2022 – 2023

Building Mineral Literacy
through STEM Education

groundWORK

Contents

From Waste to Wealth - Sustainable Mining

Cliché but true; one person's trash is another person's treasure. Whether for economic reasons or concern for the environment, from clothing to furniture to building materials, thrifting has become trendy. The mining world is taking this trend to a whole new level. Mining companies are examining what was once considered waste material and discovering a treasure trove of valuable metals and minerals or finding new ways to use it.

In 2021, Canada developed a list of 31 minerals considered critical to developing a low-carbon economy, maintaining domestic industry and security, and providing critical minerals to our global partners. They are minerals necessary for renewable energy technologies, manufacturing, aerospace and defence, information and communications technology, agriculture, health and life science applications, and critical infrastructure. Other major Canadian mineral products include iron, gold, silver, and more.

While Canada has producing mines and/or promising sources of these minerals, the demand is great for more, now. Considering looming global deadlines for net-zero carbon emissions, concern about the environmental impact of increased mining, and the economics of bringing new mines into operation--it can take 10 to 20 years to bring a mine from discovery to production--it makes sense to take another look at mineral waste generated during mineral extraction and processing. Older, less effective separation and processing techniques left valuable minerals behind in waste rock and tailings.

Waste rock is rock that is removed in the mining process to provide access to a desired ore and is not processed. Tailings are the waste material, which might or might not be mixed with water, that remains after processing ore, ore concentrate, or mined materials. Tailings storage presents a significant challenge for mining companies; responsible management practices demand environmental impact be considered a top priority. But today, tailings should be considered an opportunity.

Demand for certain minerals, such as critical minerals, has soared, making tailings worth the effort of reprocessing. In the article Waste Not, Want Not (The Intelligent Miner, March 2022), author Carly Leonid reports "the Global Tailings Review has calculated that 12.7 billion metric tonnes of tailings are produced every year. There are around 8,500 active, inactive, and closed tailings storage facilities worldwide whose collective footprint exceeds 280 billion metric tonnes, and the estimated value of precious, critical, and strategic metals contained within those sites is thought to exceed US$3.4 trillion."

Metso Outotec, a Finnish company described as a frontrunner in sustainable technologies, solutions and services for the aggregates, minerals processing, and metals refining industries, states on its website,

"There are millions of tons of tailings being discharged today and billions lying in legacy dams. A lot of older tailing facilities have impressive residual mineral values, which could provide opportunities to help in environmental reclamation, while at the same time, generate additional revenue. With reprocessing, the mining companies can set the agenda to transform the tailings ponds from a liability into an asset."

In gold, copper sulfide, and iron ore tailings, the potential of extracting minerals is an opportunity. Reprocessing tailings to collect the valuable minerals can be a cost-effective approach compared to processing virgin material. At Metso, we have conducted studies recently that tell us that processing one unit of tailings could be *three times more cost-effective* than virgin material."

Innovative processes are being developed to meet the challenge. For example, Toronto-based BacTech Environmental Corporation uses bacteria in an eco-friendly bioleaching process to recover metals from mining waste, including gold, silver, copper, nickel, and cobalt, the latter two being significant components of electric vehicle (EV) batteries and advanced energy storage technologies. In the Sudbury area, they hope to tackle over 100 years of nickel mining tailings to extract nickel and cobalt.

In Quebec, mining giant Rio Tinto has found a way to extract scandium, listed as a critical mineral used in industries like aerospace and defence, and clean technology, from titanium dioxide production waste. Also, Rio Tinto scientists, working with construction materials company Lafarge Canada, have developed a cement product using waste from aluminium smelting, aiming to reduce landfill, use fewer non-renewable resources, and help customers meet their sustainability goals.

Canadian company Geomega, which develops innovative technologies for extraction and separation of rare earth elements and other critical metals, is also targeting bauxite residues produced by aluminum processing. Their website states that, with over 150 million tonnes of bauxite residues produced annually worldwide and over four billion tonnes stored in tailings globally, $400 billion in untapped metal value exists, including aluminum, rare earths, scandium, vanadium, titanium dioxide, and iron oxide. Geomega hopes to extract close to 80 per cent of those potential metals. The company also built, in Quebec, the world's first sustainable rare earth elements recycling plant, using discarded material from magnet manufacturers, alloy makers, and recyclers across Europe and the USA.

Natural Resources Canada's Green Mining Initiative has an overall goal of reducing environmental impacts of mining and improving Canada's competitiveness. One project works to find economic and technically feasible ways to reprocess mining waste. NRCan estimates there to be $10 billion in metal value in Canadian gold mine waste. It would be challenging to extract, with millions of tonnes of waste to process and harmful elements such as mercury and arsenic to remove, but well worth pursuing.

Projects are appearing around the world. In Australia, Geoscience Australia and its partners are developing an Atlas of Australian Mine Waste, a public database that will highlight the opportunity in reprocessing mining waste for new markets. Also, the University of South Australia Future Industry Institute, funded by the Australia-India Strategic Research Fund, will explore new mechanisms to safely extract critical minerals from downstream ore processing, tailings reprocessing, and wastewater treatments. On the commercial level, Canada-headquartered EnviroGold Global has signed on to reprocess tailings at Australia's Hellyer Gold Mine to extract gold, silver, zinc, lead, and copper.

In South Africa, tailings dumps created from the processing of platinum group elements (PGEs) are being retreated to recover chrome, while tailings from chrome processing are yielding PGEs, and gold processing tailings are sources of further gold extraction. At mines operating in Spain and Serbia, a mineral leaching and metal recovery protocol is being used to extract copper from tailings. In Ecuador, Peru, and Columbia, BacTech aims to use their bioleaching process to extract gold from tailings, while transforming harmful contaminants like arsenic into EPA-approved products for landfill.

While accessing untapped mineral resources from waste material is one way to utilise it, other solutions can put it to good use. According to tailings management specialists at Scotland-based mining technology business Weir Group, alternatives to re-mining tailings include using it for backfill or creating more sustainable by-products. Using a mine's tailings for backfill provides a resource to the mine, reduces necessary storage capacity and rehabilitation costs, and recovers 60 to 80 per cent of the tailings' processed water, while the resulting structural stability offers a safer workspace for employees to continue.

As for sustainable by-products, this includes everything from commercial shotcrete (a variation of concrete that incorporates less water, "shot" or pumped through a hose at high velocity) and concrete products such as mine roads, brick and tile manufacture, insulation, or foamed products. Using tailings as a resource transforms waste into products, and like backfill, reduces the need for water and storage.

Mining waste can now be considered an asset. Mining companies benefit, the environment benefits, the world benefits. The potential is everywhere.

6TH OCTOBER
INTERNATIONAL GEODIVERSITY DAY
THE DIVERSITY SUSTAINS THE LIFE

UNESCO International Geodiversity Day

Geodiversity is defined as the natural range of geological features that make up a landscape. It includes minerals, rocks, fossils, and sediments; geomorphological features, like landforms and processes; and soil features, along with their assemblages, relationships, properties, interpretations, and systems. Geodiversity underpins biodiversity, since it provides the foundation and habitat for all living things, but it also has intrinsic value, independent of biodiversity. (Gray, M. (2003): Geodiversity – Valuing and Conserving Abiotic Nature). Geodiversity is important to humanity because it provides energy, drinking water, and the materials with which we create the built environment.

Acknowledging the importance of international cooperation to recognize and manage Earth's geodiversity and geoheritage, the United Nations Educational, Scientific, and Cultural Organisation (UNESCO) declared October 6th as International Geodiversity Day.

