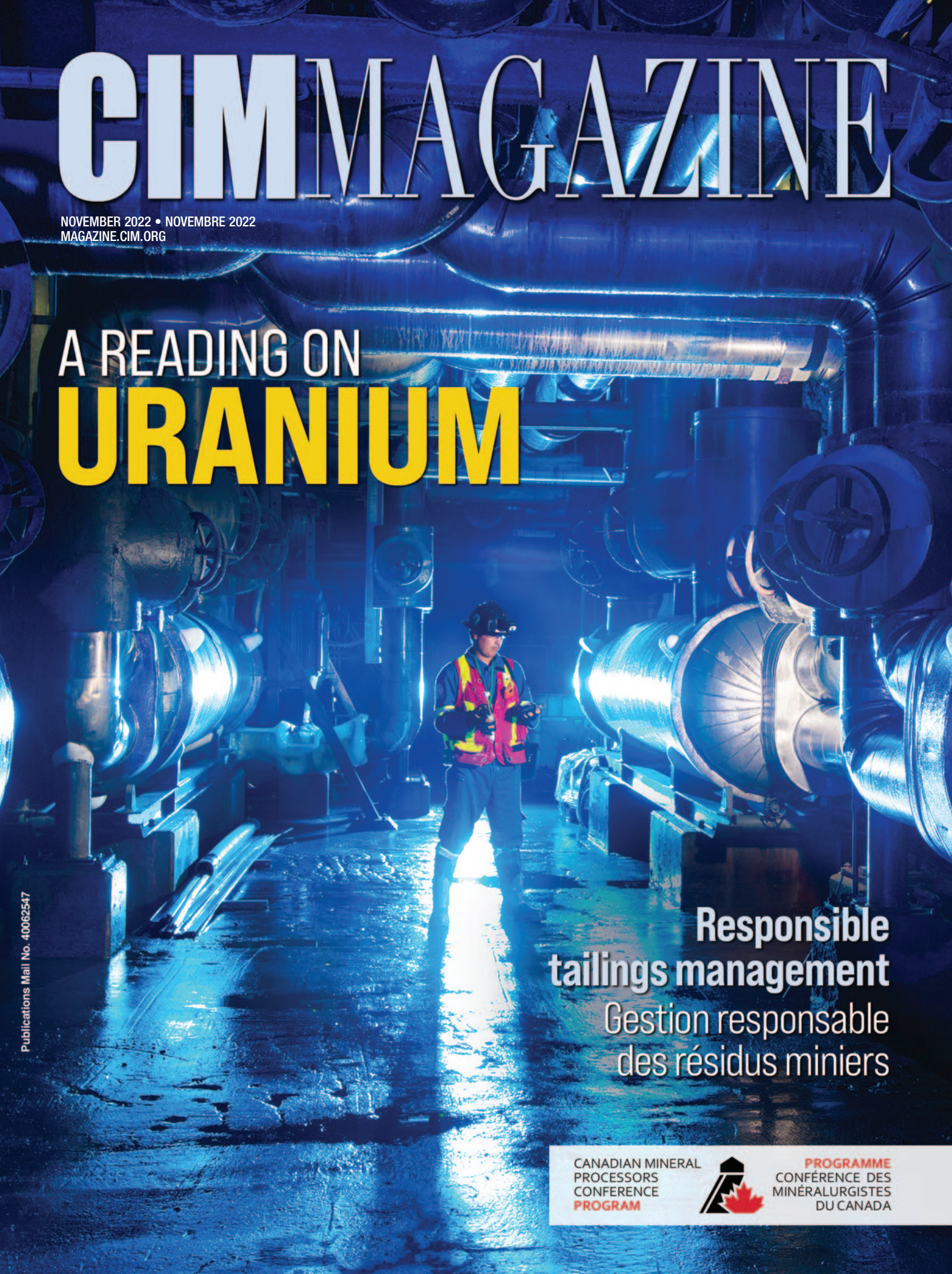
CIM MAGAZINE

NOVEMBER 2022 • NOVEMBRE 2022
MAGAZINE.CIM.ORG



A READING ON URANIUM

Responsible tailings management
Gestion responsable des résidus miniers

CANADIAN MINERAL PROCESSORS CONFERENCE PROGRAM

PROGRAMME CONFÉRENCE DES MINÉRALURGISTES DU CANADA

Publications Mail No. 40062547

corem

Innovation in mineral processing

TEAM UP WITH US

We offer you complete and innovative solutions in mineral processing for the benefit of a sustainable mining industry.

Successful mining companies around the world partner with us.

corem.qc.ca

INFO:

info@corem.qc.ca
+1 (418) 527- 8211

CONCRETE BENEFITS AT YOUR FINGERTIPS

Improvement

- Metallurgical process performance
- Operational efficiency

Reduction

- Operating and R&D costs
- Risk linked to new equipment
- Water and energy consumption
- Environmental impact

High return on investment

Financial partners:

Québec

Développement économique Canada pour les régions du Québec

Canada Economic Development for Quebec Regions

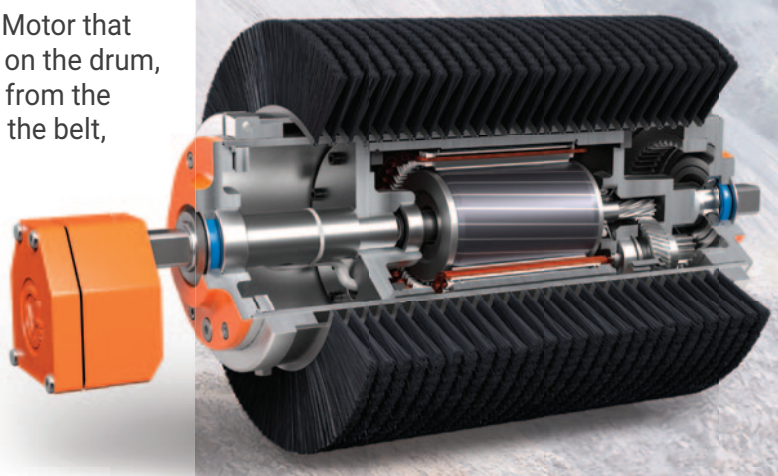
Canada

VDG Drum Motors

Built To Do More

The innovative **Belt Cleaner** is a VDG Drum Motor that rotates a replaceable spiral brush mounted on the drum, effectively removing wet and dry carryback from the conveyor belt without wearing or damaging the belt, increasing belt life.

- Effective on belts with cleats, lacing, repair patches, and sidewalls
- Easy installation under the conveyor belt

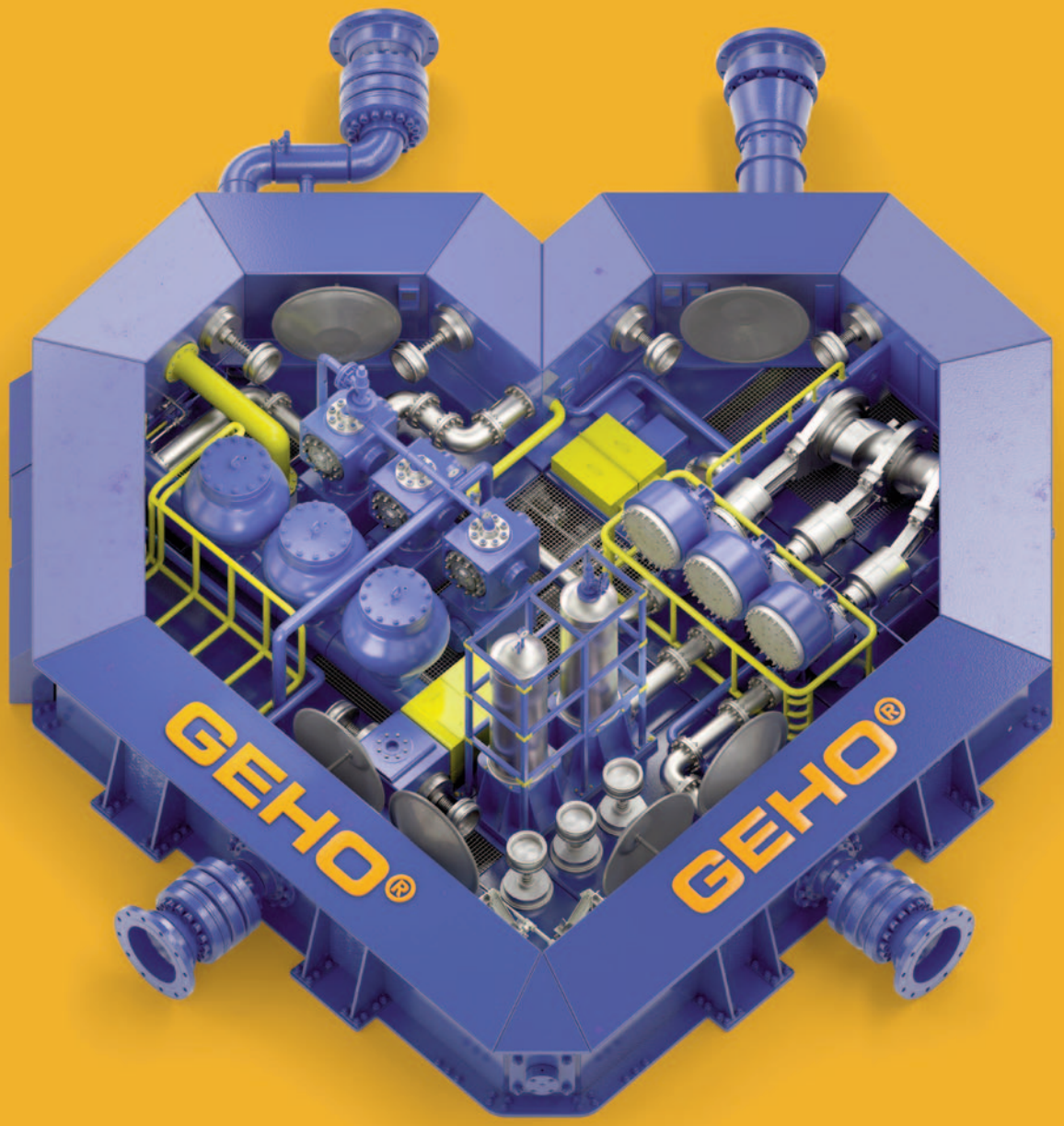


The robust **GrizzlyDrive®** Drum Motor is designed for demanding belt conveyor applications and 80,000 hours of continuous operation before maintenance, reducing operating and maintenance costs.

- Robust mechanical seals
- Heavy-duty planetary gear reducer
- Long-life IronGrip™ lagging

Learn more at **vandergraaf.com/CIM**

Opportunities Available: Sales Personnel • Sales Representatives • Resellers
Apply at: vandergraaf.com/jobs • (888) 326-1476



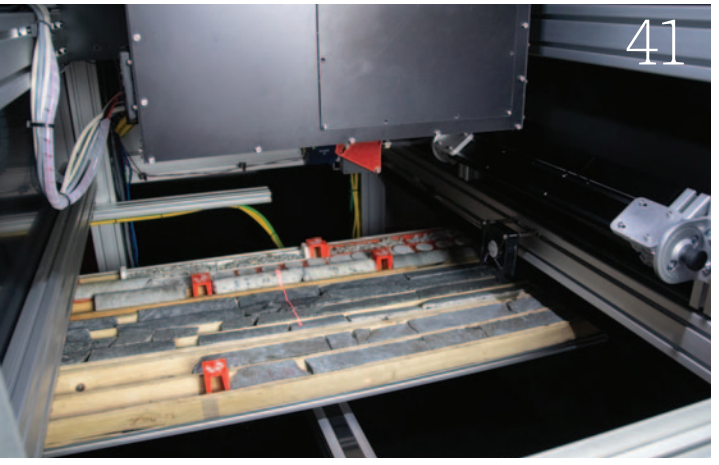
The heart of the mine.

The lifeblood of your mine relies on the healthiest of hearts. GEHO pumps all day every day. Supported by Synertrex® real time performance data and unrivalled aftermarket service from the Weir Minerals global network, GEHO® positive displacement pumps have been trusted across the globe for over 100 years. With up to 98% availability and outstanding efficiency that could cut your energy usage & carbon emissions by up to 50% and reduce water consumption by up to 30%, GEHO® pumps are simply unbeatable.

info.global.weir/geho

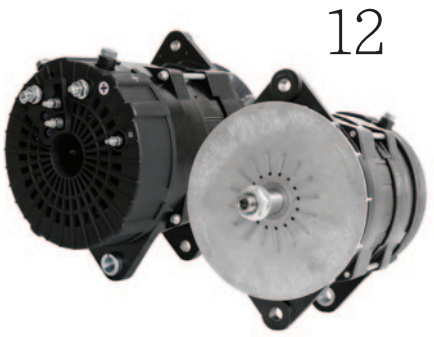
WEIR
Minerals

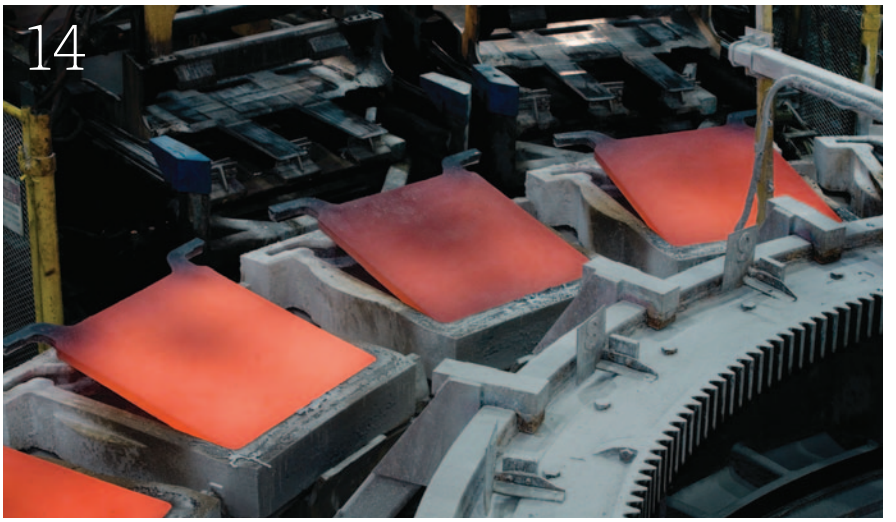
CIM MAGAZINE
NOVEMBER 2022 | NOVEMBRE 2022



feature

technology





MINOVA

INJECTION CHEMICALS

BOLTS & PLATES

RESIN CAPSULES

POWDERED SOLUTIONS

SELF DRILLING ANCHORS

EQUIPMENT & ACCESSORIES

RELIABLE GROUND SUPPORT

SOLUTIONS FOR THE CANADIAN MARKET

Our wide range of products and services ensure your teams work safely and efficiently

VIEW OUR PRODUCTS

MINOVAGLOBAL.COM

The view from the Nickel City

The latest edition of the Maintenance, Engineering and Reliability/Mine Operators conference in Sudbury arrived at its theme "Perseverance in a New World" honestly. The event, delayed more than once by the pandemic, finally came together in September. Congratulations are due to the Sudbury-based organizing committee for its perseverance in making it happen. The event's keynote address from Johnna Muinonen, president of Dumont Nickel, made a strong case that it is a new world for metal miners, particularly those looking to supply materials for the decarbonization of the economy.

To meet projected nickel demand, the world will need at least another 40 nickel mines turning out 38,000 tonnes per year by 2030, said Muinonen.

Canada's nickel resources put the country on good footing to potentially meet some of the needed production capacity. However, Muinonen made it clear that our store of raw materials answers only one of the many obstacles that stand between current output and anticipated demand.

"I do think Canada has a role to play and there's an exciting future there," she said and noted this country's share of global nickel production has been shrinking over time as Indonesia has become a nickel-mining giant. Muinonen argued the combination of Canada's access to secure and clean energy, its regard for ESG, local expertise in mining the metal, supportive government policies and our proximity to the United States, which has committed hundreds of billions of dollars to energy and climate-change spending, with some of that available to its free trade partners, gives Canada an opportunity.

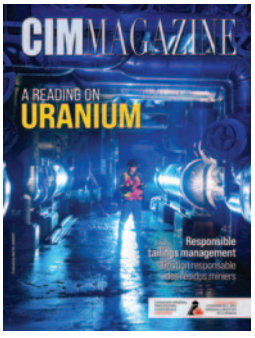
To realize that future, she said, there will need to be more processing capacity, more technical expertise and much better integration along the supply chain.

"You can't say, 'Okay, we're going to build a ton of nickel sulfate plants and we're going to sell it to somebody.' If you haven't integrated downstream, the battery makers may turn around and tell you it is not to specification. The qualification process is extremely complex. Working with partners throughout the ecosystem is going to be really important."

Muinonen also noted how advancements in the processing of nickel laterite and the run up in the nickel price have changed the market. Laterites are now a source of nickel for battery materials, which, until recently was an application assumed to be the domain of nickel sulfides. It was a good reminder of how quickly change can come.

The fact that we need an improbable number of new nickel mines in the next eight years makes it clear that we will have to find substitutes to help meet the underlying demand for greener energy. Nevertheless, I trust those with nickel projects in development will persevere. The alternative is that we just don't achieve the objectives of decarbonization that have been set. I hope that isn't the direction we take. Of course, one of the challenges of new worlds is they don't come with a map.

Ryan Bergen, Editor-in-chief
editor@cim.org
@Ryan_CIM_Mag



This issue's cover

A worker conducts radiation monitoring at Cameco's Cigar Lake mine in northern Saskatchewan.

Courtesy of Cameco Corp.

Editor-in-chief Ryan Bergen, rbergen@cim.org

Managing editor Michele Beacom, mbeacom@cim.org

Section editors Carolyn Gruske, cgruske@cim.org; Matthew Parizot, mparizot@cim.org

Editorial intern Ashley Fish-Robertson, afrobertson@cim.org

Contributors Jacky Burke, Carolyn Cooper, Franciska Lake, Alexandra Lopez-Pacheco, Tijana Mitrovic, Kelsey Rolfe, Sarah St-Pierre, Scott Sych

Editorial advisory board Mohammad Babaei Khorzhoughi, Vic Pakalnis, Steve Rusk, Nathan Stubina

Translations Karen Rolland, karen.g.rolland@gmail.com

Layout and design Clò Communications Inc., communications.clo@gmail.com

Published 8 times a year by:
Canadian Institute of Mining, Metallurgy and Petroleum
1040 – 3500 de Maisonneuve Blvd. West
Westmount, QC H3Z 3C1
Tel.: 514.939.2710; Fax: 514.939.2714
www.cim.org; magazine@cim.org

Advertising sales
Dovetail Communications Inc.
Tel.: 905.886.6640; Fax: 905.886.6615; www.dvtail.com

Senior Account Executives
Leesa Nacht, lnacht@dvtail.com, 905.707.3521
Dinah Quattrin, dquattrin@dvtail.com, 905.707.3508
Christopher Forbes, cforbes@dvtail.com, 905.707.3516

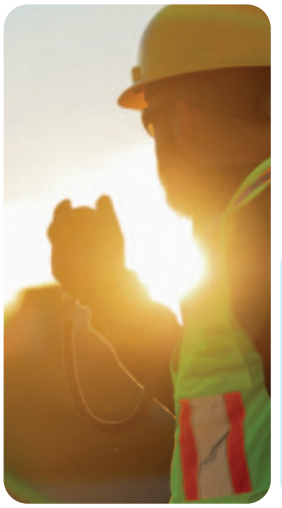
Subscriptions
Online version included in CIM Membership ($197/yr). Print version for institutions or agencies – Canada: $275/yr (AB, BC, MB, NT, NU, SK, YT add 5% GST; ON add 13% HST; QC add 5% GST + 9.975% PST; NB, NL, NS, PE add 15% HST). Print version for institutions or agencies – USA/International: US$325/yr. Online access to single copy: $50.

ISSN 1718-4177. Publications Mail No. 09786.
Postage paid at CPA Saint-Laurent, QC.

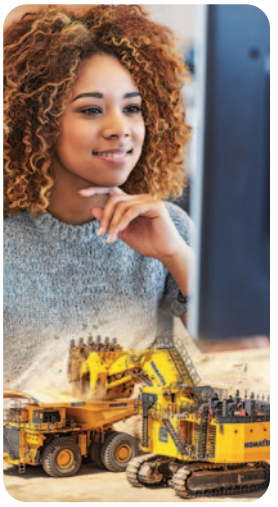
Dépôt légal: Bibliothèque nationale du Québec.

Gold Winner
Silver Winner
ABBIES 2019 Award Winner
ABBIES 2020 Award Winner
ABBIES 2021 Award Winner
ABBIES 2022 Award Winner
Magazines Canada
cup Canadian Business Press
Printed in Canada
Funded by the Government of Canada | Canada

When you picture an autonomous mine, what do you see?



500+
FrontRunner autonomous haul trucks – worldwide



If an endless stream of driverless trucks moving across the mine site is what comes to mind, you might want to think again.

Through advances in the FrontRunner Autonomous Haulage system and the teleoperation surface mining excavator, our customers are moving toward more productive operations, while upskilling personnel to transition from the cab to the control room. Komatsu's autonomous and semi-autonomous technology is continually evolving and redefining what it means to work for, and do business in, the mining industry.

With a tech-forward workforce and next-level equipment and solutions, we can work together to move mining toward a more innovative and sustainable future.

Develop your team. Drive efficiency.

komatsu.com/autonomous

Scan to learn more

KOMATSU

Courtesy of Anne Marie Toutant

Trust

> "Trust opens up new and unimagined possibilities."
>
> – Robert C. Solomon

Trust is the glue of society, wrote Dennis Jaffe, who specializes in working with family businesses. "Its presence cements relationships…allows organizations and communities to flourish, while the absence of trust can cause fragmentation, conflict, even war."

This power-punching word caught my attention a couple of weeks ago when, combing through hundreds of emails that had flooded my inbox overnight, I glimpsed the subject line "Building Trust to Decarbonize the World." Clicking open, instead of the usual delete, I saw to my delight that this was the theme of the 2023 CIM Convention + Expo, selected by the organizing committee led by convention chair David Cataford, CEO and director of Champion Iron.

Societal trust is a belief in the honesty, integrity and reliability of others; it builds slowly and can be lost in an instant. Evidence of increased trust with the Canadian mining industry was highlighted in a poll conducted by Abacus Data and released by the Mining Association of Canada on June 27, 2022. The poll report identified that over the past seven years there has been a modest increase from 76 per cent to 81 per cent in the number of Canadians who believe mining companies in Canada are earning the trust of Canadians. Abacus Data chair Bruce Anderson noted that Canadians expect progress on climate action and a lower carbon future and the 2022 poll results revealed a couple of trends. "First, Canadians are seeing economic opportunities in the mining sector when it comes to the future uses of sustainably produced minerals and metals, and second, that they observe Canadian mining companies moving in a good direction across a range of priorities, from environmental stewardship to emissions reduction to Indigenous relations," he said.

Going forward, maintaining this trust-building momentum will be critical for Canadian companies involved in sustainably producing the metals and minerals needed to move the world to a lower carbon future. The transition from carbon-neutral declarations to the execution of concrete first-step actions, while partnering in trusted alliances with others to advance technologies for mid- and longer-term reductions, is happening all around us. Several operators partnering with original equipment manufacturers have declared that they will in the next few years start transitioning fleets to zero-emission battery-powered large mining trucks. Projects are being advanced through permitting and into construction by leveraging new business models that include local and First Nations communities. Advancements in dry stacking, co-disposing and co-mingling waste and tailings is reducing risk by removing water from tailings storage.

What are you doing to inspire trust in both the industry and in your business? What actions are your company taking to drive forward sustainable mining in Canada? How are you implementing technologies, partnering with others, protecting your workforce, securing financing, reducing your footprint? One way to build trust is to be transparent and to share knowledge and best practices. The call for abstracts for the 2023 CIM Convention is open – inspire us and share!

Anne Marie

Anne Marie Toutant
CIM President

CIM IEM MTL23

Building trust to decarbonize the world

Contribute your knowledge and submit your abstracts before NOV 30, 2022

Technical Program Topics:

- Minerals and Materials
- Mining in the 21st Century
- Mine Operations
- ESG and Building Trust
- Energy and Circular Economy
- Mine Waste Impoundment
- Mining for Talent
- Environment: Minimizing Our Footprint
- Markets and Finance
- Protecting Our People
- Decarbonization Technologies: From Mining to Metals
- Iron Ore Symposium

Submit your short-course abstracts, too!

Convention + Expo
APR 30 - MAY 3 Montréal

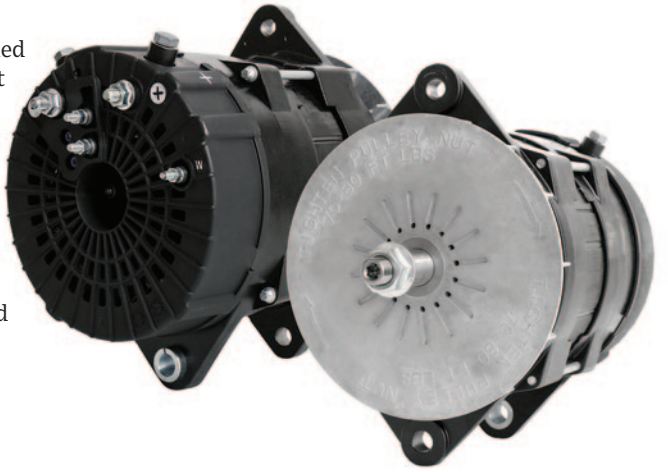
Courtesy of Michelin North America Inc.

