2017-2018

groundWORK

At **Mining Matters**, our goal is to inspire Canadian students, teachers, and the public to become excited about Earth science and mineral resources. We want to instill a fascination with geology and geography, and show how relevant the mining and mineral exploration industry is to our daily lives. To raise awareness, we provide current information about rocks, minerals, metals, and mining, and offer exceptional resources that meet curriculum expectations in Earth science and geography.

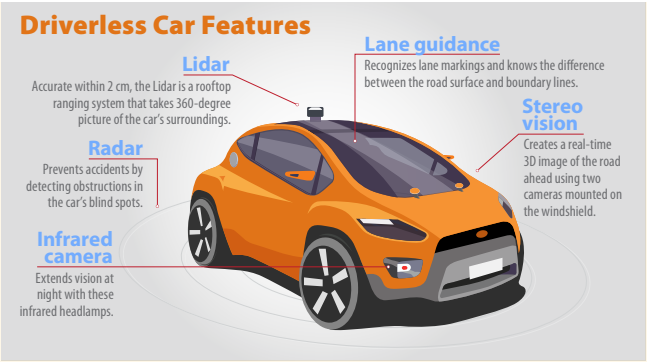
To support and motivate educators teaching Earth science, **Mining Matters** publishes *groundWORK*, an annual bilingual educator newsletter, designed to help nurture students' natural curiosity about Earth science and mineral resources. The newsletter features informative articles, news about our available resources, hands-on learning activities, field trip suggestions, links to teaching resources, contests, and more!

GOING DRIVERLESS

The Internet has radically changed the way people learn and communicate. The autonomous vehicle, better known as a self-driving car, could possibly have an equivalent impact on how people get around and transport products. While many see this development happening somewhere in the distant future, others predict that it's right around the corner. Businessinsider.com reported on June 15, 2016, that 10 million self-driving cars will be on the road by 2020.

The race is on to produce the first, the best, the safest, the most reliable self-driving car, all at an affordable price. BMW, Mercedes-Benz, Audi, Volvo, Volkswagen, Daimler, Tesla, General Motors, Ford, Honda, Toyota, and Hyundai are all on board, along with technology giants like Google, Intel, Samsung, and Apple testing out integral components, and the list keeps growing. Marking the significance of the developing technology, the first Self-Driving Cars AI/Deep Learning conference was held in March 2017, in San Francisco, California.

2016 seems to have been a turning point in the self-driving vehicle revolution. According to an Allied Business Intelligence (ABI) research report, released in January 2017, Advanced Driver Assistance Systems (ADAS) are entering the mainstream, with cost reductions in the various sensor technologies employed making self-driving vehicles more affordable. The key sensor is Lidar, an acronym for **L**ight **D**etection and **R**anging, complemented by Radar (**R**adio **D**etection and **R**anging), ultrasonic devices, and video cameras.



Lidar bounces pulses of laser-generated light off a car's surroundings, measures the time taken for each pulse to bounce back, and develops a map of those surfaces. Radar tracks the position of large objects at long range and fills in when Lidar is hampered by rain, snow, and fog; ultrasonic sensors detect curbs and nearby vehicles when parking; and video cameras read traffic lights and road signs, and monitor obstacles. All the sensor input must then be computer analyzed to produce decisions about steering, acceleration, and braking.

So, what does all this have to with metals and minerals? Quite simply, without metals and minerals, these sensor technologies and computer analysis could not exist. Let's look at Lidar and Radar.

Lidar includes a laser transmitter, a photodetector or photodiode receiver, and a processing component. Lasers comprise rare earth components such dysprosium, yttrium, and neodymium. Materials commonly used for photodiodes include silicon, germanium, and indium gallium arsenide. To process the sensor input, silicon is one of the most important semiconductors, and gallium nitride is new on the scene, said to be faster than silicon. The ABI research report forecasts that more than 69 million automotive Lidar sensors will ship in 2026.

Similarly, radar incorporates a transmitter, this one sending out electromagnetic energy pulses, a transmit/receive switch, an antenna, and a receiver. Silicon chips, capable of steady vibrations, or oscillations, regulate the flow of electricity in radar. Copper and copper alloys play a role in printed circuits and waveguides.

Of course, all this technology goes into the basic vehicle structure, made from steel, or possibly carbon fibre, if looking at lighter models being developed for the electric vehicle (EV) market. Copper plays an increasing role in self-driving and EV wiring, and cobalt and lithium are critical to EV rechargeable batteries.

New transportation technology is transforming our world. The components originate from the ground. Mining makes it happen.

Contents

PDAC CONVENTION EDUCATION PROGRAM

The Prospectors and Developers Association of Canada (PDAC) hosts the world's largest annual mineral exploration convention and trade show. Each year, **Mining Matters** provides a unique professional development day for teachers during the PDAC convention featuring hands-on workshops, industry professionals, and access to the Trade Show.

2017

Teachers' Day

"Innovation: Mineral Exploration, Mining, and Education" was the theme of the 2017 PDAC Convention **Mining Matters** Education Program. The Teachers' Day program featured hands-on learning sessions focused on exploration geophysics; geochemistry and computer modeling; activities exploring diamonds, mining, and the environment; engaging plenary and panel speakers; and access to the Trade Show. Twenty educators from elementary, secondary, and post-secondary schools in Ontario, and for the first time, from Quebec and British Columbia, participated in the event. The event received excellent reviews from participating teachers, facilitators, and Education Partners, and their feedback will serve to inform future events.

Junior Day

The Junior Day Program involved 78 grades 3 and 4 students and teachers from the Richmond Hill Montessori and Elementary Private School. The program immersed students in Earth science and mineral resources using a series of hands-on educational activities focused on minerals, their uses, their optical properties, and the types of careers available in the mineral industry. Students also toured the Trade Show Floor.

Senior Day

Sixty-eight grade 9 students and teachers, from École Secondaire Jeunes sans Frontières, in Brampton, enjoyed learning activities focused on understanding mineral properties, the array of mineral uses as well as the techniques used in mineral exploration. Senior Day students also participated in guided tours of the Trade Show Floor, where they visited a series of booths as part of an Exploration Challenge.

We would like to thank the University of Waterloo Earth Sciences Museum, Carleton University, and the University of Toronto for their support in the planning and delivery of the PDAC Convention Education Program.

2018 PDAC CONVENTION SAVE THE DATE

The **Mining Matters** Teachers' Day is scheduled for Sunday, March 4, 2018. The theme will be "Big Data."

Please visit the **Mining Matters** website for details and to complete your registration: MiningMatters.ca

WHERE challenge

Sponsored by Teck

Water Hazards Energy Resources Environment

The **Mining Matters** WHERE Challenge is a national contest that promotes awareness of non-renewable Earth resources. WHERE stands for **W**ater, **H**azards, **E**nergy, **R**esources, and **E**nvironment, the fields in which geoscientists work. Launched each September, the WHERE Challenge welcomes entries, submitted online, until the following March.