The inaugural Geodiversity Day was celebrated on October 6, 2022. Visit the International Geodiversity Day website for information, including future education and outreach events that may be planned for your region.

Going Platinum

Platinum (Pt) / Atomic Number 78 / Top Producers: South Africa, Russia, Zimbabwe, Canada, U.S.

Platinum has become the symbol of ultimate success. It's hard to imagine that, when Spanish conquistadores found platinum in South America in the 16th century, they considered it worthless, even a nuisance. Platina, they called it, meaning "little silver," and tossed it back in the river when panning for gold, thinking that it was unripe gold. Ancient Egyptians and pre-Incan civilizations had recognized its value and worked with it, fashioning ceremonial jewellery and royal burial artifacts. But then, it was lost to history.

From there, platinum grew in popularity, fashioned into jewellery and artifacts for kings, queens and popes, decorating fabulous Fabergé eggs, and adorning Hollywood stars in the 1930s' newly invented talking pictures—hence the term "platinum blond." Today, jewellery takes up nearly 40 per cent of platinum production.

Platinum, one of the rarer elements in the Earth's crust, has so many useful properties that, as an integral part of today's industrial processes, it is now considered a critical mineral. It is used in chemical, industrial, and electronic applications, medical and biomedical applications, and petroleum refining, as well as green energy. One of the densest and least reactive of all metals, it has a high melting point of 1,772°C and high corrosion resistance. It is easily worked and has exceptional catalytic properties. Platinum is classified as a "noble" metal, along with other platinum group metals (PGMs) and gold, having outstanding resistance to oxidation, even at high temperatures, and occurring in nature in its raw form.

Since 1979, PGMs have largely been used in catalytic converters for automobile exhaust systems, including hybrid vehicles, to reduce the toxic pollutants of tailpipe emissions, helping to improve air quality. Today, over 40 per cent of platinum production is used for this purpose. Platinum also plays an essential role in hydrogen fuel cells, which according to the Canadian Hydrogen and Fuel Cell Association (CHFCA), "can deliver the power for a new, clean energy era." Hydrogen fuel cells power satellites; homes; passenger vehicles [fuel-cell electric vehicles (FCEV)]; trucks, busses, trams, trains, and boats; mobile homes; and backup power to businesses. Even shipping and aviation are exploring the use of hydrogen fuel cells. Canada has a sector-leading position in advanced hydrogen fuel cells.

Platinum crown made for Queen Mother in 1937, featuring the 105.6 carat Kohinoor diamond

In the chemical industry, platinum and platinum alloy catalysts are used to produce nitric oxide, the raw material for fertilizers, explosives, and nitric acid. Platinum supported catalysts are used in the refining of crude oil and other processes used in the production of high-octane gasoline and compounds for the petrochemical industry. Platinum is frequently used as a catalyst in the curing process of silicone rubber. Platinum and platinum alloys are also used as crucible materials.

Platinum turns up in a variety of medical applications due to its biocompatibility, inertness within the body, durability, and electrical conductivity. It is commonly used in surgical tools, dental material, heart pacemakers, cochlear implants, medical implants, and catheters that allow for minimally

The six platinum-group metals are:

- ruthenium
- rhodium
- palladium
- osmium
- iridium
- platinum

invasive heart disease treatments. Platinum compounds, the most commonly used being Cisplatin, damage cancer cells and are used to treat testicular, ovarian, bladder, lung, and other cancers.

The glass-making industry also relies heavily on platinum and platinum alloys. Their resistance to corrosion and erosion allows them to protect many of the components involved in the glass-making process, making them indispensable to the production of glassware such as sheet glass, bottle glass, optical glass, and fibreglass.

Platinum is a key component in a variety of electronics. It can be found in electrical contacts and electrodes, computer hard drives with high storage densities, smartphones, televisions, and sensors in home safety devices. It is also used to make an alloy with cobalt to produce strong, permanent magnets.

Where does all this platinum, so essential to today's society, come from? The silver-white metal occurs in alluvial deposits and is also produced as a byproduct of copper and nickel refining. The bulk of global production comes from South Africa, followed by Russia, and Zimbabwe. In Canada, the fourth largest producer, the Sudbury Basin, Ontario, accounts for nearly 80 per cent of the country's platinum output, with the remainder coming from Quebec, Manitoba, and Newfoundland and Labrador.

In the music industry, "going platinum" describes a single or album that sells one million copies or more, a rare and significant milestone. From an unwanted lump of "unripened gold," platinum has become the symbol of ultimate success, coveted globally for its rarity, beauty, and properties that contribute so much to our society.

Platinum Metrics

Platinum, as one of the densest and least reactive of all metals, with high corrosion resistance, was used to define the measurements of the metric system, developed in France in the late 1700s. In 1799, the definitive standards of the metric system, the platinum metre and the platinum kilogram, were placed in the French National Archives, and a law was passed confirming their status as the only legal standards for measuring length and mass in France.

Painting with Minerals

Lascaux Cave

Humans are an artistic bunch, finding various ways to portray their world, ideas, and beliefs. Painting has been one significant method of artistic expression since prehistoric times, developing from hand shapes and animals depicted on cave walls to the glories of the Sistine Chapel and beyond. We credit artists for their creations, but where did their colours come from? Many of them come from mineral and metal sources.

The hand stencils in the Cave of Maltravieso in Spain, over 64,000 years old, are the oldest known cave paintings in the world; possibly created by Neanderthals. Other prehistoric rock paintings have been discovered around the world, including Australia, Indonesia, Brazil, South Africa, India, Bulgaria, Argentina, Canada, and France. Like most early cave paintings, France's renowned Lascaux cave, 17,000 years old, displays a limited colour palette, featuring yellow, brown, red, and black, and some white. The yellow and red are iron oxide coloured clay known as ochre, the oldest known natural pigment, the brown and black are made with manganese oxide, and calcite makes the white. Cave paintings in other parts of the world show similar use of these minerals, along with black charcoal elements.

As people developed more sophisticated cultures, they created surfaces on which to paint, such as walls, statuary, wooden objects, ceramics, and paper. Egyptian painting, spanning over 5,000 years, built on the prehistoric mineral pallet, adding blues made from azurite and lapis lazuli, green from malachite, red from cinnabar, and bright yellow from orpiment. After grinding, minerals were mixed with plant or animal-based glue, then applied, sometimes layered to create additional colours, such as pink or grey. The Greeks added further to the mineral-based palette, discovering chemical processes to produce white lead, red lead, and yellow lead from lead, verdigris from copper, and red vermilion from mercury and sulphur.

Doni Tondo by Michelangelo

Italians of the Middle Ages and Renaissance discovered how to process lapis lazuli to extract the brilliant blue pigment ultramarine, highly prized and often reserved for the Virgin Mary's mantle in religious scenes. Malachite became a popular green in creating manuscripts and in medieval painting in Europe and Asia, and azurite also became an important blue pigment.

The Muse by Pablo Picasso

The Renaissance era brings many artistic achievements to mind, including the genius of artists such as Leonardo da Vinci, Michelangelo, and Raphael. The range of colours they had to work with had grown significantly including Naples yellow, from the slopes of Mount Vesuvius; lead tin yellow; sienna and burnt sienna, and umber and burnt umber, shades of brown pigments from a mixture of iron and magnesium oxides.

Indigenous peoples of Canada have used mineral pigments for millennia, many of which were sourced locally from the land. Across Turtle Island, First Peoples created pictographs using red ochre, made from hematite, mixed with clay minerals. The Beothuk of the east coast applied ochre to their hunting implements and canoes and applied it to their bodies as adornment and as an insect repellent. Black, red, blue and green paint pigments have been used by First Nations on the Northwest Coast for thousands of years. Artists derived green pigment used to adorn masks and totems from a mixture of the minerals celandonite and glauconite. Blue pigment used to create traditional ritual and ceremonial objects was sourced from vivianite. Honoring connections to the land, some indigenous artists have returned to traditional ways of producing and using mineral pigments.

