2020 – 2021

Building Mineral Literacy through STEM Education

groundWORK




Metals and Minerals Send a Clear Message

The world has entered a new era of connectivity. With the onset of COVID-19, the year 2020 has seen the social fabric of our networks physically ripped apart but digitally stitched together. Online shopping replaced in-person experiences; working from home became safer than people-packed office towers; screen entertainment took over from live experiences; and video chats became essential for school, work, or social gatherings. Employees work productively from home, artists feature their work online, and movie-makers release product directly to home viewing. All of this connectivity demands strong networks, whether through cellular networks, wireless internet, or fibre optic cable. Those networks could not exist without metals and minerals.

Contents

Cellular Networks and Wireless Internet

Cellular networks and wireless internet use broadcast towers, masts, or poles to transmit radio frequencies to a wireless internet service provider, which in turn, sends the signal to a device, be it a cellphone, tablet, or modem. Broadcast towers might be constructed from an aluminum alloy, steel, and/or concrete. Structural steel comprises largely iron and carbon (see Iron: An Essential Metal, page 14) but might include manganese, phosphorus, sulfur, or silicon. Concrete comprises water, aggregate (rock, sand, or gravel), and Portland cement. Portland cement is typically made from materials such as limestone, sandstone, marl, shale, iron, clay, fly ash, and gypsum.

The signal brought to those towers, until recently, has mostly been through coaxial cable, constructed from copper or copper-coated steel or aluminum wire at the core. The latest generation of radio signal is 5G, an extremely high-frequency radio wave that provides massive but reliable network capacity for more users. The signal, while powerful, has a limited range, so many more and smaller signal distribution centres are needed. These depend on an extensive fibre optic network as well as such metals as silver, copper, gallium, and cesium, the latter two listed as critical minerals by the U.S. and by Canada in the Joint Action Plan on Critical Minerals Collaboration. Critical minerals are those whose availability is essential for high-technology, green, and defense applications, but vulnerable to politically or economically driven fluctuations in supply.

Fibre Optic Cable

Fibre optic cable is one of the most effective tools in data transmission today. Pulses of light sent through flexible glass or plastic tubes transmit data at extremely high speed. Glass fibres are made from the purest optical glass, most commonly produced from silicon dioxide (SiO_2), also known as quartz or silica, by chemical processes.

Quartz is one of the most common minerals found in the Earth's crust and occurs in all forms of rock: igneous, metamorphic, and sedimentary. Pure quartz presents as colourless, transparent, and hard glass-like crystals. Quartz with impurities presents a range of varieties and colours, e.g., purple (amethyst), pink (rose quartz), and yellow or orange (citrine). When quartz-bearing rocks get eroded, weather-resistant quartz grains get carried to deposits in soil, in rivers, and on beaches as sand. Deposits are primarily open-pit mined, but dredging and underground mining are also used.

From Silica Sand to Fibre Optics

Alloying silica sand with iron makes ferrosilicon, which then undergoes chlorination to produce silicon tetrachloride ($SiCl_4$), a colourless, volatile liquid that fumes in air. Burning $SiCl_4$ in pure oxygen inside a hollow substrate rod, usually a silica tube, results in layers of highly purified SiO_2 (called soot) deposited on the inside surface of the rod. The substrate rod and soot layers solidify to form a glass boule, or preform, which is then melted and drawn into a thin strand of glass. Some fibres can be up to 300 kilometres long.

Great Reception

Numerous metals and minerals go into the equipment that carries or sends out communication and data signals, but the devices designed to receive those signals contain a myriad of components as well. For example, the ubiquitous cellphone is filled with metals and minerals that enable high-speed performance and data, along with vivid, high-resolution screens. Here are the top 10 metals and minerals that power a cellphone:

- Aluminum: cases and components
- Cobalt: rechargeable battery
- Copper, Gold, Silver, Zinc: circuit board
- Lithium: battery
- Lead: solder
- Nickel: electrical connections, capacitors, and batteries
- Crude oils: hard plastic and fibreglass circuit boards

And the list goes on—laptops, tablets, servers, satellite dishes, wiring, and more. From complex circuitry to wiring to the screws that hold them together, the message is clear: metals and minerals make them happen.

Rocks + Kids = Opportunities

Mining Matters continues to provide specialized learning for students and teachers in underserved schools in the Greater Toronto Area and is expanding the program to schools across Canada. The *Rocks + Kids = Opportunities* program is connected to the curriculum and available at no cost to eligible schools. The program offers Earth science and mineral resource education workshops to students in grade 4 and provides each participating school with a set of teacher and student resources. For the 2020-2021 academic year the workshops will be delivered virtually. **Mining Matters** continues its formal partnership with the Toronto District School Board to offer this program to their Model and Priority Schools. The program is available throughout the academic year to all GTA school boards with eligible schools. In addition, a limited number of workshops are available to eligible Canadian schools on a first-come first-served basis. 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 in making this program possible.

