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Saskatchewan mining jobs are rapidly evolving into high-tech occupations. See page 18 to learn more about tomorrow's workforce.

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HEAD OFFICE
Suite 610
2220-12th Avenue
Regina, Saskatchewan
S4P 0M8

Telephone: (306) 757-9505
Fax: (306) 569-1085

www.saskmining.ca

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COVER

From jet-boring uranium in the north to flying drones over southern projects, Saskatchewan mining companies are embracing technologies that improve safety and ore recovery and reduce costs.

CONTENTS

COVER THE DIGITAL AGE How Saskatchewan mining companies are transforming their operations 6	FEATURE BLOCKCHAIN New tracking technology works for diamonds... and other commodities 12	eARTh NUTRIEN WONDERHUB Children experience the reality of mining 29
ORE DEPOSITS 14 Coal fires Saskatchewan's power plants		
SAFETY 16 Drones contribute to mine safety		
WORKFORCE 18 Creating the workforce of the future		
ENVIRONMENT 20 Small nuclear reactors provide clean energy, small footprints		
BEYOND THE BIO 22 Jim Corman, President and CEO of Orano Canada, comes home		
TAGGING ALONG 24 Brody Wasmann, Technical Services Analyst, K+S Potash Canada		
EDUCATION 26 Digital Literacy: Bringing robotics to students across the province		
INNOVATION 27 Denison Mines prepares to use in-situ recovery in Athabasca Basin		
BUILDING BLOCKS 32 Fun facts and more!		
LIST OF ADVERTISERS 34		



A MESSAGE FROM
SMA PRESIDENT, PAM SCHWANN

MINING – A TECHNOLOGICAL HUB OF ACTIVITY

Technology has changed virtually every industry in our modern world, and mining is no exception.

The stereotype of someone in the mining sector has historically brought up images of someone involved in manual labour. However, visit a mine today and you are more likely to see people working with smart phones and laptops or a machine operating on its own (autonomously) rather than someone working with a shovel. Today’s mine is a technological hub of activity, both above and underground, all connected to corporate offices that are hundreds of kilometres away.

This issue of ORE will inform you about the fundamental transformation underway in the mining sector, whereby digital technologies and the use of data — digitalization — is being integrated on a platform to include into all aspects of a mining operation, from how ore is mined, equipment maintenance and repair, how employees communicate with each other, environment and safety inspections through to procurement processes.

Ultimately, blockchain technology can be utilized to trace a product from its origins to its final destination. While this concept is in its infancy in Saskatchewan, we were fortunate to speak with Eira Thomas, President and CEO of Lucara Diamond Corp., about her vision to transact diamonds using blockchain technology – completely disrupting the traditional diamond marketing system.

Adoption of technology also has the potential to be a game-changer in terms of realizing reductions in global greenhouse gas (GHG) emissions. This edition of ORE brings updates on the Small Modular Reactors (SMR) and Carbon Capture and Sequestration (CCS) technologies that provide baseload power and which both utilize resources mined in Saskatchewan.

The rate of technological change in the sector will require shifting skill sets for future employees. This issue explores how tomorrow’s mine employees will have common skill sets with Silicon Valley entrepreneurs, and shares some of the innovative and fun ways that technology is being adopted in classrooms across Saskatchewan, so students have the digital skills necessary for tomorrow’s workforce.

In our Tagging Along section, we get a glimpse of what a workday in the life of a miner is like in the digital era. Sooner than later, employees will be conversing with Siri or Google to “bring up drawing number XYZ” or “policy 123” or projecting holograms of equipment in mining environments.

For companies that are digital leaders, embracing a sound digitalization strategy will provide a competitive edge. Digital laggards will face the same ending as video stores. 📺

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P: (306) 933-3010 P: (306) 435-2148 P: (204) 235-4013

F: (306) 242-3156 F: (306) 425-5311 C: (204) 962-8440

E: nrtinquiry@nrtip.com E: rmihilewicznrtp@sasktel.net E: dgravatt@nrtip.com

Feeding the Future

With our significant reach and influence, Nutrien can help find solutions to challenging global issues. Our efforts around the world help improve sustainable agriculture practices.

Nutrien is undertaking a transformative initiative to bring our potash business into the next generation by developing proprietary means to increase productivity, reduce costs, and create a safer work environment for our people.

Our efforts here at home will improve sustainable agriculture practices around the world and help feed a growing population.



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MINING SURGES INTO THE DIGITAL AGE

Automation, robotics, big data transform Saskatchewan mines for the future

Once upon a time, prospectors headed into the bush with a pick-axe and shovel to search for new ore deposits. After discovery, extracting resources out of the ground was performed with equally low-tech tools.

No longer.

"This isn't the era of your grandfather's mine anymore," said Pam Schwann, President of the Saskatchewan Mining Association. "Mining has evolved over the last couple of decades, adopting technology to improve safe production."

Cameco Corp., for example, has long used innovative jet-boring and remote mining techniques for efficient production and to protect its employees from high-grade uranium ore.

Today, however, mining is undergoing technological change at an unprecedented pace, says Mosaic Company's Tom Olson.

"It's overdue," said Olson, Technical Director for Mosaic's Potash Business Unit. "The industry is undergoing a sea change at the moment. The expectations are that we need to be as high-tech as the aerospace industry. We need to get there."

"Certainly over the last four years, we've put a huge focus on it. We need to move in that direction from the productivity standpoint and safety, as well."

Indeed, a study performed by the profes-

sional services firm EY (Ernst & Young) for the Australian mining industry indicated that 100 per cent of mining occupations will be touched by the digital revolution; but it also found that more than three-quarters of those positions will be enhanced or improved by digitalization.

"Digital will transform mining," said Al

“Digital will transform mining.”

**AL SHPYTH
EXECUTIVE DIRECTOR,
INTERNATIONAL MINERALS
INNOVATION INSTITUTE**

Shpyth, Executive Director of the International Minerals Innovation Institute (IMII). "That Australian study suggests that more often than not it will be about enhancing and improving rather than removing people. Where mining operations can remove people from potential hazardous situations, they're going to look for that."

Saskatchewan mining companies are now plunging into many forms of new technology, such as digitalization, automation, ro-

botics, big data and artificial intelligence. These technologies are expected to have enormous positive impacts on safety, reliability, environmental protection, commodity recovery and global competitiveness.

"We are looking at everything across the whole value chain," said Theuns Roux, Transformation Director at Nutrien, who heads the company's Potash Full Potential Transformation.

"It's important for safety, increased reliability, reducing our costs and making sure we stay competitive; it's enabling and improving our flexibility as an operation. We have six sites, and at every site we have a different cost profile. In addition, it's all about people and culture. What works today, and what has worked for the last 40 years, will not work for the next 40 years. Developing and attracting the right talent are crucial.

"The mining industry historically has not been able to attract top talent globally. There are many reasons for that, one of which is that mines are often in remote or rural locations.

"New technologies and ways of working is an attractive proposition for young talent coming in, and I expect to see the diversity in the industry continuing to grow over the next couple of years."

Nutrien's program addresses modern

technology under three pillars: operational excellence, digitized operations and digital transformation.

Operational excellence involves embracing best practices and new ways of working to extract more from the existing asset base.

“Digitized operations will allow us to leverage select digital capabilities, such as IoT (the internet of things), big data and advanced analytics to enable better and more timely decisions, and digital transformation means redesigning and redefining the way that we work, through things such as autonomous operations, predictive maintenance and connected workers, among others.

“Connected worker, as an example, is enabling the workforce to collaborate better and more often, but also driving increased safety. If there’s a hazard underground you can very quickly understand what needs to be done, who’s underground and who’s not. It also allows the ability to communicate with your people in real time to direct them away from any potential hazard,” said Roux.