In the 20th century, titanium dioxide, a naturally occurring fine white powder, was first intentionally produced as a white pigment. Today, paint is a common interior design element, and many pigments are now synthesized from various sources; however, many still rely on mined ingredients or additives. The world of painting still relies on the world of mining.

If you are an educator interested in exploring an art project using natural pigments, visit the Natural Earth Paint website for supplies and ideas. (shop.naturalearthpaint.ca/)

Stonehammer, in New Brunswick stonehammergeopark.com/
Tumbler Ridge, in British Columbia tumblerridge.ca/
Percé, in Québec geoparcdeperce.com/en/
Discovery, in Newfoundland & Labrador discoverygeopark.com/
Cliffs of Fundy, in Nova Scotia fundygeopark.ca/

The Advocate Harbour Geosite.

Cliffs of Fundy UNESCO Global Geopark

Field Sites for Nova Scotia Educators

UNESCO Global Geoparks are special places, branded as such in celebration of globally significant connections between geology, local communities, culture, and nature. Canada currently has five Global Geoparks, located in five provinces, and several aspiring Geoparks well on their way to becoming certified. The Cliffs of Fundy Global Geopark, located in Nova Scotia, includes more than 40 geological sites, or geosites, located along the north shore of the Bay of Fundy, home to the highest tides in the world. The Geopark theme is two-eyed seeing, viewing the world through an Indigenous lens with one eye (perspective), while seeing through a Western lens with the other. It shares stories of the Mi'kmaq, the original habitants of the land, and the stories of the formation and breakup of the ancient supercontinent Pangea.

The Cliffs of Fundy Global Geopark is an accessible and exceptional outdoor classroom that provides educators and learners with an experiential environment that complements a range of subjects, including Indigenous studies, geology, geography, ecology, marine science, history, and more. Visit the Geopark website for more details and to access educational resources.
fundygeopark.ca/educational-resources/

SMA
Saskatchewan
Mining Association

Saskatchewan Mining Association Educational Resources

The Saskatchewan Mining Association (SMA) represents the mining and mineral exploration industry in the province. In addition to advocating on behalf of its members regarding provincial and federal regulations, the association develops free curriculum-correlated resources to promote mineral literacy and provides educational programs to support Saskatchewan educators and communities.

The SMA website features a wealth of Earth science and minerals industry educational resources for teachers, developed by teachers, mineral industry experts, and geoscientists. These free resources include grade specific lesson plans including Indigenous perspectives, posters and infographics, links to industry videos and information, potash kits for the classroom, workshop opportunities for educators and career education. SMA has recently launched the first of 5 lessons to accompany the new SMA Mining Industry Robotics Kit that focuses on the advancement of technology in mining, available through SaskCode.

A unique opportunity for educators is "Rock n' The Classroom GeoVenture", an annual, Earth science and mineral resources professional learning program for Saskatchewan educators, offered in the summer. During the week-long program, participants take part in an introductory workshop, followed by site visits to an underground potash mine, potash solution mine, uranium mine, coal mining, mills, processing labs and sites of geologic interest across the province. The program is fully sponsored by the SMA and includes meals, travel, and accommodation. Enrollment is limited. To apply, educators must submit a letter of interest. For more information on SMA educational resources and the GeoVenture program, please visit the SMA website and select the Educational Outreach tab.
saskmining.ca/Mines-in-Saskatchewan/Education-Outreach

Rocks + Kids = Opportunities

The *Rocks + Kids = Opportunities* program is entering its fifth year! Offering specialized learning for students and teachers in underserved schools in the Greater Toronto Area and across Canada , the program is connected to the curriculum and available to eligible schools at no cost. The focus of the program is grade 4 Earth science and mineral resource education. Workshops can be customized, providing teachers with the opportunity to select from a series of 14 hands-on learning activities. Included in the workshop is a complimentary set of teacher and student resources. For the 2022–2023 academic year, workshops will be delivered virtually and in-person, in select locations. Mining Matters continues its partnership with the Toronto District School Board to offer this program to their Model and Priority Schools. To learn more about *Rocks + Kids = Opportunities* or to request a workshop, contact schoolprograms@miningmatters.ca

Mining Matters thanks Kinross Gold for their generous support of this important initiative.

Mining Makes It Happen Poster – Critical Connections

The Mining Makes It Happen (MMIH) poster series explores how minerals, metals, and elements connect with different aspects of daily life. *Critical Connections* is the sixth poster in the series and features the 31 critical minerals, metals, and elements declared by the Canadian government as raw materials essential to renewable energy technologies, manufacturing, aerospace and defence, information and communications technology, agriculture, health and life science applications, and critical infrastructure. Critical minerals include both base and precious metals as well as industrial minerals. Locating and producing critical minerals in Canada is a strategic goal.

Critical Connections examines the role of critical minerals, metals, and elements in the Canadian aerospace, telecommunications, and automotive industries, and in green energy generation. The poster also provides a snapshot of the role that Canada plays in the global production of critical minerals. Mining Matters thanks the Government of Canada and the Government of the Northwest Territories for their support of the project.

Critical Minerals Activities for Secondary School

Mining Matters recently developed a new suite of classroom activities for secondary school students. Themed around Critical Minerals, the suite includes three separate modules, aimed toward students in grades 7 to 12.

The first module, Critical Minerals Lab, includes a series of hands-on activities, by themes, that explore critical minerals through physics, including material properties, circuits, and magnetism.

The second module, Deconstructing Technology, introduces students to the connection between critical minerals and modern life, examining the critical minerals used in a smartphone, tracing their sources, and creating a scale of their use on a global basis.

What's Next, the final module in the series, has students examine and discuss critical minerals issues using a World Café model, a simple, effective, and flexible format for hosting large group dialogue, through multiple rounds of discussion.

WHERE challenge
Sponsored by Teck

The WHERE Challenge has returned, and the 2022–2023 edition features a brand-new website! Launched annually in September, the WHERE Challenge is a national contest endorsed by the Canadian Earth sciences community.

The Challenge is a contest that provides an opportunity for students ages 9 to 14 to discover "What on Earth is in your stuff?" and "WHERE on Earth does it come from?" WHERE stands for the fields in which geoscientists work: Water, Hazards, Energy, Resources, and Environment.

A total of $5,000 in cash and prizes is available to be won. The Early Bird Bonus and Teacher Incentive Deadline is December 31, 2022. The deadline for student submissions is March 30, 2023. Please visit the new WHERE Challenge website for complete contest details, a list of 2022 winners, and to see their winning entries. wherechallenge.ca/

Mining Matters offers WHERE Challenge student workshops at no cost with the commitment of

student entries to the contest. The workshops provide students with the knowledge required to participate in the WHERE Challenge, including

- the connections between rocks, minerals, metals, and everyday life
- the location of minerals and mines by province and territory
- descriptions of non-renewable and finite resources and their conservation through reducing, reusing, recycling, and consumer behaviour
- how to enter the WHERE Challenge

Details and registration are available on the Mining Matters website. miningmatters.ca/school-programs/teachers/virtual-where-challenge-workshops

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The WHERE Challenge is made possible with the generous support of Teck Resources Limited.