WHERE challenge

Sponsored by Teck

The 2020-2021 edition of the WHERE Challenge launches this fall! The Challenge provides an opportunity for students ages 9 to 14 to discover the role that non-renewable resources play in their daily lives. Through the contest, students learn about where non-renewal resources are sourced and where they are used. Entries must be submitted online by March 5, 2021, at earthsciencescanada.com/where. The contest features cash prizes totalling $5,000. Please visit the WHERE Challenge website for a comprehensive list of 2020 winners and to see their winning entries.

Water Hazards Energy Resources Environment

Mines to Microbiomes! Exploring the Mining Cycle and Treatment of Mine Waters

Mining Matters and the University of Toronto, Lassonde Institute of Mining (Mine, Water and Environment Research Group) have partnered to expand outreach and deliver the "Mines to Microbiomes! Exploring the Mining Cycle and Treatment of Mine Waters" educational workshops to students in grades 7 and 8.

Lassonde Institute of Mining
UNIVERSITY OF TORONTO

Mines to Microbiomes! is a hands-on learning experience that explores connections between water sustainability and the mining industry. Workshops bring water research scientists directly into classrooms, where they engage students in learning about how the minerals industry uses and manages water resources.

Exposing students to current, real-world issues through this active learning experience enhances interest in science and the environment. Students learn how the minerals industry and environmental scientists collaborate to ensure protection of our water and ecosystems. In addition, students learn about industry careers, link chemistry with the microbiomes in mine waters, and utilize the chemical reaction (neutralization of acid) that is widely utilized in mine water treatment.

Field Trip Ideas (including virtual)

Earth science education that is delivered in the classroom can be augmented with field-based teaching. Teachers with any level of Earth science knowledge can get excited about taking their students outside. Resources are available to support your efforts.

Outdoor Rock Exhibits

Some Canadian universities have installed curated outdoor rock exhibits that are open to the public, making them excellent destinations for class field trips.

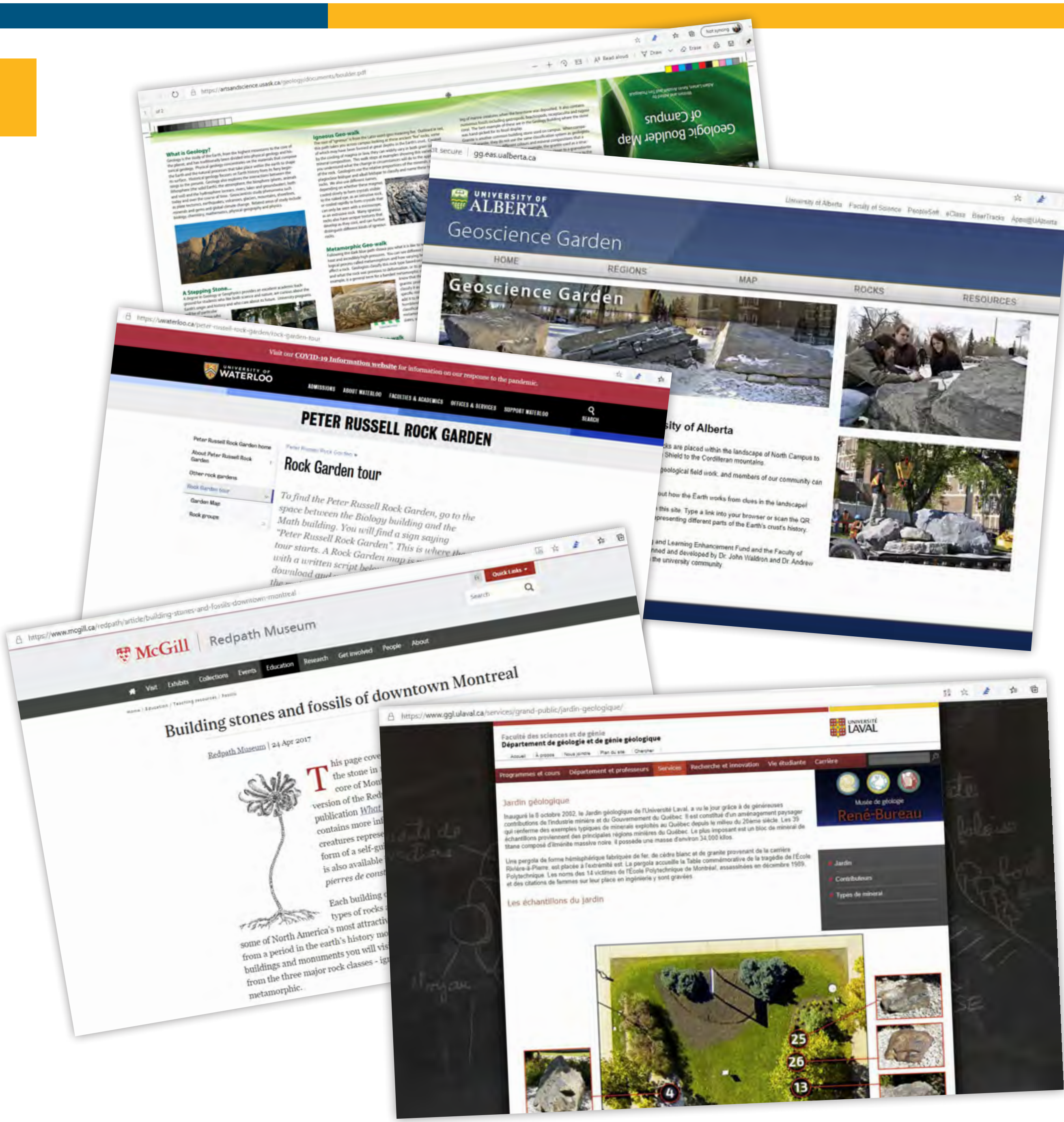
The Department of Geological Sciences at the University of Saskatchewan has created a "Geologic Boulder Map of Campus" brochure. The brochure provides an introduction to Geoscience, a snapshot of Geoscience education and career opportunities, and details about the origin of boulders and the building stones present on the Saskatoon campus. Included is a map showing the location of the boulders, along with information about their types and geologic history. Three Geo-walks—Igneous Rocks, Metamorphic Rocks, and Unique Boulders—are described for teachers and students interested in focusing on a specific topic or theme.