The contest challenges students, ages 9 to 14, to consider "What on Earth is in your stuff?" and "Where on Earth does it come from?" It encourages them to see their world in new ways and to explore the mining, energy, and environmental sectors for possible career opportunities. Most importantly, it excites their curiosity about the origins of everyday items.

The 2017 Challenge was the most successful in the contest's history, with more entries than ever before: 394 from 739 students. Congratulations to all students who participated for having the courage to show off their creativity! Congratulations and thanks go to the 10 schools and 12 teachers who inspired their students to explore!

2017 WINNERS	Multimedia		Literary		Graphic Art
	Ages 9 to 11	Ages 12 to 14	Ages 9 to 11	Ages 12 to 14	Ages 12 to 14
Best Overall	'La monnaie canadienne' ($500) Maude Carrier Lévis, QC	'What's in an English Saddle' ($500) Ashley Risseeuw Saskatoon, SK	'The Loonie' ($500) Sofia Scasserra Scarborough, ON	'The Story of Oilver' ($500) Bella Huang and Victoria Shen Toronto, ON	'Geo Girl vs. Zinc Zero' ($500) Emily Zhang Toronto, ON
Best Creative	'Le maquillage' ($250) Ashley Guimond, Naomie Gilbert- Morel, and Sarah Collins Pincourt, QC	'Aluminum Madness–Juice Box Edition' ($250) Rachel Tang Toronto, ON	'La montre' ($250) Amélie Boucher Ste-Marie-de-Blandford, QC	'Pencils-Not Pointless' ($250) Aryan Rastogi and Zayd Tahir Milton, ON	'A Spoon's Iron Journey' ($250) Dinah (linh Quan) Hoana Toronto, ON
Best Research	'Glasses' ($250) Georgia Obere and Mya Kelemen Scarborough, ON	'What's Inside Glasses?' ($250) Wil Lenkov, Sam Tatoff, and Simon Peterson North York, ON		'Earth to Mechanical Pencil' ($250) Gavin Tse Toronto, ON	'Sterling Silver Earrings' ($250) Amy Cao Toronto, ON
Honourable Mention					'Aluminum in Figure Skates' Nancy Feng Toronto, ON

School Winners

Three school prizes were awarded, $750 each. School prizes are based on a combination of quality and quantity of entries from each school.

- Dr. Norman Bethune Collegiate Institute, Toronto, ON
- Milton District High School, Milton, ON
- École Notre-Dame-de-Lorette, Pincourt, QC

Quebec students Logan Lemay and Léonie Désalliers-Auger were winners of the $250 Early Bird Prize. Their project was randomly drawn from the eligible entries submitted by the midnight December 31, 2016 deadline.

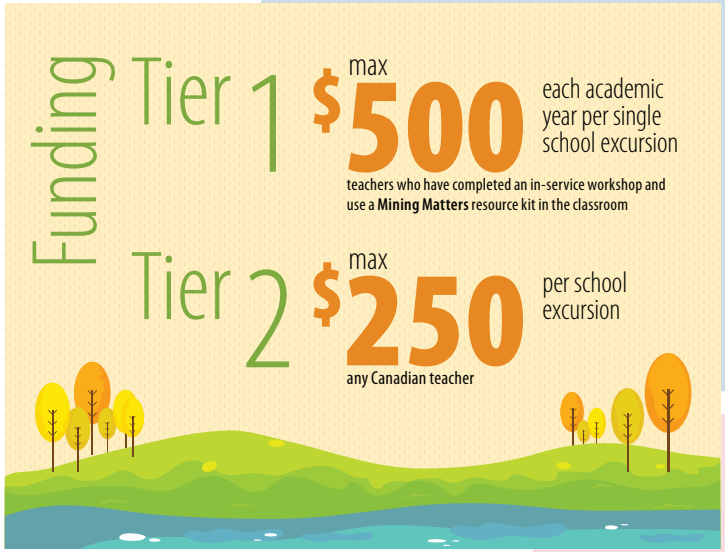
The Teacher Incentive Draw Winner was Pierre Couture from l'École secondaire de Saint-Charles. Mr. Couture received an iPod Mini. His name was randomly drawn from a list of eligible teachers who submitted a minimum of 10 entries by the midnight December 31, 2016 deadline.

You Be the Judge!

Volunteer to be a contest judge in the 2017–2018 WHERE Challenge. If you can spare just a few hours of your time and possess a degree in geosciences, education, environmental studies, or resource management, or work in a similar field, please consider participating in our judging panel. For more information about the contest, to see the rules, or to view winning entries, visit earthsciencescanada.com/where

FIELD TRIP SUBSIDIES FOR STUDENTS

Mining Matters has long offered a highly successful Field Trip Subsidy Program to enrich Earth science learning. The subsidies are intended to help offset the cost of transportation and entrance fees to geoscience venues; stone, sand, and gravel operations; and for trips involving Earth materials, processing, and manufacturing. We encourage both active outdoor field exploration, such as rock walks and visits to quarries and rehabilitated mine sites, as well as indoor excursions to museums and science centres to experience and reinforce geoscience concepts.



All applications will be considered on a first-come, first-served basis. For complete details, visit MiningMatters.ca, and enter Subsidy Application Procedures in the Search box.

MINERAL RESOURCES AND MINING EDUCATION TOURS

Mining Matters, the Ontario Mining Association, and the Canadian Ecology Centre are partnering to deliver the Mineral Resources and Mining Education Tours, an innovative and fully sponsored professional development program for educators.

Tours are structured as a series of three programs, each with a different focus: Life in a Mining Camp, Mineral Resources and Mining Foundations, and The Mine Life Cycle. The tours are delivered in August over a three-week period.

The Life in a Mining Camp Tour provides a snapshot of an employee's life at the Lac des Iles Mine and of the mineral exploration and mining industry in northwestern Ontario. Participants are provided with an underground and surface tour of North American Palladium's Lac des Iles mine and mill, site visits to Amethyst Mine Panorama and the ALS Environmental Laboratory, and geological tours in the Nipigon and Thunder Bay regions.

The Mineral Resources and Mining Foundations Tour provides a fundamental understanding of Earth science and mineral resources. Participants embark on a field trip to Kafka Granite; visit mineral exploration and mining services suppliers, including Atlas Copco, Metso Minerals, and Redpath Mining; participate in **Mining Matters** curriculum-linked workshops; and take a geologically themed canoe trip.

The Mine Life Cycle Tour focuses on the phases of the mineral resource development cycle, from start to finish. Participants learn about environmental assessments, the mineral deposits of the James Bay lowlands, the development of the Nickel Rim South Mine, the reclamation of Sudbury, and they participate in tours of the Sudbury area, including Dynamic Earth and Glencore's Integrated Nickel Operations.