Mining Matters Escape Rooms

Mining Matters continues to develop a three-part Virtual Escape Room series. Each part can act as a stand-alone game and have been developed to be accessible, using screen readers. The game is themed around a character, a dragon "Sodalite," who has claimed the mine and its contents as part of its hoard, offering a chance for the players to win back the mine if they complete three challenges. Players first find themselves in the mine's refuge station and must complete a series of tasks to access passwords, retrieve clues, interact with surroundings, and collect personal protective equipment (PPE) to successfully fulfill the first challenge requirements. After escaping the refuge station, players must make their way through the mine to the cage to take them to the surface, once again their path is strewn with obstacles and puzzles. At the surface there will be one more test, however at this time the final challenge is still in development and will remain a mystery. Mining Matters thanks Teck Resources Limited for its project sponsorship and SenseTech Solutions for providing technical expertise to the project. For the second installment we also partnered with an Ontario Tech University Capstone Team from the University's Game Development and Interactive Media Program to develop the prototype of the game.

miningmattersescaperooms.ca/MMRefugeStation/

Mineral Resources and Mining Education Tours: Experiential Professional Learning for Teachers

For more than a decade, Mining Matters, the Ontario Mining Association, the Canadian Ecology Centre, and the Canadian Institute of Mining, Metallurgy and Petroleum have partnered to deliver the Mineral Resources and Mining Education Tours, an experiential professional learning program for formal and informal educators and mineral development advisers, from across Canada. The tours are delivered in August annually, in Ontario, or by request, during the academic year. The program includes three, scaffolded tours that provide participants with a comprehensive understanding of Earth science, mineral resources education, and modern mining.

Mineral Resources and Mining Education Foundations

Hosted at the Canadian Ecology Centre, this tour provides participants with a foundational understanding of Earth science and mineral resources, including the fundamentals of mineral and rock identification and the early phases of the mine life cycle, including prospecting. Participants tour North Bay mineral exploration and mining supply and service providers.

Mine Life Cycle

Participants learn about each of the phases of the mine life cycle and explore the geology and history of the Sudbury region, known globally for nickel production, or the Timmins area, known globally for gold production. The program includes visits to underground mines and reclaimed sites, opportunities to engage with industry professionals, and hands-on instructional development workshops focusing on Earth science and mineral resources.

Life in a Mining Camp

This tour showcases Impala Canada's Lac des Iles operation and provides an overview of minerals industry careers. Participants attend a management meeting, tour underground and surface operations, including the mine and mill, and stay overnight at the mine, located north of Thunder Bay. The tour also includes visits to geological sites of interest in Thunder Bay and Nipigon.

The three tours are fully sponsored and available for a fee of $50 per tour. Registration includes transportation, accommodation, and meals, while on site. Participants are responsible for all expenses incurred travelling to and from tour locations (i.e., the Canadian Ecology Centre or the Thunder Bay International Airport). Visit the Canadian Ecology Centre website for additional details and to complete your registration. canadianecology.ca/professional-development/miningtour

Minerals Industry Career Spotlight:

Rilea Kynock

The Minerals Industry Career Spotlight aims to raise career awareness among educators and their students by featuring an outstanding professional. In this edition of the Spotlight, we feature Rilea Kynock, an early career geoscientist and former member of the 2017-2018 Mining Matters staff.

Describe your career path and any important milestones.

My career path in geology has taken a sharp turn from where I saw myself as a student. I chose to pursue a bachelor's degree in Earth science because I was interested in the subject and planned to work in education or science communication. My first job after graduation was doing just that, Instructor, Education and Outreach Programs with Mining Matters, but I also wanted to achieve the professional geoscientist registration. For that I required applied work experience, so I accepted a job offer to work at the newly developed Touquoy gold mine in Halifax County, Nova Scotia.

I am still working at Touquoy almost five years later. The mine is approaching the end of production and the site is transitioning to a processing facility for nearby satellite deposits. Although I have worked at only one operation, the rapid changes in the mine's life cycle, combined with a change in ownership, made for a dynamic experience and provided opportunities for me to assume multiple roles. I started as a field geologist, spending most of my time outside with a grade control drill rig, securing samples and transporting them to an assay lab for analysis. Although the job was laborious, I felt a strong sense of purpose, learning about sample quality and contamination, along with the domino effect that poor grade control practices has on the wider operation.

My role evolved to include mine planning and designing ore blocks, with consideration of production guidance and targeting of milled ounces and mined tonnes. Eventually, I would be trained to perform numerical block modelling and monthly reconciliation to predict and then calculate the actual recovered grades after dilution and ore loss.

I currently serve in a backfill role, completing a contract in engineering geology. My future plans include branching out into other industry roles. I am particularly interested in assuming an exploration role and one that involves environmental assessments.

What motivated you to choose a career in the minerals industry?

My work with Mining Matters motivated me to choose a career in the minerals industry. In university, I focused on science outreach and education, working for Let's Talk Science as a site coordinator, and I considered working as a teacher or museum curator. Mining Matters was my first job out of university, and while I was thrilled to work in geology-focused education, the slant on mineral resources and focus on remote community outreach showed me how the mining industry appealed to my values. I learned about the critical role that mining plays in the transition to renewable energy and carbon emission reduction. I also learned about mine reclamation and policies to protect local environments. Visiting rural and remote communities across Canada and the north that are influenced or dependent on mining was eye opening, regarding the positive impacts and opportunity mining brings to often forgotten areas in our country.

What are the responsibilities of your current role, in a typical work week?

In my engineering geology role, I focus on mine safety through structural modelling, mine planning, ground monitoring, and inspections to prevent or mitigate geotechnical hazards. I review the mine's blasting plan and compare it to computer-aided design (CAD) hazard models, with consideration to safety and pit design. I map fault lines and update the structural interpretation and 3D models as new areas of the deposit are exposed. I inspect and document the conditions of the pit and material stockpiles, so potential rock mechanics issues are identified and managed.

What do you like most about your job?

What I like most about my job is my workplace colleagues. While the mining industry attracts a diverse range of people with varying backgrounds and skills, there are definite shared traits that lead us to choose a mining career. The mine's culture is positive, and my colleagues are approachable, hilarious, and unpretentious, leading to enjoyable days on the job, even in situations where tasks are challenging.

What education and training are required for your work?

A geologist typically enters industry after completing a Bachelor of Science degree in Earth Sciences or Geology. While a student, someone considering a career in mining would benefit from choosing electives founded in environmental science, economic geology, statistics, rock mechanics, and geography. Outside of university, geologists entering the mining and exploration industry could prepare for running drilling programs by educating themselves on some of the technical aspects of mining, such as sampling quality assurance/quality control (QA/QC), first-aid, and relevant environmental and occupational health and safety regulations in their jurisdiction. On the job training is required, since every operation uses particular software and systems for data management and geological modelling. Lifelong learning is an expectation and something to look forward to in this career.

What are the skills and qualities that you consider important to succeed in the minerals industry?

In my opinion, given the demand for mining industry human resources, lacking a particular skill or experience is not a barrier to success in the mining industry, as there are plenty of on-the-job training opportunities. Instead, the qualities workers should bring to workplaces are coachability, respect for safety practices, and flexibility. Plans and goal posts can and do shift. It is important that workers are adaptable.

What advice do you have for a student interested in learning more about or considering a career in the minerals industry?

I would advise a student to research the locations where mines operate, or are proposed, and consider if life in those locations is attractive to them. Most mines are located in remote areas, requiring relocation and either a daily commute to a mine or living on-site at the mine. Each of these scenarios offers perks and poses challenges.

My recommendation for students looking to get their foot in the door would be to branch out beyond schoolwork to make connections. They should attend geology or industry conferences, eager to learn, listen, and ask questions. I recommend that they participate in field trips and volunteer opportunities organized by the school or local society. As a graduate starts their career, they should be humble and recognize that the mining industry relies on teamwork involving a diverse range of people with different training and experiences. They should respect the knowledge and experience of everyone in their workplace and be prepared to learn on the job.