The Geoscience Garden at the University of Alberta is an outdoor classroom that features rocks from central and western Canada, from the Canadian Shield to the Cordilleran mountains, organized by region. The Garden includes a collection of 80 rocks that are marked by plaques containing links to the Garden's website. Resources to support a self-directed field trip, suitable for teachers and students, are available, including a digital and printable version of a site map and guide.

The Peter Russell Rock Garden, on the University of Waterloo Campus, offers a Rock Garden Tour featuring a curated collection of 76 rock specimens, a map of the installation, and a comprehensive document to accompany the collection. A 360° virtual tour of the Garden is also available.

The Geological Garden of Laval University includes 39 examples of typical Quebec ores representing the province's main mining regions. The installation also commemorates the tragedy of the École Polytechnique, displaying the names of the victims and quotes from women in Engineering.

The Redpath Museum, McGill University, has developed a walking tour of the Building stones and fossils of downtown Montreal. The tour looks at 14 buildings, each featuring different types of rocks and fossils from across North America and Scotland. This tour is a shorter version of the publication What Building Stones Tell, available in both French and English at the Redpath Museum.



Professional Learning Opportunities

Geological Society of America Online, October 26–30, 2020

This conference will feature geoscience education Technical Sessions and Short Courses of interest to K–12 Educators. community.geosociety.org/gsa2020/home

Geological Association of Canada Conference, May 17–19, 2021, Western University, London, Ontario

This conference will include a Teacher Professional Learning Workshop and Field Trip gac.ca/gac-mac-london-2021/

GEOLOGICAL ASSOCIATION OF CANADA
ASSOCIATION GÉOLOGIQUE DU CANADA

Mineral Resources and Mining Education Tours

Since 2010, **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 educators. The tours are delivered annually over the summer, or by request, during the academic year. The program includes three tours:

Mineral Resources and Mining Education Foundations

Develop 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. Tour North Bay mineral exploration and mining supply and service providers.

Mine Life Cycle

Learn about 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. Visit an underground mine and reclamation sites, engage with industry professionals, and participate in hands-on instructional development workshops focusing on Earth science and mineral resources.

Life in a Mining Camp

Tour underground and surface operations, including the mine and mill, and stay overnight at the North American Palladium's Lac des Iles Mine, located near Thunder Bay.

The 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 expenses incurred travelling to and from tour locations. At this time, it is unclear as to whether or not the tours will proceed in 2021. Dates are pending. Visit the Canadian Ecology Centre website for updates, additional details, and to complete your registration. canadianecology.ca/professional-development/miningtour

International Year of Plant Health: Protecting Plants, Protecting Life

In December 2018, the United Nations General Assembly adopted a Resolution declaring 2020 as the International Year of Plant Health (IYPH). This was meant to raise global awareness on how protecting plant health can help end hunger, reduce poverty, protect the environment, and boost economic development. Plant health takes the entire planet into consideration, from Amazonian rainforests, boreal forests, and desert scrub, to the world's farmed land and urban green spaces. The world's green mantle allows us to breathe, to eat, and to play, as it does also for the world's diverse fauna. fao.org/plant-health-2020/home/en/

The mining and metals industry plays an important role in plant health in the world of agriculture. All plants require certain basic nutrients in the soil if they are to thrive: nitrogen (N), phosphate (P), and potassium (K). As crops deplete nutrients, farmers turn to fertilizer to replenish them, using nutrients that come from mining and manufacturing operations around the world. Nitrogen is fixed from the air we breathe; potash, a source of potassium fertilizer, is mined from evaporated seabeds; and phosphate is mined from fossilized sea creatures.