Another digital destination Nutrien is exploring is about integrated operations and understanding how to bring the technologies together, “where you can become a lot better at your network strategy, your network planning and maintenance, among other things.

“Each one of these digital destinations are at different stages of maturity. We’ve been at this for more than a year now, with some more mature than others, where we are seeing tangible results, and for some others we are only getting started.

“This is a multi-year journey. Our ambition is to deliver the majority of these digital destinations by 2023.”

At Rocanville, Nutrien’s largest mine, automation capability will be embedded by the end of the year across the entire fleet. The company is currently conducting trials across its fleet on rotor machines running through shift changes.

At the same time, Nutrien has performed an energy assessment at all of its sites, seeking ways to mitigate energy sources and usage. Roux expects adaptations and changes will start to take place in 12 to 18 months.

Shift-change challenges have impacted The Mosaic Company, another major potash miner in Saskatchewan. As at Nutrien, shift changes, along with the massive nature of the mines, mean a lot of downtime and travel time as workers come on and off shift.

Olson picked up the ball and ran with it four years ago, when he pitched the idea of creating an automation team.

“You’re looking for bright young ener-

“The most fun part is watching the teams come up with the ideas and install them.”

TOM OLSON,
TECHNICAL DIRECTOR,
MOSAIC, POTASH DIVISION

Tom Olson





K+S Potash Canada has incorporated new technology to manage its information systems.

On the safety front, we looked for opportunities to manage information that's coming from a lot of different directions and put it in a place that's easy to understand and visualize.

SAM FARRIS
KSPC PRESIDENT
AND GENERAL MANAGER

genetic people, who have good engineering backgrounds. We said, they should not report to operations; keep them separate. By making automation independent, the team could focus solely on new technology and not the current operations. This type of work is building for the next 20 years instead of keeping the operations moving for the next 12 hours.

"So we did. We built the team."

Mosaic asked the team to "make their mining machine run by itself," said Olson, and once that was in place, the team was tasked with figuring out a way to automate the building of the conveyor system that follows the mining machines. He calls that job "back-breaking work."

"That's really critical, because that got us a lot of buy in. It's a manual job, it's hard on the back, hard on the arms and presents a lot of opportunity for injuries. We had a really good safety win with that."

Adding automation in places that keep their people safer and give them opportunities to best leverage their skills in the operation are two main goals when they

consider adding technology to a process.

A year and a half ago, the company also created a process automation team to look at automating various aspects of the mill processes.

"As far as automation goes, those are the initiatives we've taken. We did that at Esterhazy, our biggest operation, where we would have the most impact.

"At Colonsay, we have ore guidance systems and ground penetrating radar systems. Colonsay is a little different; we are mining the upper Patience Lake unit, and it's more challenging. You've got a lot of clay seams within the ore, which means you have to be very careful.

"The safety component is much more significant at Colonsay. We're trying to take our learnings at Esterhazy and apply them to Colonsay."

Another "small group of one" has been working on underground drone applications for about three years. Mosaic is working with Silicon Valley companies that are producing applications for drones.

"We have drones that can fly around, that can take video. You can use drones for routine inspections, to go to old abandoned areas of the mines, you can put gas meters on them. He's also working on a search and rescue application.

"We're doing other things. We've built mine-wide fiberoptic networks so we have wi-fi. We're launching a maintenance planning software called Maximo. Mechanics and electricians don't have to carry any paperwork with them. They can fill out work orders online, type in comments, add photos. We're going digital.

"We have advanced analytic projects and artificial intelligence projects on the go as well. You have huge amounts of data and want the machines to learn as they go as well.

"The exciting part is, I've been around the industry for a long time. Now, you get some bright young people working on these areas unencumbered by history. The most fun part is watching the teams come up



Nutrien employees plan for digitalization

with the ideas and install them.”

The use of technology, particularly robotics, is somewhat different at K+S Potash Canada’s Bethune mine. The first greenfield potash mine in decades is a solution mine, which therefore does not use, for example, boring machines or packaging equipment.

“But we do certainly have a lot of automation,” said KSPC President and General Manager Sam Farris.

“On the infrastructure side, we’re definitely trying to use the best available technology economically achievable. Not everything was the absolute leading edge, because there can be a lot of risk around adopting that standard. But in some cases, especially around our process control system, there was a lot of new technology used.”

Bethune, formerly known as the Legacy Project, had some early quality issues that needed to be solved. One approach has been the use of big data.

“Our team back in Germany, where we have a digitalization data science group,

developed some interesting models that helped us see things that weren’t otherwise obvious,” said Farris.

“On the safety front, we looked for op-

“We use drones for routine inspections, to go to old abandoned areas of the mines.”

TOM OLSON

portunities to manage information that’s coming from a lot of different directions and put it in a place that’s easy to understand and visualize.

“We’ve adopted a tool that excels in being flexible in receiving information from diverse sources, giving us a really clear picture of

the information and helping us organize our workflow around that.

“You are doing area inspections, observational activities, you have experts like the mine safety unit coming in to do inspections, you have safety meetings. With all of these diverse sources of information, and with the corrective actions that come out of it, the challenge is, without an overarching system, you can easily lose track of them.

“It’s a way to collate it, manage that information. That’s been a real key for us in building a strong safety culture here at KSPC.”

A new technology on the environmental front is a “best-in-class” leak detection system KSPC proposed in its permitting phase.

“We have a lot of underground pipelines, with a fiberoptic network capable of detecting temperature differences that might be a very early indication of a leak well before you can see it on surface, and before you have had any potentially significant impact on the surrounding environment,” Farris said.

“We’re using technology right now to get ready for some new projects that will ensure we can maintain our level of production in the future.”

**VINCENT LANIECE,
VICE-PRESIDENT,
SAFETY, ENVIRONMENT, AND ENGINEERING,
ORANO CANADA**

KSPC is also piloting some new cloud-based approaches so that everyone can see the same information in one place. It’s about managing data, visualization of safety or technical information, and having easy access to it, even if coming from multiple sources.

Company-wide, “there’s a global project going on trying to harmonize the safety and environmental data – a strategy to have all the information across the company. We have operations that are more than 100 years old all the way to us; we’re brand new. It’s really trying to harmonize that, so we have a common view of where we are at and what our focus should be.”

Process modernization continues in the uranium industry, as well. Vincent Laniece, Vice-President, safety, environment, and engineering at Orano Canada, says Orano has been largely focused on automation.

“We’re embracing, right now, what I would call the industry 4.0, digitaliza-

tion and big data, overall,” he said. “We started on the automation with good success there.

“For example, at the McClean Lake mill, the high-grade uranium ore slurry we are currently treating is such that in the process there is a fair amount of hydrogen being generated, and in our process that’s not a good thing.”

To ensure everyone’s safety and the optimization of the processing, some circuits had to be upgraded and new processes implemented to eliminate the hydrogen.

“We’ve been doing that by automating some of the circuits as much as we can. We are mitigating the hydrogen release issue by sweeping it with air and blowing it into storage tanks.

“The system is fully automated, which then of course helps the operators make sure we have the right parameters and the required levels coming in and out, and also the right kind of controls, to remove

An Orano employee uses a control panel in the yellowcake packaging area.



and store substances such as hydrogen.”

Orano has also automated the yellowcake packaging enclosure. At the McClean Lake mill, one of the largest such facilities in the world, Orano produces approximately 18,000 drums of yellowcake annually, which can be sealed with minimal intervention from the operator.

“Again, we needed to have a system designed to handle yellowcake (uranium concentrate), which is a fine powdery substance. We wanted a system that would automatize the packaging process as much as possible to prevent workers from being exposed to yellowcake dust. We were able to make that happen and improve the overall process.”

Orano is also “embracing big data” and virtual reality to generate 3-D images and animation of existing circuits, including parts that are incased in concrete.