Was there an inspirational moment or educator in high school that helped set you on your path? If so, please describe the moment or educator.

The most inspirational moment in high school was shared with my physics teacher. She said that she had no concerns with regard to my success in university, because I was someone who knew how to work hard. Before that was said, I had doubts that I would be successful pursuing sciences, although they were my favourite subjects, because I dreaded math and taking tests. Her words bolstered me. They prevented me from feeling that I was not suited to university and from withdrawing when faced with challenges.

Mining Matters Resources

Mining Matters Classroom Resource Kits

Mining Matters resources for classrooms are developed in collaboration with educators and Earth science and mineral resource specialists to meet provincial Earth science and Geography curriculum mandates and guidelines. Kits include lesson plans, black line masters, mineral and rock samples, equipment, and student visuals. Three resource kits are available for use across Canada:

- Junior/Elementary: Deeper and Deeper: Discovering Rocks and Minerals
- Intermediate/Middle: The Earth's Crust
- Senior/Secondary: Discovering Diamonds

Resource kits are available in both official languages through a prerequisite in-service workshop. Workshops can be organized for groups of 10 to 24 teachers, anywhere in Canada, given four weeks' notice. Learn more about these resources and how to access them at miningmatters.ca/school-programs/teachers

Mining Matters thanks BMO for their generous support of these important resources.

Deeper and Deeper Video Tutorials

For teachers who have previously participated in a Deeper and Deeper: Discovering Rocks and Minerals professional learning workshop, Mining Matters offers a chance to refresh instructional skills through training videos. The Deeper and Deeper "Unboxing" video provides a detailed overview of the contents of the kit, while other videos present select learning activities from Topics 2 through 4.

Core Concepts

Core Concepts is a series of classroom-ready lesson plans for students in grades 7 to 9. The topics explored include the structure of the Earth, rocks and minerals, soil and erosion, the mining cycle, and social and environmental responsibility.

Mining Matters Activity Book

Created for youth ages 9 to 13 years, this booklet is full of fun activities, including puzzles, codes to crack, things to spot, word searches, crosswords, Sudoku, and more. Available in English, French, Inuktitut, and Spanish, it supports learning about mineral, rock, metal, and mining, and minerals industry careers.

What is a Mine?

The Mining Matters *What is a Mine?* colouring book features Mighty Miner, who guides students through an adventure that helps them learn about mining.

MMIH Posters

The Mining Matters *Mining Makes It Happen* poster series helps students understand the role that minerals, metals, and elements play in manufacturing, medicine, sports, music, energy, and technology. The six posters are available for download from the Mining Matters website.

Other Resources

Podcasts

Created by the British Geological Survey, **Rock the Mic** features a wide range of experts from the field of geology exploring the intersection of geoscience and modern life.

audioboom.com/channels/5039164

The **Geology Podcast Network** is a source for geology news, career highlights, and insights by experts in the field from around the world.

travelinggeologist.com/series/geologypodcastnetwork

In **Simply Science – Earthquakes in Eastern Canada**, a Geological Survey of Canada Seismologist discusses his 30-year career studying earthquakes in Canada.

nrcan.gc.ca/simply-science/earthquakes-eastern-canada/24176

Videos

Boseman Science is a YouTube Channel created by an experienced classroom educator and consultant. Aimed toward secondary students, the video content features many Earth science topics including geology, energy, mining, and soil. youtube.com/bozemanscience/videos

Crash Course for Kids is a YouTube Channel aimed toward elementary students. Video content includes Earth, Habitats, Space, Chemical Reactions, Engineering, and more. Earth science topics presented include dinosaurs, weathering, volcanoes, the atmosphere, and other relevant geoscience studies. youtube.com/c/crashcoursekids

Smile and Learn is a YouTube Channel for learners aged 3 to 12 years. Videos are designed and lead by educational experts. The channel features Geography, Science, and other curricular content. youtube.com/c/SmileandLearnEnglish1/featured

GeoscienceINFO.com hosts a series of GeoVideos that explore the themes of the importance of geoscience, volcanoes, rocks, and where water comes from. geoscienceinfo.com/

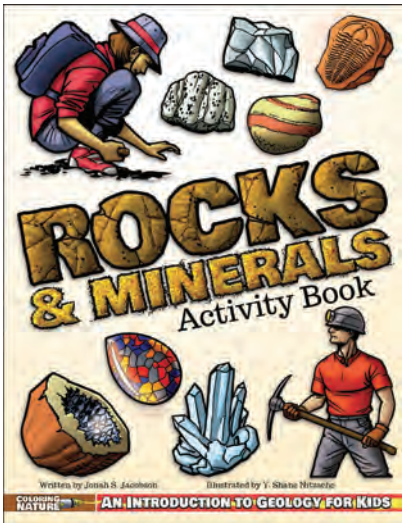
Websites

Earth Learning Idea was created by Earth science educators to provide easy, accessible education ideas to promote knowledge and understanding of planet Earth. All of the content is available free to everyone, everywhere in the world. ELI activities are practical, and many are hands-on, using minimal equipment and minimal resources. The ELI website hosts a wealth of content aimed towards educators and learners, including teaching strategies, teaching videos and workshops, Earth science videos and content, the ELI Virtual Rock Kit, and Geoscience textbooks. The activity database is searchable by theme and includes a repository of more than 300 free hands-on activities in English. earthlearningidea.com/index.html

The Natural Resources Canada **Atlas of Canada** website is a key source of geographic information. The website provides a selection of interactive and historical maps and geographical data available for reference or download. atlas.gc.ca/mins/en/index.html

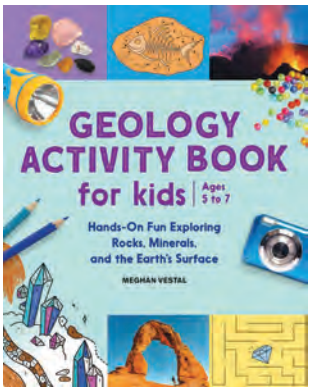
Science4Fun is aimed toward young children and teens. Founded by an engineer who is also an educator, the website content includes a variety of science subjects, including Earth science. The Earth science chapters include fundamental content such as minerals and rocks, land formations, and hazards, as well as advanced content, including green energy, pollution, climate change, and various ecosystems and spheres. science4fun.info/earth-science/

Books



Rocks & Minerals Activity Book
by Jonah Jacobson (2021)

The Rocks & Minerals Activity Book, introduces learners ages 5 to 10 to geology, including common rocks and minerals. The book's colouring pages and activities reinforce the information that is presented in interesting and creative ways. Readers can also learn how to start their own rock collection.

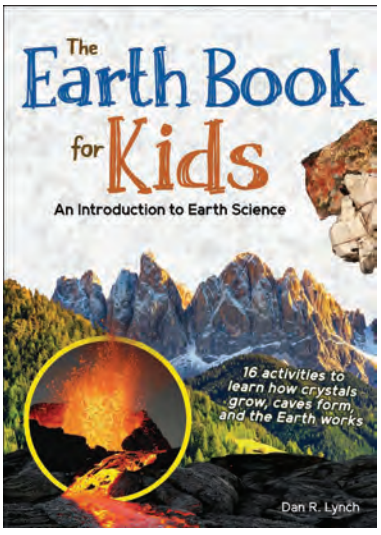


Geology Activity Book for Kids: Hands-On Fun Exploring Rocks, Minerals, and the Earth's Surface
by Meghan Vestal (2022)

This book, aimed toward early learners ages 5 to 7, teaches about planet Earth through a series of 19 geological topics that feature hands-on experiments, activities, and fascinating facts.