The Mineral Resources and Mining Education Tours were recently featured in *World Mining Magazine*. To access *Seeing is believing*, by Bill Steer, go to issuu.com/worldminingmagazine/docs/wm_issue_10__web_ and flip to page 37.

The Mineral Resources and Mining Education Tours are sponsored and open to educators from across Canada. Please visit the Canadian Ecology Centre website for more information and to complete your registration for upcoming 2018 tours. canadianecology.ca/professional-development/

DEEPER AND DEEPER ONLINE TUTORIALS

Mining Matters worked with Penda Productions to create online teacher training tutorials for five hands-on learning activities from **Mining Matters** Junior resource *Deeper and Deeper*. The videos, available in English and French, cover *The Scientific Testing of Minerals; Making Sense of Igneous, Sedimentary, and Metamorphic Rocks; The Three Rock Groups; Operating a Surface Mine;* and *Understanding Erosion*. The tutorials provide support for teachers whose remote locations prevent them from attending a workshop, for previously trained teachers who would like to refresh their skills, and for teachers who have the resource at their school but need to be qualified to use it in the classroom. The videos are now available on our website.

RFG 2018

RESOURCES FOR FUTURE GENERATIONS 2018

PREMIER CONFERENCE ON ENERGY • MINERALS • WATER • THE EARTH

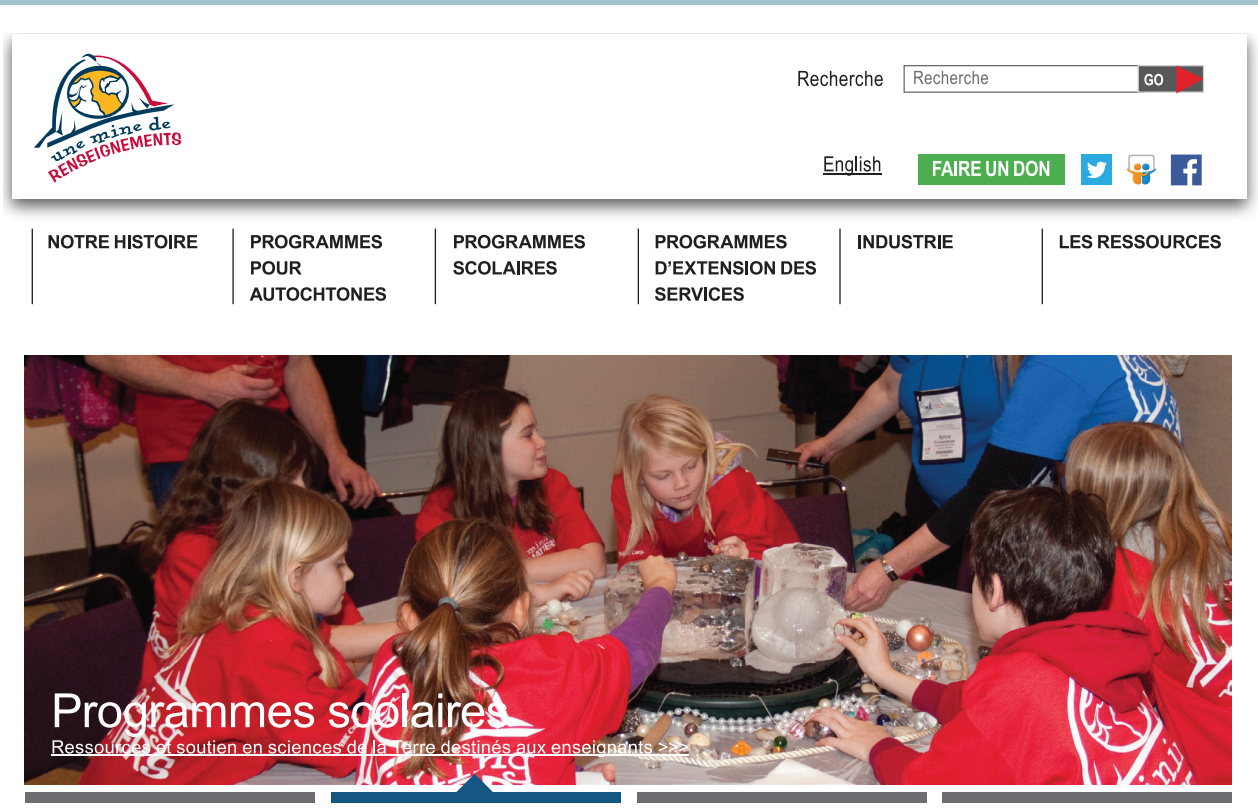
The Resources for Future Generations Conference (RFG 2018) is an international gathering that will examine the sustainability of energy, minerals, and water and provide a forum where geoscientists, policy-makers, and other stakeholders can explore resource and related sustainability issues. Geoscience Education will feature prominently in the conference program and related programming. Presentation and poster sessions, a Teacher Training Workshop and Field Trip, and educational special events are planned. The conference will take place June 16–21 at the Vancouver Convention Centre in Vancouver, B.C. Please visit the RFG 2018 website for more information about the conference and details about the education and outreach elements. rfg2018.org

GEOSCIENCE AWARE CHALLENGE

The Canadian Geoscience Education Network, **Mining Matters**, and the Government of Manitoba have developed a "Geoscience Aware Challenge" for the Girl Guides of Canada, Manitoba Chapter. The Challenge explores a series of Geoscience Literacy Principles through more than 30 hands-on learning activities. Guides, ranging from Sparks through to Rangers, will earn their Challenge badge by completing a requisite number of activities, depending on category of Guide (Sparks = 7, Brownies = 8, Guides = 9, and Pathfinders plus = 10) associated with each of the stated Geoscience Literacy Principles.

ROCKS + KIDS = OPPORTUNITIES

Acknowledging that socio-economic barriers can affect students' performance, **Mining Matters** is targeting underserved schools in the Greater Toronto Area with its curriculum-linked school program *Rocks + Kids = Opportunities*. The program offers education workshops for students in grades 4 and 5, at no cost to schools, and includes a set of teacher resources and student handouts. Teachers can customize their workshops by selecting several themes from a set of 12 Earth science and mineral resource activities. *Rocks + Kids = Opportunities* uses engaging, hands-on activities to stimulate interest in Earth science and the role rocks, metals, minerals, and mining play in everyday life. Interactive activities allow students to participate, providing a greater impact than simple observation. Students work collaboratively to identify properties of Earth materials and engage in lively discussions to better understand where and how these resources form. Workshops are 50 to 75 minutes in length and address curriculum expectations for the topic "Rocks and Minerals." In the 2016–2017 school year, 608 students and 23 teachers benefited from this enriching program. Another series of workshops is being delivered in the 2017–2018 school year, supported by Kinross.