Long-lasting tires

Michelin North America Inc. announced the launch of the MICHELIN X Mine D2 Extra Load tire, designed to be used in quarry and underground mining. The tire is expected to better withstand harsh mining environments while also being able to support heavier loads, up 16 per cent from 28,000 kilograms to 32,500 kilograms. “Michelin is extremely proud of this tire because of the increased benefit it offers our customers,” said Sarah Robinson, segment manager of mining for Michelin North America. According to Michelin, this product includes new plies in the sidewall that keep sidewall injuries from spreading and prevent rock cuts from penetrating the sidewall.

Extreme alternators

The IdlePro Extreme M-Series alternators have been unveiled by Prestolite Electric as part of its new extreme-use product lineup. The alternators provide mining workers with enduring protection from dust and particle infiltration. Additionally, according to Prestolite, these new alternators offer prolonged service life, improved battery life and increased vehicle uptime. “This is a powerful, protected and uniquely capable mining design that delivers extra sealing against the invasive powder often generated during mining,” said Jonathan Smith, assistant director of sales and marketing at Prestolite Electric.



Courtesy of Prestolite Electric

Courtesy of Komatsu

Manoeuvrable haul trucks

Komatsu offers increased production at quarry, aggregate or mine operations with its new energy-saving HD1500-8E0 haul truck. The HD1500-8E0 features a 1,580 gross horsepower Komatsu SDA16V159E-3 engine, which the company said will give users a smooth ride and effective operability. According to Komatsu, the HD1500-8E0 features a tight turning radius suitable for tight manoeuvres when spotting to be loaded or positioning to dump. The cab also features a 360-degree monitoring system using six cameras and a dedicated monitor that can display the bird’s-eye view as well as any of the six camera views simultaneously.

Compiled by Ashley Fish-Robertson

FRANK
CHENG
PROFESSOR
CANADA RESEARCH CHAIR
UNIVERSITY OF CALGARY

MAUREEN
JENSEN
DIRECTOR AND ADVISOR

PHILLIP JOHN
MACKEY
PRESIDENT,
P.J. MACKEY TECHNOLOGY INC.

STEVEN J.
THORPE
PROFESSOR,
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING,
UNIVERSITY OF TORONTO

CIM
ICM

2022-2023 DISTINGUISHED LECTURERS

SCAN THIS CODE FOR MORE INFORMATION.

THE PROGRAM

LECTURERS ARE AVAILABLE FOR YOUR ONLINE OR IN-PERSON EVENTS.

The Distinguished Lecturers program is offered to 31 CIM Branches, 11 Technical Societies and 8 Student Chapters. Universities can also request a lecture.

The CIM Distinguished Lecturers program started in 1968 and has continuously provided a lineup of individuals who have shared their knowledge with the mining community for over five decades.

Every year, the lecturers are elected by their peers through the CIM Awards program and hold the title for a complete season (September to June).

CIM is privileged to count more than 260 of the industry's finest as its lecturers. Because the motto "once a lecturer, always a lecturer" defines our pride and dedication in ensuring that the learning curve is endless, a complete list of past lecturers is available at www.cim.org, where you can benefit from the ever-growing pool of expertise that the program has to offer.

B2GOLD
Teck
WHEATON PRECIOUS METALS

CIMF FICM
CIM FOUNDATION | FONDATION ICM

The CIM Foundation's generous support allows the CIM Distinguished Lecturers Program to connect CIM members with leading industry expertise. The CIM Distinguished Lecturers program is owned and operated by the Canadian Institute of Mining, Metallurgy and Petroleum (CIM).

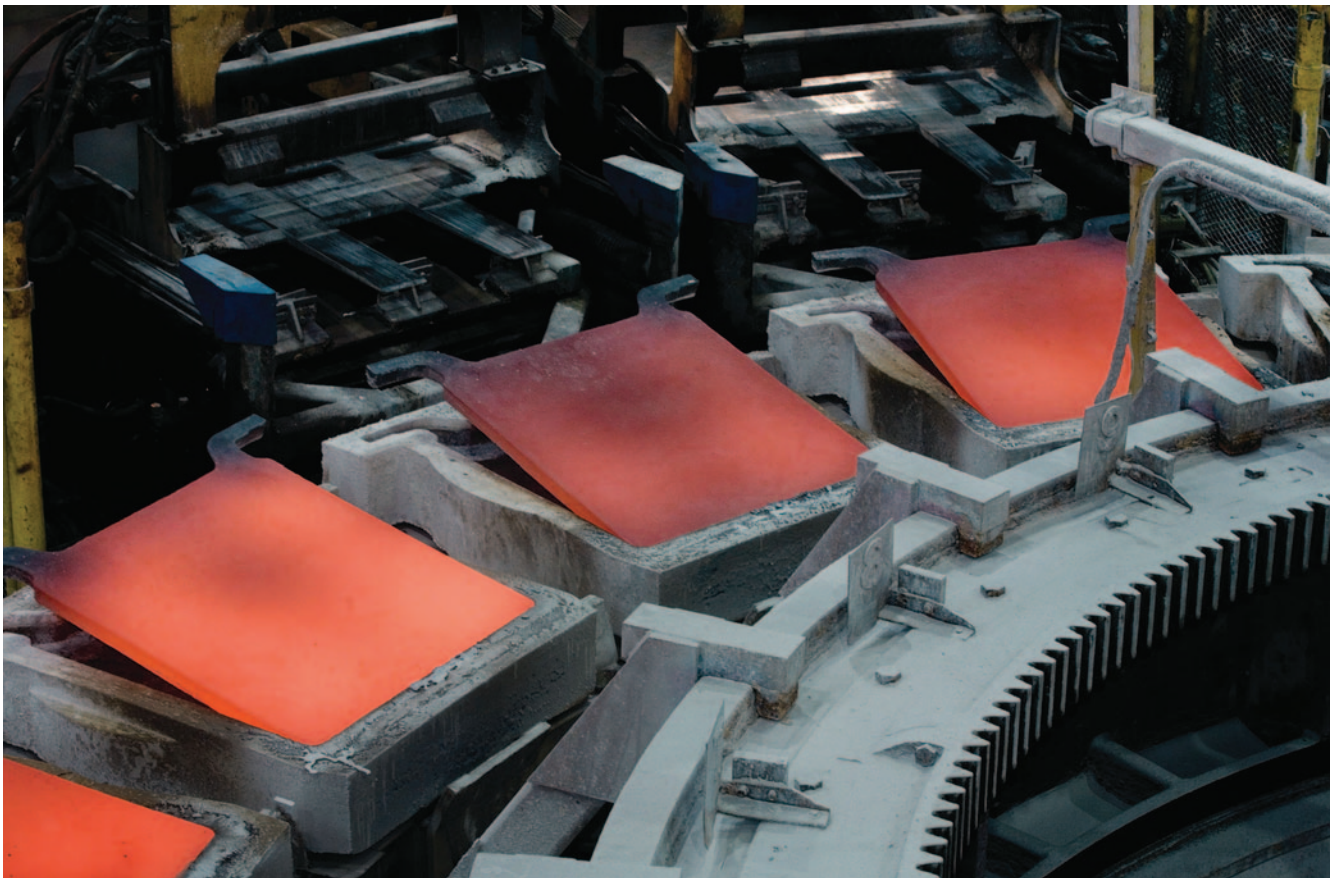
Developments

The copper gap

According to a study from S&P Global, even in the most optimistic scenario, much needs to be done for copper supply to meet upcoming demand

By Matthew Parizot

Courtesy of Glencore



In the study's forecasts, copper demand is expected to rise to 50 million tonnes by 2035, but production is not on track to keep up.

Copper has an outstanding importance in the race to reach net-zero greenhouse gas (GHG) emissions by 2050. Massive amounts of copper will be required to wire the technologies needed to transition the world away from fossil fuels but, according to a report released by S&P Global titled "The Future of Copper," the supply gap created by the increasing demand for the critical mineral might be too wide to fill.

According to the study, copper demand is expected to grow from 25 million tonnes in 2022 to 50 million tonnes by 2035. This could lead to a potential supply gap as large as 9.9 million tonnes, 20 per cent of the required copper to meet the energy transition goals. Electric vehicles, solar power, wind power, all require copper to function.

"What really causes this is a whole slew of new technologies landing on top of the other standard, or traditional, end markets, which is going to require during the next 13 years a tremendous amount of copper… and those energy technologies are just starting right now," said Mohsen Bonakdarpour, executive director, economics and country risk at S&P Global Market Intelligence and project director of the study.

The study proposed two scenarios: a "High Ambition Scenario" that sees mine capacity utilization and recycling rates increasing through 2035, and a "Rocky Road Scenario" that sees mine capacity utilization holding constant at 84.1 per cent (the global average capacity utilization between 2012 and

2021) through to 2050, as well as a steady recycling rate of 17 per cent. The first scenario could see global refined copper production of 47.3 million tonnes by 2035, representing a supply gap of 3.2 per cent, with a projected surplus of 1.3 million tonnes in 2045. The latter is where the 9.9 million tonne supply gap appears, with no projected surplus leading to 2050. According to the study, the highest shortfall of copper supply to demand from 1994 to 2020 was 2.5 per cent, and even the High Ambition Scenario's gap of 3.2 per cent would have "serious consequences for several markets."

According to Bonakdarpour, one of the main obstacles in addressing this unavoidable supply gap is the sheer length of time required to get a mine up and running. The permitting process has only become more complicated for most nations, with some drafting new laws to protect their resources from foreign mining companies. Chile, one of the world's largest copper and lithium producers, recently held a referendum for its new constitution that would have included new restrictions for mines operating in the country. While Chile's constitution was ultimately rejected, the rules certainly are not getting any looser.

"The [International Energy Agency] says it takes 16 years to develop a mine and to have it fully operational, while in the 1950s and '60s it was only four or five years, and the majority of that increase is really the permitting process," Bonakdarpour said. "So, having that 16-year boundary is really challenging to meeting this 2050 goal, because one has to move very quickly and start development right now."

The study arrives at three areas where efforts can be made to try and address this gap. First is the development of standard policies for exploration and development in countries around the world. Second, the development of new technologies that enable cleaner, more efficient and lower cost extraction of copper. Last is the interdependence between copper and other critical minerals, some of which are produced as by-products of mineral processing, so that similar issues do not arise for other minerals needed for electrification.

"I think governments and private sectors do have to move. And it's not only copper, we're getting all kinds of requests to study lithium and nickel and cobalt, as they are huge," Bonakdarpour said. "And the important thing is, in order to meet the net-zero emissions by 2050, governments and companies have to work very closely together to bring predictable and sustainable policies to make this happen, otherwise we won't be able to meet our goals." CIM

Vital Metals unveils rare earths processing facility

At the Rare Earth Summit on Sept. 20, Vital Metals and the Saskatchewan Research Council (SRC) presented the initial phase of North America's first rare earth processing facility to around 200 rare earth industry leaders from around the globe.

The facility, located in Saskatoon, features a processing unit dedicated to

Courtesy of Vital Metals

Vital Metals CEO Russell Bradford (centre with tie), joined by guests representing government, Indigenous, Métis and business stakeholders celebrated the new processing facility in Saskatoon.

producing mixed rare earth carbonate, a rare earths separation unit, and lastly, a metals unit that will turn out rare earth metals.

The new facility will process rare earth deposits that originate from Cheetah Resources' Nechalacho project, acquired by Vital Metals three years ago. The project, located at Thor Lake, approximately 110 kilometres southeast of Yellowknife, is Canada's only rare earth mine. Raw ore originating from these deposits will be "processed to a high-purity, mixed rare earth carbonate," and then sent to Norway-based REEtec and U.S.-based Ucore for separation into individual magnetic rare earth metals.

The rare earths processed at the facility are essential to produce goods for a variety of global industries, including wind turbines, mobile phones, electric vehicles, technology used in the medical field and more. According to federal Minister of Natural Resources Jonathon Wilkinson, growth of the rare earth industry is a "generational opportunity" for Canada.

"Ultimately our aim is to grow the supply of critical minerals and rare earth elements, and position Canada as an indispensable nation within the global supply chain," Wilkinson said.

According to Vital Metals, Saskatchewan is considered to be the ideal location for the new 3,087-square-foot plant on account of the province's "excellent workforce, environmental protection, intermodal transportation and energy infrastructure, respected education facilities and an established mineral processing culture and infrastructure and low cost of living." The province is expected to see over 100 new job opportunities between Vital Metals' processing plant and SRC's extraction facility.

– Ashley Fish-Robertson

Copper Mountain sees big increase to reserves

On Sept. 28, Copper Mountain Mining updated its mineral reserve estimate and life-of-mine plan for southern British Columbia's Copper Mountain mine, increasing both its total copper and its life span by over a decade.

According to the report, the new Measured and Indicated mineral resources estimate of 1.1 billion tonnes saw the amount of copper increase by 70 per cent to 5.5 billion pounds at average grades of 0.22 per cent. The gold estimate increased 68 per cent to 3.4 million ounces at average grades of 0.09 grams per tonne, and silver rose 62 per cent to 23.4 million ounces at average grades of 0.64 grams per tonne.

Additionally, the Proven and Probable mineral reserves estimate of 703 million tonnes increased copper reserves by 57 per cent to 3.7 billion pounds of copper at average grades of 0.24 per cent, gold by 54 per cent to 2.3 million ounces at average grades of 0.10 grams of per tonne,

Courtesy of Copper Mountain Mining

The new mine plan for Copper Mountain supports a 65,000 tonne per day mill expansion, according to the company.

and silver up 49 per cent to 16 million ounces at average grades of 0.71 grams of silver per tonne.

The company's updated life-of-mine plan has been extended to 32 years, up from 21 previously, and indicates that the operation supports Copper Mountain's planned mill expansion to 65,000 tonnes per day. The plan also reflected an annual average production of 138 million pounds of copper equivalent – consisting of 114 million pounds of copper, 54,000 ounces of gold and 367,000 ounces of silver – with 4.1 billion pounds of copper equivalent expected to be produced over the mine's life, at an all-in sustaining cost of US$1.76 per pound.

These results have been reflected in Copper Mountain's new valuation of the mine, which sports an after-tax net present value of US$1.24 billion, at an eight per cent discount rate.

"These results illustrate the size and scale of the Copper Mountain mine," Gil Clausen, the company's president and CEO, said. "Our large mineral reserves base underpins our updated [65,000 tonne per day] expansion study, which estimates total production of over 4.1 billion pounds of copper equivalent over a mine life that will extend beyond 30 years."

According to Clausen, the mill expansion will be fully self-funded with mine cash flow, and the mine will be capable of self-funding any capital required over its life of mine, as well as generating "significant free cash flow beyond these requirements." – Ashley Fish-Robertson

FROM THE WIRE

Compiled by Ashley Fish-Robertson

David Mimran has stepped down as one of Endeavour Mining's directors. Mimran joined the company after Endeavour's acquisition of Teranga Gold during the early part of 2021.

Asante Gold has appointed **Adriano Sobreira** as the company's vice-president of operations. Sobreira served in the past as vice-president and general manager of Kinross's Bald Mountain and Chirano gold mines. **Juliet Manteaw-Kutin** was appointed as general counsel to lead the company's legal, compliance, ethics and governance functions. Manteaw-Kutin has over 17 years of legal experience in the mining and telecom industries.

Courtesy of Laurentian University

With 87 per cent of creditors voting in favour of the arrangement, Laurentian University will continue to stay open for now.

Laurentian University vote a good sign for mining education

Following the favourable results of the vote, some may be left wondering about the current state of the country's post-secondary mining programs

By Ashley Fish-Robertson

On Sept. 14, a crucial vote took place that would dictate the future of Sudbury's Laurentian University, one of Canada's premier mining education schools. Due to insolvency, the post-secondary institution announced in February 2021 that it would be filing for creditor protection under the Companies' Creditors Arrangement Act (CCAA). This financial crisis is considered to be a historical first, as Laurentian is currently the only publicly funded Canadian university to ever seek protection under the CCAA.

Votes by several hundred creditors were cast, resulting in 87 per cent of creditors in favour of keeping the school open and backing the proposed plan of arrangement.

As reported by *The Sudbury Star*, Laurentian University's debts amount to more than $91 million in loans owed to three Canadian banks, with liabilities costing the school $321 million. The institution's proposed plan of arrangement will allow the school to pay back only a fraction of the debts owed. Up to $53.5 million obtained from the sale of university real estate will be used to pay creditors.

If the plan had received a negative vote majority, the university's real

Luc Guimond was named Alamos Gold's new COO, with **Peter MacPhail** stepping down from the position. Guimond has 35 years of experience in the mining industry, especially related to operations management, project management, mine construction, and corporate development in both Canada and Australia.

Ryan MacWilliam is the incoming CFO for First Quantum Metals. MacWilliam initially joined the company in 2019 and was previously CFO of Nevsun Resources. First Quantum has also appointed **Rudi Badenhorst** as the company's COO. Badenhorst joined the company in 1996, later fulfilling general manager positions at several of the company's mining sites.

Fred Stanford has been appointed to the board of directors of Reunion Gold. Stanford brings valuable experience to this position from past executive roles in the mining industry, including as CEO of Torex Gold Resources. **Justin van der Toorn** is the incoming vice-president of exploration, with 18 years' experience as an exploration geologist.

Daniella Dimitrov will be stepping down as CFO and executive vice-president of strategy and corporate development of Iamgold. The company has appointed **Maarten Theunissen**, the current vice-president of finance, to assume the role in the interim while the company searches for a permanent CFO.

Doris Tam has been hired as C2C Gold's new CFO. Tam brings over 20 years of progressive finance experience to the new role, having previously worked for multiple publicly traded companies, most recently as chief accounting officer at Halo Collective Inc. and corporate controller at Namaste Technologies Inc.

Newmont Corporation has announced multiple new executive leadership hires. **Aaron Puna** will assume the role of executive vice-president and CTO beginning in January. Puna was previously CEO of Anglo American's copper business, located in Chile. **Mark Rodgers** will assume the role of senior vice-president South America, and **Bernard Wessels** will be promoted to senior vice-president North America.

estate would have been liquidated, leaving countless staff members without jobs and students in need of transfers to alternate universities in order to continue their studies. When Laurentian first announced that it would be filing for insolvency, 69 undergraduate and graduate programs were forced to close. Additionally, 194 full-time workers were terminated.

The potential closure of Laurentian, one of Canada's most prominent mining universities, could have been a critical moment for an industry that is seeing less student enrollment.

In the Mining Industry Human Resources Council's National Outlook for 2021, results from a 2020 survey reflect that younger workers (aged 15 to 30) are choosing jobs in the mining industry far less frequently than other industries, such as health care or the high tech sector. Out of 3,000 individuals surveyed, only 31 per cent displayed an interest in working in the mining industry.

Despite the uncertainty that looms following Laurentian's crisis, Hani Mitri, chair and one of the founding members of CIM's Canadian Mining Schools Committee, remains hopeful about the future of mining education in the country.

"Mining is cyclical," he said. "Mining demand gets low, we have a lot of students, and they end up finding jobs. Then, when mining picks up, it takes a while for students to catch up, too."

Mitri considers the present to be the best time for mining students who may be in search of employment. "Right now, mining is on a high. It's in huge demand, with the country looking for mining engineers." He noted that, as a result of this current demand, recently graduated mining students in most sectors can "expect to receive multiple offers, as well as good salaries."

Mitri went on to explain that, aside from Laurentian, there are eight Canadian post-secondary institutions that offer mining engineering programs: three in Ontario (the University of Toronto, Cambrian College, and Queen's University), three in Quebec (McGill University, Polytechnique Montreal, and Laval University), and two in Western Canada (the University of British Columbia and the University of Alberta).

At the moment, there are none in Atlantic Canada. "Unfortunately, three years ago, Halifax's Dalhousie University decided to close its mineral resource engineering program," said Mitri. It was announced in September 2021 that the students enrolling in the program during that fall would be the final class to take that program.

"There have been efforts to convince the university to reverse its decision, but the decision remains a no," said Mitri. Quebec is currently the closest option to the Atlantic provinces for prospective students interested in studying mining.

Don Jones, a retired Dalhousie University associate professor, made several efforts alongside former colleagues to resurrect the school's mineral resource engineering program. Unfortunately, as Jones explained, "we did a lot of things to try to make them reconsider, but none of them are going to be successful."

Jones noted that the school was even approached by an industry group who offered to make a hefty contribution to get the program up and running again, but the offer was declined. He considers Dalhousie's abandoned mining program to have been a "major contributor" to the industry, integrating a steady number of mining graduates into Canada's workforce.

While Jones's efforts may not have been successful in bringing back Dalhousie's mining program, he is particularly interested in a project that Stephen Butt, a professor at Newfoundland and Labrador's Memorial University is spearheading. Butt is currently offering several new mining courses with the hope that it may lead to a full-fledged mining program in the near future. "He's trying a couple of courses as options right now, and if they get a good buy-in on that, they may very well introduce a program," said Jones.

Despite the mining industry's ever-shifting demand for new students and workers, Laurentian University's favourable vote serves as a positive stepping stone towards improving the current state of mining education within the country. CIM

Cameco to co-own Westinghouse Electric Company

Cameco and Brookfield Renewable, a Toronto-based renewable power corporation, will become partners in order to purchase the U.S.-based Westinghouse Electric Company, one of the largest nuclear-services businesses globally.

Courtesy of Cameco

Cameco will take a 49 per cent ownership stake in its new partnership with Brookfield Renewable.

Brookfield Renewable and its consortium partners will own a 51 per cent interest in Westinghouse, while Cameco will own a 49 per cent interest. Westinghouse is valued at a total of US$7.875 billion.

The company's existing debt structure will remain unchanged, with an estimated US$4.5 billion equity cost to be split between Brookfield Renewable and its partners (roughly US$2.3 billion) and Cameco (roughly US$2.2 billion).

"Every credible net-zero pathway relies on significant growth in nuclear power. It is an essential, reliable zero-carbon technology that directly displaces fossil fuels and supports the growth of renewables by providing critical baseload to our grids," said Mark Carney, vice-chair and head of transition investing at Brookfield Renewable. "The partnership of Brookfield and Cameco will help drive forward the growth of nuclear power that the world needs for its clean energy transition."

For Cameco, this marks a significant change from being one of the largest uranium fuel producers globally to also becoming a major player in providing nuclear energy. For both companies, this partnership is meant to take advantage of the projected growth in demand for nuclear power and could offer more efficient access to uranium fuel supplies sourced in North America and Europe.

"We are witnessing some of the best market fundamentals we've ever seen in the nuclear energy sector. As one of the few forms of electricity generation capable of safely, reliably and affordably producing emissions-free, baseload power, nuclear energy is becoming increasingly important in a world that prioritizes

electrification, decarbonization and energy security," said Tim Gitzel, president and CEO of Cameco. "The opportunity to partner with Brookfield Renewable, a leader in the clean-energy space, to acquire Westinghouse is expected to create a platform for growth across the nuclear value chain. Coupled with our more than 30-year proven track record of providing secure and reliable fuel supplies to a global customer base, this transaction fits perfectly within Cameco's strategy and is expected to increase our ability to meet the growing needs of existing and new customers at a time when origin and security of supply is of significant concern." – Ashley Fish-Robertson

Courtesy of Skeena Resources

Skeena believes its Eskay Creek project can be considered a tier-one operation.

Skeena Resources releases Eskay Creek feasibility results

The results of Skeena Resources' feasibility study for its Eskay Creek gold-silver project in British Columbia's Golden Triangle were released on Sept. 8.

The highlights of the study commence with the after-tax net present value of $1.41 billion at a five per cent discount rate, at a base case of US$1,700 in gold and US$19 in silver. The after-tax internal rate of return is 50.2 per cent, with an after-tax payback on pre-production capital expenditures of one year.

The life-of-mine production is estimated at 3.2 million gold equivalent ounces from 2.4 million ounces of gold and 66.7 million ounces of silver. Years one to five show an average annual production of 431,000 gold equivalent ounces, ranking Eskay Creek as a tier-one operation, according to Skeena. Total life of mine is currently estimated at nine years.

Proven and Probable open-pit mineral reserves for the project are listed at 29.9 million tonnes containing 2.87 million

ounces of gold and 75.5 million ounces of silver grading at four and 2.99 grams per tonne, respectively. Finally, according to the study, Eskay Creek reports a carbon intensity of 0.20 tonnes of CO2 equivalent per ounce of gold equivalent produced, which, according to Skeena, makes it one of the lowest carbon intensity mines in the world.

Randy Reichert, the company's president, explained that "the feasibility study confirms the robust economics of the world-class Eskay Creek project originally shown in the pre-feasibility study, but with improved definition." Reichert added that while the development team continues to work on optimizing the project, and as it progresses closer to construction, one of the primary areas of focus for Reichert is the advancement of the permitting process.