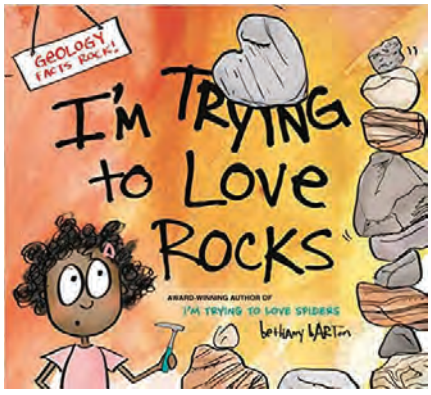
We Are Water Protectors
by Carole Lindstrom (2020)

For ages 2 to 8, this book is written from the perspective of a young Indigenous girl whose community is threatened by a black snake foretold to come and poison the land. Winner of the 2021 Caldecott Medal, this beautifully illustrated story presents an Indigenous perspective, issuing a cry to protect the Earth's water from harm and corruption.



The Earth Book for Kids: An Introduction to Earth Science
by Dan Lynch (2022)

For ages 6 to 12, this book introduces learners to the Earth's composition, rock types and their formation, landforms, natural disasters, and other Earth science related topics. As an added bonus, 16 fun and simple activities teach how crystals grow, how caves form, and how the Earth works. Build a molecule, make sandstone, and more.



I'm Trying to Love Rocks
by Bethany Barton (2020)

In a dialogue between the author and the main character, a young geology enthusiast, Bethany Barton discusses the relevance of geology. Geared for ages 4 to 8, the book touches on rock type, rock cycle, plate tectonics, natural disasters, and minerals, and offers a fun way to introduce children to Earth science topics and the stories rocks have to tell.

Posters

The Geological Society has developed a series of excellent posters that feature topical content such as the carbon cycle, minerals in a smartphone, and plate tectonics. They are ideal for use in developing lesson plans and displaying in the classroom. geolsoc.org.uk/Posters

Did You Know?

Canadian Aspiring Geoparks

Canada has six aspiring Geoparks under consideration for inclusion in the UNESCO Global Geoparks Network canadiangeoparks.ca/aspiring-geoparks

Cabox Aspiring Geopark, in Western Newfoundland, traces its origins back to the Tropics, where 500 million years ago, it lay at the eastern edge of the landmass that would become North America.

Charlevoix Aspiring Geopark, in Quebec, comprises three major geological areas: the Canadian Shield; the St. Lawrence Lowlands; and Isle-aux-Coudres, which belongs to the Appalachians. Charlevoix also features an ancient meteorite impact crater about 54 kilometres in diameter.

Georgian Bay Aspiring Geopark, in Ontario, features a shoreline that exposes the most diverse geology found anywhere in North America, recording in total more than 2 billion years of Earth history.

Fire & Ice Aspiring Geopark, in British Columbia, is the most geologically active area in all of Canada. It features some 70 geosites that tell an end-to-end story of ongoing mountain building, glaciation, volcanism, and collapse.

Temiskaming Rift Valley Aspiring Geopark, in northern Ontario, highlights the Temiskaming Rift Valley, formed 450 million years ago, and features agricultural plains and rich mining history, thanks to a system of rifts and faults.

Niagara Peninsula Aspiring Geopark, in Ontario, features a fascinating geologic foundation over 500 million years old, with world-renowned Niagara Falls as its beacon.

Drill Bits

Historic Discovery

In Canada's Yukon, Stanford University-led expeditions found the **longest known continuous rock record of the Paleozoic era**. The scientists uncovered a 120-million-year-long geological record of a time when land plants and complex animals first evolved, and ocean oxygen levels began to approach those in the modern world.

Galactic Wonders

On July 12, 2022, NASA released the first full-colour images of the cosmos captured by the James Webb Space Telescope. The most advanced space telescope ever built, the Webb Telescope is an international collaboration between NASA, the European Space Agency, and the Canadian Space Agency (CSA). CSA contributed two principal elements to the telescope: the Fine Guidance Sensor (FGS), which allows the telescope to point at and focus on objects of interest, and the Near-Infrared Imager and Slitless Spectrograph (NIRISS), a scientific instrument that helps study astronomical objects, from exoplanets to distant galaxies.

Canadian Rare Earth Firsts

Rare Earth Elements (REEs) are in numerous applications, including electronics, clean energy, aerospace, automotive, and defence.

In August 2022, the first rare earth metal ingot ever produced in Canada was unveiled. The ingot is a product of the **Saskatchewan Research Council's (SRC) Rare Earth Processing Facility in Saskatoon, the first facility of its kind in North America**. The facility will process monazite concentrate from Brazil to produce rare earth oxides and metals and will produce REE products for sale internationally in 2024.

Canadian company Vital Metals, processing ore from their Nechalacho mine in the Northwest Territories, is the **first rare earth producer in Canada** and the second in North America. The company has built a facility to refine the concentrate in Saskatoon, Saskatchewan.

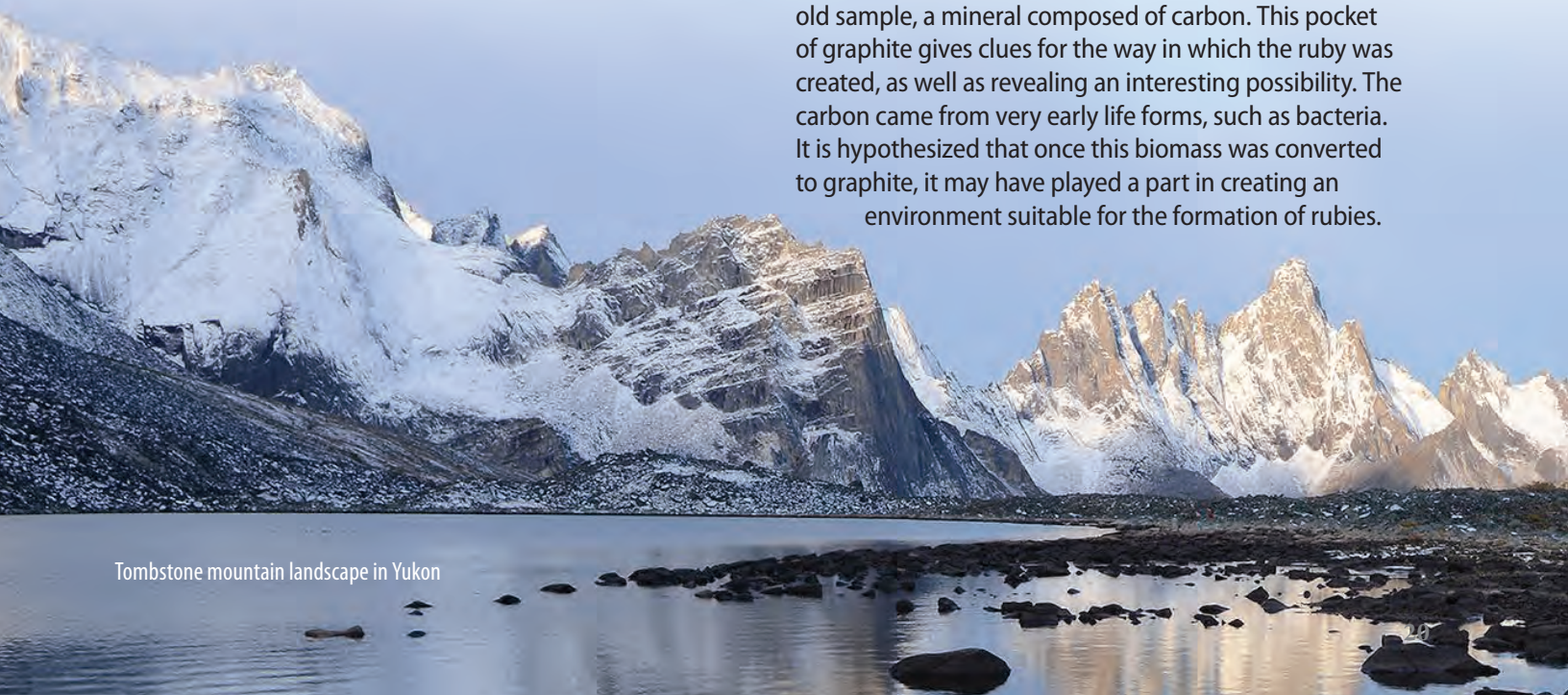
In Quebec, Canadian company Geomega Resources is building **the world's first sustainable rare earths recycling facility** to help meet surging global demand for permanent magnets, needed in vehicle electrification and renewable energy sources. The plant will use an in-situ recovery process to recycle rare earths, with a focus on the permanent magnet industry, and will produce four high-demand elements, including neodymium, praseodymium, terbium, and dysprosium.