PROGRAMMES POUR AUTOCHTONES

L'excellence en matière d'enseignement et d'extension des services aux Autochtones et un engagement à leur offrir des expériences d'apprentissage exceptionnelles et des partenariats communautaires en priorité.
Programmes Mining Rocks en science de la Terre
Ateliers pour enseignants
Extension de services

PROGRAMMES SCOLAIRES

Ateliers de perfectionnement professionnel et ressources interactives à l'appui des enseignants.
Élèves
Enseignants

PROGRAMMES D'EXTENSION DES SERVICES

Activités interactives au cours d'événements pancanadiens en vue d'en accroître la notoriété.
Nos tournées
Clubs et expositions pour amateurs de roches et de minéraux

LE SECTEUR INDUSTRIEL

Nous sollicitons le secteur industriel à soutenir notre mandat depuis 1994.
Événements
Bulletins d'informations

BILINGUAL WEBSITE

The **Mining Matters** website is now available in French. Over the years, we have been called upon more and more to create awareness about Canada's geology and mineral resources for students and teachers in Francophone communities. We took up the challenge, particularly over the last year, working hard to make our resources accessible to a wider audience. From generating French translations of activity books and newsletters to adding a "français" button on our website, **Mining Matters** is making sure that minerals education can be taught in both official languages. miningmatters.ca/fr/accueil

Our bilingual website and additional resources translated into French were made possible with funding support from the Department of Canadian Heritage and the Institut national des mines Québec.

PICTURE THIS!

Mining Matters puts you in the picture! We now have a photo booth available at public outreach events that allows participants to see themselves visiting or even working at a mine site. A person's picture is taken in front of a green screen and they get to choose a mining location background: underground at a mine, in front of a massive haul truck, or near an open pit operation. Kids love it, adults love it! Check it out when you have the chance!

ENRICHMENT OPPORTUNITIES OUTSIDE THE CLASSROOM

Royal Ontario Museum (ROM)

The new **James and Louise Temerty Galleries of the Age of Dinosaurs** showcases one of the world's best collections of material from that fascinating time. The gallery features iconic and unusual dinosaurs, fossilized plants, insects, and marine life. Trace the development, relationships, and legacy of all creatures that lived during the Age of Dinosaurs.

Get a sneak peek of the future **Dawn of Life Gallery**; visit the ROM's second floor for a preview of an epic tale that stretches over more than three billion years—from the Earth's earliest simple beginnings to the first dinosaurs—and spans an ever-changing globe.

The **Teck Suite of Galleries: Earth's Treasures** features meteorites, rocks, precious minerals, and gems in one of the finest museum collections on display anywhere. **Vale Gallery of Minerals**, the **Canadian Mining Hall of Fame Gallery**, and the **Gallery of Gems and Gold** show how Earth is constantly changing, what it's made of, and how we interact with it in our day-to-day lives. The **Barrick Gold Corporation Gallery** showcases mineral specimens and presentations on the global mining industry, including stories about mining, and how the mining industry impacts our daily lives. The digitally enhanced games and other interactives, such as a touch wall, are the most advanced, hands-on, user-driven visitor experiences in the ROM.

The ROM also offers a **Rock, Gem, Mineral, Fossil, and Meteorite Identification Clinic** at which visitors with rocks, minerals, gems, fossils, or suspected meteorites can have them identified at free ID clinics, held six times a year. rom.on.ca

Dynamic Earth

Dynamic Earth, located in Sudbury and home of the iconic "Big Nickel," is an immersive, hands-on science centre that features Earth science and mining experiences, focusing on Northern Ontario's geological history and Sudbury's mining heritage. A highlight of the centre is an underground mine tour. The centre provides educational support for teachers, including instructional development workshops, resources, and school programs. sciencenorth.ca/dynamic-earth/

Royal Alberta Museum

A brand new Royal Alberta Museum is set to open in downtown Edmonton's Arts District in early 2018. The museum will be the largest museum in Western Canada and one of the province's greatest cultural attractions. It will embody the story of Alberta, preserving experiences of its people and places and inspiring Albertans and visitors to explore and understand the world around them. In building the museum, natural materials were chosen for strength, beauty, and durability. Limestone covers the museum's exterior walls and is used in the interior public spaces along with granite flooring. royalalbertamuseum.ca

Burgess Shale

The Burgess Shale, in Yoho National Park, B.C., is a seabed in the sky, located at 2,336 m. Part of the Canadian Rocky Mountains World Heritage Site, it is famous for fossils that offer a spectacular picture of marine life that populated our planet 500 million years ago. The comprehensive website allows visitors to observe the creatures who lived in the Burgess Shale community from a "virtual submarine," browse through hundreds of fossil images, discover the science of the area in an evolutionary and geological context, learn about the discovery of the first fossils and various field expeditions, and find out how to visit. burgess-shale.rom.on.ca/en/index.php

Canada Science and Technology Museum

The Canada Science and Technology Museum, in Ottawa, Ontario, opened its doors to a new exhibit called "From Earth to Us," exploring non-renewable resources and their impact and uses in technology and green energy. **Mining Matters** supported the experience with hands-on activities, including a product-matching activity, reclamation matching game, and much more. ingeniumcanada.org/scitech/whats-on/exhibition-from-earth-to-us.php

The **Mining Matters** website includes a comprehensive list of interesting and enriching places to visit, outside of the classroom, across Canada: MiningMatters.ca/resources/links/places-to-visit

METEORITICAL MYSTERIES

Space offers countless mysteries. But there are clues, some of them literally right under our noses. Meteorites—planet, asteroid, or comet fragments that strike our Earth—contain clues about what's out there and even about our own planet's composition.

First of all, let's define "meteorite," since there are several similar terms, which can be confusing. Meteoroids are rocky remnants of an asteroid or comet in space. When meteoroids enter the Earth's atmosphere, they become meteors, often burning up as they streak across the sky as "shooting stars." When meteors make it through the atmosphere and hit the Earth's surface, they are called meteorites.

Asteroids originate from the Asteroid Belt, comprising about 100,000 small irregular rocky bodies between the orbits of Mars and Jupiter. Some asteroids could be large enough to have layers, like the Earth's core, mantle, and crust, producing different types of meteoroids when broken up.

Comets are largely composed of ice and dust and were likely formed at the distant margins of our galaxy over 4.5 billion years ago. They orbit the sun in elliptical orbits that can take them out to the very edge of our galaxy. Coming back through the inner solar system, their surfaces become heated by the Sun's energy, causing their icy surfaces to vapourize. This leaves a trail of gas and dust, the "tail" of the comet, that we call a coma. If the Earth, in its orbit, passes through this coma, the dust particles burn up in the upper atmosphere, producing the periodic meteor showers (such as the Perseids) that we see. These showers never produce meteorites that we can recover on the ground.