The project is expected to be an open-pit operation that will utilize conventional mining equipment. It is still being evaluated whether or not there is potential for the project to include an underground mining component.

– Ashley Fish-Robertson

Baffinland receives six million tonne limit approval

Baffinland was prepared to suspend operations at its Mary River mine if it had not received an extension for its production limit

By Ashley Fish-Robertson

After several uncertain months, Baffinland has received approval to continue producing and shipping iron ore at a limit of six million tonnes for 2022 at its Mary River mine. Dan Vandal, minister of Northern Affairs, permitted the company to continue operating at the same limit they have respected since 2018.

This decision will protect over 1,100 jobs, with over 300 of those positions being occupied by Inuit employees. Termination notices had been sent by the company to its employees working at the Nunavut-based iron mine in July.

Baffinland was prepared to suspend its operations for the rest of the year if it was denied reapproval from the government. The company was granted renewed permission for one year in 2019 and for two years in 2020 from the Nunavut Impact Review Board (NIRB) to exceed the originally permitted limit of 4.2 million tonnes.

The company completed its revised renewal application on May 30. On Sept. 22, the NIRB recommend that Baffinland be granted the extension of its six million tonnes permit for 2022.

In a recent letter addressed to Kaviq Kaluraq, chair of the NIRB, Vandal wrote that the proposed renewal should be allowed to proceed, but with additions to

Crédit photo : Jean Philippe Richard

MACHINES ROGER INTERNATIONAL

Machines Roger International participates in humanitarian rescue in Dominican Republic

Machines Roger International is proud to have participated in a successful humanitarian mission to the Dominican Republic to assist in the rescue of two trapped miners in Cormidom's Cerro de Maimon mine this past August.

With the assistance of the Royal Canadian Air Force, the company was able to send more than 27,000 kilograms of specialised mining equipment and a dedicated team of experts that were a critical element in the rescue of the two trapped miners, Gregores Mendez and Carlos Yepez.

We would like to extend our heartfelt thanks to all who made our participation possible and successful: the Machines Roger International management and operations team, the Royal Canadian Air Force, the Canadian Embassy of the Dominican Republic, the Minister of National Defense, Meglab and Moran Mining.

Courtesy of Baffinland

Bafflinland is awaiting approval for its Phase 2 expansion plans at Mary River.

the monitoring and reporting programs applicable to Mary River.

These additions include more detailed definitions of the Terrestrial Environmental Working Group and Marine Environment Working Group to provide guidance and oversight of the environmental impacts of the project. Additionally, there are new guidelines for ice breaking during shipping season, maintaining access routes for hunters and for dust monitoring.

In the letter, Vandal went on to say that "the designated Inuit organizations, Inuit from impacted communities, and regulators have observed that better monitoring of compliance with project commitments would assist in improving the monitoring and adaptive management functions for the project."

In order to achieve this goal, the Qikiqtani Inuit Association (QIA) and Baffinland suggested the appointment of an independent third party to supervise general commitment implementation.

Vandal and other ministers are in support of this objective and have instructed relevant government officials to commence discussions about employing a third-party monitor for the project. Discussions between Baffinland, the QIA and Nunavut Tunngavik Incorporated are expected to take place by Nov. 30.

Baffinland is currently awaiting a decision from Vandal regarding its application for Phase 2 of the Mary River expansion plan, which is expected to come in the following months. CIM

Seabridge Gold recognized for reclamation

Seabridge Gold has been recognized by the British Columbia Technical and Research Committee on Reclamation (TRCR) for its Legacy Mine reclamation project. On Sept. 22, the company was awarded the 2022 Jake McDonald Annual Mine Reclamation Award by the TRCR for the $12 million environmental and reclamation program that it is voluntarily pursuing with B.C.'s Tahltan Nation.

Seabridge purchased SnipGold Corp. and its accompanying Iskut project in 2016, which included a historical mine. "Along with SnipGold came the Johnny Mountain mine, which was incomplete and came with significant existing historical liabilities," said Elizabeth Miller, vice-president of Seabridge Gold. "As a result of that, we immediately reached out to the Tahltan Nation to let them know that we were purchasing the project."

Seabridge is currently working in collaboration with members from the Tahltan Nation Development Corp. (TNDC) and took care to include them in the project planning stage early on. "The reclamation work that we're voluntarily undertaking at the Iskut project is a great example of how mining exploration companies can collaborate with Indigenous nations to reclaim and advance projects that benefit both parties," noted Miller.

Once the plan was completed, Seabridge conducted a detailed site investigation of all groundwater and surface water, examined reports about the mine that had been compiled over the years, and finally, began work to remove the hazardous materials that had been piling up in unauthorized landfills around the property.

Other reclamation work the company has undertaken at the site includes completing in-situ hydrocarbon remediation of contaminated soil, transport of potential acid-generating waste rock from the portal pads to the tailings management facility and the closure of five vent raises that posed potential safety risks.

An important goal for the company is transparency about its project, Miller said. "We want to have annual and visual progress on the project. Every year, we choose one or two major activities, and we want to make sure that there's some real visual change on the project." The major activity for 2022 consisted of demolishing a mill building that was found on the site.

Courtesy of Seabridge Gold

The major activity for the reclamation project in 2022 was the dismantling of a former mill found on site.

Seabridge is expected to complete the full reclamation and closure of the mining site in 2025. – Ashley Fish-Robertson

Sabina Gold & Silver approves Goose gold mine development

Vancouver-based company Sabina Gold & Silver Corp. announced on Sept. 7 that it has made the formal decision to move forward with the Goose gold mine, located at the company's fully owned Back River Gold District in Nunavut. The multigenerational mining district spans 80 kilometres, with the Goose gold mine set to be Sabina's first mine to be situated in this region.

Courtesy of Sabina Gold & Silver

The new mine will be the company's first to be situated in Nunavut's Back River Gold District.

After several years, the company has completed all pre-development activities for this project. Full construction is now set to begin in 2023. Additionally, all the major equipment and materials needed for the development of the mine have been either acquired, marshalled at the company's transportation hubs, delivered or are currently in transit to Nunavut.

Following the completion of these crucial steps, Bruce McLeod, president and CEO of Sabina Gold & Silver, said that "This is a milestone decision for the company. We are excited to formally commit to becoming a significant Canadian gold producer. In the meantime, we have been steadily advancing the project to be in a position to commence full construction in early 2023 with first production expected in Q1, 2025." McLeod also noted that the recruitment process for the project was under way, with 142 personnel employed as of now.

A 2021 technical report lists the project's Measured and Indicated resources at 6.32 million ounces of gold from 33.45 million tonnes grading at 5.88 grams per tonne and Proven and Probable reserves at 3.59 million ounces from 18.69 million tonnes grading at 5.97 grams per tonne. The mine is expected to operate for 15 years.

Earlier this year, Sabina secured over $800 million in project financing, which the company said has greatly helped to advance engineering and civil work and the procurement of materials and equipment necessary for the project.

– Ashley Fish-Robertson

Courtesy of Stantec

In order to meet their net-zero targets mining companies are going to have to take a chance on unproven technologies and turn to existing – but not commonly implemented – technologies like ore sorting.

At the turning point

Rather than being "first to be second," mining companies must take risks on new technology implementations now if they hope to meet their future net-zero goals

By Kelsey Rolfe

Newmont Corp.'s Tanami mine in Australia and its Cripple Creek & Victor (CC&V) operation in Colorado are two very different mines. Tanami, an underground operation, has decades of life ahead of it and has attracted major investment dollars from Newmont for a new shaft; the surface CC&V mine, meanwhile, has a much more limited mine life after a decades-long production run.

But each, in its own way, is the perfect place for a partnership between Newmont and Caterpillar Inc., to develop and test battery-electric surface and underground fleets. The agreement, signed last year, saw Newmont make a US$100 million initial investment towards developing a "zero-carbon-emitting end-to-end mining system" with Caterpillar, including electric mine vehicles, infrastructure, automation and data collection and analysis.

Tanami will give the equipment giant the proving grounds for underground battery-electric technology, which it does not currently have, and its decades-long mine life grants Newmont the flexibility to experiment with new mine designs that accommodate electric infrastructure.

At CC&V, meanwhile, Caterpillar will get to test its battery-electric surface haul trucks in tough weather conditions – from sweltering summers to frigid winters, torrential rain to high winds. "If the technology works there, it's proven categorically," said Rob Atkinson, Newmont's executive vice-president and chief operating officer. For Newmont, Atkinson explained, the benefits at CC&V are proving to the industry that there is a strong economic case for rolling out BEVs, even for a long-existing and mature mine.

The companies are targeting an underground electric and automation rollout by 2026, and above-ground electric trucks and infrastructure by 2027. Atkinson said the development timelines are aggressive, but Newmont felt an imperative to be part of fast-tracking these vehicles.

"We recognize we can't wait to act, we've got to do something absolutely tangible," said Atkinson, who noted roughly 40

per cent of the company's emissions come from its surface and underground fleets.

To reach their net-zero goals, mining companies are having to go against the industry-wide preference for being "first to be second" and plan to integrate technologies and processes that are not yet widely adopted or even commercially available.

"We're really at a turning point in the industry now. It's not about why we're doing this but about how," said Brian Mashford, senior vice-president of mining for Stantec. "We're seeing a lot of requests to help clients figure out how to implement technologies and become more comfortable with where things are going to be downstream."

Mashford sees battery-electric fleets for open-pit operations and hydrogen-powered vehicles, small modular nuclear reactors (SMRs), autonomous modular haulage, and ore sorting as just some of the technologies that will have important future roles in net-zero mining, but he acknowledges that companies are still grappling with how to implement them.

In the pilot seat

In the past year, numerous mining companies have announced partnerships or consortiums with original equipment manufacturers (OEMs) and suppliers to fast-track the development of battery-electric or hydrogen fleets, and pilot vehicles as they become available.

In June 2021, Montreal-based Nouveau Monde Graphite (NMG) announced a collaboration agreement with Caterpillar to develop a zero-emissions fleet for its flagship Matawinie mine by its fifth year of commercial production. Matawinie, which is slated to be operational by 2025, will first begin operations with a diesel fleet, and receive new electric equipment from Caterpillar over the subsequent years. Eric Desaulniers, NMG's founder, president and CEO, said this timeline will allow the company to gradually test and insert the new vehicles into production, and measure their key performance indicators against the existing diesel fleet.

Teck Resources, meanwhile, has committed to testing a Caterpillar pre-commercial zero-emissions vehicle (ZEV) starting in 2024 at its steelmaking coal mines in the Elk Valley, but not in a production capacity, said public relations manager Chris Stannell. The company expects to begin production testing a small fleet of pilot ZEVs by 2026, with the goal to start deploying 30 commercially available trucks the following year.

Stannell said the company will be looking at metrics like speed on grade, component life and mechanical availability, as well as battery-electric powertrain metrics such as charge rate and energy efficiency. "The core objective of the testing will be to understand the scale of opportunity to displace the diesel fleet in operations by evaluating a range of operating parameters, including extreme heat and cold, variable rolling resistance, uphill and downhill loaded haul cycles and many others," he said. The Elk Valley operations utilize over half of the company's truck fleet and more than two-thirds of its ultra-class

haul trucks, so it was "strategically important" to the company to ensure ZEFs were designed to perform well in those conditions, Stannell explained.

In central British Columbia, Martin Turenne, president, CEO and director of Vancouver-based FPX Nickel Corp., is planning for a different type of in-progress technology. For years, FPX's Decar nickel project has played host to Greg Dipple, a University of British Columbia professor of geological sciences whose CarbMinLab is advancing carbon sequestration through tailings. Dipple's research has found that ultramafic rock – igneous rocks with low silica content and high magnesium oxide, iron oxide and potassium content – is the most optimal for capturing and mineralizing carbon dioxide. Decar's deposit more than fits the bill.

Carbon sequestration through tailings is, according to Dipple's previous work at BHP's Mount Keith mine in Western Australia, a process that happens naturally: he found that the mine's tailings were naturally capturing 40,000 tonnes of carbon dioxide, or 11 per cent of its annual emissions. Dipple has been working on speeding that process up – and even though that research is still under way, Turenne said FPX is building it into its mine plan for Decar. The company expects to reach a construction decision on the nickel project by 2027.

"Our advantage is we can hopefully build some of those opportunities to engineer specifically for this within the overall site and mine development plan – to build it in and really embed it into the DNA of the project through relatively early-stage engineering work."

Turenne said FPX will need to conduct pilot testing to get an accurate read on the sequestration potential of its tailings by tilling the surface of the tailings and measuring the naturally occurring sequestration against a controlled amount of material that hasn't been tilled. He noted that according to Dipple's research, the more that is done to agitate the tailings – such as by chilling the surface of them – the more sequestration is possible.

"There's going to be quite a bit of piloting ahead of us, but at its root, we know we're definitely going to get a fairly substantial amount of sequestration, even if we do nothing to enhance the chemical reaction," he said.

Design considerations

Planning for new technology comes with significant design challenges, Atkinson said. Traditional underground mines face particular constraints, including the reality of narrow tunnels and turning circles that need to accommodate charging infrastructure. "You've really got to think about the whole infrastructure as well, and does that mean you design your intersections differently? Do you have to design blank headings for the charging, do you have to have new facilities that run alongside the trucks so they're constantly getting a zap of charge?" he said. "If we think it's simply about equipment getting plugged in, we're never going to achieve it."

He noted that mines that have employed autonomous vehicles have historically designed wider roads and corners to account for those trucks, but Newmont is looking at how to make those roads narrower given the evolution in automation technology to date, and to avoid creating additional waste.

NMG made several mine-design changes in anticipation of having a fully electric vehicle fleet at Matawinie, said Desaulniers.

The company switched its mine plan to begin with mining the south portion of its three-kilometre-long deposit for the first five years. It is an uphill application, where trucks go down into the pit empty and come up heavy – something that Desaulniers said was not ideal for electric vehicles, but the initial diesel fleet will be able to accommodate. As of year six, by which point the fleet will be all-electric, mining will switch to a downhill application elsewhere in the deposit. "Downhill is much better, much more productive and cheaper for an electric fleet: you don't have to waste energy on brakes, and you'll have to recharge the truck less."

It also decided not to operate Matawinie overnight, which will give BEVs additional charging time, he added.

Bumps in the road

For BEV fleets specifically, Mashford acknowledged there is an up-front financial tradeoff. Electric vehicles and their associated infrastructure are more capital intensive at the front end, though they work out to be less costly than diesel over their lifetime given the higher operational costs of diesel equipment, such as additional ventilation requirements. Miners will also have to contend with the cost and process of switching out their diesel-powered fleet for all-electric, something that can be particularly challenging for smaller companies.

NMG is mitigating these cost challenges by entering into a job-site solution agreement with Caterpillar: the OEM will charge a per-hour rate for each piece of equipment the company uses, allowing NMG to avoid the prohibitive capital costs of purchasing equipment outright and then trading it in.

"It's difficult when you're a start-up to justify a big capital expense like [BEVs]. The solution where Cat is taking it on their balance sheet is very attractive," Desaulniers said, adding that he expects this type of agreement to become more popular as more miners adopt electric fleets.

Stannell pointed out shifting to ZEVs will require changes to "almost every aspect of how we operate and maintain trucks today," and said Teck expects these vehicles will demand new or expanded employee skillsets.

While the last few years have seen a rush of decarbonization commitments from miners, Mashford said there is still often a "disconnect" between corporate net-zero commitments and on-the-ground operations.

He gave the example of ore sorting, an advanced and available technology that could help reduce miners' energy usage, but one that is not well-used or built regularly into mine plans.

Turenne called it "ironic" that FPX, a small junior company, was one of the few mining companies backing carbon-sequestration research. "We'd like to see other companies step up... and fund more [research] in this space," he said. "For a small company like ours to be leaders in the space speaks, unfortunately, to a lack of focus on innovation." CIM

Net-Zero Challenge will run throughout 2022. It will examine the challenges involved with reducing greenhouse gases and eliminating carbon footprints, and it will also look at the opportunities those actions can represent. If you have something to contribute, reach out to us at editor@cim.org.

Photos courtesy of SRK Consulting

Building social engagement into tailings management

By Franciska Lake and Jacky Burke

Tailings facility owners are facing the challenge of how to practically integrate social impacts with the systems that manage tailings – as required by the Global Industry Standard for Tailings Management (GISTM). In fact, building social engagement into tailings management is the first topic addressed in the 2020 standard, requiring mines to "respect the rights of project-affected people and meaningfully engage them at all phases of the tailings facility lifecycle, including closure."

For a start, according to the GISTM, meaningful engagement requires a range of formalized systems, procedures and monitoring of the mine's environmental and social management system (ESMS). However, a key hurdle on most mining sites is the typical separation of the more "technical" tailings systems from environmental, social and governance (ESG) systems.

Mines will generally have an ESMS that puts into operation several of the ESG requirements of the GISTM, while there is also a tailings management system (TMS) that executes both the engineering and governance considerations of the GISTM. The current challenge is to integrate the ESMS with the TMS in a way that is practical and effective.

Indeed, the ESMS itself has both environmental and social components that are often not adequately integrated within the mining operation. They are usually managed as separate entities, and often within different departments. While environmental issues may fall under the safety, health and environment department, social management may fall under a community engagement or social performance department.

There are, of course, many different disciplines and skill sets involved in each function – and each team has its own day-to-day responsibilities and imperatives. Conformance to the GISTM will require strong interaction and integration between the disciplines and various systems dealing with engineering, social and environmental monitoring, risk management and change management.

Driving this integration is the growing urgency on the compliance front, as International Council on Mining and Metals members are working towards a looming conformance deadline. Mines that operate their TSFs with extreme or very high consequence ratings must comply with the GISTM by August 2023.

Key to the paradigm shift essential to the GISTM will be the elevation of social engagement from being intermittent to being ongoing. Focused engagement is often associated with permitting, as part of the regulatory public participation process during environmental authorization processes and water use licensing applications.

Engagement with affected people should instead be meaningful and ongoing throughout the lifecycle of a TSF – with integration into the regular routines of tailings and environmental management.

A four-step process for effective implementation of the GISTM

As the cross-cutting demands of the GISTM may present challenges, we propose a four-step process to provide a framework in which mines can structure and evaluate their progress. Importantly, the steps need to be iterative and ongoing throughout the life of the tailings facility.

1. Knowledge sharing, training and awareness: The aim is to build mutual understanding among the respective experts of a mine's environmental, social and tailings management teams on their roles and functions within the context of the site operation and the risks posed.

It is critical that this first step involves tailings engineers and operators in collaboration with environment and social management personnel to facilitate the integration process. This collaborative group needs to share how site-specific risks are currently being dealt with by the ESMS and TMS, and find opportunities to engage affected people on identified tailings facilities.

2. A critical review of systems for gaps and opportunities: This step lays the groundwork for the mines to comply with the GISTM requirements through reviews and internal audits. It conducts a critical review of the ESMS and TMS, looks at specific areas for improvement and integration, and identifies gaps in its conformance with the GISTM.

3. Upgrading of data systems to highlight targets and trigger action: This step is underpinned by step two. Data systems must be able to set performance targets and to act if the targets are not met. Along with specifying people responsible for each variable being monitored, the system would also need to include reporting frameworks and schedules in line with what the GISTM requires.

4. Strategies for ongoing collaboration and development: This step could involve, for example, regular meetings of a forum of GISTM disciplines on the mine. This forum shares lessons learned and keeps everyone informed of risks and corrective actions.

Applying the four-step approach demands considerable effort and commitment by mine personnel, especially being an iterative process where adaptation and adjustment would always be required. With the GISTM firmly embraced by the sector, and with investors and regulators alike watching its implementation closely, it is vital that mines invest the necessary resources and time to ensure conformance to the GISTM. CIM

Franciska Lake is a partner and principal environmental scientist and Jacky Burke is a principal environmental consultant, both at SRK Consulting.

Courtesy Purepoint Uranium

Geopolitical and ecological concerns have sparked a new interest in nuclear energy resulting in more uranium exploration activities in areas like Saskatchewan's Athabasca Basin, where Purepoint Uranium's Hook Lake project is located.

The nuclear renaissance, reborn

Exploration activities are on the uptick as uranium is, once again, in demand

By Alexandra Lopez-Pacheco

After a crushing 11-year downturn, the uranium sector is experiencing the beginning of a revival. Many are hoping that this is the one that turns the sector into a key player in the decarbonized economy of the future.

The last time junior uranium explorers had so much reason to be optimistic was in the years between 2004 and 2008. Duane Parnham, executive chairman and CEO of the Toronto-based uranium junior exploration company Madison Metals, recalls that excitement is what got him into the sector after attending the Prospectors & Developers Association of Canada's (PDAC) annual convention in 2006. "All the buzz was about uranium and nuclear fuel," he said. "The institutional investors wanted to invest in the sector. I was actually looking for copper, zinc and gold in Namibia. So, when the investors said, 'Do you have any uranium in Namibia?' I said 'Yes, Namibia's a fantastic place for uranium.'"

Parnham founded Forsys Metals that year and joined forces with geological engineer Roger Laine to grow a uranium project in Namibia called Valencia. Now Valencia is part of Forsys's Norasa project, which has a proven and probable reserve of nearly 91 million pounds of U308 grading at 200 parts per million out of 206 million tonnes of ore.

Around that same time, but closer to home, Toronto-based Purepoint Uranium had been exploring for the element in Saskatchewan's Athabasca Basin – the world's richest, high-grade uranium region – for two years when interest in uranium exploded in 2004. "There had been no real exploration for the previous 20 years because the price of uranium was well below what it cost to produce it," said Chris Frostad, the company's president and CEO. "And no one was building new reactors. Then it came back and things got kind of crowded in northern Saskatchewan."

Risks realigned

That uranium renaissance was driven by a resurgence of interest in nuclear power plants, first developed and built in the 1950s. By the 1970s, nuclear power plants were operating across Canada, the U.S., Europe, Asia and the then USSR. Two major nuclear reactor accidents, however, shattered the public's trust in nuclear energy, replacing it with fear. The first was at the Three Mile Island nuclear plant in the U.S. The second and most devastating was the 1986 nuclear accident at Chernobyl in Ukraine, then under the control of the Soviet Union. Even Canada, recognized as a world leader for the CANDU nuclear reactor it had developed with India, pulled back from expanding its fleet of nuclear plants.

By 2004, the threat of climate change was sinking in. That year, countries including Canada ratified the United Nation's Kyoto Protocol. At the time, nuclear power was seen as the best technology option capable of generating enough near-carbon-

free baseload electricity to light up cities and power industries. The closest alternative was hydro-electric power, but that relies on the right combination of water and landform.

Interest in nuclear energy returned. In June 2007, uranium's spot market price skyrocketed to US$136 per pound. While uranium is sold through private long-term contracts – typically lasting five to 10 years – between producers and utilities rather than on the open market, high prices attract investors. In 2008, the financial crisis plunged the price down to US$45 per pound. For the next two years, prices remained low, but nuclear energy as an alternative solution to fossil fuels continued to gain traction.

In 2009, there were 435 nuclear reactors operating in the world and 52 units under construction. A growing number of countries was interested in adding or expanding nuclear power as part of their energy strategy, including Germany and Japan, which was planning to increase the 30 per cent of its electricity generated by nuclear power to 40 per cent by 2017. Then on March 11, 2011, just after the price of uranium had bounced back to US$72 per pound, a magnitude 9.0 earthquake and subsequent tsunami hit Japan, triggering the Fukushima Daiichi nuclear accident.

Once again, the global public recoiled in anti-nuclear fear. Japan cancelled its nuclear expansion plans as did many other governments around the world. Germany declared it would phase out all its nuclear energy by 2022 and replace it with natural gas power plants, which emit 50 to 60 per cent less carbon dioxide than coal plants. While about 10 per cent of the world's electricity production continued to be generated uneventfully by nuclear power, the technology was cut out as a key player in the race to decarbonize global energy. All bets were placed on developing new renewable alternatives such as wind and solar.

To compound the challenges for Canada's uranium junior exploration sector, Kazakhstan was flooding the market with low-cost uranium. "In 2000, Kazakhstan was producing zero uranium," said Frostad. "But over the course of ten years, it really started ramping up." Today, producing 45 per cent of all the world's uranium, Kazakhstan dominates the market.

Utilities with nuclear reactors began snatching up low-cost uranium and stockpiling. Those activities were just part of the pressures on the market. "Excessive oversupply of primary uranium production has contributed to very low uranium prices, which have been depressed for more than a decade," wrote the World Nuclear Association in its April 2022 *Fuel Report*. It went on to say "These unfavourable market conditions caused a sharp fall in investment at existing and new mining projects, as well as a reduction of production levels at existing mines, in an attempt to bring balance back to the market."

Uranium exploration and mine development expenditures worldwide shrunk from US$2 billion in 2014 to half a billion U.S. dollars in 2018, according to a joint 2020 report from the International Atomic Energy Agency and the OECD-Nuclear Energy Agency. "That was a very difficult time in the uranium and nuclear space," said Ross McElroy, CEO of Kelowna, B.C.-based Fission Uranium.