Geological Anomaly

Researchers at Cambridge University recently discovered a puzzling **geological anomaly** centred on the portion of the Earth's core located almost directly below the Hawaiian Islands. Using advanced seismic imaging systems, geologists were able to identify a zone where earthquake waves propagate much more slowly relative to other areas. It is theorized that this phenomenon occurs because the zone contains high amounts of iron, resulting from the presence of remnants of ancient rock created early in the planet's formation.

Early Life in a Ruby

While performing studies on ancient rubies to learn more about their formation processes, researchers from the University of Waterloo detected carbon residue indicative of the past presence of early life. Researchers noted the presence of a pocket of graphite within a 2.5-billion-year old sample, a mineral composed of carbon. This pocket of graphite gives clues for the way in which the ruby was created, as well as revealing an interesting possibility. The carbon came from very early life forms, such as bacteria. It is hypothesized that once this biomass was converted to graphite, it may have played a part in creating an environment suitable for the formation of rubies.



Tombstone mountain landscape in Yukon

Field Trip Subsidies

The return to in-person learning means a return to field trips and the Mining Matters Field Trip Subsidy Program. This annual program provides support for experiential Earth science learning, offsetting some of the costs associated with transportation and entrance fees. Available to teachers across Canada, applications are considered on a first-come, first-served basis. For complete details, including eligibility, visit MiningMatters.ca, and enter Subsidy Application Procedures in the Search box. Mining Matters thanks SGS for their generous support of this important program.

Field Trips

Willner Madge Gallery

The Willner Madge Gallery, Dawn of Life Gallery has opened at the Royal Ontario Museum. The gallery explores the theme of early life on Earth and four billion years of evolution, displaying and interpreting an impressive fossil collection. The rocks of Canada include nearly a complete record of the history of life. The gallery showcases fossils from all Canadian provinces and territories, including special locations designated today as UNESCO World Heritage Sites, including Yoho National Park, Parc National de Miguasha, Anticosti Island, and Mistaken Point.

GeoTrails

GeoTrails are hikes that include curated scientific content that highlight an area's geological features. They offer field-based learning opportunities with many elementary and secondary curriculum connections founded on the natural environment.

The website Geotrail.ca offers "customized guides for outdoor adventures," currently listing detailed guides for the Royal Botanical Gardens, Hamilton's Waterfalls, and the Bruce Trail. geotrail.ca

Several GeoTrails are on offer at GeoscienceINFO.com, an initiative of the APGO Education Foundation, which is an education partner of the Niagara Peninsula Aspiring Geopark.

- The Niagara Region Geotrails feature Ball's Falls, Chedoke Radial, and Tiffany Falls. geoscienceinfo.com/vft/geotrails.html
- The University of Toronto Urban GeoTrail tours seven buildings on the University of Toronto campus and features the geological significance of the Earth materials used in their construction. geoscienceinfo.com/vft/urban-geotrails.html

The GeoscienceINFO.com GeoTrails are also featured on the Aspiring Geopark Website. experience.arcgis.com/experience/c39fea16e5994697844239ba5a2f2e84/

Virtual Field Trips

The GeoscienceINFO.com website also hosts 17 geologically themed field trips to locations across Ontario and Quebec that feature important geologic and mineral discoveries, ancient ocean environments, and past catastrophic events like explosive volcanoes, giant meteorite strikes, glaciation, and more. Field trips feature curated geological sites of interest that include geospatial data, photographs, and geological history. geoscienceinfo.com/virtual-field-trips.html

Elementary Activity: Reclamation Matching

BACKGROUND

Canadian provinces and territories require that mining lands be reclaimed, meaning that they must be returned to a natural, or near natural, and productive state when mines cease operating. This means ensuring that the area is capable of supporting plant, wildlife, and fish communities. Reclamation involves several processes, including land contouring, replacing subsoil and topsoil, and seeding and revegetating lands. Many reclaimed mines feature land that has been restored to its prior landuse. Others have been reclaimed to other land uses, such as recreational areas. Prior to operating, mines must develop an approved reclamation plan. Amendments must be sought should any plans require revisions.

LEARNING OUTCOMES

Students understand and appreciate:

- The final stage in the mine life cycle
- The processes involved in reclamation
- The minerals used to create some products

MATERIALS

Reclamation Mining Card Sets

- Red cards display photographs of operating mine sites, list the name of the mineral resource being mined, and a product made from that resource
- Blue cards display photographs of the same operations following reclamation and the product made from that resource

Reclamation Matching Table

INSTRUCTIONS

1. Students match the red and blue cards. There is only one correct match for each card set.
2. In the table below, students record the mined resource, the product it is used to make, and the differences they observe in the matching pictures.

RECLAMATION MATCHING

Mined Resource	Product	Observations

CONCLUSIONS

Review each match (the mined resource and the product)

Discuss which changes were the most interesting or impactful.

Reclamation Mining Card Set

QUARTZ
QUARTZ

Photo courtesy of MHR and MNDM

COUNTERTOP
COMPTOIR

Santalla Quarry, ON

Photo courtesy of MHR and MNDM

COPPER
CUIVRE

Photo courtesy of MHR and MNDM

ELECTRICAL CABLES
CABLES ÉLECTRIQUES

Brenda Springs Mine, BC

Photo courtesy of MHR and MNDM

CRUSHED STONE
PIERRE CONCASSÉE

Photo courtesy of MHR and MNDM

ROADS
ROUTES

Butchart Gardens, BC

Photo courtesy of MHR and MNDM

COAL
CHARBON

Photo courtesy of MHR and MNDM

ELECTRICITY
ÉLECTRICITÉ

Elk Valley Coal, BC

Photo courtesy of MHR and MNDM

LEAD
PLOMB

Photo courtesy of MHR and MNDM

CAR BATTERY
BATTERIE D'AUTO

Heath Steele Mines, NB

Photo courtesy of MHR and MNDM

ZINC
ZINC

Photo courtesy of IAMGOLD

SUNSCREEN
ÉCRAN SOLAIRE

Solbec, QC

Photo courtesy of IAMGOLD

MOLYBDENITE
MOLYBDÈNE

Photo courtesy of MHR and MNDM

BICYCLES
BICYCLETTE

Photo courtesy of MHR and MNDM

Secondary Activity: Critical Minerals World Café

Duration: 60 to 90 minutes

BACKGROUND

In 2021, Canada developed a list of 31 minerals considered critical for the sustainable economic success of Canada and of its global partners. The minerals, all of which are or can be produced in Canada, are essential to transitioning to a low-carbon economy, to domestic industry and security, and to ensuring a sustainable source of critical minerals for our global partners. They are minerals necessary for renewable energy technologies, manufacturing, aerospace and defence, information and communications technology, agriculture, health and life science applications, and critical infrastructure.