Potash, used since antiquity, was at one time produced by extracting lye from wood ashes in iron pots. Today, potash is produced by mining, the most common source being naturally occurring beds of potassium ore that developed as seawater evaporated and potassium salts crystallized. Canada is the world's largest producer and exporter of potash.

Phosphate is another key ingredient in modern agriculture. A century ago, phosphate was derived from bones, as well as guano excavated from Pacific islands where birds had been defecating phosphate for millions of years. With those sources exhausted, increasing global food production turned to mined phosphate in the mid-19th century. Today, principal producers are China, the U.S., Morocco and the Western Sahara, and Russia.

Not only does the mining and metals industry provide the nutrients for food growing, but also the raw materials from which farming implements are made. From simple garden trowels and forks to combines, tractors, threshing machines, and more, such metals as steel, copper, zinc, nickel, and aluminum make them happen. At the end of their useful life, the metal components of these tools can be recycled.

One more aspect of the industry's relationship with plant health is reclamation. In Canada, mining companies must plan for closure before entering into production. The Mining Association of Canada (MAC) states that "Reclamation is an essential aspect of the mining process and integral to MAC's Towards Sustainable Mining program, which focuses on the importance of sustainable practices, particularly with a focus on environmental stewardship, in the mining sector. Reclaiming the land we borrow is a responsibility we take as seriously as creating jobs and building vibrant communities." For examples of reclamation projects, see mining.ca/resources/canadian-mining-stories/reclamation/

2020 has proved to be more challenging than anyone expected with the COVID-19 pandemic sweeping the world. Staying socially distanced but engaged has brought people outside more and more to enjoy the world's green spaces and to grow their own food. The International Year of Plant Health brings those green spaces and gardens into the spotlight. It's up to us to take care of them.

The Saskatchewan Mining Association has developed a series of potash lesson plans and an accompanying potash rock kit. Visit the Association's website to access the lesson plans and for more information about the kits.

saskmining.ca/Mines-in-Saskatchewan/Education-Outreach

Evergreen Brick Works: The Mud Beneath Our Feet

In the heart of a city where the eye is drawn up by towering buildings, Evergreen Brick Works, an environmental jewel in Toronto's Don Valley, gives viewers a fantastic place to think about what is under their feet. Not only does Canada's first large-scale community environmental centre offer the public a chance to explore leading-edge green technologies and hands-on environmental programming, but it also offers exploration of the area's geological history.

When William Taylor was sinking a post hole on his property in 1882, he discovered clay exactly right for brick making. With all the necessary components to make bricks at hand—clay, shale, sand, and water—Don Valley Pressed Brick Works was born. The site became a quarry, and as the earth was stripped away for nearly 100 years to supply brick-making materials, so were fascinating layers of geological history exposed. Geologists could explore a fossil-rich interglacial period that occurred between successive ice ages—now known as the Don Formation (120,000 years ago)—which made the Don Valley world-famous. A self-guided geology tour is available at the site showing a region shaped by recurring glaciers, giant lakes, and ancient, fast-flowing rivers. As well, visitors can learn about brick making at this site and how it contributed to the building of Toronto. Significant buildings include Casa Loma, Osgoode Hall, Massey Hall, and the Ontario Legislature.

Evergreen Brick Works is situated in the Don Valley Brick Works Park, an outstanding reclamation project undertaken in the 1990s by the Toronto and Region Conservation Authority, the City of Toronto, and the Province of Ontario. The quarry was transformed into a natural environment and cultural heritage park for the citizens of the greater Toronto region. The project earned the Bronze Plaque Reclamation Award in 2000, presented by the Ontario Stone, Sand and Gravel Association.

"The story of this place is the story of change," says a short historical video about Evergreen Brick Works. It is a story worth exploring. evergreen.ca/evergreen-brick-works/

Mining Matters Resources

GEMS

To support the recent transition to online learning at home, **Mining Matters** has created GEMS. These "Do it Yourself" Geology, Engineering, Mining, and Sustainability themed educational activities are directed toward children and families. The activities are well suited for learning at home, with easy-to-understand instructions and easily sourced materials. They also make an excellent addition to STEM learning activities for educators who are teaching remotely. miningmatters.ca/resources/education/gems---diy-activities

Deeper and Deeper Video Tutorials

Are you a grade 4 teacher who has participated in an in-person Deeper and Deeper instructional development workshop? Are you interested in refreshing your mineral and rock identification skills? Visit the Mining Matters website to review a series of training videos that present select learning activities from the resource.