The turnaround

Over the last three years, severe weather events linked to climate change have intensified a sense of global urgency. The energy crisis sparked by Russia's invasion of Ukraine has added geopolitical concerns and a tug of war between the dependency on fossil fuels and the race to end climate change. Dependent on Russian gas, Germany has become a metaphor for post-Fukushima energy contradictions. With 14 of the 17 plants the country had in 2011 already decommissioned by the time the invasion started, Germany decided to fire up old coal plants to deal with interruptions to its gas supply.

In September 2022, Russian-based Gazprom said it would not restart the flow of gas to Europe through the Nord Stream 1 pipeline. That decision led to the German government deciding to extend the life of two of the three remaining nuclear plants until April 2023, to ensure the country has enough energy to get through the winter. Then, according to *Nuclear Engineering International Magazine*, in early October, after explosions caused the Nord Stream 2 to leak under the Baltic Sea, Germany modified its plan once again. Now, the country intends that "Neckarwestheim 2 and Isar 2 be taken off the grid but kept on standby so that they could still be reconnected in a crisis situation."

There is still no new renewable technology capable of generating sufficient baseload electricity to replace fossil fuels.

"As we start moving towards electric vehicles," said Stephen Keith president and CEO of Labrador Uranium, "where is all that electricity going to come from? We need battery metals and we need batteries, but they still need to get charged. We're going to have greater demand on our electricity. We're demanding that supply comes from carbon-free or carbon-neutral sources. Really, the only available choice is nuclear power."

With that realization, 30 countries worldwide are now considering, planning or starting nuclear power programs. Another

Courtesy of Madison Metals

Madison Metals is developing the Madison North Uranium project in Namibia.

20 have expressed interest. Even Japan announced this summer it is restarting its nuclear power plants.

This summer, the European Union officially labelled nuclear power as a green energy, which opens up access for the uranium industry to more than US$8 trillion in green investments.

In September, the Ontario government said it would refurbish the Pickering Nuclear Generating Station and extend its life into 2026, after the plant had been slated to close in 2025.

McElroy believes the shift is "due to an understanding starting to take root at all levels that nuclear is an important part of the clean green energy mix."

Renaissance 2.0

There was a lot of buzz about uranium at PDAC's 2022 convention this year. Saskatchewan's Athabasca Basin remains the epicentre of uranium exploration by juniors, including Toronto-based Appia Rare Earths & Uranium, Vancouver's Skyharbour Resources, Standard Uranium and CanAlaska.

In the Athabasca Basin, where major discoveries were made during the challenging last decade, uranium juniors that persevered are now poised to take advantage of the anticipated increased demand for uranium. Purepoint has explored some 450,000 hectares and now has 12 advanced-exploration stage uranium projects. It also formed two joint ventures with deep-pocketed Cameco and Orano. One involves its flagship Hook Lake project, where it partnered with both companies. The other is with Cameco alone at the Smart Lake project.

"We know we are in a bit of a sweet spot right now in that there is a lot of money available in the sector and we are really keen on taking advantage of all this funding that's available right now, whether that is using a lot of money ourselves or partnering with other companies," said Frostad. "Any way we can advance them as aggressively as possible during this period, that's what we want to do. We can demonstrate on any one of these projects that there is a potential there for a big find."

In the Basin's Patterson Lake corridor, two companies managed to make major discoveries through the downturn. Fission, which discovered its near-surface resource Triple R deposit at its PLS project in 2012, is leveraging the uranium revival by shifting into development. The company is completing its feasibility study this year and hopes to start building a mine in 2026 that will be able to produce uranium at around US$7 per pound, which is lower than Kazakhstan's approximate US$11 per pound. And it plans to continue exploring. "We haven't even yet begun to start exploring the other 90 per cent of the property in any meaningful way," said McElroy.

Vancouver-based NexGen Energy, which also began exploring at its Rook I property in the southwest Athabasca Basin in 2011, discovered its large Arrow deposit in 2014. NexGen is in the process of developing the project, making it one of the largest development-stage uranium projects in the world.

While the Athabasca Basin is the world's hub of high-grade uranium, Newfoundland and Labrador is also rich in the element. There, Labrador Uranium is advancing its Moran Lake deposit and Mustang Lake project in the prolific Central Mineral Belt (CMB) in central Labrador as well as the Notakwanon project in northern Labrador. The company has consolidated 139,000 hectares with more than 140 identified mineral occurrences, including significant uranium and copper showings, and believes the area's potential for iron oxide-copper-gold (IOCG)-style mineralization could lead to a large polymetallic mine. "One of the largest uranium mines in the world is actually an IOCG project in Australia, Olympic Dam," said Keith. "It's an IOCG project that has a huge amount of uranium in it. We have experts looking at what's happening at depth to see if there's a large IOCG deposit beneath our near-surface uranium."

Canadian juniors are looking outside of Canada as well. Vancouver's Azincourt Energy, which has two uranium projects in Saskatchewan's Athabasca Basin, is also exploring for lithium and uranium on its property in the Picotani Plateau in Peru. Toronto-based Global Atomic is now in the process of developing its Tier 1 Dasa deposit, which it discovered in 2010, in the Republic of Niger.

With Madison Metals, Parnham and Laine are back to exploring in Namibia, the world's second-largest uranium producer. The company is acquiring highly prospective properties near two of the world's largest uranium mines, Rössing Uranium and Husab, to build its Madison North Uranium project. Madison is also exploring new territory when it comes to the selling of uranium, having signed a five-year supply agreement with fintech company Lux Partners that links delivery of up to 20 million pounds of U308 to uranium-backed non-fungible tokens (NFTs).

It is still early days in the uranium renaissance. Should nuclear energy be embraced as a key player in achieving net-zero carbon emissions by 2050, uranium production will need to dramatically ramp up.

"The support for nuclear is starting now," said Keith. "As we move forward, and people get more comfortable with it, this is going to help us over the long term. Our job is to keep funding, keep putting money into the ground and discover some great deposits." CIM

Courtesy of Cameco

One way to keep workers safe when working around uranium is to keep them from handling the material. At Cigar Lake, Cameco uses a jet-boring process to keep the ore in containment.

Safety first

Technology, design and training ensure workers handling radioactive minerals stay safe and protected

By Carolyn Cooper

Demand for uranium and rare earth minerals is growing as the world slowly moves away from fossil-fuel dependence and towards clean, renewable electricity generation. That is good news for Canada, which, according to the World Nuclear Association is the world's fourth-largest total uranium producer and third-largest producer via mines (as opposed to in-situ leaching), and home to a significant amount of rare earth reserves and resources.

With new demand, comes new players entering the industry – companies and people who have never worked with these elements and ores before and who may not have experience handling or processing radioactive material. Fortunately, there are measures in place to keep workers safe, as well as a wealth of expertise in the industry at large, ready to ensure that risks associated with exposure to radioactivity is low.

Oversight

The Canadian Nuclear Safety Commission (CNSC) regulates all uranium mining and milling in Canada and has set strict regulations and requirements for radiation safety that companies must meet to obtain and maintain an operating licence. As part of the nuclear-energy sector, uranium mining is also subject to a regulatory framework that includes monitoring and oversight at the federal, provincial and even international levels. In addition, provincial occupational health and safety standards apply.

Modern uranium mines are designed to minimize workers' exposure to uranium and its decay products, based on the ALARA (As Low As Reasonably Achievable) principle. "When working with radioactive substances, including ores, consideration has to be given to the physical, chemical and radioactive properties of the materials," explained Brian Bjorndal, director, National Laboratories, Radiation Safety Institute of Canada. "Radioactive ores pose potential radiation exposure risks to individuals working with or near such materials. Radiation exposures can include external exposure from radiation striking the individual to internal exposures if radioactive material is taken into the body. The risk to individuals is dependent on the amount and types of exposures received."

Despite the perceived risks, Bjorndal put the hazards of working with uranium into perspective: "Uranium-mine-worker annual radiation exposures are well below regulatory dose limits and similar to that of natural background exposures we all receive." He added that, "today, workers are protected from radiation through best practices such as mine design and technology, personal protective equipment (PPE), and most importantly, proper safety training."

Danger mitigation

As a well-established producer, Saskatoon-based Cameco Corporation mines uranium and turns it into fuel for nuclear reactors around the world. As such, the company has experience in protecting employees from the hazards associated with handling uranium. "Safety is a top priority in every aspect of our operations," said Jeff Hryhoriw, director of government relations and communications.

"With uranium, the primary radiological challenges are airborne particulate containing radioactive contaminants, gamma radiation and radon progeny. Airborne particulate can be caused by manually or mechanically handling ores that create dust or small particulate, which could be inhaled. This hazard is present throughout all phases: exploration, mining, milling, refining and conversion. Uranium itself does not produce much gamma radiation; however, some of its decay products create measurable gamma fields. This hazard may be present at various stages such as prior to the production of ore concentrates during milling and while removing residual contaminants during refining and conversion. Radon gas (Rn-222) occurs naturally as part of the decay series of uranium. This gas further decays into several short-lived decay products called radon progeny. Radon gas and progeny can be present during the exploration, mining and milling phases but are removed during the production of uranium concentrates at the end of the milling phase."

Cameco, which is expected to produce up to 18 million pounds of packaged uranium in 2022, has systematic safety programs and worker training to address the risk of potential hazards, starting with the design of its mines. "Our mining methods and processing circuits are highly engineered to ensure safe and efficient production," said Hryhoriw. "An example of this sophisticated engineering is the jet-boring process at the Cigar Lake uranium mine, which allows us to keep the ore in containment throughout the mining process, preventing any manual handling of the ore and reducing the presence of airborne contaminants and gamma radiation."

Hryhoriw added, "Specific to radiological safety, we employ key controls such as time, distance, shielding and ventilation to mitigate hazards. These types of controls are applicable throughout all phases of production, from exploration to delivery of a final product. Examples of these controls include isolated storage areas for higher grade core samples during exploration, very high ventilation rates in mines to quickly remove airborne contaminants, containment of ore and processed uranium in pipes and tanks, additional protective equipment and time restrictions on jobs where exposure rates could be elevated above routine conditions, and use of metal, concrete or water to shield sources of elevated gamma radiation."

Equipment, technology and training

Automated technology is also making the process safer. "In recent years, we have been able to employ more automation techniques – for example, remote measuring devices for airborne conditions, measurement tools that provide faster notification to workers of changing conditions, and automated equipment to enter areas of elevated radiation – to further improve the safety of our workers," said Hryhoriw. "In the future, we expect to see additional opportunities to improve safety, including increased responsiveness of our controls such as ventilation, to changing radiological conditions, more auto-

mated equipment, and enhanced notification and planning through facility-wide WiFi."

Some form of PPE is always necessary when working around radioactive minerals. Depending on their job, workers may wear personal dosimetry devices to track radiation dosages, and they may require respirators, goggles, gloves, sleeves, footwear covers or safety clothing made specifically for handling radioactive materials. DuPont offers two brands of protective clothing designed to protect workers against hazardous particles: Tyvek, for protection against radioactive particles, and Tychem, which has options for protection from acids, bases, hydrocarbons and other organic chemicals. The Tyvek line includes coveralls with respirator-fit hood and attached skid-resistant boot covers, all with serged and over-taped seams.

Determining which protective gear is needed means examining worker exposure risk, said Lori Gettelfinger, global marketing communications and brand leader for DuPont Tyvek. "Selecting a protective garment is based on a comprehensive hazard risk assessment to identify all the hazards present and their physical state, along with the conditions for contact exposure, including amount of hazard contact, duration of contact, intensity of contact, direction of contact, and whether elevated or low temperatures are involved." DuPont offers a web-based and mobile app called SafeSPEC to help companies select the most appropriate PPE.

Of course, none of it matters if employees are not properly trained on the hazards of working with uranium or low-dose radioactive materials. That means specialized training is emphasized at every stage in the mining, transport and handling of radioactive minerals. "One of the biggest challenges is education," said Kurtis Hinz, CEO of TAM International, a transporter of radioactive materials including uranium, monazite, naturally occurring radioactive materials and rare earth minerals. The company works with mines to determine how materials should be properly packaged, and to ensure that shipping complies with all regulations. "Anytime you put a radioactive placard on the side of a container it has a lot of negative connotations, and it has certain things assumed," said Hinz. "You have to have the education to understand exactly what you're handling, to understand the real risks versus the perceived risks. And that goes in terms of educating suppliers, insurers, all the different parts of [the industry]." In terms of safe transportation of radioactive materials, Hinz said only authorized, properly trained TAM International staff work around radioactive material, and tracing and tracking technology with geofencing capabilities is used to monitor all movement, and ensure drivers do not accidentally enter residential areas.

Handling and transport of these materials may also require PPE. Depending on the products they are around, TAM International staff and carriers wear dosimetry devices, as do workers at Energy Fuels Resources (USA) Inc., a vanadium and uranium producer that transports and processes uranium ores, uranium and rare earth materials containing monazite sands, and uranium-bearing materials called alternative feeds at its White Mesa Mill in Utah. In addition to area air-monitoring systems, workers may also use individual air-monitoring devices to ensure the atmosphere is safe. "Radiation-safety officers ensure that all employees stay well below exposure limits set by government agencies," added Curtis Moore, vice-president of marketing and corporate development for Energy Fuels. As a result, he said, "Energy Fuels' mill employees are exposed to roughly the same amount of radiation annually as a typical airline pilot or flight attendant." CIM

A global concern

Tailings management has been brought to the forefront of the industry, but much remains to be done to ensure future disasters are prevented

By Tijana Mitrovic

This past September, a tailings failure at an abandoned diamond mine in South Africa caused heavy flooding and left at least three people dead. The failure at the Jagersfontein mine is the latest in a string of recent tailings disasters, including the failure at Vale's Córrego do Feijão mine in Brumadinho in 2019, which killed 270 people and decimated the nearby communities and environment, prompting worldwide outcry and calls for change.

Operating as the Global Tailings Review, in August 2020 the International Council on Mining and Metals (ICMM), Principles for Responsible Investment and the UN Environment Programme co-created the Global Industry Standard on Tailings Management (GISTM) in response to the tailings failure in Brumadinho. The goal of the global standard is to strengthen the safety and governance of tailings facilities worldwide, to protect people and the environment, and to prevent another Brumadinho – and now, another Jagersfontein – from occurring.

The global mining industry has had the GISTM for two years now. These standards represent important first steps in a very long journey. The process of rolling them out around a world with a patchwork of pre-existing standards, incomplete data, a skills shortage and growing social concerns is a monumental task. Following the latest failure in South Africa, it is a task that is as urgent as ever.

An incomplete picture

While standards and guidance on tailings management already existed, such as Towards Sustainable Mining (TSM) from the Mining Association of Canada (MAC), the GISTM is the first standard to be designed with worldwide adoption in mind. Yet the scale of the standard has led to some confusion among operators.

"A lot of companies are still trying to digest the GISTM," explained Charles Dumaresq, MAC vice-president of science and environmental management. "There's a lot of uncertainty still on exactly how it is going to be implemented and how performance is going to be measured against the requirements of the standard."

Many questions remain about the GISTM and how the future of tailings management will look. How will companies report on requirements, Dumaresq asks, and how will compliance with those requirements be audited? Will results be publicly available? "In some cases, that'll be straightforward. For other requirements, that's a fairly complicated question," he said.

Another one of the major problems facing tailings management is that there is no exhaustive record of how many tailings facilities exist worldwide. Estimates of the number of tailings facilities range from some 7,000 to nearly five times as many.

Tracking failures is also difficult. According to Jan Morrill, tailings campaign manager at Earthworks, an environmental nonprofit organization focused on the mining industry, "There is no

central registry of tailings failures, and so no one is really tracking and keeping an eye on that. It [becomes a question of] 'Did you happen to come across the news article in the Turkish press about the tailings failure in November of 2021?' It's really hard to know."

The status of standards

Today about 78 companies have indicated they are working towards the global standard. Adam Matthews, chief responsible investment officer at the Church of England Pensions Board, believes there is still some distance to go. "Unquestionably, progress is being made," he said. "But this issue requires continued attention from boardrooms, from the chief executives, from chairs, as well as from investors and all the other stakeholders that have an interest in ensuring that this issue is properly addressed."

However, not all mining companies are required to adopt the GISTM. "The standard itself is only as good as the people and the processes at every site," Amanda Adams, principal engineer at Stantec, said. "In other words, it's only as good as how people implement it."

And for those not paying attention? According to Matthews, investors are ready to act: they are poised to start voting against the chairs of companies that are not clearly committed to implementing or working towards the standard. "The dynamics on this issue have changed," stated Matthews.

The upcoming Global Tailings Management Institute will play a key role in ensuring that wider stakeholders, from investors, banks, insurers and communities, have confidence and evidence that the standard is being applied at individual mine sites on a broad, global scale.

The institute will also help clarify how other standards, such as MAC's TSM tailings management protocol, first released in 2004 and most recently revised in 2019, relate to the GISTM. "That's going to be a really important part of ensuring clarity amongst companies and all stakeholders as to how all these things fit together," said Matthews.

Navigating a multi-standard system

According to Andre Gagnon, director of tailings at Lundin Mining, the company's corporate tailings team is currently managing the implementation of the GISTM at its operating sites across five different countries. Gagnon said Lundin Mining has already completed the initial gap assessments at its priority operating sites in Chile, Brazil and Portugal, and plans to be in conformance with the global standard at these sites by August 2023.

When the GISTM was introduced, Lundin Mining turned to review its own global tailings management standard, a supporting standard to the company's overall Responsible Mining Policy. "One of the challenges we had to deal with right away [was that] we had an existing tailings standard and existing company policies that overlapped with the GISTM," Gagnon explained. "In collaboration with the operating sites, Lundin Mining needed to consider: 'How do we design or update our tailings standard to align with the GISTM and not duplicate efforts that already exist?'"

The solution was to keep the same numbered principles and requirements in the GISTM and reference the company's other existing policies and standards, rather than duplicate them. While Lundin Mining found its solution, Gagnon said the GISTM could still clarify some processes. "The industry could use more clarity going forward on how to measure and quantify conformance so there is increased consistency across various jurisdictions and the industry as a whole," he said.

MAC's TSM was inspired by a series of tailings dam failures in the early and mid-1990s. Dumaresq said that the era acted as a catalyst for MAC to say, "We need to do better," and to ask itself, "What can we as an association do?"

After the release of the GISTM in 2020, MAC did a gap analysis on the alignment between existing TSM and GISTM requirements, which Dumaresq said led to updates to MAC's tailings guide and minor updates to its guide on developing and implementing operation, maintenance and surveillance manuals. According to the analysis, there are nine GISTM requirements that TSM only partially meets and only five requirements that TSM does not address out of the 77 GISTM requirements.

The scope of GISTM and TSM do differ, with TSM covering a range of topics other than tailings. For example, the GISTM includes aspects related to affected communities, while this is covered in TSM in a separate protocol. As well, TSM will sometimes defer to the Canadian Dam Association on some more technical pieces of guidance.

Karen Chovan, founder and CEO of Enviro Integration Strategies, believes that TSM has garnered broader industry support due to its longevity and greater detail in guidance. "With TSM, there is a more multifaceted system because they have several individual protocols, enabling focus on tailings specifics separate from other areas like climate change and community relations, even as they are integrated," said Chovan. "MAC has their governance established differently than GISTM, but offers a much more rigorous process on making sure you can evaluate properly and determine whether you have the right things in place."

According to Dumaresq, there are also some aspects of TSM that go beyond the GISTM. "The GISTM says to 'have a tailings management system,' but it doesn't describe what a good tailings management system looks like," he explained. "Whereas we have that similar requirement, have a tailings management system, but then we have all this detail in the table of conformance... that provides a much more complete picture of what a good tailings management system looks like and how you make it really function effectively."

The goal, said Dumaresq, is for TSM to be recognized as equivalent to the GISTM to a certain degree so that companies do not necessarily need to follow two separate systems. Of course, this will depend on how the global institute decides to proceed with equivalencies.

Until then, companies will have to manage a multi-standard system. "I think the challenge going forward for Lundin Mining, and probably other companies, is doing internal and external audits on all these various standards and making sure that where there's overlap," Gagnon said. "We need to carefully plan and execute these audits so we're not duplicating efforts."

In practice

The increased focus on tailings management has also brought newer challenges to those on the ground, including the expectation for tailings engineers to expand their expertise. In her work, Adams said that the many requirements of the GISTM are a learning opportunity for engineers to improve their understandings of dam-break analysis, risk assessments, social impacts and more.

"Tailings dam engineers now have to have a whole new skill set," Adams explained. "We have to become more familiar with risk assessment because evaluating the risk of these facilities is a


Feijao. Brazil, 2019.


Jagersfontein. South Africa, 2022.


Philex. Philippines, 2012.


Hindalco. India, 2019.


Akja. Hungary, 2010.


Mount Polley. Canada, 2014.

huge part of the GISTM… It's been a real challenge to build up those skills. It's also challenging to find enough people that have those skills and bring them onto tailing projects so that we can perform additional studies, tasks and evaluations within the timeline that's required."

When it comes to navigating the challenges of working across multiple jurisdictions with different regulations, following best practices no matter the location is still critical. "If you're adopting best practices and applying that wherever you work, then you shouldn't run into major issues," Chovan explained. "That's why the standards were developed: to give guidance on the best practice to those without."

From an investor perspective, this stance is even more firm. "We need assurance that companies are operating to the best standard in all jurisdictions," Matthews stated. "It's not acceptable because you're in a different jurisdiction that may have weaker governance that you can operate to a lesser standard. Why is that possibly right? It isn't."

Yet finding ways to communicate well and maintain that communication on a tailings dam project can be challenging given the massive scope of these projects. "There may be dozens of people who touch that project on a given day," Adams explains of her experience working on tailings dams. "How do we communicate those most important things to prioritize dam safety?"

The communication piece matters not only to keep stakeholders in the loop, but also to allow them to potentially bring up concerns or risk management actions that people should be doing, and Chovan still considers this part a challenge. "There's a lot of focus now on governance and getting the right systems in place, but we still seem to need focus on the people side, the communication and the culture," said Chovan. "You really need to dig into getting cross-department teams to be open and transparent and talking to each other and having clear communications because there are so many different people involved with these facilities."

Social standards

There is also a growing conversation on the need for community outreach in tailings management, in addition to focusing on technical standards that go beyond company walls. Sometimes companies still fall short regarding communicating and collaborating with local communities. In her research, Chovan has seen companies gather information for technical analysis on the local communities, their activities and potential risks, but not truly connect with these communities on the topic of tailings.

"We don't actually engage them in a transparent fashion to understand their concerns before we make decisions and decide on what kind of facilities or technology we want," Chovan explained. "Nor do we often do a good job of working with – if we have an existing facility – and communicating to them the potential risks of these facilities that are right next to them or upstream of them."

Some companies also remain uncertain about the level of transparency necessary given the complexity of the subject matter. It can be challenging to put out information with the proper context, given how technical it is, in addition to the work companies are doing to improve and handle risk management. Companies may worry that the complexity will either worry engaged communities or be misinterpreted. "To communicate all that is still a big struggle," Chovan said. "We don't speak the same language."

According to Morrill, this is at odds with what affected communities expect, especially those who have already experienced tailings dam failures. "They want to see strong measures for corporate accountability," Morrill said. "They want to see strong measures in place for protecting communities in the event of failures. And that's not far enough in the current standards."

Earthworks released its own set of recommendations on tailings failure management, Safety First, in June 2020 and re-released it with updates in May 2022. Co-authored with Mining Watch Canada, it says the guidelines can protect communities, workers and the environment from the risks of tailings dam failures.

The organization wants significant changes beyond those outlined in current standards. "There also needs to be these hard and fast guidelines around other pieces: banning upstream dams, ensuring there's a certain probability of failure, ensuring a certain factor of safety… regulating the distance between dams and communities," Morrill said. "There are certain things that can be set in stone that just haven't been put into any standard."

Earthworks' stance is that while there has been uptake on the GISTM from ICMM members and beyond, many communities inevitably remain at risk due to industry stragglers. "From our perspective, we still see both dangerous tailings proposals across the world, but also some pretty substandard tailings management practices that are aimed at reducing cost or supporting a company's bottom line," said Morrill.

Looking ahead

Within the industry, Chovan highlights the greater collaboration and open discussion between professionals on methodologies for studies and evaluations. "There's been a lot of sharing of knowledge, best practices, common risks and common solutions that have been discussed," she said. "There's been a lot of positive effort that's gone forward."

Companies are also already turning to train the next generation of tailings engineers and share their existing knowledge. "There's been a lot of development of new training programs, and they're all being developed with contributions from professionals in the industry who are giving their time to do it," Chovan said. "Everybody [is] trying to help fill the gap of the next generation of experts."

Before these recent developments, good tailings management was practiced more on an individual level than on an industry level. "This issue hadn't been owned across the industry," Matthews explained. "[There was no] global best practice standard that everyone was working towards. That's what we're now working towards."

The tailings dam failure in South Africa is just the latest tragic reminder of the gravity of the task.

