knows what the future holds. As far as long-term fundamentals, the migration in the developing world toward further urbanization will create more demand for metals. People will continue to strive for a better life for themselves and their children, which means better homes that consume more power, more tech and more metals. Let’s hope the world economy continues to grow. Misguided or not, the march toward further decarbonization will continue, which also creates more demand for metals.

While they could substitute other metals, there is no way for manufacturers to recycle their way into the future. Exploration activity has found few new major deposits. Many existing operations are looking at ways to extract more metal from a deposit with a declining grade. For now, today’s miners are in a relatively good position as long as they can hold operating costs at bay. Will this trend last for another decade? Yes, it could.
JENNMAR has been the innovative leader in ground control for the mining industry for more than forty years. Over the past decade, our growth has led us to structural support in tunneling and civil construction projects, implementing the same vigor and detailed processes. Our JENNMAR Civil arch systems, lattice girders, and liner plates, as well as other products are made in the U.S.A. and backed by experienced engineers and technicians who are with you every step of the way, from initial consultation to qualified instruction and on-going technical support. We support and are dedicated to rebuilding America’s infrastructure.
Groundbreaking Products. Forward-Thinking Solutions.

Polydeck – A global leader in screening solutions for the coal and mining industries.

For more than half a century, our innovative products have helped shape this industry with unparalleled designs and engineering.

Polydeck's groundbreaking trommel designs combine customization and modularity with the best safety and maintenance features, for a more robust solution to meet your production needs.

25% more open area when used with Polydeck's PipeTop system.

Over 1,500 screen media options to mix and match for feed zone and discharge zone needs.

Twice the wear life by choosing our flippable design.

Together, we’re stronger. Learn more at polydeck.com/Trommels