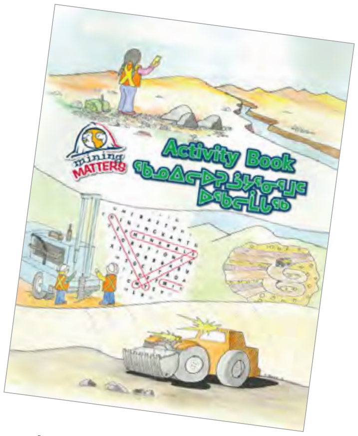
Classroom Resource Kits

Mining Matters resources for classrooms are developed in collaboration with educators and technical 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: *Core Concepts*
- Senior/Secondary: *Discovering Diamonds*

Resource kits are available in both official languages through a prerequisite in-service workshop, available virtually. Workshops can be scheduled for groups of 10 and 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 *Core Concepts* are a series of classroom-ready activities that reflect key foundational ideas in Earth science, including the structure of the Earth, rocks and minerals, soil and erosion, the mining cycle, and social and environmental responsibilities.



The **Mining Matters** *Activity Book* created for youth ages 9 to 13 years, 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.

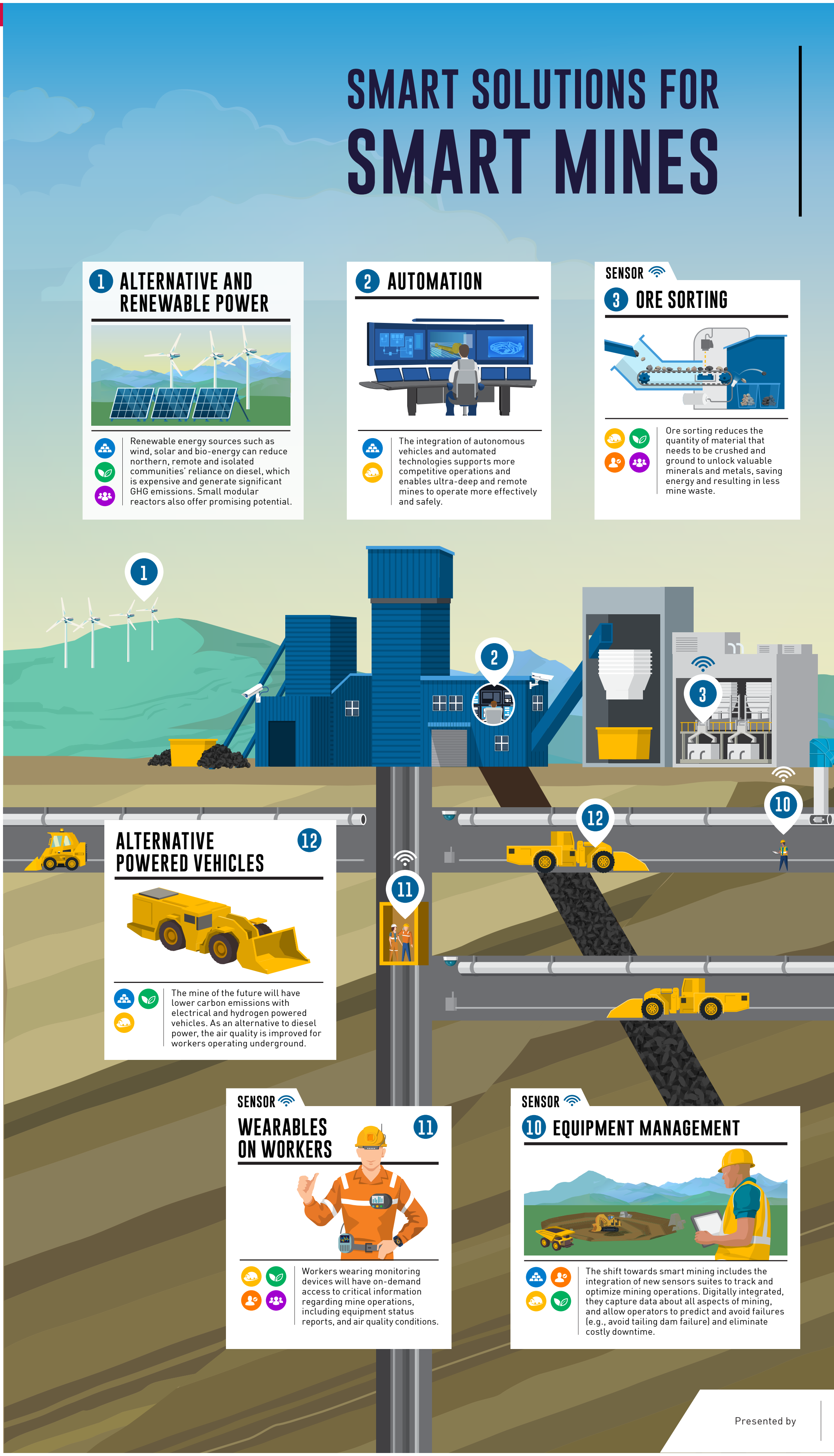
Mining Matters *What is a Mine?* colouring book features Mighty Miner, who guides students through an adventure that helps them learn about mining.

Posters

The **Mining Matters** *Mining Makes It Happen* poster series helps students understand the role that minerals, metals, and elements make in manufacturing, medicine, sports, music, and energy. The posters are available in English, French, Ojibway, Cree, and Oji-Cree.