"A disaster in a company doesn't just impact the company – it impacts the whole industry," Matthews said. "It challenges the social licence of the whole industry. It makes it difficult for people to have confidence in the whole industry. It makes it difficult for investors to have confidence in the whole industry. And that's what we want to avoid. We want to be able to really ensure this issue is well addressed and that we can have confidence in it." CIM

A September 2022 study in *Earth-Science Reviews* titled "Global magnitude-frequency statistics of the failures and impacts of large water-retention dams and mine tailings impoundments" recorded 303 reported tailings failures at 249 distinct mine sites between 1965 and 2020. However, due to the uncertainty of the true number of facilities and failures, such as in regions with poor reporting, this number might be incomplete.

- Jagersfontein image courtesy of Planet Labs. All others taken using Google Earth.

Courtesy of Altiplano Metals

Altiplano Metals mines copper, gold and iron at Farellon.

Small and symbiotic

Altiplano Metals builds a mill to get the most out of its Chilean mine

By Carolyn Gruske

Normally, junior mining companies promote their projects with talk of the potential for sky-high growth and expansion, but Altiplano Metals is taking a different approach: working with a hard limit on the output from its flagship mine and using a newly constructed mill to extract as much value as possible from that production.

Altiplano's El Peñón mill, which is located in the vicinity of La Serena, Chile, was designed to handle 5,000 tonnes per month – the same 5,000 tonnes per month that the company is permitted by the Chilean government to extract from its nearby Farellon mine.

Since June, Altiplano has been in the commissioning phase of the operation, and is expecting to begin full production in the fourth quarter of 2022. The timeline to getting up and running is relatively short, considering the company only received its government-issued construction permit in September 2021 and its final operating permit in June 2022. The mill had a capital cost of US$3 million and has an anticipated payback period of less than a year once it begins selling concentrate from the processing facility. In addition to copper, the mill will enable Altiplano to recover gold and iron from the mineralized material – metals that, until now, have not generated any revenue for the company.

Controlling its own future

The Farellon mine is a historical producer dating back to the 1970s, but Altiplano has been mining it only since 2018. Although Altiplano falls into the junior mining category, Alastair McIntyre, president and CEO, described the company as one focused on production, in addition to exploration. As a result, the company is "generating cash" through the sale of the Farellon mine production to the state-owned Empresa Nacional de Mineria (ENAMI), an agency that purchases and processes ore in addition to supporting small- and medium-sized miners in Chile.

Taking the processing in-house at the El Peñón mill will enable Altiplano to actually get paid for everything Farellon produces, explained McIntyre.

"When you're using a third-party processor, you're relying on their assays and their output. Whereas, when we are using our own facility, we are reducing our processing costs and getting a better handle of the contained metals because we're in control... and we have a product that's a little more homogenous and easier to analyze, in terms of a concentrate."

McIntyre explained that ENAMI does not credit shippers for contained gold below particular thresholds. By processing the material itself, the company expects to produce a concentrate that is approximately 26.5 per cent copper with between one and 1.5 grams of gold. "This way, we get credit for the copper, and also for the gold and the magnetic iron – which is expected to be above 62 per cent iron concentrate. Depending on the iron market, we could see as much as one third of our revenue coming from the iron alone."

Beyond giving Altiplano the ability to extract the full value for all of its products, the new mill cuts transportation costs by approximately 70 per cent, as the company is saved

from trucking its mined material to ENAMI, which is 35 kilometres away.

The mine

The underground mine's minerals reside primarily within the steeply dipping Farellon iron oxide-copper-gold vein system. (Two similarly mineralized veins, Laura and Rosario, are also located nearby.)

"The vein is very consistent and is continuous along strike and at depth. We have some dikes within the vein system, but they only extend for a maximum of 20 metres, and after that, we can get to the vein again," said operation manager Sebastián Badilla.

"When we started work on the mine, we built a decline with a 15 per cent grade for access by workers and machines. The access tunnel, named the Hugo decline, spirals to lower depths where we run horizontal sub-drifts to access working production headings. We are currently working at the 352 metre level, and we are pleased to see that the copper grade keeps getting better as we go deeper. The width of the vein is very consistent, rarely less than two metres, with an average of about three to four metres. We have seen the vein up to 10 metres wide in certain areas of the mine, especially as we go deeper. According to the drilling work we did last year, we have enough material for three years and we are working on a new drilling campaign to begin shortly."

The expected drill results should allow Altiplano to get an additional three years' of production from the mine, and allow the company to go 30 to 40 metres deeper.

Farellon operates under Chile's small-mining permit regime, which is where the 5,000 tonnes per month limit originates. It is also an achievable number for the mine, as that maximum output capacity was obtained in August, according to the company's most recently reported figures – figures that also show a 2.01 per cent copper grade (up from 1.69 per cent in July) out of 3,227 tonnes shipped and processed (up from 1,667 tonnes in the previous month), resulting in sales of 136,753 pounds of copper, which the company said was both a record amount for a month's production and 44 per cent higher than the 2022 monthly average of 95,000 pounds. August's revenues were US$313,000, in comparison to the US$149,579 earned in July.

Being small and sticking to limits is not a hindrance, explained McIntyre, especially given the supports the government has in place, including ENAMI, to back the industry. "Canada doesn't have that, nor do too many other countries. It supports small-scale mining and provides an opportunity to work, to establish new projects and to make money," he said. "Chile understands mining very well."

Altiplano also understands Chile's small-mining permit regime very well, and plans to keep working within its parameters. Future projects that the company pursues in Chile – such as the Maria Luisa gold-copper project, which is currently undergoing underground exploration – would be operated under the same regime.

The mill

The milling and flotation circuit at El Peñón is a relatively simple one, but even so, it is attracting attention in the industry. It consists of a crushing stage, two ball mills, a copper-gold flotation system, and a magnetic separation system. It also includes a dewatering circuit to produce dry tailings. The mill site totals nine hectares. Half of that land is being earmarked for tailings storage, and a large portion of the rest is set aside to stockpile enough ore to run the plant for at least one month.

The two 1.5 metre by three metre ball mills are run in parallel as that allows the circuit to keep running even if one mill goes down or requires maintenance, said Badilla. The two flotation cells have 15 banks, which are expected to turn out nearly 300 tonnes of 26.5 per cent copper concentrate every month.

"After the flotation system, we take the copper concentrate to a thickener to increase the solid content of the copper concentrate flow. Then, a high-pressure system pumps our copper concentrate to a vertical-plate filter to dry the copper concentrate to just under 50 per cent, which obviously saves a lot of water."

Badilla explained that the tailings are sent to a magnetic separator with three inline magnetic drums that will capture

Courtesy of Altiplano Metals

Altiplano CEO Alastair McIntyre (left) and operation manager Sebastián Badilla (right).

Q1 2018 to Q2 2022 figures for the Farellon mine	
Mined tonnes	156,308
Processed tonnes	118,916
Copper sales (in pounds)	4,469,803
Copper grade	1.78%
Revenue	$9,855,078

Figures supplied by Altiplano

the iron, which is then dried using a vacuum-disk filter that will yield 1,850 tonnes of at least 61 per cent iron concentrate each month. The tailings remaining in the magnetic drums are then placed into a second, larger thickener (measuring 12 metres vs. the seven metres of the first thickener). This is the step Badilla calls "unusual" in a plant of this size. "We wanted to save a lot of water in a country where water is a precious resource and we wanted to save a lot of space. The process also provides the opportunity to recover valuable iron from the tailings." Two vertical-plate filters will then dry the tailings until they reach 18 per cent moisture. "We could reduce it more, but if we reduce too much of the water content in the tailings, with the wind, we will have problems with generating dust."

The dry tailings are then moved to the storage part of the site, deposited in layers and compacted. "All the water recovered from the filters is sent to our process-water pool, and all the water will be reused in our processes. We are not using fresh water or potable water for our processes. We have a provider of industrial water and we can use recycled water from the Farellon mine," said Badilla. He estimates that the dry-stack approach will require approximately 75 per cent less water than facilities that use a traditional tailings-pond operation.

While dry-stack tailings may be common in large mining operations or in other parts of the world, no other small-miner in Chile has implemented them, according to Badilla. "We are the first... That is a good benefit for us and for our neighbours, because the impact – visual and environmental and social – of a tailings dam is huge compared with only a benign tailing deposit." He noted that the company is also looking to sell its final tailings for use in the construction and agricultural industries.

McIntyre said that other mining companies as well as financial companies have made inquiries about Altiplano's dry-stack tailings approach. "We're definitely getting interest."

Part of that interest allowed Altiplano to raise "a small amount" of capital financing to help pay for the mill, but most of the recent construction costs have been covered from revenue generated by Farellon.

Being a good neighbour

Creating a process where the output is dry tailings and not a tailings pond is important to Altiplano's goal of being the kind of neighbour – and business – that is welcomed by the local community. Other efforts to cement that reputation involve running the crushing facilities only during daylight hours, thereby reducing noise levels at night, and taking into consideration prevailing winds to ensure dust does not blow towards the plant's neighbours.

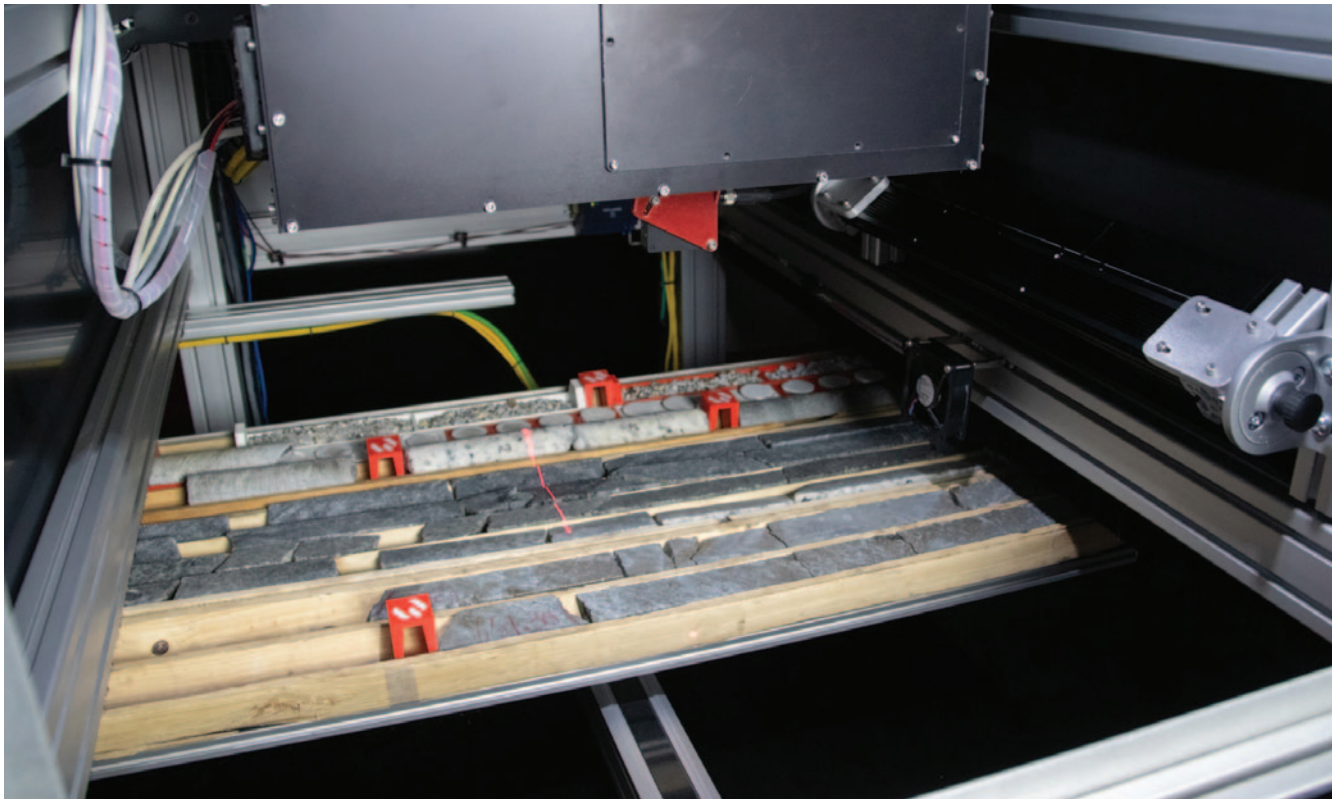
Courtesy of Altiplano Metals

When working at full capacity, El Peñón's flotation cells are expected to produce 300 tonnes of copper concentrate per month.

Hiring local contractors to perform construction, plumbing and electrical work was also important to Altiplano. "When we are talking about local providers, we aren't only talking about Chilean companies or contractors from La Serena. We have contractors who are neighbours. We already have a good relationship with them, especially in the Tambillos community at the Farellon mine. That's very helpful for the business. One focus for our plant and also for Farellon mine is to hire local workers. They live very close to both projects. That's a benefit for the company. We can save money on transportation, but our neighbours are happy with us, too, because we have a good relationship and common goals."

Once the mill is fully operational, Badilla expects it will employ 28 people. The mine, in comparison, employs 22 workers and contractors.

McIntyre said that Altiplano wants to go further than the "old-school" approach that sees mining companies hiring workers from the host country and building a school. Altiplano's goal is to extend services to the local community. For example, it has plans in place to provide Internet access for area residents. "We insure people have water. We ensure the roads are clear. We integrate ourselves into the community and support the community and they support us. We are an entity that is symbiotic and, from my perspective as CEO, we need to focus on those things and not just focus on the bottom line. The community around the mine and processing facility has grown up around our projects and we are sensitive to the people who are there.... We ensure everybody has a little bit better quality of life with our presence." CIM



Courtesy of Elemission

Elemission's ECORE allows for assaying without any sample preparation.

Assaying in the fast lane

Lab-tech companies are breaking the mould when it comes to mineral assaying, introducing faster, more efficient methods

By Sarah St-Pierre

Mineral assay results saw significant delays in 2021, with turnaround times shifting from a standard two to six weeks all the way to a range of eight to 12 weeks. As drilling activity significantly increased across the industry following several years of lower demand and investment in assaying, labs found themselves having to play catch up while also juggling labour shortages and pandemic safety measures. The ensuing delays left many mining companies frustrated and yearning for more efficient means to determine what mineral resources lay at their drill sites.

"Let's say you do a drilling campaign for one month. You drill the core, you send the core to the lab, you wait two to three months to have the result. The drills have been removed from the site, and maybe you didn't drill enough, deep enough and you didn't know, so now you have to bring back the drills," said François Doucet, CEO of Elemission. "If you had the feedback in real time, you'd be rescheduling on site without moving the drill. That's a very big implication in terms of greenhouse gas emissions."

And that is without pointing out the even more obvious: the logistical possibilities that come from adjusting drilling plans thanks to faster turnaround. For junior explorers who depend on being able to communicate a steady flow of information to investors to keep them interested, the financial implications are particularly significant.

Beyond the time-sensitivity benefits, new assaying technologies are also able to bring down costs and increase health and safety factors for lab employees. Removing the inputs of traditional assaying, such as the lead involved in fire assays or the perchloric and hydrofluoric acids of wet chemistry assays, more

Courtesy of Chrysos Corporation

Chrysos's PhotonAssay technology is able to perform analysis in minutes, compared to the hours required for traditional fire assay methods.

efficient technologies are not only eliminating recurring costs, but also reducing human exposure to hazardous substances and reducing their impact on the environment.

Automated X-rays

When it comes to gold, assaying is particularly challenging. According to James Tickner, chief technology officer and co-founder of Chrysos Corporation, gold has historically been difficult to measure due to its presence at very low concentration in core samples, requiring assaying methods sensitive enough to detect it.

Fire assay has long been the industry standard for gold because of the method's capacity to deliver these precise results. However, fire assays can take hours to conduct from start to finish, involving lead and furnaces to refine the sample down to a bead of silver doré that can be analyzed.

Chrysos's PhotonAssay technology instead uses X-rays to analyze ground-down rock samples. X-rays penetrate the sample for 15 seconds, exciting the atomic nuclei of the elements contained, such as gold, silver and copper. The activated sample can then be put in front of a very sensitive detector. Because activated atoms give off characteristic gamma rays, the detector can then count the gamma rays to measure how much of an element is present in the sample.

"The whole process takes less than two minutes and it's fully robotized, fully automated," said Tickner. "You more or less stick the sample in the slot, it comes out the other end and the result is returned to you."

The main benefits of PhotonAssay lie in its simplicity when compared to traditional means like the fire assay. The use of X-rays removes concerns for the sample's mineralogy; as long as there's gold in the sample, it does not really matter what else it is mixed with, according to Tickner. This eliminates the need for all the sample manipulations required by fire assays, improving the speed of the analysis and reducing both the amount of labour going into it as well as the safety hazards inherent to lead manipulations.

"In our experience, a single operator can run a PhotonAssay machine doing about 70 assays per hour, so 500-plus assays in an eight-hour shift," said Tickner. "For a typical lab, you'd be looking at several fire assay operators to do the same number of samples."

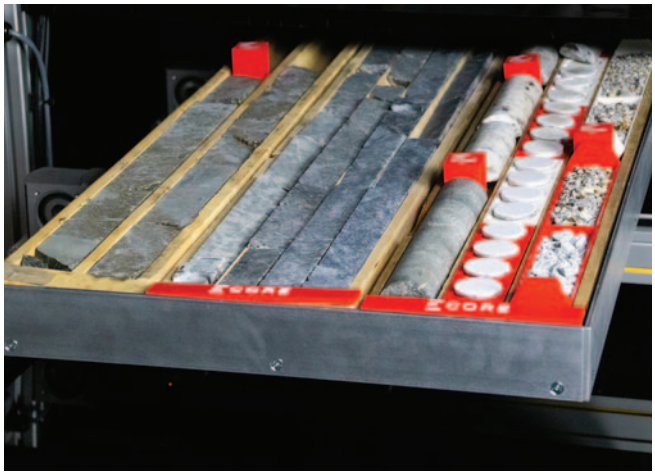
The ability to measure large samples – fire assay typically samples 30 to 50 grams of material, compared to PhotonAssay's 500 grams – also increases the likelihood of getting results that are actually representative of the mining core. "What we've shown [through repeat analysis] is pretty consistently that this bigger sample size just means that we get a more accurate and more precise result," explained Tickner.

Laser focus

Laser-induced breakdown spectroscopy (LIBS) is a well-researched technology used across a variety of applications, having been deployed as far as Mars through the probes of the Curiosity and Perseverance rovers. Creating another alternative to conventional assaying, Elemission applies LIBS to mineralogy and geochemistry in mining.

The company's first foray into the mining industry occurred in 2016 with its CORIOSITY hyperspectral imager. The CORIOSITY is now on its sixth generation and is regarded by Elemission as the "big brother" to its newer ECORE laser core scanner,

Courtesy of Elemission



Results can be obtained as fast as five minutes after the core is placed into the ECORE.

unveiled in 2021. The ECORE allows assaying without any sample preparation, and is able to process intact drill cores through LIBS and additional sensors.

Elemission's LIBS technology runs a laser through a lens and directs the laser on a metre-long drill core to create a white light. This is plasma light, which is then separated by wavelength thanks to an optical spectrometer that determines what emission lines are present. Each element on the periodic table has its own emission line measured in nanometers, which is how the minerals present in the samples can be identified. The intensity of their emission lines is proportional to their concentration in the sample.

The CORIOSITY and ECORE take the measurements and convey the results to the operators, requiring no more safety precautions than operating a standard laser printer. The ECORE can be deployed at the drill site in a mobile lab, whether the company's own or Elemission's, meaning that results can be obtained in as fast as five minutes after the core is removed from the drill and put in the ECORE.

"We are able to take 1,300 measurements per second," explained Doucet. "We can map a surface in no time, and with a multi-elemental fingerprint that includes light elements."

This specification makes the LIBS technology stand apart from scanning electron microscopy and energy dispersive X-ray spectroscopy, which, according to Doucet, are currently held up as the gold standard for mineralogy characterization. Their indirect detection, however, often wrongly attributes light element minerals, such as lithium and beryllium, or confuses spodumene and petalite, a problem that LIBS does not run into.

"You're not extracting the element; you're extracting the minerals," highlighted Doucet. "It's important to know the average saturation of the element in the one metre of core, but to extract it, it's more important to know which mineral you can find it in. For example, in some processes, you can extract the lithium in spodumene, but if it's in petalite, you can't do it because your process might not be tuned to extract from both petalite and spodumene. That's a game changer."

Cooler digestion

For minerals that do not require the precision of fire assays, a popular alternative is that of wet chemistry assays, through which core samples get dissolved in a solution to be analyzed. Digestion, a wet chemistry process, combines acidic reagents and energy to break down samples into liquid form.

Typical digestion assaying will involve a hot block or microwave unit to supply the energy component, taking over an hour to complete. Whereas hot blocks use heat and microwave units use microwaves, ColdBlock Technologies has introduced infrared waves as an alternative that significantly speeds up the process.

"The infrared waves pass through the test tube and acid and are absorbed by the sample," explained Craig West, CEO of ColdBlock Technologies. "That's why it's so fast and efficient: most of the infrared energy is absorbed by the sample directly, and this is what allows the digestion process to complete."

A ColdBlock unit, which can be placed under an existing vent hood, is typically able to achieve digestion in under 20 minutes. While such a rapid process would normally induce enough vaporization to threaten the remaining volume of the sample, a cooling zone at the top of the test tube takes care of recondensing vapours. This cooling zone is where ColdBlock digestion gets its name. The whole process yields enough remaining sample to test, delivering it in a relatively cool test tube that needs no further cooldown time.

West pointed to three assaying stakes that were front and centre in what ColdBlock strived to accomplish when designing its technology: speed, accuracy and employee safety.

"We have a customer who required both fire assay and a separate digestion method because they were testing for both gold and copper, so they were running two different processes for two different elements," recalled West. "What ColdBlock offered them was a single process that got them both gold and copper results at the same time. And by eliminating fire assay, they no longer need to worry about employee exposure to lead."

ColdBlock also makes it easier to digest elements that are typically challenging to assay through digestion, including volatile elements like mercury, and refractory elements like chromium. The company will soon be officially launching its ColdBlock Pro Series, the third generation of its digester. Aiming to improve scalability, the Pro Series will accommodate up to four digesters together, able to digest up to 80 samples at a time.

"Mining is where we started and where we have been focused for the last a couple of years," said West. "We see a real need within mining to streamline and improve the assay process and to shorten wait times." CIM

Courtesy of ColdBlock Technologies

ColdBlock uses infrared waves to significantly speed up the digestion process.

Courtesy of Mining Industry Human Resources Council

Ambassadors wanted

CIM and Mining Industry Human Resources Council launch program to inspire next generation of mine workers

By Michele Beacom

The shortage of talent is one of the most pressing issues facing the mining sector. Attracting, recruiting and developing the next generation of workers is vital to the industry's sustainability and growth. Youth and other jobseekers need to see mining as an innovative, challenging and rewarding career choice. To that end, CIM has joined forces with the Mining Industry Human Resources Council (MiHR) to launch the We Need Mining. Mining Needs You. Career Ambassador Program.

The ambassador program expands on MiHR's We Need Mining. Mining Needs You. website campaign to build awareness among young people and includes an interactive career pathway that outlines more than 50 potential mining careers as well as a scholarship section. "The ambassador program supports the campaign by connecting industry representatives with youth to inspire them with their mining stories and to provide guidance," said Ryan Montpellier, MiHR executive director.

"One of CIM's three strategic goals addresses expanding the awareness of the essential contribution mining makes to society," said Angela Hamlyn, CEO of CIM. "Through important partnerships and collaborations – such as this ambassador program – we are able to tap into our vast array of industry professionals to share the safe, responsible and sustainable practices of our industry and its many career opportunities."

"Our collaboration in co-branding the program as a joint initiative will help build a skilled, diverse and sustainable Canadian mining workforce," added Montpellier.

The idea of a career in mining has flown under the radar for young people. One objective of the new program is to enhance awareness amongst youth of the benefits of careers in mining, including financial rewards and working with cutting-edge technology.

Another goal of the program, one that has proven elusive with other initiatives to lure young people to mining, is to improve perceptions of the industry. To turn the negative image on its head, career ambassadors will focus on mining's role in environmental sustainability, social responsibility and technological innovation.

Through virtual and in-person speaking engagements organized with high schools, post-secondary institutions and other groups, career ambassadors will tell their mining stories, provide guidance and promote the sector and its numerous benefits and career opportunities.

Who are these career ambassadors? The short answer is CIM members. The program aims to connect knowledgeable and passionate industry representatives from among CIM's membership of mining, minerals and materials professionals with youth to increase awareness of the breadth of career opportunities our industry offers. Career ambassadors can come from a broad range of experience, such as someone enrolled in mining-related post-secondary studies, employed in any stage of a mining career or even retired from mining. Above all, career ambassadors are passionate and dedicated to promoting Canada's innovative, safe and sustainable mining sector.

The program framework makes becoming a career ambassador easy. Potential ambassadors can apply online and the program provides training by a MiHR program coordinator, as well as a program toolkit and supporting materials to help schedule, prepare for and deliver speaking engagements.

Attracting, recruiting and developing the next generation of workers is vital to the mining sector's sustainability and growth. The success of the We Need Mining. Mining Needs You. Career Ambassador Program relies on qualified and passionate volunteers to communicate mining's value to our standard of life and to encourage youth to pursue careers in the sector. CIM

Visit www.miningneedsyou.ca/career-ambassador-program/ for more information on how you can become a career ambassador.