Some rare meteorites do not come from asteroids but from the Moon and Mars, both of which are occasionally struck by small asteroids just as the Earth is (just ask the dinosaurs). Since the Moon and Mars have much less gravity than the Earth, an asteroid impact can actually launch rocks from their surfaces out into space. With luck, this material crosses the Earth's orbit and lands as meteorites. This process has given us our only samples of another planet, Mars.

Ninety to 95 per cent of small meteors burn up in the Earth's atmosphere, but every year thousands become meteorites weighing a pound or less. Occasionally, they strike inhabited areas, but mostly they go unnoticed, landing in forests and oceans. Meteorites are often found in geologically stable desert regions, like North Africa or Antarctica, where low precipitation preserves them and exposed ground reveals them.

Meteorites can be classified into three types

Stony

- Stony meteorites, the most common type but difficult to spot, often have a composition similar to the Earth's mantle. They comprise mainly the minerals olivine and pyroxene.

Iron

- Iron meteorites typically found are iron and nickel alloys, which have a much higher density than typical crustal rocks. When cut and polished, they display a unique design, called a Widmanstätten pattern, the result of slow cooling a hot solid material.

Stony Iron

- Stony iron meteorites combine stony silicate material and iron or iron-nickel alloy.

Widmanstätten pattern

What can we learn from meteorites? According to the Arizona State University Center for Meteorite Studies (meteorites.asu.edu), they reveal information about many things:

- Stellar evolution: Studying meteorites containing "stardust" (produced by stars before the formation of our Solar System) can add to our knowledge about star formation and evolution.
- Solar System age and composition: Analyzing the components of meteorites, we can learn about the age, formation, and bulk chemical composition of the Solar System.
- Solar System evolution: Analyzing different types of meteorites, we can learn about the earliest conditions in our Solar System.
- Earth and Moon geologic history: Looking at large meteorite impacts, we can understand the shaping of the face of our planet and the Moon.
- History of life: Examining meteorites for the components necessary for life—many organic compounds can be transported great distances inside space rocks—we can add to studies about the origins of life. Also, large meteorite impacts can influence the course of life on Earth.

Rarely, a big meteor makes it into the Earth's atmosphere. The Chelyabinsk meteor, as big as a six-story building, broke up 24 km above Russia in 2013, generating a shock wave of a 500-kiloton explosion and injuring 1,600 people.

The Meteoritical Society, International Society for Meteoritics and Planetary Science, is a non-profit scholarly organization that promotes research and education in planetary science with emphasis on meteorites and other extraterrestrial materials. To learn about meteorite strikes around the world, look at the Society's Meteoritical Data Base. lpi.usra.edu/meteor/metbull.php

Also, for information specifically about meteorites in Canada, see the Meteorite and Impact Advisory Committee (MIAC) of the Canadian Space Agency website. uqac.ca/miac/miac_frames_e.html

Nickel Iron Meteorite
Photo credit: R.Weller/Cochise College

As of July 2017, the Meteoritical Society records show 100 validated meteorites or impact craters in Canada. Find them, as well as links to Google Earth locations, at tinyurl.com/y95ze6ml

Lepidolite
Photo Credit: R.Weller/Cochise College

Uses for Lithium

Portable electronic devices

Electric vehicles

Ceramics and glass

Lubricating greases

Continuous casting mold flux powders

Polymer production

Air treatment

Medical uses

LIVING WITH LITHIUM

Just over 200 years ago, the element lithium (Li) was unknown. In 2017, not only did we celebrate Canada's 150th anniversary as a country, but we also celebrated the 200th anniversary of lithium's discovery. There weren't any fireworks celebrating the discovery, but since we can hardly do without lithium today, perhaps there should have been. Quite simply, lithium makes things work, from electronics to aircraft to the human body.

Discovered in 1817 by Swedish chemist Johann August Arfvedson in the mineral petalite, lithium never occurs in nature as a pure element, and it proved difficult for him to isolate. Using electrolysis on lithium oxide worked however, as discovered by William Thomas Brande and Sir Humphry Davy in 1818. The alkali metal was then detected in the minerals spodumene and lepidolite and found in lithium chloride salts dissolved in brine pools.

One of the world's hot commodities, silvery-white lithium, Atomic Number 3, is the lightest known metal, the least dense solid element, and can be cut with a knife. It is also highly reactive and flammable. An essential component of lithium-ion batteries, 39 per cent of world production powers portable electronic devices such as laptop computers, smartphones, and electric tools, as well as, on a much larger scale, electric vehicles and grid storage applications. Production ramped up 12 per cent from 2015 to 2016 alone.

Ceramics and glass use another 30 per cent of produced lithium. Lithium oxide and lithium-bearing ores such as spodumene reduce energy requirements in making glass. Lithium fluoride, with the highest UV transmission of any material, is used in the manufacture of optical devices, lenses, glassware, and X-Ray plates. Lithium carbonate is used in ceramics.

Other uses include eight per cent for lubricating greases, five per cent each for continuous casting mold flux powders and polymer production, and three per cent for air treatment. A final 10 per cent includes important medical uses. As a drug, lithium carbonate stabilizes a person's mood by affecting the flow of sodium, which affects excitation or mania, through nerve and muscle cells in the body. It effectively treats bipolar disorder and depression, and it reduces the risk of suicide in patients with those conditions.

There are two ways to obtain lithium: mining and extraction from brines containing lithium leached out of volcanic rocks, found below the surface

Spodumene
Photo credit: R.Weller/ Cochise College

of salt flats. Australia, the world's largest producer, mines for spodumene. In other parts of the world, until recently, mining operations did not make economic sense, but with increased demand, they are being re-examined. Canada's lithium resources are about two million tons, with mining projects in Quebec and potential mines in Nova Scotia.

Producing lithium carbonate from salt brines is the most efficient method; most of the chief world producers—Chile, Argentina, and China—have highly concentrated lithium deposits in brines at high altitudes. The Atacama salt flat in Chile holds about 37 per cent of the world's entire lithium production. Lithium-rich brine gets pumped into man-made solar evaporation ponds, where it takes about 18 months for evaporation to occur. In the U.S., a new technology in development allows extraction of lithium from brine which gets injected into the ground by geothermal power plants after steam is produced; the process takes only 90 minutes.

In just 200 years, lithium has gone from being barely known to indispensable. And demand will only go up as technology further develops and the world goes "green" with battery-powered transportation options. It seems that living with lithium is the way of the future.

15 YEARS IN THE NORTH

May 2002 marked the beginning of **Mining Matters** focused effort to deliver workshops to Indigenous youth, as part of our Indigenous Communities Education and Outreach Programs (ICEOP). In our first year, we visited Cambridge Bay, Nunavut, delivering one week-long program and fueling enthusiasm for mineral resources, mining, and Earth science.

Fifteen years later, ICEOP has expanded to more than 33 communities, offering current material, relevant hands-on activities, and location-tailored information. In 2016–2017 the program reached 2,583 participants in Yukon, Northwest Territories, Manitoba, Ontario, Quebec, and Newfoundland and Labrador.