Modern Mines are Smart Mines

Infographics are exceptional teaching tools that present complex topics in interesting and stimulating ways. The "Smart Solutions for Smart Mines" infographic tells the important story of the roles that innovation and technology play in the modern mining sector. Image courtesy of Natural Resources Canada and Visual Capitalist

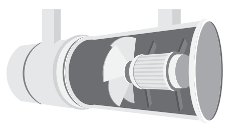


Smart mines produce the minerals and metals needed for our evolving economy. With highly engineered technologies and the application of artificial intelligence, Internet of Things and Big Data, the modern mine is digitally connected and operations are optimized in all aspects, including productivity, safety, accountability, environmental performance and local community support.

PRODUCTIVITY · SAFETY · ACCOUNTABILITY · ENVIRONMENT · COMMUNITY

SENSOR

4 VENTILATION ON DEMAND



This airflow system saves energy by safely directing fresh air only when and where it is needed. This reduces ventilation costs and increases the potential for expanding a mine without the need for new infrastructure.

SENSOR

5 HIGH ACCURACY GPS

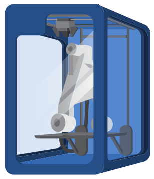
High accuracy GPS technology brings precision to mining. From GPS assisted precision drilling to autonomous haul trucks for worker safety, GPS enables safe and efficient operations.

6 DRONE TECHNOLOGY

Drones provide real-time aerial footage of mining sites for maintenance, monitoring (e.g., the environment) and mapping, which improves safety, and increases efficiency and cost savings.

7 3D PRINTING AND MODULAR EQUIPEMENT

The integration of 3D printing technologies into mining operations could increase efficiency and flexibility of operations, including the production of on-demand parts for replacement and repairs.

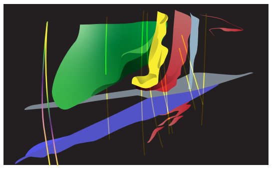


SENSOR

9 DATA OPTIMIZATION & MACHINE LEARNING

Optimizing data collected from equipment and monitoring devices enables engineers to create simulations to precisely plan and schedule operations, and complete highly complex tasks.

8 3D IMAGING



3D imaging of ore deposits, from their deep roots to the actual deposit, helps understand the geology of deposits for more efficient mining that reduces waste and minimizes disturbances.

THE CANADIAN MINERALS AND METALS PLAN · LE PLAN CANADIEN POUR LES MINÉRAUX ET LES MÉTAUX

Funded by Natural Resources Canada · Financé par Ressources naturelles Canada · Canada

Download the final Plan at MinesCanada.ca

VISUAL CAPITALIST · /visualcapitalist · @visualcap · /visualcapitalist · visualcapitalist.com

Other Resources

Apps

The Let's Rock Ontario App for Android devices is a curated guide to more than 500 sites of scientific and natural interest across Ontario. It is a useful resource for teachers who want to take their students outside to explore rocks, fossils, and other natural attractions in their regions. The App is a companion to the Let's Rock Ontario website.

Puzzles

The Occurrence, a Canadian company, creates science-themed puzzles, novelties, apparel, and prints. Many of their puzzles feature geological themes and explore geological principles, including the Minerals of Canada, Mohs Hardness Scale, Trilobites, and Ammonites. The puzzles would make an enriching addition to classroom resources and activities.

Websites

Resources for Rethinking provides access to more than 1,000 classroom resources that have been teacher-reviewed and matched to relevant curriculum outcomes for each province and territory across Canada. It connects teachers to lesson plans, books, videos, and other materials that address the environmental, social, and economic dimensions of important issues and events unfolding in our world today. Most of the materials can be downloaded directly from the website.

The Saskatchewan Mining Association offers educational resources for teachers, including a curriculum-correlated diverse collection of lessons plans in a searchable database, career profiles, videos, and the GeoVenture program for teachers. GeoVenture is an Earth science and mineral industry experiential, professional-learning program that includes a workshop and field trips to underground and surface potash and uranium mines and milling operations, coal mines, and the Potash Interpretative Centre.

The Saskatchewan Geological Society website hosts educational resources for educators. Geoscape Saskatchewan and Lesson Plans explores many aspects of the geology of the province, including stratigraphy, mineral resources, groundwater, fossils, glaciation, and geological hazards. The website also hosts a Field Guide for a Building Stone Tour of Regina and the recently launched GeoExplore Saskatchewan, a digital, interactive version of the Geological Highway Map of Saskatchewan, both suitable references for class trips. The website also hosts a detailed repository of provincial geological information, organized by themes such as the Canadian Shield, sedimentary basins, fossils, the Ice Age, landforms, and water.