Pathway to Net Zero

This year's Conference of Metallurgists returned in person for CIM's Metallurgy and Materials Society

By Michele Beacom

This year marked the 61st annual Conference of Metallurgists and to celebrate the return to in-person, the conference focused on more networking events and debates than COM has had in the past. With daily keynotes, three panel discussions and debates and a net-zero workshop, plus the traditional technical program of research papers, attendees had a lot of options to build their itineraries. "We really wanted to focus on speaking and debating with one another on the reality of net-zero. We were especially interested in reconnecting after such a long absence," said Brigitte Farah, MetSoc's managing director.

COM was lucky to have its usual strong student participation. Prizes were awarded to students in both the material field and the processing field. Students also had the opportunity to visit the Canadian Electrolytic Zinc Ltd. chemical plant and to have their own social programming such as a tour of the city, a student-industry mixer and a student lounge.

CIM and MetSoc thank all the chairs, the technical committee and the volunteers for the dedication and hard work that goes into making COM a success year after year for six decades.

COM 2022 AT-A-GLANCE

- 179 abstracts on Net Zero from Materials to Mineral Processing
- Over 400 attendees
- Keynote: A Tale of Two Worlds – From the Present World to a Low-Carbon One: The Importance of Metals and the Role of Canada
- Keynote: Canada's Critical Mineral Strategy?
- Big Idea Session on transformational R&D
- Attendees-wide workshop on Inspiration from Unexpected Places: People, Innovation, and the Pathway to Net Zero

Courtesy of MetSoc

COM's opening plenary was one of many panel discussions and debates on the challenges and opportunities this community faces to reach net zero. From left: conference chair and moderator Janice Zinck and panellists Rod Guthrie, Elvi Dalgaard, Joël Kapusta, Priti Wanjara and Chris Twigge-Molecey.

In particular, we thank the COM 2022 organizers and their supporting employers: Janice Zinck, Government of Nova Scotia; Roki Fukuzawa, Hatch; Sumanth Shankar, McMaster University; Sidney Omelon, McGill University; Niels Verbaan, SGS Natural Resources; Britt MacKinnon, Hatch; Chris Pickles, Queen's University; Elmira Moosavi, École de technologie supérieure; Jinhyuk Lee, McGill University; Mihaeila Isac, McGill University; Peng Peng, University of Waterloo; Penghao Xiao, Dalhousie University. CIM

Watch COM's curated panel session, Bottlenecks & Opportunities: The Material Foundations of a Net-Zero Economy, on YouTube!

Get more information on COM 2022, including statistics, summary content and more, by visiting the conference report website at: https://com.metsoc.org/2022/

Thank you to our sponsors and exhibitors

Continue the net-zero conversation next August in Toronto at COM 2023: Climate Change and Sustainability. com.metsoc.org

JANUARY 17 TO 19 JANVIER 2023 | WESTIN HOTEL | OTTAWA, CANADA

55th ANNUAL

CANADIAN MINERAL PROCESSORS

CONFERENCE

We are pleased to invite you and your colleagues to attend the 55th Annual Conference of the Canadian Mineral Processors (CMP).

The CMP conference has provided a forum for discussing best practices and the latest improvements in mineral processing technology. Almost 600 delegates attended the last in-person conference and profited from the outstanding opportunities in networking, knowledge sharing and personal development the CMP conference consistently offers.

The technical program is the heart and soul of the conference. This year, there will be approximately 40 technical papers presented by fellow mill operators and mineral processing professionals, and one panel discussion on comminution. In addition to discussions on Canadian milling practices, international speakers will weigh in on the mineral processing challenges they encounter abroad.

Students are invited to participate in this year's mentorship program and the student poster session.

We look forward to you joining us in the capital this January for this very special 55th anniversary of the conference.

Andrew Taylor, Chair

55e CONFÉRENCE ANNUELLE DES

MINÉRALURGISTES DU CANADA

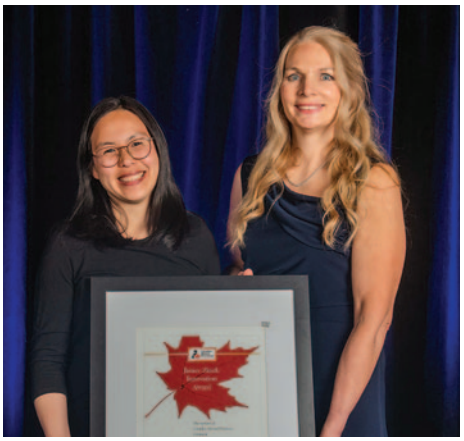
Nous sommes heureux de vous inviter à participer à la 55e Conférence annuelle des Minérallurgistes du Canada.

La conférence offre une plateforme afin de discuter des meilleures pratiques ainsi que des dernières avancées en matière de technologie de traitement des minéraux. Plus de 600 délégués ont participé à la conférence l'année dernière et ont pu profiter d'opportunités de réseautage, de partage de connaissances et de développement personnel.

Le programme technique est au cœur de l'événement avec près de 40 articles techniques présentés par des collègues opérateurs d'usines et des professionnels en traitement du minerai ainsi qu'une table ronde sur la comminution. En plus des discussions portant sur les pratiques d'usinage canadiennes, les conférenciers internationaux donneront leurs avis sur les défis relatifs au traitement des minéraux auxquels ils ont fait face à l'étranger. Les étudiants sont invités à participer au programme de mentorat de cette année et à la session d'affiches des étudiants.

En espérant vous voir en grand nombre dans la capitale canadienne en janvier prochain afin de célébrer avec nous cet événement très spécial.

Andrew Taylor, président



GENERAL INFORMATION | RENSEIGNEMENTS GÉNÉRAUX

Held in Ottawa at the Westin Hotel on January 17-19, 2023, the conference will feature presentations on various aspects of mineral processing including comminution, flotation, gold and iron ore processing, mineralogy, mill optimization, and process control.

La conférence se tiendra à l'Hôtel Westin à Ottawa du 17 au 19 janvier 2023. Elle comprendra des présentations traitant de divers aspects minéralurgiques tels que la comminution, la flottation, le traitement de l'or et du fer, la minéralogie, l'optimisation des usines de traitement, le contrôle de procédés.

ACCOMMODATIONS | HÉBERGEMENT

A special rate of $236 (standard/premium) and $286 (deluxe) which includes complimentary internet has been negotiated at the Westin Hotel (reference the Canadian Mineral Processors Conference). The Westin Hotel will only guarantee these rooms until January 2, 2023, so book early to avoid disappointment.

Un nombre limité de chambres incluant l'accès internet a été négocié avec l'Hôtel Westin à un tarif spécial de $236 (traditionnelle/premium) et $286 (de luxe) (référence à la Conférence annuelle des Minérallurgistes du Canada). Veuillez noter que les chambres sont retenues à notre intention jusqu'au 2 janvier 2023. Veuillez réserver votre chambre le plus tôt possible afin d'éviter tout inconvénient.

AUTHORS | AUTEURS

Authors, session chairs and regional representatives must register as conference delegates. A speaker's breakfast will be provided the day of their presentation at 7:00 a.m. Authors, please contact Irma Gabric Burk (Irma.Gabric@transmin.com.au) for presentation information.

Tous les auteurs, les présidents de sessions et les représentants régionaux doivent s'inscrire à titre de délégués à la conférence. Un déjeuner sera servi le jour de leur présentation à 7 h. Auteurs, veuillez contacter contact Irma Gabric Burk (Irma.Gabric@transmin.com.au) pour obtenir de l'information au sujet des présentations.

SHORT COURSES | COURS ABRÉGÉS

COURSE / COURS	**PRESENTERS /** PRÉSENTATEURS
Attendance is limited, please register early! La participation est limitée, s'il vous plaît, inscrivez-vous tôt!	
Ore Characterization for Sensor-Based Sorting |	Jane Danoczi (SRC)
Preconcentration: What, When, Why, How	Harold Cline (Tomra)
Title TBD	Glencore Technologies

TECHNICAL PROGRAM | PROGRAMME TECHNIQUE

Program subject to change | programme sous réserve de modifications

TUESDAY, JANUARY 17 | MARDI 17 JANVIER

8:30	CHAIR OPENING REMARKS | **ANDREW TAYLOR**
8:40	**PLENARY PRESENTATION** – SOCIAL LICENSE – DRIVE TO DECARBONIZE
	FLOTATION
9:30	**[BREAK]**
10:00	VACANT
10:30	SULPHIDE MINERAL FLOTATION USING AN ENVIRONMENTALLY FRIENDLY COLLECTOR | **CHARLOTTE GIBSON**
11:00	RECOVERING GRAPHITE FROM SPENT LITHIUM-ION BATTERY BLACK MASS VIA FLOTATION WITHOUT PRE-TREATMENT | **BEN YU**
11:30	PREDICTING THE METALLURGICAL RESPONSE OF ORE BLENDS | **JUSSI LIIPO**
12:00	**[NETWORKING LUNCHEON]**
13:30	TECHNICAL AND ECONOMIC IMPACTS OF SPLIT FLOTATION VS CONVENTIONAL BULK FLOTATION IN POTASH PROCESSING | **TIM MBANGA**
14:00	INVESTIGATIONS INTO SPODUMENE AND LEPIDOLITE FLOTATION | **MASSOUD AGHAMIRIAN**
14:30	METALLURGICAL PERFORMANCE OF THE CONCORDE CELL™ AS OPPOSED TO SELF-ASPIRATED PNEUMATIC FLOTATION TECHNOLOGY IN AN INDUSTRIAL PLANT | **NATHALIE KUPKA**
15:00	**[AFTERNOON BREAK]**
	GOLD PROCESSING
15:30	REAL TIME MONITORING AND CONTROL OF GOLD PROCESSING PLANTS | **KEN ROBERTS**
16:00	FUTURE OF SO2/AIR CYANIDE DESTRUCTION PROCESS | **RANDY AGIUS**
16:30	GOLD METALLURGICAL ACCOUNTING – A CASE STUDY | **MANOCHEHR OLIAZADEH**
16:45	**DAY 1 CONCLUDES**
21:00	**CHAIR'S RECEPTION**

WEDNESDAY, JANUARY 18 | MERCREDI 18 JANVIER

	PROCESS PERFORMANCE AND RELIABILITY / (PLANT PERFORMANCE MONITORING AND OPTIMIZATION)
8:30	ASSESSMENT OF THE TURN-BY-TURN MASS BALANCE IN A GRAVIMETRIC SEPARATION SPIRAL | **LAURENCE BOISVERT**
9:00	NICKEL ORES – NEW TOOLS FOR SUSTAINABLE AND EFFICIENT PROCESS MONITORING | **MARIE-EVE PROVENCHER**
9:30	MODELING OF GRINDING CIRCUIT CONTROL USING DATA–DRIVEN APPROACH FOR AN INDUSTRIAL CASE STUDY | **ALI VAZIRIZADEH**
10:00	**[BREAK]**
10:30	IMPLEMENTATION OF A NOVEL ADVANCED PROCESS CONTROL STRATEGY TO REDUCE MILL POWER CONSUMPTION | **JULIAN KNIGHT**
11:30	**[CMP ANNUAL GENERAL MEETING AND LUNCHEON]**
	FLOWSHEET, OPERATIONS AND START-UP
13:00	BLOOM LAKE PLANT UPGRADE - ITERATIVE TESTING HELPS CHOOSE THE FLOWSHEET TO BRING OPTIMUM VALUE | **TRACY HOLMES**
13:30	CROSS BELT SAMPLER: MECHANICAL DESIGN OF THE WORLD'S LARGEST HAMMER SAMPLER FOR BAUXITE EXPORT CONTRACTUAL REQUIREMENTS | **WILLEM SLABBERT**
14:00	SILVER GRAPHENE OXIDE PRODUCTION | **JIM KAMBOSSOS**
14:30	**[AFTERNOON BREAK]**
15:00	PRODUCTION OF CHEMICAL-GRADE SPODUMENE CONCENTRATE BY DENSE MEDIA SEPARATION FROM THE CV5 PEGMATITE | **VU TRUONG**
15:30	COREM CYANIDATION REGENERATION AT LARONDE | **PATRICK LAFLAMME**
16:00	VACANT
16:30	**DAY 2 CONCLUDES**
19:00	**[GALA]**

SOCIAL EVENTS | ACTIVITÉS SOCIALES

MONDAY | LUNDI

9:00–11:00 p.m.	Student mixer | Mixer étudiant

TUESDAY | MARDI

noon | midi	Networking luncheon | Dîner de réseautage
9:00 p.m.–midnight | 21h00 à minuit	Chair's Reception | Réception du président

WEDNESDAY | MERCREDI

noon | midi	Annual Business Meeting Luncheon | Dîner annuel de la réunion des affaires
evening | soirée	Awards Gala, Pre-, Post and VIP Receptions | Gala de remise de prix, Réceptions de Pré-, Post et VIP

THURSDAY, JANUARY 19 | JEUDI 19 JANVIER	
COMMINUTION AND ORE SORTING	
8:30	COARSE GRINDING ON AN ISAMILL? | **ION GURNETT**
9:00	THE EFFECTS OF DIFFERENT DISCHARGE DESIGNS ON WET BALL MILLING PERFORMANCE | **ROB MCIVOR**
9:30	THE CONJUGATE ANVIL HAMMER MILL – A NEW, HIGH EFFICIENCY, COARSE GRINDING MACHINE | **STEVE WILSON**
10:00	**[BREAK]**
10:30	MACHINE LEARNING ANALYSIS OF THE CANADIAN ROYALTIES CRUSHING AND GRINDING CIRCUITS | **TONY DI FEO**
11:00	THE CRUSH IT! CHALLENGE PROGRAM AS CRITICAL CANADIAN INNOVATION IN DRIVING INNOVATION | **ROB STEPHENS**
11:30	**[LUNCH BREAK]**
13:00	ORE HETEROGENEITY ASSESSMENT: IN SEARCH OF UNIVERSAL METRICS | **ANDRIY PLUGATYR**
13:30	REDUCED LOAD SORTERS TO ACCOMPLISH MODULAR MILL DESIGN | **AMY ZHOU, BRENT HILSCHER**
14:00	ADVANCING CONCEPTS FOR MULTI-CHANNEL LASER SORTING | **HAROLD CLINE**
14:30	GRADE DEPENDENT SAMPLE TIME FOR PGNAA | **AMY ZHOU, BRENT HILSCHER**
14:40	**[PRE-PANEL RECEPTION]**
15:15	PANEL - DECARBONIZATION
16:45	**[CLOSING RECEPTION]**
18:00	**CONFERENCE CONCLUDES**

REGISTRATION | INSCRIPTION

(includes one-year membership to CIM/
comprend un abonnement d'un an à l'ICM)

CIM MEMBERS |
MEMBRES DE L'ICM
$925 (+ HST)

•

NON-MEMBERS OF CIM |
NON-MEMBRES DE L'ICM
$1,122 (+ HST)

Registration includes the three-day meeting, a downloadable PDF of the conference proceedings, coffee breaks, the Tuesday and Wednesday luncheons and evening social receptions, the Wednesday reception and awards banquet. Conference registration and attendance at social events should be indicated when registering.

L'inscription donne droit aux trois jours de réunions, à une copie PDF des comptes rendus, aux pauses-café, au dîner du mardi et du mercredi, et à la réception sociale en soirée ainsi qu'à la réception/souper le mercredi soir. Veuillez vous inscrire aux activités sociales pendant que vous vous inscrivez à la conférence.

Conference registration now open.
L'inscription à la conférence est maintenant disponible en ligne.

www.cmpsoc.ca

THE WORLD COMES HERE.

TMS 2023

152nd Annual Meeting & Exhibition

MARCH 19–23, 2023 | SAN DIEGO, CALIFORNIA, USA
#TMSANNUALMEETING | www.tms.org/TMS2023

REGISTER AND BOOK HOUSING TODAY: JOIN US FOR THE FULLY IN-PERSON TMS2023

Join us at one of our most popular destinations for the TMS Annual Meeting & Exhibition: San Diego, California! Historically, San Diego has hosted the Society's best-attended meetings, and—with more than 4,500 abstracts submitted—we expect strong attendance once again for TMS2023.

WHY TMS2023

"TMS is a very meaningful conference for two types of people: 1) Full-fledged academicians trying to learn and solve for 'Whys' and 2) Industry people who have to create large workflows with known pieces of technology implemented in innovative ways, then can either replace or learn how to change portions of that workflow in alternative ways for their customers."

—**Deepankar Pal,**
Senior Principal, Ansys Inc., Clemson University

KEY DEADLINES

January 31, 2023: Discount Registration Deadline

February 23, 2023: Housing Deadline

SCAN ME

REGISTER AND BOOK HOUSING AT: www.tms.org/TMS2023

SECTION
FRANCOPHONE

NOVEMBRE 2022

Point de vue depuis *Nickel City*

La dernière édition du *Maintenance, Engineering and Reliability/Mine Operators Conference* (MEMO, le colloque sur l'ingénierie, la maintenance, la fiabilité et l'exploitation minière) à Sudbury, dont le thème était *Perseverance in a New World* (La persévérance dans un monde nouveau), n'aurait pu, en toute honnêteté, trouver de titre plus pertinent. L'événement, reporté plus d'une fois en raison de la pandémie, a finalement eu lieu en septembre. Je tiens à féliciter le comité organisateur de Sudbury et sa persévérance pour que l'événement ait lieu. Le discours-programme, présenté par Johnna Muinonen, présidente de Dumont Nickel, a pris fait et cause pour les sociétés d'extraction des métaux qui font face à un nouveau monde, notamment celles qui assureront l'approvisionnement en matériaux nécessaires à la décarbonation de l'économie.

Pour répondre à la demande prévue en nickel, la planète devra compter sur au moins 40 mines de nickel supplémentaires produisant chacune 38 000 tonnes par an d'ici 2030, indiquait M^me^ Muinonen.

Les ressources en nickel du Canada lui confèrent une bonne position et permettront d'assurer une partie de la capacité de production nécessaire. Toutefois, M^me^ Muinonen insistait sur le fait que nos réserves de matériaux bruts ne couvriront qu'un seul des nombreux obstacles qui se profilent entre la production actuelle et la demande prévue.

« Le Canada a, selon moi, un rôle à jouer, et l'avenir s'annonce intéressant », déclarait-elle, ajoutant que la part du pays dans la production mondiale de nickel s'est contractée au fil des ans, à mesure que l'Indonésie s'est imposée en tant que géant de l'extraction du nickel. D'après M^me^ Muinonen, le Canada a un avantage certain du fait de son accès à une énergie sûre et propre, de sa considération envers les critères environnementaux, sociaux et de gouvernance (ESG), de son expertise locale en matière de mines et de métaux, de ses politiques gouvernementales favorables et de sa proximité aux États-Unis, qui se sont engagés à investir des centaines de milliards de dollars dans l'énergie et le changement climatique et d'en mettre une partie à la disposition de leurs partenaires en vertu des accords de libre-échange.

Pour que cet avenir se concrétise, indiquait-elle, il faudra renforcer la capacité de traitement et l'expertise technique, et améliorer l'intégration dans l'ensemble de la chaîne d'approvisionnement.

« On ne peut pas simplement dire que l'on va construire une myriade d'usines de sulfate de nickel et qu'on va le vendre à quelqu'un. Si l'intégration ne s'est pas faite en aval, les fabricants de batterie peuvent se retourner contre vous et vous dire que le sulfate de nickel n'est pas traité selon les spécifications. Le procédé de qualification est extrêmement complexe. Il sera primordial de collaborer avec des partenaires dans l'ensemble de l'écosystème. »

M^me^ Muinonen faisait aussi remarquer que les progrès en matière de traitement de latérite nickélifère et la montée en flèche du prix du nickel ont bouleversé le marché. Les latérites sont désormais une source de nickel pour les matériaux nécessaires à la fabrication des batteries. Il y a encore peu de temps, cette application relevait du domaine des sulfures de nickel. Cela vient nous rappeler l'allure à laquelle se produisent les changements.

Le fait que nous ayons besoin d'un nombre invraisemblable de mines de nickel dans les huit années à venir montre clairement que nous allons devoir trouver des produits de substitution qui aideront à satisfaire la demande d'énergie verte sous-jacente. Je suis toutefois convaincu que les sociétés dirigeant des projets d'exploitation du nickel feront preuve de persévérance. L'autre option est que nous ne parviendrons pas à atteindre les objectifs de décarbonation qui ont été fixés. J'ai espoir que ce n'est pas la direction que nous prendrons. Mais bien entendu, les nouveaux mondes ne sont pas livrés avec un mode d'emploi.

Ryan Bergen, Rédacteur en chef
editor@cim.org
@Ryan_CIM_Mag

Avec l'aimable autorisation d'Anne Marie Toutant

Confiance

La confiance est le ciment de la société, écrivait Dennis Jaffe, spécialiste de la collaboration avec des entreprises familiales. « Sa présence consolide les relations… elle permet aux organisations et aux communautés de s'épanouir. L'absence de confiance est source de confrontation, de conflit, voire de guerre. »

Ces mots puissants ont attiré mon attention il y a quelques semaines. Alors que je ratissais les centaines de courriels qui avaient inondé ma boîte de réception pendant la nuit, l'objet de l'un d'eux, *Building Trust to Decarbonize the World* (Instaurer la confiance pour décarboniser le monde) m'a interpellée. Je décidais de l'ouvrir, et non pas de le supprimer comme je procède le plus souvent. À ma grande surprise, je constatais qu'il s'agissait du thème du congrès et du salon commercial de l'ICM 2023 sélectionné par le comité organisateur, dirigé par le président du congrès David Cataford, chef de la direction et directeur de Champion Iron.

La conviction de l'honnêteté, de l'intégrité et de la fiabilité des autres est la base de la confiance sociale. Cette confiance se forge lentement, et peut disparaître en un instant. Un sondage mené par Abacus Data et publié par l'association minière du Canada (AMC) le 27 juin 2022 vient confirmer la confiance accrue accordée à l'industrie minière canadienne. Ce rapport, élaboré sous forme de sondage, indiquait qu'au cours des sept dernières années, le nombre de citoyens canadiens qui pensent que les sociétés minières au Canada inspirent confiance à la population a légèrement augmenté, de 76 % à 81 %. Bruce Anderson, président d'Abacus Data, déclarait que la population canadienne attend des progrès en matière d'action climatique et un avenir générant moins d'émissions de dioxyde de carbone (CO_2). Le sondage de 2022 a révélé quelques tendances. « Tout d'abord, la population canadienne a conscience des possibilités économiques qu'offre le secteur minier en termes des usages futurs des minéraux et des métaux produits de manière durable. Ensuite, elle constate que les sociétés minières canadiennes avancent dans la bonne direction dans tout un éventail de priorités, qu'il s'agisse de la gérance de l'environnement, de la réduction des émissions ou des relations avec les Autochtones », indiquait-il.

> « La confiance ouvre la voie à des possibilités nouvelles et insoupçonnées. »
>
> – Robert C. Solomon

À l'avenir, les sociétés canadiennes participant à la production durable des métaux et des minéraux nécessaires à la planète pour parvenir à un avenir à faibles émissions de CO_2 devront impérativement préserver cet élan de confiance. La transition devient omniprésente : les déclarations en faveur de la neutralité carbone se transforment en premières étapes d'actions concrètes, et des partenariats sous forme d'alliances se créent avec d'autres dans le but de faire progresser les technologies en faveur des réductions sur les moyen et long termes. Plusieurs exploitants faisant équipe avec des fabricants d'équipement d'origine (FEO) ont déclaré qu'ils commenceront leur transition dans les années à venir, en remplaçant leurs parcs de véhicules par de gros camions miniers électriques alimentés par batterie ne générant pas d'émissions. L'avancement des projets depuis l'obtention des permis jusqu'à la construction implique de mettre à profit des modèles économiques qui incluent les communautés locales et des Premières Nations. Les progrès en matière d'empilage à sec (*dry stacking*), d'évacuation et de mélange mixtes des déchets et des résidus miniers réduisent les risques en éliminant l'eau des zones d'entreposage des résidus.

Et vous, que faites-vous pour inspirer confiance en l'industrie et en votre société ? Quelles mesures votre société prend-elle pour faire avancer l'exploitation minière durable au Canada ? Quelles mesures prenez-vous pour mettre en œuvre les technologies, faire équipe avec d'autres, protéger votre main-d'œuvre, obtenir des financements et réduire votre empreinte ? Une manière d'instaurer la confiance consiste à faire preuve de transparence et à partager les connaissances et les meilleures pratiques. L'appel à contributions du congrès de l'ICM 2023 est ouvert. Inspirez-nous et partagez !

Anne Marie

Anne Marie Toutant
Présidente de l'ICM

Avec l'aimable autorisation de Stantec

Afin d'atteindre leurs objectifs de neutralité carbone, les sociétés minières doivent prendre le risque de tester des technologies non éprouvées et de se tourner vers des technologies qui existent mais sont rarement mises en œuvre, comme le triage du minerai.