Q&A

Sean Morriseau is a past participant in a First Nations Natural Resources Youth Employment Program (FNNRYEP), a program that partnered with **Mining Matters**. We asked Sean about his experience participating in the program and working as a Drill Helper with Niiganii Drilling.

When did you participate in the FNNRYEP program?

I started the FNNRYEP program back in the summer of 2014 and continued into my second year in 2015. I also worked in between the two summers for Outland, the company that ran the program. I was often asked to go on side jobs such as a camp helper or cook. I really enjoyed each opportunity that I was given. It really gave me a great work ethic and showed me how to build a career.

Were you aware of the minerals industry prior to taking part in the FNNRYEP?

I wasn't too aware of the mineral industry before I started the program. I knew that there were different types of minerals and that we needed to mine them to get them out of the rock, but I didn't know all the different processes it takes just to be able to start mining and how long it could take and how much it would cost.

Did you share your experience with others and encourage them to consider participating in the FNNRYEP and consider the minerals industry as a workplace?

I enjoyed the program so much that it became my second home. I told everybody about FNNRYEP and tried to encourage my friends to join, but for most of them, it just wasn't their thing. I had a family member who took the program a couple years before I did who was looking for a job. I pointed him in the right direction and a couple days later he was working by my side in the mineral industry. I encourage anyone who believes that they have a great work ethic to work in the mineral industry.

What was the most interesting thing you learned during the program?

During the program, one of the most interesting things I have learned was the role of leadership. Not a lot of people have someone they can look up to or has been there for them. I believe that a good leader makes a hard worker and during the program I was definitely challenged in my role of being a leader. I feel now that I've grown into a young hard-working man just from a short period of time.

Is there anything in particular that you would say about Mining Matters or the mineral resources and careers?

Mining Matters provides a great learning experience for all ages, and I think that they need to be recognized more for how much impact they make on young adults everywhere. They make learning fun and unique, the way it should be.

ACTIVITY: RESOURCES, MINING, AND ENVIRONMENT

Senior Activity: Flocculation—Water Treatment and Tailings
Source: MineralsEd Science of Mining: A Resource Unit

Backgrounder

Flocculation serves to treat effluent, or liquid waste, from mine and mill operations, much of which has been used to produce a concentrated target mineral from raw ore.

After excavation from an underground or open pit mine, ore is sent to a concentrator, or milling plant, which liberates the minerals, metals, or elements it contains. First, the ore is ground and crushed. The ground particles then go through a flotation process, which allows for the selective separation of different minerals using a froth.

For the flotation process, water is added to the particles to form a slurry. Surfactants and pH modifiers added to the slurry condition particle surfaces to become either hydrophobic (to float out of the liquid) or hydrophilic (to sink into the liquid). The target mineral is rendered hydrophobic.

The slurry of hydrophobic and hydrophilic particles goes into tanks known as flotation cells, which are aerated to produce bubbles. Frothers and other collector reagents cause the hydrophobic particles to attach to the air bubbles, which rise to the surface, forming a froth. The froth is removed from the flotation cells, usually through multiple flotation stages, producing a concentrate of the target mineral. The remaining slurry, a fluid mixture of pulverized solids with a liquid, is considered waste material, called tailings.

Some tailings may be used to make mine backfill; additional processing prepares these tailings for reuse in the underground mine they were taken from. The remaining tailings can be stored in tailings ponds, which allow the sedimentation of solids from the water and prevent the generation of acidity. Tailings ponds, usually impounded with a dam, are designed to contain the remaining byproducts as detailed in site closure plans.

Solids are settled using flocculents or quiescent conditions, or both. The water then has its pH raised to precipitate dissolved metals, and then the pH is lowered to neutral condition, before the water is either recycled back to the concentrator or released into the environment.

Purpose

To simulate a method used by the mining industry to:

1. Treat mine discharge and effluent
2. Reclaim solid mine waste

Materials

- 1 Mason jar per group
- 2 plastic or Styrofoam cups per group
- A pinch of flocculent (alum generally available for purchase from the grocery store)
- Simulated tailings made from a mixture of sand, clay, and potting soil
- Litmus paper or a pH meter (science supplier)
- Calcium carbonate (lime)
- Funnel (optional)
- Filter paper or coffee filter per group
- Potting soil
- Peat moss plugs (garden store)
- Marigold seeds
- 2 small plastic plant pots, with saucers, per group
- Spoon

Instructions

Note that this experiment can be delivered in two phases if the flocculation rates differ among the "tailings" samples. Observing and speculating about the causes of the different rates of settling makes for an interesting extension to the activity.

Safety

Caution students not to drink the clarified water.

Method

1. Break up the peat plug and place "the pieces" into one of the cups.
2. In a Mason jar, mix the simulated tailings with tap water to form a slurry.
3. Test the pH of the slurry with litmus paper or a pH meter. If the slurry is acidic, add lime to achieve a neutral pH (7) or slightly basic solution (>7).
4. Add a few grains of flocculent to the slurry; agitate the jar to simulate clarification.
5. Line the funnel with the paper filter. Hold the funnel over the second cup and pour the flocculated slurry into the funnel. Some sludge will remain in the jar and some will collect in the filter. The filtered water in the cup should be clear, free of solid material.
6. With a spoon, place the sludge into a plant pot.
7. Mix the sludge and peat, at a ratio of 3:1, and add the mixture to one of the pots.
8. Plant 4 to 6 marigold seeds in the pot.
9. Fill a second pot with potting soil and plant 4 to 6 marigold seeds in the soil.
10. Place the pots either on a windowsill or shelf in the classroom or in a greenhouse, if one is available.
11. Have the students check their pots daily and record the following:
    i. When the seeds first started to sprout
    ii. Their rate of growth
    iii. Their heights, over time

Questions

1. **Career Connection: What prior knowledge would an Environmental Scientist or Engineer need before starting this process at a mine?**
   - They would require a strong background in sciences such as engineering, chemistry, biology, and pedology (soil studies).

2. **What is flocculation and what does the flocculent do to the slurry?**
   - Flocculation is the process by which individual particles aggregate into masses or precipitate into small lumps. Aggregates of particles then quickly bridge together to form microflocs, which in turn gather into visible floc masses. These floc masses then precipitate. Ultimately, the flocculent helps separate the sludge from the water.

3. **How can a mine reuse water?**
   - Mines can reuse water in mineral processing, in surface treatments like dust control, and for watering reclaimed lands to promote the growth of vegetation.

4. **Do you think the reused water would be safe to drink?**
   - If bacteria concentrations in the water are not significant, then the answer could be "yes." Students should be advised to not drink the water as a test.