Created by Natural Resources Canada, Watching over our planet from space: A kit for kids provides an overview of the theory and practice of "Remote Sensing." Intended for senior elementary and secondary students, the kit provides an introduction to remote sensing, 12 hands-on learning activities, and a supplemental reading section, all rich with satellite imagery, photography, and illustration. Students will learn about the nature of satellite imagery and how it can be applied to sustainability, including monitoring mining activities. This kit is particularly useful for Geography teachers.

Books

Old Rock (is NOT Boring)

by Deb Pilutti (Author/Illustrator) (2020)

This book, written for children ages 4 to 8, tells geological stories through the character "Old Rock" and his friends in the forest. The story presents many geological themes including geologic time, volcanism, glacial processes, mass wasting, and paleobiology. This is a wonderful story to read aloud and includes delightful illustrations.

Water Is Water: A Book About the Water Cycle

by Miranda Paul (Author), Jason Chin (Illustrator) (2015)

Written for students in grades 1 and 2, this wonderfully illustrated book brings the water cycle to life through the story of a group of children, moving from one "phase" of water to another. The back matter includes the "More About Water" section where teachers will find detailed information about water and the water cycle.

Rock Collecting for Kids: An Introduction to Geology

by Dan Lynch (2018)

This book provides an excellent introduction to the science of geology, including foundational knowledge about important concepts such as where rocks originate and how the Earth's surface changes over time. It also includes an identification guide with full-colour photographs, ID tips for 75 common rocks and minerals, and a "how to" section that outlines recommended practices for collecting minerals and rocks in the field.

Fossils for Kids: An Introduction to Paleontology

by Dan Lynch (2020)

This book provides an excellent introduction to fossils and the science of paleontology. It includes information about how fossils form and a guide for identifying common and collectible invertebrate fossils.

Canada Close Up: Canadian Rocks and Minerals Paperback

by Joanne Richter (2007)

Brought to you by Scholastic Canada, this book for students ages 7 to 9, presents foundational Earth science information important for the learners aspiring to collect minerals and rocks and includes interesting facts about Canadian Rocks and Minerals.

Go! Field Guide: Rocks and Minerals

Scholastic Canada (2019)

The *Go! Field Guide: Rocks and Minerals* is aimed towards students ages 8 to 12. The pocket-sized book informs readers about rocks and minerals they might find in North America, helping them to identify them and test their physical properties.

Government Publications

GeoTours Northern Ontario, created in collaboration with specialists from the Geological Survey of Canada, Ontario Geological Survey, Dynamic Earth Science Centre, and Laurentian University, are excellent references for field-based teaching. GeoTours explore 17 geological and mining sites of interest across Northern Ontario, including Thunder Bay, Sudbury, Cobalt, and Timmins. Downloadable PDFs provide detailed information, including maps, figures, and photographs.

Videos

The Manitoba Minerals YouTube Channel features Manitoba Virtual GeoTours, a series of 43 geoscience videos that highlight notable features across the province. Suitable for secondary students, the GeoTours provide educators with a novel way to teach about local and regional geoscience and geoscientists.

The Natural Resources Canada Byte-Sized Science YouTube Channel features a series of short Earth science and mineral-resource-themed videos that feature NRCan scientists and the research they conduct across Canada. The videos are suitable for introducing a variety of resource and sustainability topics and for exploring careers.