Le tournant décisif

Si elles espèrent atteindre leurs objectifs de neutralité carbone, les sociétés minières doivent prendre des risques concernant la mise en œuvre de nouvelles technologies plutôt que de se contenter d'être « les premières à arriver deuxième »

Par Kelsey Rolfe

La mine de Tanami de Newmont Corp. en Australie et son exploitation de Cripple Creek & Victor dans le Colorado sont très différentes. Tanami, une exploitation souterraine, a devant elle des décennies de vie et a reçu un investissement majeur de la part de Newmont pour la construction d'un nouveau puits. La mine à ciel ouvert de Cripple Creek & Victor (CC&V), quant à elle, a une durée de vie bien plus limitée après une campagne de production de plusieurs décennies.

Chacune, à sa manière, est le lieu idéal pour un partenariat entre Newmont et Caterpillar Inc., qui développera et testera des parcs de véhicules électriques à batterie dans des environnements souterrains et à ciel ouvert. Au titre de l'entente, conclue l'année dernière, Newmont a initialement investi 100 millions de dollars américains pour développer « un système minier de bout en bout sans émissions de dioxyde de carbone » avec Caterpillar, notamment des véhicules miniers électriques, l'infrastructure, l'automatisation ainsi que la collecte et l'analyse de données.

Tanami donnera au géant de l'équipement les terrains d'essai pour sa technologie souterraine de véhicules électriques à batterie, dont il ne dispose pas actuellement. Ses décennies de vie prévues donnent à Newmont la flexibilité nécessaire pour expérimenter de nouvelles conceptions de mines qui pourront s'adapter à une infrastructure électrique.

Quant à la mine CC&V, Caterpillar y testera ses tombereaux électriques à batterie pour les mines à ciel ouvert dans des conditions météorologiques austères, des étés étouffants aux hivers glacials, et des pluies torrentielles aux vents forts. « Si la technologie fonctionne ici, les essais sont catégoriquement probants », déclarait Rob Atkinson, vice-président exécutif et directeur de l'exploitation de Newmont. Pour Newmont, expliquait M. Atkinson, les avantages de CC&V montrent à l'industrie les solides arguments économiques pour déployer les véhicules électriques à batterie (VÉB), même pour une mine en exploitation depuis de longues années et arrivée à maturité.

Les sociétés prévoient l'adoption du parc électrique souterrain et de l'automatisation d'ici 2026, et celle de camions électriques et d'une infrastructure électrique à ciel ouvert d'ici 2027. D'après M. Atkinson, le développement des calendriers est agressif, mais Newmont a ressenti l'impératif de faire partie des premières sociétés à adopter ces véhicules.

« Nous sommes conscients que nous ne pouvons plus attendre pour agir, que nous devons prendre des mesures absolument tangibles », indiquait M. Atkinson, qui faisait remarquer qu'environ 40 % des émissions de la société émanaient des parcs de véhicules souterrains et de surface.

Pour atteindre leurs objectifs de neutralité carbone, les sociétés minières doivent choisir de s'opposer à une préférence propre à cette industrie, consistant à être « la première à arriver en deuxième position ». Elles prévoient d'intégrer des technologies et des processus qui ne sont pas adoptés à grande échelle ni même commercialisés.

« Nous nous trouvons vraiment à un tournant dans l'industrie. La question n'est pas de savoir *pourquoi* nous procédons de la sorte, mais plutôt *comment* », déclarait Brian Mashford, premier vice-président de l'exploitation minière à Stantec. « Nous recevons de nombreuses demandes de la part de nos clients qui sollicitent notre aide pour mettre en œuvre certaines technologies et pour se familiariser avec la direction que va prendre l'industrie en aval. »

D'après M. Mashford, les parcs de véhicules à batterie pour les exploitations à ciel ouvert ainsi que les véhicules à l'hydrogène, les petits réacteurs modulaires (PRM), le transport modulaire autonome et le triage du minerai sont des technologies qui contribueront énormément à l'objectif de neutralité carbone de l'industrie minière. Il reconnaît toutefois que les sociétés sont encore aux prises avec leur mise en œuvre.

Tenir les rênes

Durant l'année qui s'est écoulée, nombre de sociétés minières ont annoncé des partenariats ou des consortiums avec des fabricants d'équipement d'origine (FEO) et des fournisseurs afin d'accélérer le développement des parcs de véhicules électriques à batterie ou à l'hydrogène, ainsi que de véhicules pilotes à mesure qu'ils deviennent disponibles.

En juin 2021, la société Nouveau Monde Graphite (NMG) de Montréal annonçait un accord de coopération avec Caterpillar pour développer un parc sans émissions pour sa mine phare de Matawinie d'ici sa cinquième année de production commerciale. Matawinie, qui devrait être opérationnelle d'ici 2025, commencera les activités avec un parc de véhicules fonctionnant au diesel, et recevra son nouvel équipement électrique de Caterpillar au cours des années à venir. Eric Desaulniers, fondateur, président et chef de la direction de NMG, indiquait que ce calendrier permettrait à la société de progressivement tester et intégrer les nouveaux véhicules dans la production, et de comparer leurs indicateurs de rendement clés (IRC) à ceux du parc existant au diesel.

Teck Resources, de son côté, s'est engagée à tester un véhicule à émission nulle (VÉN) en phase précommerciale de Caterpillar à compter de 2024. L'essai aura lieu à sa mine de charbon d'Elk Valley, mais pas dans une capacité de production, indiquait le directeur des relations publiques Chris Stannell. La société prévoit de commencer la production en testant un petit parc de VÉN pilotes d'ici 2026, dans l'objectif de commencer à utiliser 30 camions commercialisés l'année suivante.

D'après M. Stannell, la société étudiera des paramètres telles que la vitesse en pente, la durée de vie des composants et la disponibilité mécanique, ainsi que des données sur le groupe motopropulseur électrique à batterie telles que le taux de charge et le rendement énergétique. « L'objet de ces essais sera de comprendre le bien-fondé du remplacement du parc au diesel dans l'exploitation en évaluant un éventail de paramètres opérationnels, notamment la chaleur et le froid extrêmes, la résistance variable au roulement, les cycles de transport d'un véhicule chargé à la montée et à la descente, et beaucoup d'autres paramètres », indiquait-il. L'exploitation d'Elk Valley utilise plus de la moitié du parc de camions de la société, et plus de deux tiers de ses camions de transport de la catégorie *ultra-class* (les plus gros tombereaux). Il était donc « stratégiquement important » pour la société de s'assurer que les VÉN sont bien adaptés à ces conditions, expliquait M. Stannell.

Dans le centre de la Colombie-Britannique (C.-B.), Martin Turenne, président, chef de la direction et directeur de la société FPX Nickel Corp. basée à Vancouver, envisage une technologie différente en cours de développement. Pendant des années, le projet Decar d'exploitation du nickel de FPX a accueilli Greg Dipple, professeur de sciences de la Terre de l'université de la Colombie-Britannique (UBC), dont le laboratoire CarbMinLab travaille sur l'avancement de la séquestration du carbone dans les résidus miniers.

Les travaux de recherche de M. Dipple ont montré que la roche ultrabasique (ou roche ultramafique, des roches magmatiques très pauvres en silice et très riches en oxydes de fer et de magnésium et en potassium) est la plus optimale pour capturer et minéraliser le dioxyde de carbone (CO_2). Le gisement de Decar est plus qu'adapté à cette technique.

D'après les précédents travaux de M. Dipple à la mine de Mount Keith de BHP, en Australie-Occidentale, la séquestration du carbone dans les résidus est un processus naturel. Il a découvert que les résidus de la mine captaient naturellement 40 000 tonnes de CO_2, soit 11 % des émissions annuelles de l'exploitation. M. Dipple s'efforce d'accélérer le processus. La recherche n'est pas terminée, mais M. Turenne indiquait que

FPX l'intégrera à son plan de mine pour Decar. La société prévoit de parvenir à une décision concernant la construction du projet de nickel d'ici 2027.

« Notre avantage est que nous avons espoir de pouvoir développer nous-mêmes certains de ces procédés. Nous les fabriquerons de manière à les adapter spécifiquement à notre plan de développement du site en général, et de la mine. Nous pourrons les construire et les intégrer à l'ADN du produit en effectuant des travaux techniques relativement tôt. »

D'après M. Turenne, FPX devra mener des essais pilotes afin d'obtenir des données précises quant au potentiel de séquestration de ses résidus en grattant leur surface et en comparant le degré de séquestration naturelle à une quantité contrôlée de matériaux qui n'ont pas été grattés. Il ajoutait que d'après les travaux de recherche de M. Dipple, c'est en « perturbant » les résidus (par exemple en refroidissant leur surface) que l'on obtient une plus grande séquestration.

« Se profile devant nous une longue phase d'essai, mais nous savons qu'en prenant le problème à la racine, nous allons pouvoir parvenir à une séquestration relativement importante, sans rien faire pour renforcer la réaction chimique », indiquait-il.

Critères de conception

La planification inhérente à l'adoption de nouvelles technologies s'accompagne de difficultés en termes de conception, indiquait M. Atkinson. Les mines souterraines traditionnelles présentent des contraintes particulières, notamment des tunnels étroits et des rayons de braquage qui doivent s'adapter à l'infrastructure de chargement. « Il faut aussi vraiment penser à l'intégralité de l'infrastructure, et déterminer si cela implique une conception différente des intersections. Il faut calculer si des galeries d'avancement vides doivent être prévues pour le chargement, si de nouvelles infrastructures doivent être installées latéralement aux camions afin qu'ils soient constamment alimentés en électricité », expliquait-il. « Si l'on considère qu'il ne s'agit que d'un équipement à brancher, on ne parviendra jamais aux résultats. »

Les mines qui utilisent des véhicules autonomes, expliquait-il, ont toujours construit des routes plus larges et des virages qui tiennent compte de l'envergure de ces camions. Toutefois, Newmont cherche à réduire la largeur de ces routes étant donné l'évolution de la technologie d'automatisation à ce jour, afin d'éviter de créer des résidus supplémentaires.

Nouveau Monde Graphite a procédé à plusieurs changements au niveau de la conception de la mine en prévision du parc de véhicules entièrement électriques à Matawinie, indiquait M. Desaulniers.

La société a changé son plan de mine afin de commencer l'extraction dans la partie sud de son gisement de trois kilomètres de long pour les cinq premières années. Il s'agit d'une application à la montée, où les camions descendent à vide dans la fosse et remontent à plein. D'après M. Desaulniers, cette situation est loin d'être idéale pour les véhicules électriques, mais le parc initial fonctionnant au diesel pourra assurer ces besoins. À compter de la sixième année, date à laquelle tous les véhicules devraient être électriques, l'exploitation minière passera à une application à la descente dans le reste du gisement. « La descente est bien plus simple, plus productive et moins onéreuse pour un parc de véhicules électriques. De fait, on ne gaspille pas d'énergie pour freiner, et le camion n'a pas besoin d'être rechargé aussi souvent. »

La société a également décidé de ne pas faire fonctionner la mine de Matawinie la nuit, accordant ainsi un temps supplémentaire pour la recharge des VÉB, ajoutait-il.

Les aléas

Particulièrement en ce qui concerne les parcs de VÉB, M. Mashford reconnaissait qu'il existe un compromis financier en amont. Les véhicules électriques et l'infrastructure qui leur est associée requièrent plus de capital au début, mais s'avèrent être moins onéreux que le diesel sur leur durée de vie. De fait, les coûts opérationnels de l'équipement fonctionnant au diesel sont supérieurs, notamment au niveau des exigences en termes d'aérage. Les sociétés minières devront aussi composer avec le coût et le procédé de remplacement de leur parc de véhicules au diesel pour un parc entièrement électrique, ce qui peut s'avérer extrêmement difficile pour des sociétés plus petites.

Nouveau Monde Graphite maîtrise ces coûts en concluant une entente avec Caterpillar dans le cadre de ses services de gestion de flotte *Job Site Solutions*. Le FEO facturera un tarif par heure pour chaque équipement que la société utilise, ce qui permettra à NMG d'éviter des dépenses en immobilisations exorbitantes liées à l'achat d'un équipement en totalité, puis à son remplacement.

« Il est difficile pour une petite entreprise en démarrage de justifier une telle dépense en immobilisations telle que celle requise pour les [VÉB]. La solution que propose Caterpillar, qui consiste à l'intégrer à son bilan, est très intéressante », indiquait M. Desaulniers, ajoutant qu'il s'attend à ce que ce type d'entente devienne plus populaire à mesure que les sociétés minières s'équipent de parcs de véhicules électriques.

M. Stannell ajoutait que le passage aux VÉN nécessitera des changements « dans pratiquement chaque aspect du fonctionnement et de l'entretien de nos camions aujourd'hui ». D'après Teck, ces véhicules exigeront un complément ou un élargissement des compétences des employés, ajoutait-il.

Ces dernières années, les sociétés minières ont redoublé d'engagements envers la décarbonation. Pourtant, M. Mashford précisait que le « fossé » entre les engagements des entreprises envers la neutralité carbone et les activités sur le terrain est encore bien réel.

Il donnait l'exemple du triage du minerai, une technologie avancée et existante qui pourrait aider les sociétés minières à réduire leur utilisation d'énergie, mais qui n'a pourtant pas été très utilisée ou régulièrement intégrée dans les plans des mines.

M. Turenne trouvait « ironique » que FPX, une petite société minière, soit l'une des rares sociétés minières à soutenir la recherche sur la séquestration du carbone. « Nous souhaiterions voir d'autres sociétés faire le pas… et financer davantage de [travaux de recherche] dans ce domaine », indiquait-il. « Le fait qu'une petite société comme la nôtre devienne un chef de file dans ce domaine met le doigt sur un manque d'intérêt notoire envers l'innovation. » ICM

La série **Objectif neutralité carbone** se poursuivra tout au long de l'année 2022. Elle examinera les difficultés liées à la réduction des gaz à effet de serre et à l'élimination des empreintes carbone, et étudiera également les possibilités qu'offrent ces actions. Si vous souhaitez apporter votre contribution, veuillez nous contacter à l'adresse : editor@cim.org.

Une préoccupation internationale

La gestion des résidus miniers est au cœur des préoccupations de l'industrie, mais il reste encore beaucoup à faire pour éviter les catastrophes futures

Par Tijana Mitrovic

En septembre dernier, une digue à résidus miniers a cédé dans une mine abandonnée d'Afrique du Sud, entraînant une violente inondation et le décès d'au moins trois personnes. La rupture qui s'est produite à la mine de Jagersfontein est la dernière d'une série de catastrophes récentes liées aux résidus miniers, notamment la rupture de la digue à résidus à la mine de Córrego do Feijão de Vale à Brumadinho en 2019, qui a entraîné la mort de 270 personnes et a décimé les communautés et l'environnement à proximité, entraînant une révolte et des appels au changement à l'échelle internationale.

Dans le cadre du *Global Tailings Review* (GTR, l'examen international des résidus miniers), l'*International Council on Mining and Metals* (ICMM, le conseil international des mines et métaux), le *Principles for Responsible Investment* (PRI, l'organe défenseur des principes de l'investissement responsable) et le programme des Nations Unies pour l'environnement (PNUE) ont créé conjointement, en août 2020, le *Global Industry Standard on Tailings Management* (GISTM, la norme industrielle mondiale pour la gestion des résidus miniers) en réaction à la rupture du parc à résidus miniers de Brumadinho. L'objectif de cette norme mondiale est de renforcer la sécurité et la gouvernance des parcs à résidus miniers à l'échelle internationale afin de protéger les habitants et l'environnement, et d'éviter une autre catastrophe telle que celle de Brumadinho (et aujourd'hui, celle de Jagersfontein).

La GISTM est à la disposition de l'industrie minière internationale depuis deux ans. Ces normes constituent les premières étapes importantes d'un long trajet. Leur introduction dans un monde parsemé de normes préexistantes et de données incomplètes, confronté à une pénurie des compétences et à des préoccupations sociales croissantes est une tâche colossale. Après la dernière catastrophe en Afrique du Sud, cette tâche est plus urgente que jamais.

Un tableau incomplet

Des normes et des guides sur la gestion des résidus miniers existent déjà, notamment l'initiative Vers le développement minier durable (VDMD) de l'association minière du Canada (AMC). Toutefois, la GISTM est la première norme à être élaborée dans une optique d'adoption à l'échelle mondiale, et l'ampleur de la norme a entraîné une certaine confusion chez les exploitants.

« Nombre de sociétés essaient encore de digérer la GISTM », expliquait Charles Dumaresq, vice-président des sciences et de la gestion environnementale de l'AMC. « On ne sait pas encore exactement comment elle va être mise en œuvre ni comment la performance va être comparée aux exigences de la norme. »

De nombreuses questions restent en suspens concernant la GISTM et la forme que prendra la future gestion des résidus miniers. Quelles seront les obligations des sociétés en termes de communication des exigences, et comment seront vérifiées ces exigences ? Les résultats seront-ils rendus publics ? « Dans certains cas, les choses seront très simples. Pour d'autres exigences, la question est relativement complexe », indiquait-il.

L'un des autres grands problèmes que rencontre la gestion des résidus miniers est qu'il n'existe aucun registre exhaustif du nombre de parcs à résidus miniers dans le monde. Les estimations du nombre de parcs à résidus miniers varient d'environ 7 000 à près de cinq fois ce chiffre. Il est également difficile de suivre le nombre de ruptures.

D'après Jan Morrill, directrice de campagne pour la gestion des résidus miniers à Earthworks, une organisation environnementale à but non lucratif, « il n'existe aucun registre des ruptures de parcs à résidus miniers, et personne ne surveille véritablement ni ne suit de près la situation. Tout [est question de] coïncidence. Par exemple, si l'on tombe par hasard sur un article dans la presse turque relatif à la rupture d'un parc à résidus miniers en novembre 2021. Il est très difficile de savoir. »

Le statut des normes

Aujourd'hui, environ 78 sociétés indiquent qu'elles s'efforcent de se conformer à la norme mondiale. D'après Adam Matthews, directeur principal de l'investissement responsable de la *Church of England Pensions Board* (la commission des pensions de l'Église anglicane), il reste encore beaucoup à faire. « Les progrès sont indéniables », indiquait-il. « Mais cette question nécessite une attention perpétuelle de la part des salles de conseil, des administrateurs généraux, des présidents ainsi que des investisseurs et de toutes les autres parties prenantes qui ont un intérêt à garantir qu'elle soit traitée comme il convient. »

Toutes les sociétés minières ne sont toutefois pas contraintes d'adopter la GISTM. « La norme en elle-même dépend des personnes et des procédés dans chaque site », déclarait Amanda Adams, ingénieure principale à Stantec. « En d'autres termes, tout dépend de la façon dont elle sera mise en œuvre. »

Qu'en est-il de celles et ceux qui n'y prêtent pas attention ? D'après M. Matthews, les investisseurs sont prêts à agir. Ils sont sur le point de commencer à voter contre les présidents des sociétés qui ne s'engagent pas clairement envers la mise en œuvre de la norme ou qui ne cherchent pas à s'y conformer. « La dynamique sur cette question a changé », indiquait-il.

Le *Global Tailings Management Institute* (l'institut mondial dédié à la gestion des résidus miniers) jouera un rôle important pour s'assurer que les parties prenantes au sens large, à savoir les investisseurs, les banques, les assureurs et les communautés ont confiance et ont la preuve que cette norme est mise en application dans chaque site minier à l'échelle mondiale.

L'institut aidera aussi à clarifier dans quelle mesure les autres normes, telles que le protocole de gestion des résidus miniers de l'initiative VDMD de l'AMC, publié pour la première fois en 2004 et révisé récemment, en 2019, se rapportent à la GISTM. « Cela va constituer une part réellement importante qui définira un cadre clair entre les sociétés et toutes les parties prenantes concernant la manière dont toutes ces choses se recoupent », indiquait M. Matthews.

Naviguer sur un système reposant sur plusieurs normes

D'après André Gagnon, directeur de la gestion des résidus miniers à Lundin Mining, l'équipe de direction de la société préposée aux résidus gère actuellement la mise en œuvre de la GISTM dans ses sites en exploitation dans cinq pays différents. M. Gagnon indiquait que Lundin Mining a déjà terminé les évaluations initiales des lacunes dans ses principaux sites d'exploitation au Chili, au Brésil et au Portugal. Il prévoit que la société se conforme à la norme mondiale dans ces sites d'ici août 2023.

Lorsque la GISTM a été présentée, Lundin Mining s'est lancée dans l'examen de sa propre norme internationale de gestion des résidus miniers, une norme d'accompagnement à la politique minière responsable globale de la société. « L'une des difficultés que nous avons dû gérer immédiatement [résidait] dans notre norme existante sur les résidus miniers et dans des politiques d'entreprise existantes qui recoupaient la GISTM », expliquait M. Gagnon. « En collaboration avec les sites en exploitation, Lundin Mining a dû tenir compte de certains points, notamment concernant l'élaboration et la mise à jour de sa norme sur les résidus miniers afin de l'aligner sur la GISTM et de ne pas doubler les efforts existants. »

La solution consistait à conserver les mêmes principes et exigences énumérés dans la GISTM et à documenter les autres politiques et normes existantes de la société, plutôt qu'à les reproduire. Si Lundin Mining a trouvé sa solution, M. Gagnon indiquait qu'il serait bon que la GISTM clarifie certains procédés. « Le secteur gagnerait beaucoup à obtenir quelques précisions à l'avenir quant à la manière de mesurer et de quantifier la conformité de manière à parvenir à une cohérence plus générale dans divers territoires miniers et globalement, dans l'industrie », indiquait-il.

L'initiative VDMD de l'AMC a été motivée par une série de ruptures de digues à résidus miniers au début et au milieu des années 1990. M. Dumaresq expliquait que l'époque se prêtait plus que jamais à une remise en question de l'AMC, laquelle doit mieux faire et se demander ce qu'elle peut faire en tant qu'association.

Après la publication de la GISTM en 2020, l'AMC a mené une analyse des écarts sur l'alignement des exigences existantes de la VDMD et de la GISTM. D'après M. Dumaresq, cette analyse a mené à des mises à jour du guide sur les résidus miniers de l'AMC, et à de légères mises à jour de son guide quant au développement et à la mise en œuvre de manuels sur l'exploitation, l'entretien et la surveillance. D'après l'analyse, la VDMD ne répond que partiellement à neuf exigences de la GISTM. Sur les 77 exigences évoquées par la GISTM, seules cinq exigences ne sont pas du tout traitées par la VDMD.

La portée de la GISTM diffère de celle de la VDMD. De fait, la VDMD couvre un large éventail de thèmes autres que les résidus miniers. Par exemple, la GISTM inclut des aspects relatifs aux communautés affectées, alors que la VDMD couvre ce point dans un protocole distinct. Par ailleurs, la VDMD s'en remet parfois à l'association canadienne des barrages (ACB) concernant certaines sections plus techniques du guide.

Comme l'expliquait Karen Chovan, fondatrice et directrice générale d'Enviro Integration Strategies, la VDMD a obtenu un soutien plus vaste de l'industrie du fait de sa longévité et des détails plus exhaustifs communiqués dans son guide. « La VDMD nous place face à un système à plusieurs facettes car il existe plusieurs protocoles individuels. Cela permet de se concentrer sur les spécificités des résidus miniers, tout en les distinguant

Feijao. Brésil, 2019.

Jagersfontein. Afrique du Sud, 2022.

Mount Polley. Canada, 2014.

d'autres domaines comme le changement climatique et les relations communautaires, même s'ils sont intégrés », expliquait M^me^ Chovan. « La gouvernance de l'AMC ne fonctionne pas de la même manière que celle de la GISTM, mais elle offre un procédé bien plus rigoureux qui garantit que l'on peut évaluer correctement et déterminer si les bonnes choses sont mises en place. »

D'après M. Dumaresq, certains aspects de la VDMD vont au-delà de ceux présentés dans la GISTM. « La GISTM prétend détenir un système de gestion des résidus miniers, mais ne décrit pas ce à quoi ressemble un bon système », expliquait-il. « Alors que cette exigence est la même, à savoir disposer d'un système de gestion des résidus miniers, on retrouve ensuite tous ces détails dans le tableau de la conformité… qui offre une image bien plus exhaustive de ce qu'est un bon système de gestion des résidus miniers et de la façon de le faire fonctionner efficacement. »

L'objectif, indiquait M. Dumaresq, est que la VDMD soit reconnue comme l'équivalent de la GISTM dans une certaine mesure, de manière que les sociétés ne soient pas nécessairement contraintes de suivre deux systèmes distincts. Bien entendu, cela dépendra de la manière dont l'institut mondial décide de procéder avec les équivalences.

D'ici là, les sociétés devront gérer un système reposant sur plusieurs normes. « La difficulté à l'avenir pour Lundin Mining, et probablement pour d'autres sociétés, est de mener des vérifications en interne et en externe sur toutes ces diverses normes, et s'assurer qu'elles ne se recoupent pas », indiquait M. Gagnon. « Nous devons soigneusement préparer et mener ses vérifications de manière à ne pas doubler les efforts. »

En pratique

L'attention accrue accordée à la gestion des résidus miniers s'est accompagnée de nouvelles difficultés pour les personnes sur le terrain. On attend notamment des ingénieurs en résidus miniers qu'ils approfondissent leur expertise. Dans son travail, M^me^ Adams indiquait que les nombreuses exigences de la GISTM sont l'occasion pour les ingénieurs d'apprendre et de mieux comprendre l'analyse des ruptures de digues, les évaluations des risques, les impacts sociaux et autres.