“We’re using this technology right now to get ready for some new projects that will ensure we can maintain our level of production in the future,” Laniece said.

“We’re trying to debottleneck some of our circuits to ensure we can push through the required tonnage of uranium ore slurry to meet production. We will need to install some new pipes, pumps and other equipment. By having 3-D images and being able to use virtual reality for the different circuits, it’s easier to design the new parts we need to put in and reconfigure the space.”

In maintenance, Orano is embarking on developing a system to measure equipment reliability, including the installation of instruments that tell employees whether a piece of equipment is getting too hot, experiencing too much vibration or too little lubrication. “You can

get software that tells you in real time what you need to do to your equipment and the time frame. Based on that, you can use the recommendations from the software and decide when you want to intervene — and somewhat better plan the employees’ workload and the budget.

“The new generation employees are fully aware of these wonderful technologies. Now it’s making sure the older generation is also aware and embracing it.”

“As humans, we don’t need to fear these new technologies; rather, we need to use them to make life easier and safer.

“Orano is pushing very strongly for Industry 4.0. We’re discovering what it can be and how we can make it work for us, investigating next steps. I’m sure there are many aspects we are not even aware of or thinking of and that we will discover in the next weeks and months and years.”

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Canadian potash GHG emissions are only 29% of the global average – leading the world in terms of low GHG output.

Source: Carbon Footprint for Canadian Potash Production, Cheminfo Services Inc., 2018.

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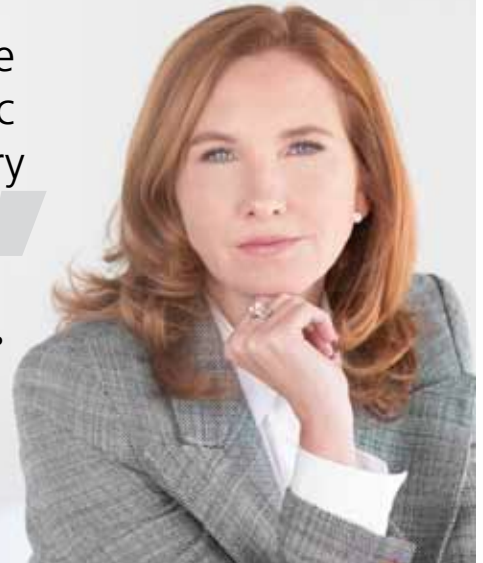


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**EIRA THOMAS,
PRESIDENT AND CEO
LUCARA DIAMOND CORP**



When a retail customer buys an engagement ring, he or she wants to know exactly where the diamond came from — not to mention its size, colour and quality.

Diamond buyers, such as large jewellery houses, are no different. Yet, until recently, those big buyers have been obliged to purchase large collections of the precious gems, generally sorted by their qualities.

Eira Thomas is revolutionizing that process, one diamond at a time, from mine to ring.

The President and CEO of Lucara Diamond Corp. has launched the Clara project, a blockchain technology that securely matches buyers and sellers in an online “cloud” environment. It’s still a very new system, begun at the end of 2018, but Thomas sees enormous potential in Clara.

“We bought it and we spent the first six months commercializing it and getting the platform up and running,” said Thomas in an interview, from London, UK, just before — appropriately — dashing off to a blockchain conference.

“We started sales in late 2018. We’ve been ramping it up, very slow and steady, which has been a deliberate strategy for us. With this type of technology it’s really critical to build up the supply and demand

at a very measured pace.

“It’s coming along really, really well. We’re pleased with the feedback we’re getting. Our customers are super happy with the platform and they’re getting very good results.”

Most people are familiar with blockchain as the system used by Bitcoin to trade the cryptocurrency. However, it can be used for other business purposes without the hyper-competitive trading element.

Essentially, a blockchain is a list of records or “blocks” that are cryptographically linked. Each piece of information is marked with a time stamp and transaction data. It is also designed to be resistant to data modification. View it as an online ledger that records transactions between parties with ongoing verifiability, or provenance — which is something all consumers, whether individual or business, are increasingly asking for.

Yet Thomas says it’s a much more than just a tracking system.

“It’s really a business solution where the tracking piece is just an adjunct, basically a bonus that comes along with this completely new way of transacting diamonds. What we’re trying to do is break up an age-old system which is very antiquated and inefficient.”

Traditionally, customers were forced to

buy the collections or “buckets” rather than individual diamonds.

“Those customers . . . take them back to the polishing factories and invariably they find that not all of those diamonds they just purchased are not suitable for their factory. They’re forced into a situation where they have to take those diamonds that are less suitable and retrade or resell them.

“What Clara is going to do is completely disrupt this whole process. What we’re doing with Clara is we’re using technology we didn’t have even five years ago, to sell diamonds stone by stone, so that our customers now can go onto the Clara platform and request specific stones . . . based on their specific requirements.”

Clara, patented globally, has created a cloud-based digital inventory for Lucara. First, the company scans the diamond using specialized technology created by a company in Israel, which makes a 3-D image and maps it perfectly.

“It becomes the immutable record of where that diamond came from. Before it’s even left the mine site, it’s scanned, it’s uploaded to the Clara platform and we producers ascribe the value, a selling price.

“We can then use Clara to track it through the value chain. But that’s not why we’re

doing Clara. We're doing Clara because we want to create a more efficient marketplace.

"As we grow this right now, we're just using diamonds from our own mine, which is a small mine (in Botswana). We're in discussion with a number of producers to use Clara as well. We intend to add third party production onto the platform, at least one other producer by the end of the year.

"It is a new business model. It's not a mining opportunity but it is a new business opportunity. It has the potential to be as important to us as our mining business."

The end consumer also benefits from the system, she said. Increasingly, consumers want to know where the steak on the table or the diamond on the finger originated.

"It's becoming a must for those (end) consumers. The younger generation of consumers, it's something they're demanding. They want to know where their diamonds are coming from and that they're working with responsible businesses.

"We think if we're going to grow demand for this product, we need the transparency. A lot of this is going this route because provenance is a hot topic today in every business."

But blockchain platforms in mining are not limited to the sale of diamonds, although it's significantly more challenging to set up for several other mined commodities.

Brian Beveridge, Partner, MNP, Technology Solutions Group runs the company's blockchain practice, and comes to it with a mining background. He and his team recently plunged into the potash sector, creating a pilot blockchain system to test its viability.

"It was about traceability of the supply chain," Beveridge said. "The issue we have with ore is that it's not packaged up – it's not a boxed product. It has to be processed and broken down, and it's granular in some cases, like potash. When it gets refined and processed down to a product (like fertilizer), it's a lot easier to trace."

In the potash case, MNP was interested in following the product's quality and evaluating challenging factors at the other end of the supply chain, in places like China or India. They asked the hard questions about finding issues, such as manual off-loading and tally sheets being hand-written and not entered into computer systems for months.

"We were trying to help the companies solve those problems by looking at end to end — when the ore is picked up at the mines, when the samples are taken. How do you match that with the shipment all the way through, going from the pickup to the port, going on to a ship, going across the ocean, coming off the ship and being accepted by the customer and all the points in between

... and making that all transparent?"

"There's a lot of opportunity in that supply chain, and the pilot we built for one company gave them for the first time a place to go where they could watch the product and the product quality data all the way through — including the shippers, the testing labs, the railways."

The challenge is less about the technology, which is increasingly improving, and more about get multiple stakeholders to agree to participate, he said.

"Typically, there's a big education process," Beveridge said. "You have to join the consortium and share the costs of running the network, talk to their IT people and go through the explanation of how it all works."

The first issue is often "getting people's heads around it" because when they hear the term blockchain, they immediately think "cryptocurrency."

"We're not processing payments here. We're tracking and tracing your product."