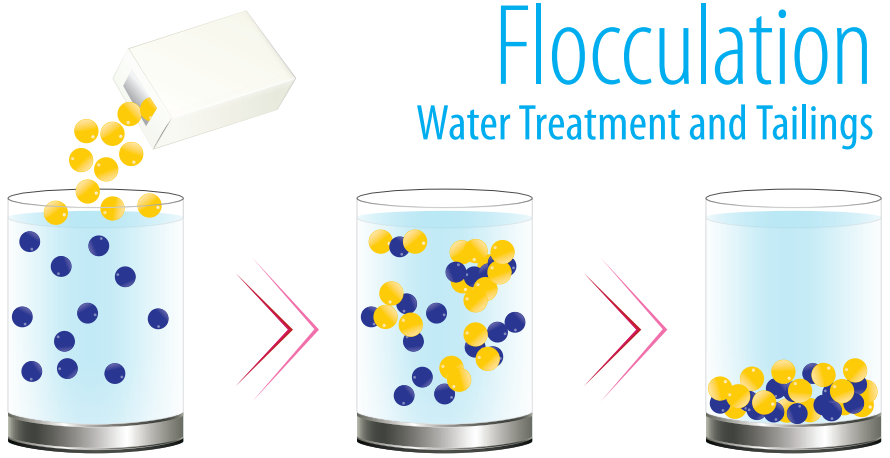
5. **Which plants sprouted first, the ones in the sludge or the potting soil?**
   - It is expected that the plants in the sludge should sprout first, because the sludge is mineral rich.

6. **After the first month, which plants showed the most growth/best results?**
   - The plants growing in the sludge should do just as well as those growing in the soil. However, over a long period of time, the plants in potting soil would be expected to do better if there are fertilizers present.

7. **What did this experiment demonstrate about mining and the environment?**
   - Answers will vary, but there should be reference to clarifying water and recycling it, establishing vegetation on mine waste, and reclaiming land for wildlife habitat or agriculture.

Flocculation

Water Treatment and Tailings



Concentrator - a milling plant that produces a concentrate of valuable minerals or metals

Effluent - liquid waste

Flotation - a process in which water and surfactants or collector chemicals are added to ground ore to selectively separate different minerals

Sludge - semi-solid slurry that can be produced as a settled suspension obtained from sewage treatment, conventional drinking water treatment, or industrial processes

Slurry - a fluid mixture of a pulverized solid with a liquid (usually water), often used to handle solids in bulk

Tailings - finely ground rock and mineral waste products of mineral processing operations—possibly containing leftover processing chemicals—usually deposited as a water-based slurry into tailings ponds

Tailings ponds - sedimentation lagoons enclosed by dams built to capture and store the tailings

RESOURCES

Books

UNDERGROUND! My Mining Adventure

By Theresa Nyabeze (Author),
Misheck Matambanadzo (Illustrator) (2016)

Every chance she can, Theresa Nyabeze, a Laurentian University graduate and Professional Mining Engineer in Sudbury, Ontario, promotes her profession, the mining industry, diversity in the workplace, and STEM (science, technology, engineering, and mathematics) careers. She does it all with her book *UNDERGROUND! My Mining Adventure*, an engaging and informative introduction to mining underground, geared for children.

In *UNDERGROUND! My Mining Adventure*, young Maiya gets one of her heart's desires for her birthday: to go down into the mine where her mother works. But Maiya's expectations and her experiences turn out to be quite different. At the beginning she says, "I imagined that underground would be very dark, dangerous, and damp, even wet in some spots. There would be mysterious tunnels, and shiny gold everywhere. I pictured the people that my mom worked with. In my mind, they were tall, strong, and even a bit scary and serious."

Instead, Maiya, suited up with hard hat, coveralls, and more, learns that safety comes first, and she is surprised to find the mine comprises bright spaces, huge machinery, and working conditions "just like on the surface." Welcoming people explain their jobs and involve her in what they do. Her best birthday ever inspires Maiya to get creative and think about how she can make working in a mine even better.

In this book, Theresa Nyabeze successfully conveys her excitement about her chosen career path. Colour and earth-toned illustrations are kid-friendly but realistic, a simplified mine map features mining terms, and photographs show the scale of the mine and equipment. It's all there to get kids thinking about the possibilities. To buy the book or learn more about Theresa Nyabeze, go to diversitystem.ca

Spenser and the Rocks

By Lawrence F. Lowery (Author),
June Goldsborough (Illustrator) (2013)

Given the differences in colours, sizes, shapes, and textures, there is much to learn about rocks. Young Spenser develops a growing fascination with rocks and minerals and has many questions as he sorts and re-sorts his rock collection. For Spenser—as well as young readers—the experience is an engaging introduction to scientific procedures such as classification and research. *Spenser and the Rocks* is part of the *I Wonder Why* book series, written to ignite the curiosity of children in grades K to 6, while encouraging them to become avid readers. These books explore the marvels of geology, land forms, weather, environments, and other phenomena related to science and nature. Included in each volume is a Parent/Teacher Handbook with coordinating activities. The *I Wonder Why* series is written by an award-winning science educator and published by NSTA Kids, a division of NSTA Press.

This book introduces primary students to rocks and minerals and gets them excited about the topic. The story includes good science, with Spenser sorting the rocks, asking questions, and wanting to know more about them. An issue is that there is no distinction between rocks and minerals, and the book refers to several minerals as rocks. This poses a problem if the book is being used in grade 4 classes to teach about rocks and minerals, but if it is being used in K to 3 as a way of getting students interested in the subject, it is fantastic. See a preview at static.nsta.org/files/PB330X6web.pdf

The Mineral Maniacs and the Magic Hardhat

By Jules Miles (Author), Meg Whalen (Illustrator) (2017)

The Mineral Maniacs and the Magic Hardhat is the first in a children's book series exploring the exciting and educational world of mining, geology, and engineering. Fifth-grade pranksters Marabel, Victor, and Herbie are familiar with being in detention. One day, under the not-so-watchful eye of science teacher Ms. Pebbles, they discover a magical hardhat that leads them on an important mission. A mystery rock or mineral is about to be stolen, and it's up to the maniacs to use their unique gifts to identify the mineral before it's taken from the world forever.