Canada's minerals sector is an important global supplier of many critical minerals and metals and ranks among the top five countries in the global production of 15 on the list. In the future, the country is well positioned to increase production of these minerals due to our geological endowment, environmental and social standards, and political stability.

The World Café model has been tested with various age groups and cultures over the last 20 years. The discussion process is structured to invite a range of different perspectives, viewpoints, and opinions in a respectful environment.

There are four keys to success in this model:

1. Establishing ground rules for behaviour and dialogue
2. Having multiple rounds of discussion (this allows for reflection on what has been said)
3. Asking groups to capture their discussion visually (explained later)
4. Developing thoughtful and thought-provoking questions

The conditions for a World Café – see the World Café Hosting Reference Guide: theworldcafe.com/wp-content/uploads/2015/07/Cafe-To-Go-Revised.pdf

LEARNING OUTCOMES

Students understand and appreciate that

- modern technology and sustainable economies are dependent upon critical minerals
- critical minerals involve global interdependence
- critical minerals pervade our lives and are inextricably tied to how our economies operate
- there are multiple perspectives and viewpoints when complex issues are considered

PURPOSE

- Introducing students to the global nature of critical minerals
- Encouraging students to reflect upon the roles that critical minerals have in their lives
- Encouraging students to consider the social and environmental connections to how critical minerals are extracted and used

MATERIALS

- Paper, sticky notes, cue cards, markers, pens
- White or black board to serve as the Wall of Ideas

INSTRUCTIONS

- Duration: 60-90 min
- In-Person or Virtual Delivery
- Groups of 4-6
- Open the lesson with a definition of critical minerals
    - Review the booklet "30 Things: The Importance of Mining Sustainability" mining.ca/resources/presentations/30-things-the-importance-of-mining-sustainability/
    - Play the video youtube.com/watch?v=IjzXFrWc44o (a tongue in cheek German video of life without metals).
    - Read the article 'The Critical Mineral Opportunity' by Janice Zinck (magazine.cim.org/en/voices/canadas-critical-minerals-opportunity-en/)
    - Examine the infographic '10 Key Facts on Canada's Minerals Sector' (nrcan.gc.ca/sites/www.nrcan.gc.ca/files/mineralsmetals/pdf/mms-smm/10_Key_Facts_on_Canadas_Mineral_Sector_EN.pdf)
- Discuss the role that metals or materials play in daily life
    - Undertake a group *"What if. . ."* exercise
- Prompt students to think about what life would be like without a certain mineral or minerals
- If possible, rearrange the classroom into café style seating.

- Set up a 'Wall of Ideas' on a white or black board at the front of the room.
- If delivering the lesson virtually, create breakout rooms (groups of 4-6, plus a host), a virtual whiteboard (Jamboard/Miro) and a separate page on the same board for a virtual 'Wall of Ideas'.
- Create the student groups to reflect the number of rounds.
- Designate a host for each table.
- Provide instructions for how the activity will proceed. Describe how the rounds of discussion will work and explain that students will be moving to a new table each round. Describe the role of the host. Explain that they are assigned to specific tables, that their role is to summarize each of the group discussions, and that they do not rotate.
- Seat students in their first round groups, assign the question, and initiate the first round of discussion.
- Allow 15 minutes of discussion per round to a maximum of 4 rounds (time permitting).
    - Invite students to research the question on their devices. Using tools to support thoughts and add to data can be useful, but encourage students to think critically and refer to credible sources.
- Instruct students to capture their thoughts and feelings, as notes, sketches and doodles, on the materials provided at their table, or on their virtual whiteboard.
- Allow 10 minutes between rounds for hosts to summarize the discussion, add sticky notes and questions to the "Wall of Ideas" or on a collaborative whiteboard, and redistribute students into new groups.
- Carry the question through each round discussion. Exploring the same question in different groups may reveal new insights. When exploring the same question between rounds, offer a secondary prompt for the subsequent rounds to encourage further discussion.
- If there is time for a 4 rounds, try the following format:
    - Round 1 → Initial question; Round 2 → Secondary question
    - Round 3 → New initial question; Round 4 → New secondary question
- If there is time for 3 rounds:
    - Round 1 → Initial question; Round 2 → Secondary question; Round 3 → Tertiary question (all building on the first); OR
    - Round 1 → Initial question; Round 2 → Secondary question; Round 3 → New question, but similar topic
- If there is time for 2 rounds:
    - Round 1 → Initial question; Round 2 → Secondary question
- At the conclusion of the rounds, group similar "Wall of Ideas" thoughts and questions into 'affinity clusters'.
- Conclude the activity by engaging students in a comprehensive discussion about the thoughts and questions that appear in the affinity clusters. Use an inquiry approach to ask students to share their insights, surprises, and questions.

SUGGESTED QUESTIONS

Initial - Are we properly appreciating critical minerals?

Initial - Who should benefit from critical mineral extraction?

Initial - Should we restrict what technologies or applications utilize critical minerals?

Secondary - Should we encourage more innovation of new products and development of the downstream value-added processing and manufacturing capacity, such as for Electric Vehicles and batteries?

Initial - How should we account for the environmental and social costs of critical minerals in Canada (for example, prioritize energy applications over personal devices)?

Secondary - How should we account for the environmental and social costs of critical minerals globally?

Initial - Should there be controls on the export or import of critical minerals?

Secondary - What would be the benefit of limiting imports/exports?

Initial - What role could recycling and recovery have for our supply of critical minerals (i.e. less reliance on mining, is it practical)?

Secondary - What are some barriers/solutions to this potential circular economy?

Initial - As a consumer, what steps can I take to help ensure critical minerals are used responsibly?

Secondary - How will this affect the global/local supply chain?

Initial - Think of your current interests and path into post-secondary education or the workforce. What role will critical minerals play in your future career choices?

Secondary - Would you consider an active role in the critical minerals sector? Why?

Tertiary – What type of role do you see yourself playing in the sector?

RESOURCES

- The World Café model – description, principles and tips: theworldcafe.com/
- Key concepts for the World Café model theworldcafe.com/key-concepts-resources/
- PDF guide to running a World Café theworldcafe.com/wp-content/uploads/2015/07/Cafe-To-Go-Revised.pdf
- Extensive guides and resources for guiding discussion in classroom settings: interactivityfoundation.org/resources/education/
- Other examples of groups using the World Café model as part of a toolkit: growthstartshere.weebly.com/cafe-conversation.html
- Comprehensive guide on convening public conversations and discussions: rockefellerfoundation.org/wp-content/uploads/Gather-The-Art-and-Science-of-Effective-Conveing.pdf
- A blog post about running a World Café in a school environment: sustainingcommunity.wordpress.com/2013/09/21/school-world-cafe/
- A similar (and more complex) model of organization and facilitation is the Youth Climate Action Workshops run by the Wild Center: wildcenter.org/our-work/youth-climate-program/
- The conditions for a World Café – see the World Café Hosting Reference Guide: theworldcafe.com/wp-content/uploads/2015/07/Cafe-To-Go-Revised.pdf

Mining Matters is a charitable organization dedicated to educating young people to develop knowledge and awareness of Earth science, the minerals industry, and their roles in society. Since 1994, Mining Matters has reached an estimated 825,000 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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