Companies like MNP, experts in the field, must not only explain blockchain's process but also "need to cover all the business planning, governance of the consortium, reward mechanisms, cost sharing and ongoing maintenance. Blockchain technology is the tip of the iceberg." 



MINING SOLUTIONS

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K+S Potash Canada



Provided by
Saskatchewan Geological Survey,
Ministry of Energy and Resources

WHAT IS SASKATCHEWAN COAL USED FOR?

Saskatchewan has vast thermal coal resources that were originally used for heating purposes, but today are mainly used for thermal power generation with a small amount going to produce lignite char for barbecue briquettes.

Although there have been hundreds of small coal mines across the province over the past 140 years, today there are only three. The Bienfait, Boundary Dam, and Poplar River coal mines, all operated by Westmoreland Mining LLC, feed SaskPower's Shand and Boundary Dam Power Stations near Estevan and the Poplar River Power Station near Coronach.

These thermal power stations collectively produce 30 per cent of the province's electricity. SaskPower operates an Emissions Control Research Facility at Poplar River and has undertaken an innovative Integrated Carbon Capture and Storage Project at Boundary Dam. Unlike other higher rank coals, lignite is not suitable for use as coking coal in steel production.

HOW IS SASKATCHEWAN COAL MINED?

Coal was the first mineral ever to be mined in Saskatchewan — as far back as the 1870s. Many of the early coal mines in Saskatchewan were small underground operations where miners would excavate

into hillsides and use logs and timbers to support their drifts.

Today, coal mining in Saskatchewan is entirely mechanized, with very large drag lines that remove the surficial cover and extract the lignite. After the coal is removed, the overlying sediments are set back in place and the land is re-contoured to improve



Coal mining in southern Saskatchewan

drainage for farming.

Saskatchewan is Canada’s third-largest coal producer, after British Columbia and Alberta, typically producing around 10 million tonnes of coal annually, which accounts for about 15 per cent of national production (Statistics Canada table 25-10-0017-01).

HOW MUCH COAL IS THERE IN SASKATCHEWAN?

While coal resources have been defined in several regions of Saskatchewan from the Kindersley area to Lac La Ronge and Hudson Bay, the majority of significant evaluation work has been done for the coal fields in the Estevan, Willow Bunch, and Shaunavon areas. These three coal fields are estimated to contain nearly five billion tonnes of readily available lignite resources of economic interest.

HOW IS SASKATCHEWAN ADDRESSING CARBON EMISSIONS FROM COAL POWER STATIONS?

SaskPower’s Boundary Dam Carbon Capture and Storage (CCS) Project (BD3), located near Estevan, is the world’s first fully-integrated and full-chain CCS facility on a coal-fired power plant. As of August 2019, according to SaskPower, 2.86 million tonnes of CO2 have been captured since operational start-up in 2017 — the equivalent of taking 616,333 cars off Saskatchewan roads. 🌱



Coal powers Saskatchewan’s electrical grid.

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Resourceful

McKercher LLP has a specialized team of lawyers and professional staff dedicated to providing advice to local and international clients in the oil patch, potash industry and other natural resource sectors. Our mining and natural resource practice includes specialized mining agreements, acquisitions & dispositions, financing, regulatory & environmental issues, First Nations & government relations, and litigation.



SASKATOON
374 Third Avenue South
Saskatoon SK S7K 1M5
(306) 653-2000

REGINA
800 - 1801 Hamilton Street
Regina, SK S4P 4B4
(306) 565-6500

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Drones offer safety and efficiency at K+S Potash Canada's Bethune Mine

When Ravi Ramdeo and his team needed to inspect a 200-foot-tall exhaust stack at the K+S Potash Canada Bethune mine in the summer of 2018, options were limited.

As Predictive Maintenance Supervisor, Ramdeo is responsible for spotting potential deficiencies in mine structures so they can be addressed proactively. For the exhaust stack, the traditional solution would be both risky and expensive: bring a large crane on site with a basket, then transport an actual person to the heights to get a closer look. Fortunately, there was another option.

"One of our contractors happened to have a drone on site and was able to get some very detailed pictures of the structure up there," Ramdeo said.

The cost was so much less — Ramdeo quips they "could have bought 10 drones" for the price of the crane — that the decision was made to purchase some drones of their own and train on-site employees to pilot them. There are currently seven pilots. Ramdeo and his colleague Kevin Gibbs specialize in safety.

Gibbs is Quality Assurance/Quality Control Inspections Coordinator, responsible for inspecting and looking after the physical condition of mine structures and stationary equipment, such as the condition of crystallizers and evaporators as well as various other pressure vessels.

Sending a human inspector inside these enclosed structures means removing all hazards to entering personnel, installing ventilation, and installing scaffolding. Care must be taken to ensure the inspection process itself doesn't cause harm to the people or equipment.

"Whenever you introduce scaffolding or dissimilar metals, that has the potential to create a hazardous position for the vessel itself," Gibbs said. "We don't introduce any new hazards or items or anything in the vessel, we just send the drone in."

Industrial drones are specially designed for their tasks, robust and equipped with high-resolution imaging systems to see in visible light and infrared (thermal imaging). Gibbs' drone, for example, is enclosed in a lightweight cage that prevents the aircraft's rotors from hitting the walls of an enclosed structure — or personnel.

"It's pretty safe to be directly beside it because the propellers are encased in the cage and you can just basically push the drone away," he said.

Ramdeo and Gibbs, as well as the other company pilots, underwent five days of training to learn how to pilot the drones and get Transport Canada certification. They stress that this is just the beginning of a process of continuous learning.

Both also stress that these machines are not toys. A drone operator must be totally focused. They must capture a thorough and complete image set for whatever they are inspecting, while at the same time protecting the drone itself. Gibbs explained that the drone he flies relies entirely on his piloting since it cannot access a GPS signal from inside a structure (exterior drones with GPS can be programmed to simply hover while they wait for pilot input).

"People think that flying drones is so much fun, but when you're actually doing it in person work-wise, it's meticulous," Gibbs said.

It's also a high-tech, new way to enhance safety at mining operations. 🚁



Project aims for precision tracking of people and assets underground



Dr. Terry Peckham, senior research associate, works with students on an Applied Research project.

One of the challenges in keeping potash miners safe underground is being able to know where they are at all times, something Terry Peckham hopes to address with an electronic system able to track people and equipment.

"The biggest challenge right now is trying to create some accurate positioning," he said. "Personnel safety is the primary push."

Peckham is the Digital Integration Research Chair at the Digital Centre of Excellence at Saskatchewan Polytechnic's Saskatoon campus. He is the lead researcher on a two-year, half-million-dollar project which started earlier in 2019.

Potash companies Nutrien and BHP, together with the International Mineral Innovation Institute in Saskatoon, are contributing \$244,000 in cash and in-kind resources to the project, with the Natural Sciences and Engineering Research Council (NSERC) contributing \$300,000 through a research grant.

Peckham said current systems allow mine supervisors to know what section of the mine their workers are in, but not precisely where. Conventional potash mines have tens of kilometres of underground tunnels, so there's a lot of area to cover. The sys-

tems he envisions would track both people and equipment to within 30 centimetres of their location.

The biggest challenge right now is trying to create some accurate positioning. Personnel safety is the primary push.

**TERRY PECKHAM,
DIGITAL INTEGRATION RESEARCH CHAIR,
DIGITAL CENTRE OF EXCELLENCE,
SASKATCHEWAN POLYTECHNIC**

The underground environment presents significant hurdles. Potash mines are typically one kilometre below the surface — far beyond the reach of GPS signals. This means the whole system must be underground, such as in-mine transceivers, placed to see around corners where necessary.

Dust in the air can interfere with signals, depending on the frequencies used. For example, Peckham explained that mining activity must shut down when survey crews come in to periodically check and ensure the boring machines are advancing in the correct location on the potash unit. This is because dust in the air interferes with the lasers used by the survey crews.