« Les ingénieurs des digues à résidus miniers ont désormais une toute nouvelle compétence », expliquait-elle. « Nous devons nous familiariser davantage avec l'évaluation des risques liés à ces digues, car cet élément est au cœur de la GISTM… Il a vraiment été difficile de renforcer ces compétences. Il est aussi très difficile de trouver suffisamment de personnes qui possèdent ces compétences et de les inciter à rejoindre des projets consacrés à la gestion des résidus afin de pouvoir mener d'autres études, tâches et évaluations dans le calendrier fixé. »

En ce qui concerne la gestion des difficultés à travailler dans plusieurs territoires soumis à différentes réglementations, il est toujours essentiel de suivre les meilleures pratiques, indépendamment de la région. « Si l'on adopte les meilleures pratiques et qu'on les applique où que l'on travaille, on ne devrait pas rencontrer de gros problèmes », expliquait M^me^ Chovan. « C'est la raison pour laquelle les normes ont été créées, pour donner des conseils quant aux meilleures pratiques à celles et ceux qui n'en ont pas. »

Du point de vue de l'investisseur, cette position est encore plus ferme. « Nous devons avoir la garantie que les sociétés fonctionnent conformément à la meilleure norme dans tous les territoires », indiquait M. Matthews. « Sous prétexte que la gouvernance du territoire dans lequel on se trouve est moins stricte, il n'est pas acceptable de fonctionner selon des normes inférieures. Cela n'est pas envisageable. »

Une étude de septembre 2022 dans le magazine *Earth-Science Reviews* intitulée *Global magnitude-frequency statistics of the failures and impacts of large water-retention dams and mine tailings impoundments* indiquait 303 ruptures de digues à résidus miniers dans 249 sites miniers distincts entre 1965 et 2020. Toutefois, en raison de l'incertitude quant au nombre réel de parcs et de ruptures, par exemple dans des régions où les déclarations ne peuvent être vérifiées, ces données peuvent être incomplètes.

- Image de Jagersfontein avec l'aimable autorisation de Planet Labs. Tous autres pris avec Google Earth.

Pourtant, il peut s'avérer complexe de trouver des manières de bien communiquer et de maintenir cette communication dans le cadre d'un projet dédié aux digues à résidus miniers, étant donné la portée massive de ces projets. « Des dizaines de personnes peuvent contribuer à un projet donné chaque jour », expliquait M^me^ Adams au regard de son expérience professionnelle en matière de digues à résidus miniers. « Comment peut-on communiquer ces choses si importantes afin de prioriser la sécurité des digues ? »

La communication est importante non seulement pour que les parties prenantes restent au courant, mais aussi pour leur permettre de soulever d'éventuelles préoccupations ou de présenter les mesures de gestion des risques qu'il convient de prendre. Pour M^me^ Chovan, cet aspect reste difficile. « On s'intéresse beaucoup à la gouvernance et à la mise en place des bons systèmes, mais il ne faut pas pour autant négliger les personnes, la communication et la culture », indiquait-elle. « Il faut vraiment creuser et demander aux équipes de divers départements d'être ouvertes et transparentes, de se parler et d'accorder de l'importance à une communication claire, car tellement de personnes différentes sont impliquées dans la gestion de ces parcs à résidus. »

Les normes sociales

Un débat prend de plus en plus d'ampleur quant au besoin de mobiliser les communautés en matière de gestion des résidus miniers. Il porte également sur les normes techniques qui vont au-delà de l'enceinte de la société. Parfois, les sociétés ne parviennent pas à communiquer ou à collaborer avec les communautés locales. Dans ses travaux de recherche, M^me^ Chovan a constaté que les sociétés recueillent des informations pour une analyse technique sur les communautés locales, leurs activités et les risques, mais elles ne créent pas de liens réels avec ces communautés sur la question des résidus.

« Nous ne les faisons pas réellement participer de manière transparente afin de comprendre leurs inquiétudes avant de prendre des décisions et de décider quel genre d'installation ou de technologie nous voulons », expliquait-elle. « Nous ne sommes pas non plus très efficaces dans notre collaboration (s'il existe déjà une installation) et notre communication avec eux concernant les risques de ces parcs qui se trouvent juste à côté ou en amont de leur lieu de vie. »

L'incertitude règne encore pour certaines sociétés quant au niveau de transparence nécessaire étant donné la complexité du sujet traité. Il peut s'avérer difficile de communiquer des informations en donnant le contexte approprié étant donné les considérations hautement techniques, en plus des travaux que mènent les sociétés pour améliorer et traiter la gestion des risques. Les sociétés peuvent penser que la complexité ne viendra que renforcer les inquiétudes des communautés impliquées, ou être mal interprétée. « Il est encore très difficile de communiquer toutes ces informations », indiquait M^me^ Chovan. « Nous ne parlons pas la même langue. »

D'après M^me^ Morrill, cela est contraire à ce à quoi s'attendent les communautés affectées, particulièrement celles qui ont déjà été victimes de ruptures de digues à résidus miniers. « Elles veulent que des mesures fortes soient prises concernant la responsabilité des entreprises », indiquait-elle. « Elles attendent que des mesures fortes soient mises en œuvre pour protéger les communautés en cas de ruptures. Cela n'est pas suffisamment mis en avant dans les normes actuelles. »

Earthworks a publié en juin 2020 sa propre série de recommandations sur la gestion des ruptures de digues à résidus miniers, intitulée *Safety First* (la sécurité avant tout), et a publié une version révisée en mai 2022. Rédigé conjointement avec Mines Alerte Canada, ce rapport indique que les lignes directrices peuvent protéger les communautés, les travailleurs et l'environnement des risques liés aux ruptures des digues à résidus miniers.

L'organisation souhaite voir des changements importants allant au-delà de ceux présentés dans les normes actuelles. « Ces lignes directrices strictes et à adopter rapidement doivent aussi concerner d'autres points, notamment l'interdiction de construire des digues selon la méthode amont, tenir compte de la probabilité des ruptures, garantir un certain facteur de sécurité… réglementer la distance entre les digues et les communautés », indiquait M^me^ Morrill. « Certaines choses qui n'ont tout simplement été mentionnées dans aucune norme peuvent être déterminées en amont. »

La position d'Earthworks est que, si les membres de l'ICMM et d'autres ont adopté la GISTM, de nombreuses communautés sont inévitablement menacées en raison des retards de l'industrie en la matière. « De notre point de vue, nous assistons encore à des propositions dangereuses concernant les résidus partout dans le monde, mais aussi à des pratiques de gestion des résidus miniers peu conformes à la norme dans la perspective de réduire les coûts ou de soutenir les résultats d'une société », ajoutait-elle.

Tournés vers l'avenir

Au sein de l'industrie, M^me^ Chovan souligne la collaboration importante et le débat ouvert entre les professionnels sur les méthodes d'études et d'évaluations. « On assiste à un grand partage de connaissances, des meilleures pratiques, des risques et des solutions communes qui ont été débattus », indiquait-elle. « Beaucoup d'efforts positifs ont été déployés. »

Les sociétés se tournent aussi vers la formation de la prochaine génération d'ingénieurs spécialisés dans les résidus miniers et le partage de leurs connaissances existantes. « On assiste au développement accru de nouveaux programmes de formation. Tous sont développés grâce aux contributions de professionnels de l'industrie qui y consacrent leur temps », indiquait-elle. « Tout le monde [essaie] de réduire le fossé qui se profile concernant la prochaine génération d'experts. »

Avant ces récents développements, la bonne gestion des résidus miniers était davantage menée à un niveau individuel qu'à un niveau sectoriel. « Ce problème n'a pas été admis par toute l'industrie », expliquait M. Matthews. « Aucune norme internationale sur les meilleures pratiques [n'existait], une norme vers laquelle tout le monde tendait. C'est ce que nous nous efforçons de mettre en place aujourd'hui. »

La rupture de la digue à résidus miniers en Afrique du Sud est le dernier rappel tragique de la gravité de la tâche.

« Les répercussions d'une catastrophe dans une société ne se limitent pas à la société en question, mais affectent l'ensemble de l'industrie », indiquait M. Matthews. « Chaque catastrophe remet en question le permis social d'exploitation de toute l'industrie. Elle ronge la confiance du public et des investisseurs envers l'industrie tout entière. C'est exactement ce que nous voulons éviter. Nous voulons vraiment que ce problème soit bien abordé et nous assurer que l'on peut avoir confiance en la gestion responsable des résidus miniers. »

CIM ICM MTL23

Instaurer la confiance pour décarboniser le monde

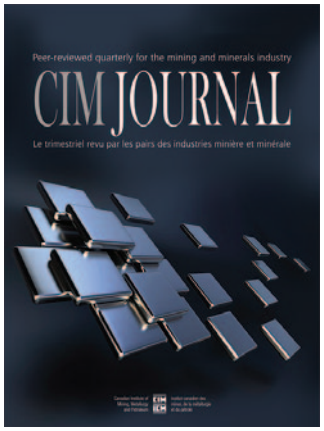
Partagez vos connaissances et soumettre votre résumé avant le 30 novembre 2022

Thèmes du programme technique:

- Les minéraux et les matériaux
- L'exploitation minière au XXIe siècle
- Mécanique des roches / Ingénierie
- Les opérations minières
- Les critères ESG et les relations de confiance
- L'énergie et l'économie circulaire
- Dépôt de déchets miniers
- À la recherche de talents
- Environnement : Minimiser notre empreinte
- Marchés & finances
- Protégeons nos populations
- Technologies de décarbonisation : Des mines aux métaux
- Symposium nord-américain sur le minerai de fer

Envoyez-nous aussi les résumés de vos cours!

Congrès + Expo
30 AVR - 3 MAI Montréal



CIM Journal

Abstracts from CIM Journal, Vol. 12, No. 4

ENVIRONMENTAL AND SOCIAL RESPONSIBILITY

Decarbonization of remote mine electricity supply and vehicle fleets

J. E. Zuliani, J. Guilbaud, and M. Carreau, Hatch Ltd, Mississauga, Canada

The need to drastically reduce greenhouse gas emissions is becoming more and more apparent. To avoid a tipping point, scientists agree that emissions need to reach net zero by 2050, which will require unprecedented changes to the way electricity is generated, particularly for remote off-grid mines. In this paper, the potential to achieve 100% renewable penetration for a remote mine will be investigated, with an example case study for a mine in the Canadian Arctic. Five key pillars to achieve net zero operation will be discussed: energy efficiency, hybrid power, microgrid integration, alternative vehicles, and low carbon technologies. In addition, the state-of-the-art in renewable generation, energy storage, and hydrogen storage are presented. The key enablers for a mine to achieve 100% renewable penetration for electricity and vehicles are identified, along with benchmark costs and savings opportunities. Strategies and challenges for existing mines to achieve high renewable penetration are discussed. The remote mine of the future will be significantly different from today's operations; changes to the operating strategy and process, energy generation, and vehicle fleet will be the key enablers.

SURFACE MINING

Design of an open-pit gold mine by optimal pitwall profiles

A. Agosti, Newcastle University, Newcastle Upon Tyne, UK; S. Utili, Newcastle University, Newcastle Upon Tyne, UK and OptimalSlope, Harwell, UK; D. Gregory, Datamine, Toronto, Canada; A. Lapworth, Datamine, Bristol, UK, J. Samardzic and A. Prawasono, Kinross Gold Corporation, Toronto, Canada

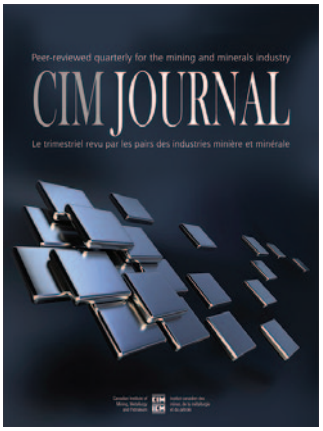
The overall steepness of pitwalls significantly influences the financial return of an open-pit mine. In current practice, pitwall profiles are planar in cross-section. In this paper, a new geotechnical software, OptimalSlope, is employed to determine depth-varying optimal pitwall profiles for each slope sector of the mine. OptimalSlope solves a mathematical optimization problem where the overall steepness of the pitwall is maximized for the assigned stratigraphy, rock properties, and Factor of Safety (FoS). Bench geometries (bench height, bench-face inclination, and minimum berm width) are incorporated into the optimization as constraints that bind the maximum local inclination of the sought optimal profile together with any other constraint related to any geological discontinuities that may influence slope failure. The optimal profiles are always steeper than their planar counterparts—that is, the profile exhibiting the same FoS, generally up to 8 degrees, depending on rock type and constraints. To showcase the financial gains that can be achieved via OptimalSlope, the design of a gold mine in a complex geology dominated by weak rocks was initially carried out for planar pitwalls and then for optimal pitwall profiles. The pit has been divided into five geotechnical sectors, each requiring a different pitwall profile design. Adopting optimal slope profiles led to a 52.7% higher net present value and reductions in the carbon footprint and energy consumption of 0.0613 million tonnes CO2 eq and 31.3 million MJ, respectively, due to a 3.5% reduction of rock waste volume.

UNDERGROUND MINING

Investigation of airflow characteristics under parallel fan conditions in a block cave mine

Y. Pan, P. Tukkaraja, S. Jayaraman Sridharan, and A. Jha, South Dakota Mines, Rapid City, USA

Block caving is an efficient underground mining method for extracting massive and low-grade ore deposits, which are too deep for traditional open-pit mining. However, in the case of orebodies with uranium mineralization, the extraction of broken rock from drawpoints will bring harmful radon gas into working areas. Airborne diesel particulate matter and dust produced from mining activities also contribute to the emissions on the production level. Maintaining relatively negative pressure in the cave by installing exhaust fans is one of the most effective approaches to mitigate gas emission concerns. The selection of proper fan systems is highly related to airflow behavior within the cave. Due to the dynamic caving process and complex cave structure, estimation of cave airflow resistance through field studies is difficult. This study developed a 1:100 scaled experimental and numerical model to investigate the effects of cave parameters (cave porosity, particle size, and undercut structure) on airflow resistance under parallel fan conditions. Results showed that cave airflow resistance increases with decreasing cave porosity and particle size; cave airflow behavior is significantly affected by undercut drift closure and the use of additional fans. This study provides valuable information to optimize ventilation system design in block cave mines.



CIM Journal

Abstracts from CIM Journal, Vol. 13, No. 1

MAINTENANCE, ENGINEERING AND RELIABILITY

Sustainable design of tailings dams using geotechnical and geomorphic analysis

N. Slingerland, F. Zhang, and N. A. Beier, University of Alberta, Edmonton, Canada

Geomorphic landform design for mine waste structures has been proposed as a sustainable alternative to traditional design approaches for decades. Over this time, the focus on mine closure and related sustainability approaches has grown steadily. Many geotechnical engineers and responsible mining companies understand the obligation to design and construct structures that will perform well in the long term. Concepts and tools are provided in this paper that will assist engineers in achieving their long-term goals. This research evaluates four tailings dam designs in terms of their geotechnical stability and long-term geomorphology: two traditional designs (uniform slope and platform-bank) and two geomorphic-inspired designs (catena and horseshoe). All four designs were subjected to two- and three-dimensional (3D) stability analysis, as well as 3D landscape evolution modeling (geomorphic analysis). Results indicated that the horseshoe-style geomorphic tailings dam design performed better than the others for each of the analyses completed. The horseshoe design consisted of interspersed catena slopes and uniform slopes, which resulted in a type of buttressing effect that enhanced the geotechnical stability of the dam while also reducing and focusing surface erosion.

SURFACE MINING

A stochastic mixed integer linear programming framework for oil sands mine planning and waste management in the presence of grade uncertainty

O. Mbadozie, E. Ben-Awuah, and A. Maremi, Laurentian University, Sudbury, Canada

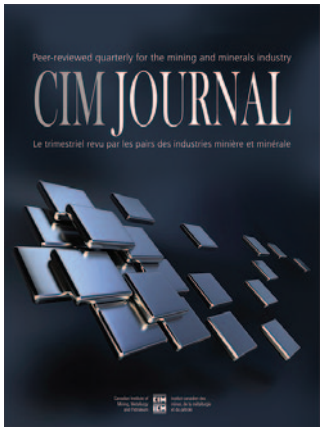
The primary purpose of oil sands mine planning and waste management is to provide ore from the mine pit to the processing plant while containing the tailings in an efficient manner in-pit. Incorporating waste management in the mine plan is essential to maximize the economic potential of the mineral reserve and minimize waste management costs. However, spatial variability such as grade uncertainty results in ore tonnage variations, which leads to fluctuations in the quantity of ore to be processed and waste to be managed. This paper investigates the application of a stochastic mixed integer linear programming (SMILP) on oil sands mine planning to integrate bitumen grade uncertainty and waste management. Sequential Gaussian simulation is employed to quantitatively model the spatial variability of bitumen grade in the oil sands deposit. Multiple simulated orebody models are used as inputs for the SMILP model to generate optimal mine plans in the presence of grade uncertainty. The results demonstrate that the SMILP schedule generates 14% and 17% improvements in net present value compared to the E-type and ordinary kriging schedules, respectively. These results indicate that the SMILP model is a robust tool for optimizing stochastic integrated oil sands production schedules and waste management.

GEOLOGY

Drillhole spacing determination with value of information

B. Harding and C. V. Deutsch, University of Alberta, Edmonton, Canada

Different quantities of information are available at various stages of the development of a mining project. Consequential decisions are made given the data available at the time. Geological uncertainty due to sparse data presents economic risk. The collection of additional information reduces geological uncertainty leading to a better technical decision and greater value. Subjectivity in the choice of data collection scheme may lead to sub-optimal outcomes. The value of information (VOI) allows a decision-maker to quantify the future value data could provide before collecting it. Evaluating many future configurations over a range of data spacings identifies the optimal outcome given the value metric. The optimal data spacing represents the balance between the cost of uncertainty and the cost of information. A framework for establishing VOI in a mining context is proposed. A geostatistical "resample and resimulate" approach is adopted: the resampling of simulated realizations provides access to virtually any future data configuration. The difference in value generated with future information and the current information is the VOI. The methodology and techniques developed in this paper are applied to a synthetic example and an operating mine case study. The case study encompasses VOI principles, data spacing, engineering design parameters, and economic factors.



CIM Journal

Abstracts from CIM Journal, Vol. 13, No. 2

GEOLOGY

Considerations for using historical geoscientific information in mineral resource estimation

R. Pressacco, L. Evans, and W. E. Roscoe, SLR Consulting (Canada) Limited, Toronto, Canada

In many cases, mineralization discovered by prior owners of a mineral property may have been considered to be too low grade to be of potential economic interest at that time. Changes in market conditions over time often warrant a review of the economic potential of historical exploration results. Therefore, any available historical geoscientific information can be of great value because it can save the cost and time required to completely replicate the historical data. As qualified persons (QPs) are ultimately responsible for all data used to prepare a mineral resource estimate, they bear the obligation of carrying out appropriate due diligence and validation of all information and historical work prior to their use for estimation. The task of assigning acceptance criteria rests upon the QP. Considering the wide range of possible scenarios, a detailed listing of acceptance criteria is far beyond the scope of this paper. Generally speaking, the acceptance criteria for using historical data will by necessity vary on a case-by-case basis. In all cases, the QPs are encouraged to fully document the criteria used to establish the acceptance criteria. This paper discusses some of the various actions that QPs may consider for validating historical data.

GEOLOGY

Prospecting for coking coal in the Plains region of western Canada

G. Jordan, Norwest Corporation, Calgary, Canada

In 2021, coking coal was discovered in a Lower Cretaceous Mannville Group seam in the Plains region of the province of Alberta, Canada. This coal seam, although thick enough, is too deep and too low a rank to have commercial development potential. Further Plains region exploration is needed to identify any new economically mineable deposits of hard-coking coal. This paper presents a methodology to achieve this. Two regions are identified where the geothermal regime might provide a suitable geological environment: the Northwest Edmonton prospect is coincident with the Edmonton Anomaly, and the Hudson's Hope prospect is coincident with the Peace River Arch (PRA). At the Hudson's Hope prospect, testing showed that the Lower Cretaceous seams host potential hard-coking coal at depths ranging from less than 400 m to approximately 750 m, and the desired prospect parameters are satisfied. Furthermore, the most prospective area where new economically viable hardcoking targets may be found is the region within the boundaries of the PRA extending to the east and northeast from the Peace River Canyon.

ENVIRONMENTAL AND SOCIAL RESPONSIBILITY

Climate change risks and vulnerabilities during mining exploration, operations, and reclamation: A regional approach for the mining sector in Québec, Canada

É. Bresson, The University of Québec in Abitibi-Témiscamingue, Rouyn-Noranda, Canada; Polytechnique Montreal, Montreal, Canada; RIME, Québec, Canada; B. Bussière, The University of Québec in Abitibi-Témiscamingue, Rouyn-Noranda, Canada; RIME, Québec, Canada; T. Pabst, Polytechnique Montreal, Montreal, Canada; RIME, Québec, Canada; I. Demers and P. Charron, The University of Québec in Abitibi-Témiscamingue, Rouyn-Noranda, Canada; RIME, Québec, Canada; P. Roy, Ouranos, Montréal, Canada; Institut de recherche d'Hydro-Québec (IREQ), Québec, Canada

Climate change (CC) has already and will continue to have a significant impact on the mining sector. A comprehensive and thorough analysis was performed to evaluate the risks and vulnerabilities resulting from CC during the exploration, operation, and reclamation phases of the mining life cycle. This analysis focused on six mining regions in Québec. Climate scenarios were produced for each region and, along with a literature review, used to assess the effects of CC on the mining sector. The results were presented to a panel of experts who highlighted the risks for each activity at each phase of the mining life cycle. A second group of experts evaluated the level of risk and the mining industry's vulnerability for each risk identified by the first group. Six main risks due to CC were identified: activity schedule disruptions, loss or limitation of site accessibility, water management issues, instabilities and failures of storage facilities, operations infrastructure instabilities, and reduction of reclamation cover performance. The mining experts performed a Delphi-type survey for each mining activity to determine the risk level for each region, leading to the production of a risk matrix. Results indicate that CC is expected to particularly affect reclamation cover performance, and extreme climate events are projected to have significant impacts on operations. Vulnerability levels were assigned by a third group of experts based on the industry's ability to adapt to these risks. Results showed a low vulnerability for exploration, low to high vulnerability for operations, and low to very high vulnerability for reclamation

CALL FOR SUBMISSIONS
APPEL À CONTRIBUTIONS

Join forces with some of the brightest minds and share your expertise by submitting a Technical Paper to *CIM Journal*.

***Rejoignez une équipe de scientifiques brillants et partagez vos connaissances en envoyant un document technique au* CIM Journal.**

www.cim.org

ADVERTISERS

Cleared for landing

Ian Wood from Yellowhead Helicopters dropping off Hy-Torque Drilling crew on P2 Gold's BAM property in the Golden Triangle.

Scott Sych,
Hy-Torque Drilling

What's your view on the industry?

Share your photos with *CIM Magazine* and each issue we will showcase the best right here.
For more information, visit **magazine.cim.org/en/voices/closing-shot/**

SAFETY, SERVICE, AND INNOVATION

JENNMAR | J-LOK P PUMPABLE RESIN A JENNMAR® PRODUCT | JENNMAR CIVIL | XCAL | JENNCHEM

CANADA LOCATION
Sudbury, ON CANADA
(705) 525-0101

GLOBAL HEADQUARTERS
Pittsburgh, PA USA
(412) 963-9071

JENNMAR
MINING • INFRASTRUCTURE • MANUFACTURING

DEMANDING CONDITIONS

DEMAND JENNMAR

JENNMAR designs and manufactures a wide range of dependable ground control products, from bolts and beams to channels and trusses, resin, rebar, and more. We're proud to make products that make the mining, tunneling, civil, and construction industries safer and more efficient.

Because we understand the ever-changing and demanding conditions above and below ground we have built the richest portfolio of diverse and complementary brands. JENNMAR sets the bar in every industry we serve and as we continue to grow, our focus will always be on the customer.

We feel it is essential to develop a close working relationship with every customer so we can understand their unique challenges and ensure superior customer service. Our commitment to the customer is guided by three words: **SAFETY, SERVICE, and INNOVATION**.
It's these words that form the foundation of our business.
It's who we are.

For more information on our portfolio of diverse and complementary brands visit us at www.jennmar.com.

LEOPARD™ DI650i
TIME FOR A NEW LEADER

New Leopard DI650i down-the-hole surface drill rig offers long-term productivity and superior stability with robust and reliable main components – seamlessly integrated with state-of-the-art technical solutions. Scalable automation, easy maintenance and outstanding movability are the features that make Leopard DI650i a premium product, which is an honour to own.

Leave your paw print and enjoy the smooth, efficient ride.

Explore the new Leopard DI650i:
ROCKTECHNOLOGY.SANDVIK/DI650i

SANDVIK