This fun and educational series will excite even the youngest readers and will inspire future generations of innovators, educators, and engineers to be forces of positive change in the world. BONUS: Includes a supplemental section for students and educators alike about how the mineral is formed, mined, processed, and used in our everyday lives. themineralmaniacs.com

Understanding the Gem Minerals: A Practical Guide

By William Revell Phillips, James Shigley (2016)

Gemstones have fascinated people for thousands of years because of their beauty, rarity, and monetary value. However, a true understanding of gemstones and their properties has only come about in the past two centuries, resulting from the developing sciences of geology and mineralogy and an increasing need to distinguish natural gemstones from those that are treated or grown in the laboratory. Numerous books describe minerals, many report on the distinctive properties of gemstones, but almost none present a detailed mineralogical description of the gem minerals along with clearly explained basic concepts of interest from both mineralogy and geology. This book bridges this gap. tinyurl.com/minas-pub

Geology of Mineral Resources

By Michel Jébrak and Éric Marcoux (2015)

Metallogeny, the study of mineral deposit genesis, is a science that originated in France in the early 20th century. Written by two experts in the field, this book provides an updated review of knowledge, focusing on its practical application in mineral exploration. Each environment is described in terms of its geology and its deposit types, along with its economics, its genesis, and relevant exploration techniques.
www.gac.ca/publications/view_pub.php?id=238

Earth: An Introduction to Physical Geology – 12th Edition

By Edward J. Tarbuck, Frederick K. Lutgens,
Dennis G. Tasa (2016)

This introductory university textbook uses augmented reality to bring geology to life. With strong readability and instructive illustrations, this edition features a hybrid and streamlined focus on core principles. It maintains a learning objective-driven approach throughout each chapter: the text provides readers with a structured learning path, tied to learning objectives, with opportunities for readers to demonstrate their understanding at the end of each section. The authors' emphasis on currency and relevance includes the latest thinking in the field, particularly in the dynamic area of plate tectonics. tinyurl.com/earth-introPG

Websites

GeoscienceInfo.com

The story of how the Earth formed and developed is a captivating tale, one that can be read in the rocks beneath our feet. A new online resource, GeoscienceInfo.com, interprets part of that tale: the geological history of Ontario.

Launched in June 2017, GeoscienceInfo.com was created by members of the Association of Professional Engineers (APGO) Education Foundation. The Foundation was established to educate the public about geoscience, promote geoscientific endeavours, and provide scholarships and bursaries to those wishing to pursue professional geoscience careers. The new website provides a valuable resource about geology, environmental geoscience, geochemistry, geophysics, and the diverse disciplines that relate to geoscience, particularly in Ontario.

On the Virtual Tours page, visit Ontario locations and learn about their geological histories. Explore where ancient seas once existed. Examine photos of such features as outcrops, rock layering, different rock types (igneous, metamorphic, sedimentary), and fossils. If physically visiting a featured location, use a smartphone with the mobile-friendly site to learn about the rocks and how they formed.

The Resources page features excellent videos explaining important and interesting geoscientific principles in captivating narratives for people of all ages. The News section posts the latest geoscience discoveries. Check out GeoscienceInfo.com regularly for new features, virtual field trips, and resource videos. Its creators want input to improve the site, particularly from teachers, aiming to improve students' geoscience learning experience and inspire the next generation of geoscientists!

The Atlas of Canada – Interactive Minerals and Mining Map 2016

This map, published annually by Natural Resources Canada, contains statistics on Canada's mineral production and provides the geographic locations of significant metallic, nonmetallic, and industrial mineral mines; oil sands mines; and gas fields for the provinces and territories of Canada. It also contains information on existing and proposed oil and gas pipelines. A mine index lists, for each identified mine, information on company ownership and the mine's type, location, and principal minerals and metals produced. A similar index is provided for each oil and gas field. Three inset maps detail the geographic locations of selected metallurgical works, and current and expected mine openings and closings. Mineral production statistics have also been incorporated in many tables and charts on the map. atlas.gc.ca/mins/en/index.html

TVO Video June 2016: Toronto: Mining Capital of the World

What's the most important mining city in Ontario? Sudbury? Timmins? You could argue it's Toronto, where almost 60 per cent of all publicly traded mining companies in the world are listed on the Toronto Stock Exchange and the TSX-Venture Exchange. And while all that may be well known to those in the business world, it's far from widely appreciated beyond that. TVO's The Agenda, with Steve Paikin, discusses how Toronto rose to be a mining capital.
https://tvo.org/video/programs/the-agenda-with-steve-paikin/toronto-mining-capital-of-the-world

Arc GIS Story Maps

Charging Up: Life Cycle of a Battery

storymaps.esri.com/stories/2017/batteries/index.html

Mountains of Fire

story.maps.arcgis.com/apps/MapJournal/index.html?appid=4c77a56bbcd743b69232cf3fd9c7a61c

Motion of Tectonic Plates

apl.maps.arcgis.com/apps/MapJournal/index.html?appid=df5f94c0050b4075adfbba54fb13eaeb

Seeing Green Infrastructure

nation.maps.arcgis.com/apps/Cascade/index.html?appid=9497dbc933bc46efacc5236722cebde6

Gros Morne Park: The Best Place on Earth

arcgis.com/apps/MapSeries/index.html?appid=882cb9c8ad534db6a690c0a15667b8bd

Big Holes

story.maps.arcgis.com/apps/MapJournal/index.html?appid=4533fec4fbb148f289bf81f9cc8adbd6

The Klondike Gold Rush

austincc.maps.arcgis.com/apps/MapTour/index.html?appid=fcf31849defd4cabb145342e80f56414

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Qazi Sohail Imran, from Islamabad, Pakistan, and a former Research Geophysicist at King Fahd University of Petroleum and Minerals, provides free download links to Geoscience books. He holds the belief that "Knowledge is power and knowledge shared is power multiplied."
geologylearn.blogspot.ca/2017/02/download-geoscience-books.html

TeachOntario

TeachOntario offers an online community for Ontario's educators, by Ontario's educators. Explore professional learning opportunities and curated resources. Share your knowledge with your colleagues. Create projects to support teaching and learning. teachontario.ca/welcome

Provincial and Territorial Teacher Associations

These organizations provide professional learning opportunities, including instructional development and content specific workshops.
tinyurl.com/ctf-fce-assoc

National Association of Geoscience Teachers

The U.S.-based National Association of Geoscience Teachers works to raise the quality of and emphasis on teaching the geosciences at all levels. The website offers links to Teaching Materials that include hundreds of K to 12 activities; Geoscience Literacy Documents about Energy, Atmospheric Science, Climate, Earth Science, and Oceans; and Special Collections that include Teaching with Maps and Teaching Systems. nagt.org/nagt/teaching_resources/index.html

The Science Education Resource Center

The Science Education Resource Center, established at Carleton College in Northfield, Minnesota, aims to improve education in the Earth sciences and beyond. The team of 14 educators, researchers, and technical specialists have worked with over 100 award-winning education projects across the STEM disciplines and allied fields. Engaging participants from more than 1,000 institutions of higher education, as well as K to 12 curriculum developers and teachers, they have created one of the world's largest collections of pedagogic resources. serc.carleton.edu/index.html

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Mining Matters is a charitable organization dedicated to bringing knowledge and awareness about Canada's geology and mineral resources to students, teachers, and the public. Since 1994, **Mining Matters** has reached an estimated 650,000 teachers and students through resources that promote the vital role rocks, minerals, metals, and mining play in everyday life. **Mining Matters** prides itself on building long-term partnerships with teachers by providing relevant, accurate, and authentic Earth science resources for the classroom, designed by teachers for teachers.

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