Another challenge is that mine walls are uneven, making it hard to predict how they will reflect signals. Still, Peckham is optimistic, particularly since they are starting from a strong foundation.

"This project is simply about proving that we can get a technology down there that is going to be able to get us within 30 centimetres," Peckham said. "Above ground? We can do way better than that. These technologies are proven technologies above ground. Moving them underground requires adaptation and augmentation."

Knowing the precise location of both personnel and equipment can help create a safer work environment in several ways. For example, Peckham explained that equipment could be programmed with safety protocols to automatically shut down if a worker inadvertently came too close to a hazardous area.

"Once we've figured out these technologies, they're small enough and lightweight enough, we can easily put these things into a helmet, a boot, a little lapel thing on the shoulder of a person walking," he said. "If we have it on the equipment and we have it on the people, we can actually stop the machinery."

As of October 2019, Peckham and his team had completed surface testing of their system with good results and were preparing to take it underground. He anticipates it will take several iterations of above-ground and underground testing and adapting over the next two years to get to a workable solution.

The multidisciplinary project also employs Saskatchewan Polytechnic students from three different programs. Some are building enclosures for equipment, others are programming it, and still others will be going underground to provide the precise surveying needed to test the system. Peckham says this integrated approach is central to the SaskPolytech experience — providing students valuable applied learning experiences with potential future employers. 🚧

High-tech jobs to attract workforce of the future



Canada's mining industry stands at the cusp of a new age: bringing digital transformation to mine sites, even as an enormous cohort of workers prepares to retire.

And so, the new age also presents a new challenge in finding workers with the skill sets and education to manage the oncoming technology.

Despite the recent commodity downturn, mining companies already face a tight labour market, says Ryan Montpellier, Executive Director of the Mining Industry Human Resources (MiHR) Council. MiHR provides labour market research on the Canadian mining sector, and specifically the supply and demand of workers and the trends affecting how efficient and effective the labour market is.

The council is presently preparing a two-

year study on this topic and has found the unemployment rate in the sector is under four per cent.

"We're facing some daunting challenges to find enough people to work in our industry in the next five to 10 years," said Montpellier.

"We continue to have an aging workforce. About 40 per cent of our industry is prepared to retire in the next decade. That exodus of workers coupled with the fact we're experiencing some growth despite some challenges — there are some new mines coming on in Canada — we have a number of factors exacerbating our challenge to attract the next generation of workers."

Montpellier points out that Canadian firms are building mines in rural and very remote

locations that simply do not have the density of population to support large industrial projects. In addition, enrolment in mining-related post-secondary education, such as mining engineering and geosciences, has declined.

"Part of the solution to (the labour crunch) is obviously the use of technology and innovation," he said. "There are different schools of thought on this, that automation will replace a lot of the jobs, but that's not necessarily the findings we're seeing."

"Across all industries, we're seeing advances in data analytics, robotics, AI (artificial intelligence), machine learning. It's going to change the way we work."

"We are embracing that. We've looked at a number of different studies on this that show adopting some of these digital



“As mining becomes more of a tech sector, using more and more robotics... the skill sets required to oversee and manage this are more complex.”

**RYAN MONTEPELLIER,
EXECUTIVE DIRECTOR,
MINING INDUSTRY HUMAN
RESOURCES (MIHR) COUNCIL**

technologies and innovations will have a significant impact on the mining industry and have potential benefits including increasing productivity, safer work environments, reducing energy consumption, environmental impacts, improving recovery rates and lower costs. All of those things have a huge potential impact on our sector.”

And so, education is key for the future of mining. The demand for STEM-related occupations — science, technology, engineering and math — has already seen a significant increase among mining companies.

“We monitor all online job postings in Canada and what’s interesting to us is that over the course of the last five years, 77 per cent of all job postings in the mining industry in Canada required a bachelor’s degree or above. That’s a significant shift from what most people would see as the traditional skill set of individuals working in the mining industry.

“It’s a shift in terms of the skill sets required in our industry. As mining becomes more of a tech sector, using more and more robotics, more technology, autonomous vehicles and so on, the skill sets required to oversee and manage this are more complex.”

However, the industry will not “flick a switch” and suddenly eliminate the jobs of miners or heavy equipment operators. They will still be needed, even as new occupations will emerge.

“There are certainly some occupations that are more vulnerable, and we’re developing a vulnerability index to identify tasks and skills that are more easily automated, and identify what those occupations are and the people who are going to be at risk and provide to them a pathway to an occupation that might be less vulnerable.”

Montpellier said there will be advantages to integrating new technology in terms of attracting a more diverse workforce. For example, a more inclusive workforce will become possible as fewer workers are needed in fly-in-fly-out remote environments. That opens the door to more women, new Canadians and people with disabilities.

He gives the example of Gold Corp.’s Musselwhite mine, which has a control centre in Thunder Bay. More people work in the city today, and fewer fly into the mine over 300 kilometres away.

“Being able to do that kind of work, which we never really thought was possible, and take some of the core production occupations outside the mine, is a game changer,” said Montpellier.

“Now we can build a workforce by addressing those barriers. It opens up the industry and allows it to access potential labour pools they haven’t had success with in the past.”

The MiHR study will help create an understanding of the impact technology will have on the workforce, and help the industry

better align with educational institutions.

“There’s no point in training students for occupations that no longer exist, and to not develop students for occupations that will exist.”

MiHR forecasts that 12,000 jobs will be added to mining in the next decade across all educational groups and careers, including suppliers. Over the previous 10 years, industry added about 40,000 workers.

While 12,000 is a lower number, consider that 60,000 people in the industry will retire within a decade, and 25,000 will leave for other reasons.

“The bulk of the hiring requirement is mostly replacements due to retirement,” Montpellier said.

“We don’t see this as a doom and gloom scenario. Our story is the opposite; this is a sector that will require a significant amount of human capital; it will require sophisticated, more advanced, STEM occupations.”

Lowering costs, meanwhile, which is among the goals of digitalization, may well mean lowering barriers to new mine creation.

“Regardless of the commodity, we need to extract them in the most cost-effective, efficient way possible to be competitive. We’re price takers. If we can control our costs and technology is a pathway to doing that, it’s in our interests to do that.

“In fact, you may see more mines come on stream.”

SMALL REACTORS COULD PAY BIG CLIMATE DIVIDENDS

Mining companies consider modular reactors to reduce GHG emissions

In November 2018, Natural Resources Canada released a long-awaited report entitled the small modular reactor or SMR Roadmap. It came after an in-depth consultation process with various stakeholders, such as Canadian provinces, society at large and industry.

“We had some participation from the mining sector, which was interested in what we were doing,” recalled Diane Cameron, Director, Nuclear Energy Division for NRCAN. “They kept an arm’s length relationship and said, ‘you have a lot of work to do.’”

“When the report was released, my phone started ringing the next day. The first day, I heard from five or six mining companies.

“It was like the mining sector said, okay, these guys have finally done their homework.”

To start at the beginning, SMRs have been around for some time. Nuclear submarines and icebreakers have been SMR-powered since the Second World War. While it’s well-understood technology, it has only been used in the public sector.

Recently, however, interest has spiked, if not gone through the roof. Climate change, energy costs, the need to provide electricity cost-effectively to remote locations and government policy have changed the landscape.

“A number of R&D projects have opened up in this space in the last five years that have made the designs possible for civilian use, such as mining operations or other off-grid operations like remote communities,” said Cameron.

Recent breakthroughs in SMR engineering appear to have shortened the time frame

for delivery by a considerable margin. And so, from NRCAN’s perspective, it was time to investigate their potential.

At this moment in time, Canada is the only country in the world that has all the conditions for success.

**DIANE CAMERON,
DIRECTOR, NUCLEAR ENERGY
DIVISION FOR NRCAN**

“We in the federal government became aware of this area of emerging technology innovation that people in Canada were looking at, but also people around the world. In 2016, this was still seen as very much future world; but the innovation has been moving very fast and the demand has been pulling it forward quickly.

“We convened the SMR Roadmap. It was a year-long project where we brought together provinces, civil society . . . a broad group of stakeholders to answer a number of different questions about the economics, will they compete on cost of electricity, how do they compare with hydro, diesel and other sources of power.”

They also looked at feasibility, regulation, waste management and Indigenous engagement, and then held a series of workshops that reached out to an even wider audience. Ultimately, it became clear that SMRs presented excellent solutions to reducing greenhouse gas emissions, and cost-effectiveness.

“An SMR emits zero GHGs. You have to transport, but the actual power source has zero GHG emissions,” noted Cameron.

“The race is on. It’s hard to know exactly, but the race is on. Investors and companies and countries are moving fast.”

SMALL COMES IN MANY SIZES

SMRs, small in both physical size and in terms of power output, are ‘modular’ because they are meant to be factory-produced.

“They’re not one-off projects you build on site. That improves the economics,” said Cameron. “You could actually deploy five or six of them to supply what you need. If you had a smaller mine you could use fewer of them, or for a larger mine, more of them. You can use the heat directly or to generate electricity.”

In terms of power output, SMRs can be built to generate power under 300 megawatts electric (MWe), which provides a huge range. The larger ones are for electrical grid generation, and New Brunswick, Saskatchewan and Ontario are considering building those units as an option to produce clean electricity, in some cases by 2028.

For the mining sector, or remote communities, SMR models generating 20 to 60 MWe seem to be the right size range,

said Cameron.

“Post roadmap, we started to understand you need a lot of redundancy and backup at a mine site. If you had a mine needing 20 MWe, you probably wouldn’t want to meet that with one unit. You’d be better off with four units of 5 MWe’s.

“It’s better to have a battery approach and you don’t even need your diesel electric. Even your mining demand would be met by smaller units.”

In terms of physical size, some of the 5 MWe units might fit into a large sea shipping container, and some of those might come fully fuelled for 20 years. That’s partly why the amount of waste is expected to be quite small.

“When we did the regulatory review, we found Canada’s regulatory and legal framework are more than adequate to deal with waste streams,” said Cameron.

WHAT’S NEXT?

Since the Roadmap’s release, things have started to move quickly. NRCan has announced its intention to have an SMR at its national labs by 2026, while Ontario intends to have one at its Darlington site by 2028.

“The real question for the mining sector is, in terms of timelines, is there appetite

to build a first of a kind reactor at a mine site?” Cameron said. “Or will they require a demonstration reactor first?”

“Some mining companies are looking into the possibility of skipping the demo and going ahead with commercial development.”

“We anticipate the global market could be \$150 billion a year by 2040.”

DIANE CAMERON

Cameron says it’s likely that some mining companies would partner with a nuclear operator, which would build and own the SMR and sell heat and power to the miner.

Canada, she added, is well-positioned to move into SMR technology. Beyond technical feasibility, SMR development requires a country ready with regulation, experienced operators, a waste management regime and demand.

“At this moment in time, Canada is the only country in the world that has all the conditions for success,” she said. “Which is why so many SMR companies have moved to Canada to pursue their development. The U.S. and UK are making massive investments to fill the gap. But we have the supply chain and the demand side.”

There’s also the affordability side. For example, Cameron says SMRs could reduce the cost of electricity by 20 to 60 per cent for companies now using diesel.

“We’ll learn by doing. There’s a learning curve and your costs go down over time. The first couple of units will be the most expensive. What’s fun to start thinking about is Canada as a world-class nuclear country as well as a world-class mining country. If companies roll out this competitive advantage, they could use these SMRs in their other operations.

“We anticipate the global market could be \$150 billion a year by 2040,” she said, adding that the number is probably low; a study by McKinsey put the amount much higher. “That’s the economic potential. There are still things that have to happen to make it real. But we see a lot of the pieces coming together.

“And think of the GHG reductions.”

Graphic published courtesy of the Canadian Nuclear Association

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In each edition of ORE, we go beyond the official bios to give our readers insight into the leaders of Saskatchewan's mining and exploration companies.

Beyond the Bio

JIM CORMAN
PRESIDENT AND CEO
ORANO CANADA INC.

One of Saskatchewan's great uranium projects has been part of Jim Corman's career from the very beginning.

The Regina-born Rider fan, with a geological engineering degree from the University of Saskatchewan, plunged into the northern bush first as a summer student. Employed by French company TOTAL S.A. out of Alberta, in the days when mining jobs were few in Saskatchewan, Corman hunted the areas around places like Black Lake, Key Lake and Stony Rapids for new deposits.

He and his team found them.

"We were successful and fortunate to find some ore bodies here in Saskatchewan that eventually turned into the McClean Lake project," he said in an interview.

TOTAL had oil and mining assets including coal and uranium; Cogema, today known as Orano, was dominantly in the uranium space. The two large French companies came to the conclusion there was no sense in both of them doing work in each other's backyards. And so, they swapped assets.

They also swapped Corman, who re-

turned to Saskatoon in 1990 to ultimately follow the Cogema projects as they evolved from exploration through environmental assessments, feasibility studies and on to operations.

"It's been an interesting career to move from the grassroots side of things to full operations. McClean is now the largest uranium processing plant in the world," he said. (Orano has halted mining at McClean, but continues to operate the mill.)

He also worked at Cluff Lake for a short time and has been involved with its closure and decommissioning.

"We've taken it from cradle to grave, and it's a real standard, I think, for modern mine closure. We're at the point where we're probably a year away from transferring the site back to the Crown."

Then, when Cogema got the go-ahead to start operations at McClean Lake, Corman moved into an operational role as the mine superintendent from 1995 until 2002, before becoming general manager for six years.

"The first part of my career was a lot of time either in the field three to four weeks at a time on the exploration side, or week-in, week-out with the operations," he said.

"When I transferred down to Saskatoon in 2008, it was the first time in my career I started doing a Monday to Friday, nine to five kind of job. Being responsible for operations at head office, I still spend a lot of time onsite in my current position, as well."

In that year, Corman became the vice-president of operations and projects during the heydays for uranium.

"The nuclear Renaissance was anticipated. We had a lot of projects we were developing – the Midwest project and a big project up in Nunavut as well. I was responsible for feasibility studies and environmental assessments for those projects.

"Unfortunately, the market didn't turn out the way we were anticipating, so we've had to put those projects on hold for better days."

A new challenge came in 2016, when he transferred to Orano's head office in Paris

as VP of projects and R&D.

“It was a great opportunity for me to see the other operations Orano has world-wide and get exposure to different types of mining methods in other locations, different processing methodologies, and different challenges in different environments,” he said.

“It was an opportunity for me to get some experience and share some of our know-how from Canada with other parts of our group in our other operations. It was a great experience — a lot of travelling to off the beaten track destinations like Kazakhstan, Mongolia, Niger, and Namibia. It was a great opportunity to see parts of the world that for most folks, it’s probably not on their bucket list of places to get to. But they are really beautiful countries, with talented people in these other locations. It was just a real great experience for me.”

His wife Brenda, a retired maternity nurse, accompanied him overseas, while their two adult sons stayed in Canada.

“It was a fairly easy move for my wife and me, living in the heart of Paris. That’s going to be one of our big adjustments, coming back to our Saskatchewan winters. I’m a little soft after three winters away

from our 40 below,” he said with a laugh.

He returned in August to take on the roles of CEO and president for Orano Canada, officially starting Sept. 1, and said he intends to continue along the path set out by predecessor Vincent Martin.

“It’s been an interesting career to move from the grassroots side of things to full operations.”

JIM CORMAN

“A key aspect for us is to continue operating our sites in a safe manner. That’s been one of our fundamental values here at Orano. Our focus and our values haven’t changed. Safety continues to be a critical aspect of our operations.

“Certainly the uranium market is challenging. We need to continue to work and focus on keeping our operation streamlined and efficient. There are things there we are working on, making structural organizational changes, embracing digital technologies to streamline our operations to make them as efficient as possible to compete in today’s market and place us in a position to take on more production opportunities when the market improves.

“I’m looking forward to it. It’s a great opportunity for me to get back and reconnect after being away for a few years.”

Among the out-of-office benefits to coming home is that he can watch his favourite sports again at a reasonable time of day; catching Canadian football or hockey games overseas meant early morning or late-night viewing.

“We have a cabin at Wakaw and it’s one of the things we missed when we were in France. We like to get up to the lake on weekends if we can and enjoy the prairie peace out there.

“I’m trying to get back into curling for the winter, to help us readjust. It’s just a good social sport. We don’t take ourselves too seriously.”

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TAGGING ALONG



BRODY WASMANN TECHNICAL SERVICES ANALYST, K+S POTASH CANADA

It's 5:45 a.m. when Brody Wasmann boards the shuttle for the 40-minute commute from Moose Jaw to his job as a technical services analyst at the K+S Potash Canada Bethune mine. The bus is one of many things Brody has come to appreciate since joining K+S.

"We work four days a week, but a longer day, so it's nice not having to drive—especially in winter."

When he arrives onsite, Brody's day can unfold in many ways.

"Bethune is still a new mine, so we're addressing some of the technology needs that weren't a priority when the operation was ramping up. You have to be agile. You can plan out your day, but then you have

to be ready to pivot 180 degrees to deal with another issue. I like that; it keeps me on my toes."

The K+S Bethune mine officially opened in 2017, the first greenfield potash mine in Saskatchewan in more than 40 years. It's a solution mine that extracts potash crude salt and then processes it into three types of potassium chloride for use in fertilizer and other products.

Brody came to K+S in January 2018 after three years as an IT support analyst at Saskatchewan Polytechnic. Friends who worked at the mine had good things to say about the company — not surprising since in 2019, K+S Potash Canada was again named one of Canada's Top 100 Employers and Sas-

katchewan's Top Employers. But it was the opportunity for advancement and the lure of being part of something new and important to the provincial economy that motivated Brody to apply when the IT posting came up. He hasn't looked back.

"One of my first projects was aligning the hardware and software needs of the designer/drafter group," he says. "I set up meetings to identify their needs, developed a computer imaging and system configuration process, created documentation for the third-party on-site support to technician to follow and trained them on the process from start to finish."

Brody is especially proud of an audio/video project that required installation of

One of my first projects was aligning the hardware and software needs of the designer/drafter group.

BRODY WASMANN

a/v systems in 14 conference rooms and two lunchrooms.

"I took over from a co-worker who had other priorities and was the sole project manager from start to finish. I met with the various departments to determine their needs, did walk-throughs with vendors, developed quotes, created implementation plans and oversaw the installation. Now, all those rooms are wired for meetings, presentations and events," he says.

Since joining K+S in 2018, Brody has taken advantage of training opportunities

to develop his skills in project management as well as in SAP, ITIL practices, Cisco Telepresence and more. And he jumped at the chance to go to K+S headquarters in Germany earlier this year.

"I was there for two weeks and it really opened my mind to the opportunities," he says.

K+S Potash Canada is part of the K+S Group, a German company that has been mining and processing potash and salt for over 125 years. The company has approximately 15,000 employees worldwide.

It's this global scope and deep well of experience that Brody hopes will lead to interesting career opportunities. Since his trip, he's started a job transition into the role of IT Business Consultant.

"This new role involves working with the business and technical teams on topics such as document management for our drafters/designers, data management and manipulation for the wellfield engineers, and implementing solutions that enhance the usage of drawings/documents with our engineering software." 



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SIEC brings robots to school to train tech-savvy workforce of the future

Digital technologies are transforming industry and driving a demand for tech-savvy workers, a demand Janet Uchacz-Hart and her colleagues are helping to meet by working with Saskatchewan students.

workforce. A KPMG survey reveals more than half of this investment is going into data and analytic tools, while about a third is devoted to autonomous vehicles and the balance to robotic process automation.

identify learning outcomes that could be matched with digital literacy material.

The resulting SaskCode initiative provides kits with robots and lesson plans that teachers can sign out for three weeks, complete with their students and return. SaskCode includes professional development sessions for teachers to learn how to incorporate the material into the math, science, and art curriculum, plus a help line for ongoing support.

The program, piloted from November 2017 to March 21, 2019, is now being expanded across the province. This includes in the north, where SIEC partnered with the Saskatchewan Science Centre, with Innovation Saskatchewan backing, to deliver the RoboX program under SaskCode. The initial effort trained 28 teachers from 10 northern communities to use the robotics kits.

"We give them all the lesson plans; they're just thrilled," Uchacz-Hart said. "Do you know who the most thrilled are? The kindergarten teachers. Because they're so engaged."

She gave the example of a young boy in a northern community who regularly missed school and wasn't terribly interested when he did attend. That all changed with the RoboX program.

"They just saw the light bulbs go off, because it was hands-on and he could see progress. He was able to spell his name out with the mouse bot; it's instant success. He'd ask, 'what are we going to do next?'"

SaskCode is gaining momentum. As of October 2019, more than 1,400 teachers have been trained, more than 800 kits loaned, and more than 40,000 students reached. A recent meeting to plan expansion of the program provincially included 23 school divisions and four tribal councils.

Uchacz-Hart acknowledged the robotics kits have a cost — about \$1,000 to \$2,700 each depending on the level. Bringing them to classrooms is made possible through school divisions, tribal councils and industry. For example, potash giant Nutrien partnered with the Saskatoon Tribal Council to pay for 20 kits.

"Industry partners are most welcome," she said. 🏠



Students around the province are learning about robotics through programs such as the one provided by SIEC.

"The majority of jobs in the future will be digitized at some point, whether it includes coding, automation, AI in terms of robotics, all of those things," said Uchacz-Hart, who is executive director of the Saskatoon Industry Education Council (SIEC).

SIEC is a non-profit that works with Saskatoon school divisions, the Saskatoon Tribal Council and industry partners to help prepare young people for future career opportunities.

Already, the mining industry is investing in technologies that demand a digital-savvy

"We're trying to create that culture, especially with various groups including Indigenous groups, girls for example, to get them really interested in coding and robotics so they look to it as a career choice," said Uchacz-Hart.

For SIEC, the challenge is how to incorporate digital literacy into the classroom right from K to 12. To tackle it, they recruited a team of five teachers for 16 months. Backed with funding from Innovation, Science and Economic Development Canada, they went through the Saskatchewan curriculum to

Denison Mines first to use in-situ mining in Athabasca Basin



Denison Mines board members, staff and senior officials gather at the planned gate of the future Phoenix operation.

Mining companies operating in Saskatchewan's Athabasca Basin have been world-leading and innovative producers of uranium for decades, through the use of robotics and automation.

Now, Denison Mines Corp. is advancing the development of its high-grade Phoenix uranium deposit in the Athabasca Basin with the application of in-situ recovery (ISR) mining — a first for the uranium-rich region in northern Saskatchewan.

"The selection of ISR mining for the high-grade Phoenix deposit has been a defining moment for our company and stands to be a potentially transformational development for the future of uranium mining in the Athabasca Basin," said David Cates, President and CEO.

"To advance the development of Phoenix, Denison has assembled a team of seasoned project development, ISR and

drilling experts to complement our extensive geological knowledge of the Phoenix deposit — working together to de-risk the project in a staged and cost-effective manner ahead of a feasibility study and a development decision."

ISR is considered to be the world's lowest-cost method for uranium mining. A pre-feasibility study completed for the Wheeler River Project in late 2018 estimated capital requirements of CAD\$322.5 million for an ISR mining operation at Phoenix, while production costs came in at \$3.33 US per pound of U₃O₈ (all-in costs of US\$8.90/lb U₃O₈).

Those production costs rank among the lowest globally for uranium producers, explaining Denison's decision to advance the project despite the current challenging uranium price environment.

Denison is running several technical pro-

grams, including ISR field tests and metallurgical work, to increase confidence and reduce risk as it works toward a feasibility study and Environmental Impact Assessment. This fall, Denison announced positive results from the ISR field tests, including the decision to install two commercial scale test wells — the first wells designed for commercial ISR production in the Athabasca Basin.

ISR mining is a well-established method which currently accounts for more than half the world's uranium production. Widely recognized for competitive production costs and low surface impacts, the method relies on uranium extraction from a suitably permeable host rock, typically sandstone.

Mining solutions are injected into the ore zone, where the uranium minerals are dissolved in place. The solution is then brought to the surface and the uranium recovered in a processing plant.

ISR eliminates the need to physically remove ore and waste from the ground, thereby eliminating related surface disturbance and tailings normally associated with underground or open pit operations.

Denison's novel design of a 'freeze cap' to encapsulate the deposit allows for the proposed application of ISR mining at Phoenix and eliminates common environmental concerns associated with ISR.

Cates said the development has the opportunity to be one of the most environmentally-friendly mining operations in the world, owing to minimal surface disturbance, mining solution containment, no tailings generation, and access to the provincial power grid resulting in a potentially near zero carbon emission mine site during operations.



Denison Mines is advancing its Phoenix uranium project, which will use ISR as its mining process.



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Nutrien Wonderhub's Discovery Mine a big hit with children



If you've never been in a potash mine, and haven't visited the Potash Interpretive Centre in Esterhazy, this is as close as you — and more to the point, your kids — are likely to get to the actual experience.

The Nutrien Wonderhub's Discovery Mine, recently opened in Saskatoon, "is designed to give kids an experience that summarizes all the various parts of the mine, and the equipment they would find in the mine," said Executive Director Amanda McReynolds Doran. "It's a very unique exhibit because it's completely walled off from the rest of the museum.

"The kids have to get into an elevator to get into it, and up the elevator to get out of it. It feels like you're going underground.

"It's a simulated elevator, but we've even fooled some adults. We have a read-out in the elevator telling them you're now at 500 feet, 1,000 feet underground so they can watch how deep they're going.

"When the doors open, everything is scenically treated from floor to ceiling. Every square inch is painted and most of it is also textured to look like a potash mine."

Once in the mine, children can choose from several games and exhibits. Among them are three vehicles, proving popular with the shorter set.

Vehicle one, says McReynolds Doran, is a mine drive-through game allowing the kids to sit in the vehicle and "drive" it.

The vehicle was created by Prairie Machine, the Saskatoon company that actually builds similar machines for the mines. As the children "drive" the vehicle, they view a curved screen showing video that takes them through the Scissors Creek mine at Rocanville.

"They can see Nutrien employees as they seem to be driving by," said McReynolds Doran.

Vehicle two is a repair vehicle that allows

kids to be mechanics.

"They can replace the tires, pull the battery out, charge it up at the battery charging station, pop the hood and look at how an engine works, plug in and unplug everything. There are even little tools they can use."

Vehicle three is a boring machine, which gives kids an understanding of how potash ore is carved from the wall of the mine.

"Connected to that is a system of conveyor belts that move our fake ore across the gallery," said McReynolds Doran. "Kids have to work together to use that conveyor system; it can't just be used by one kid. In that way, we're inviting collaborative play."

Also in the Discovery Mine is a plan-view of a mine, similar to a train table, where kids can take miniature vehicles and move them through the mine.

"They also can observe from that how they tunnel through the mines to keep the structural integrity to avoid collapses."



Two video games are also big hits. One is a mine inspection game, where children hunt for and find the safety equipment in each 'room.' The other is a game called What's Under Your Feet.

"It's all about how Saskatchewan's mineral reserves got where they are, why this used to be an ocean and why it is now a prairie . . . and why there are salts underneath us."

Another activity involves a high-powered microscope connected to a screen. Instead of just one child seeing what's under the microscope, several children can participate.

"We have potash, other types of rocks and minerals, found objects like porcupine quill or bark found on the riverbank (for the children to view). We also find what kids like looking at the most is their own hands, how dirty they get, or if they have a little paper cut, what that looks like."

An area with a crawl-through tunnel and a safety pit — "our crawler corral" — allows toddlers and babies to play safely with age-appropriate toys while older children are enjoying more advanced exhibits.

All of these exhibits and games were

pulled together with help from Nutrien, who assisted with attention to detail and allowed local digital media production company Twisted Pair to capture the imagery at Rocanville.

The Wonderhub has a feedback board for visitors to weigh in on what they enjoyed the most, and the Discovery Mine, along with a climbing net, is always at the top of the list.

"We were lucky enough to get to host the launch of Saskatchewan Mining Week in May," said McReynolds Doran. "That was the first chance we had to show it to the mining industry. They got a chance to get their hands in there in play. The feedback was great."

Children who come from mining families are enraptured by the exhibit, too, because "when Mom or Dad works in the mine, you don't get to visit them at work. With this it becomes a connection point.

"And educators are enjoying the display of the breadth of mining careers available in the mining industry. Discovery Mine allows children to envision themselves in those positions and consider if that's something they want to do in the future." 🏔️





Children "drive" a mining vehicle through the Nutrien Wonderhub.



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BUILDING BLOCKS



A-MAZE-ING!

Two distinct generations of folding can be identified in this photo. Early folds with parallel limbs (isoclinal folds) are reoriented by younger folds with limbs at larger acute angles. These rocks were folded during a mountain building event approximately 1800 million years ago.

Refolded folds of metamorphosed mudstone, Santoy Lake area,

Photo by Paul Kremer

DID YOU KNOW???

The Seabee Gold Operation has produced over 1 million ounces (1 Troy ounce = 31 g) of gold since the mine opened in 1991. A record 84,000 ounces were mined in 2017. To put this into an everyday context, a United Nations report on electronic waste states that 41 mobile phones contain about 1 g of gold. This means that 1 tonne of old phones, weighed without their batteries, contains a total of about 10 ounces of gold.

DIGGING DEEPER!

These folded and metamorphosed mudstones are part of the Pine Lake greenstone belt near the Seabee-Santoy gold mining complex north-east of La Ronge. The

blotchy whitish areas scattered through the photo are remnants of quartz veins, similar to those that developed along faults and that host the old deposits in the area.

FUN FACT!

All the gold ever mined in the world (155,000 metric tons) would fit approximately into two Olympic-sized swimming pools.



Courtesy of Saskatchewan Geological Society.

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- ALX Uranium Corporation
- BHP
- Cameco Corporation
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- Cameco Corporation – McArthur River Operation
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 B42- 12100 Ewing Avenue
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No.	Test Items	Unit	Standard Value	Test Methods
1	Tensile strength	Mpa	≥80	GB/T1040.2/1B-2006
2	Flexural strength	Mpa	≥85	GB/T9341-2008
3	Charpy impact(unnotched)	NB	≥200	GB/T1043.1/eU-2008
4	Ball indentation hardness	N/mm ²	≥120	GB/T3398.1-2008
5	Compression strength	Mpa	≥90	GB/T1041-2008
6	Density	g/cm ³	1.15-1.17	GB/T1033.1-2008
7	Water absorption rate(24h)	%	0.5-1.5	GB/T1034-2008
8	Melting point	℃	≥210	DSC DSC Method
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