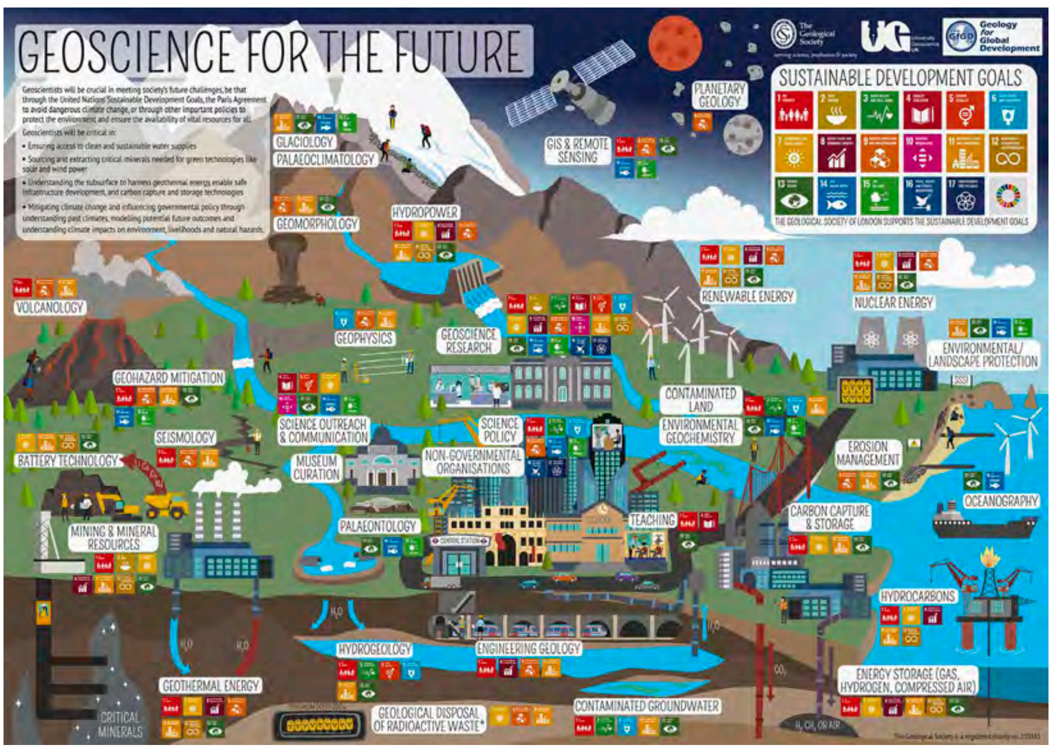
Podcasts

Earth News Interviews was launched in June 2020, a Science Communication Podcast series put together by the Earth Sciences Department at the University of Toronto. Each podcast features an interview with an Earth scientist, discussing the most recent developments in their field and how these discoveries impact all of us. This series is best suited to a secondary school audience.

Published by Natural Resources Canada, Simply Science is an online magazine that features the Earth sciences, mining, energy, and forestry research through articles, podcasts, and videos.

Posters

The Geological Society, the United Kingdom's national society for geoscience, hosts some excellent teaching resources on its website, including the Geoscience for the Future poster, which illustrates the critical role that geoscience plays in the achievement of the United Nations Sustainable Development Goals. Other posters illustrate A Year of Carbon Images, the Carbon Cycle, Minerals in a Smartphone, and Plate Tectonics.



Iron: An Essential Worker

2020 has been the year to recognize essential workers, the people at the foundation of our society, without whom we could not function. Their dedication has been the strength of our economy and the key to our ongoing health; we hope that going forward, their service will always be recognized. In the metals and mineral world, another kind of essential worker comes to light: Iron (Fe), Atomic Number 26, the raw material at the heart of steel, the world's most commonly used material.

Iron, defined as a silver-white, malleable, and ductile magnetic heavy metallic element that readily rusts in moist air, occurs in pure form in meteorites and combined in most igneous rocks. It is the most abundant metal on Earth, but the technology to melt it at the necessary temperature of 1,538 °C (2,800 °F) did not exist until about 1200 BCE. Before that, bronze, an alloy of copper and tin, both with much lower melting temperatures, was the hardest and most durable metal available. With the development of technology to smelt iron—combining carbon with iron ore in a high heat furnace to separate the metal from the ore—the Iron Age was born. Civilizations were able to produce tools and weaponry by ironworking, particularly from carbon steel.

The only mined source of iron is iron ore, primarily the iron oxides hematite (Fe_2O_3) and magnetite (Fe_3O_4). Today, iron ore is mined in about 50 countries. Canada is the world's eighth largest producer. Most of Canada's iron ore comes from the Labrador Trough region, along the border between Quebec and Newfoundland and Labrador, and from Nunavut.

Per cent of mined iron production that goes into:

98 % Primarily to manufacture steel

- building and infrastructures 52 %
- mechanical equipment 16 %
- automotive products 12 %
- metal products 10 %
- other transport 5 %
- electrical equipment 3 %
- domestic appliances 2 %

2 %

- powdered iron—for certain types of steels, magnets, auto parts, and catalysts
- radioactive iron (iron 59)—for medicine and as a tracer element in biochemical and metallurgical research
- iron blue—in paints, printing ink, plastics, cosmetics (e.g., eye shadow), artist's colours, laundry blue, paper dyeing, fertilizer, baked enamel finishes on vehicles and appliances, and industrial finishes
- black iron oxide—as a pigment in polishing compounds, metallurgy, medicine, magnetic inks, and ferrites for the electronics industry

World Steel Association

While iron is the most abundant metal on Earth, and steel accounts for the bulk of its use, it should be noted that steel is also one of the most recycled materials in the world. According to the Steel Recycling Institute, approximately 66 percent of new steel is produced from scrap steel. Each recycled tonne of scrap steel saves more than 1,400 kg of iron ore, 740 kg of coking coal, and 120 kg of limestone. The increasing use of electric arc furnaces will allow steel to be made entirely from scrap metal, a supply which is projected to reach 755 million tonnes by 2024.

So, when you are driving a car or riding a bike, taking an elevator or running a dishwasher, working on a farm, in a hospital, office building, or manufacturing facility, think about how iron, an essential material in our civilization, makes it happen.

Elementary Activity: Outdoor Rock and Mineral Scavenger Hunt

BACKGROUNDER

Rocks and minerals, and the elements they contain, play an important role in our daily lives. They are used in the manufacture of familiar things all around us. We see them in buildings made from bricks and concrete; roads made from crushed stone, sand, gravel, and asphalt; and the structural elements in between, such as windows, roofs, fences, sidewalks, benches, railings, street lights, and signs. We see automobiles made from steel; sports equipment crafted with aluminum, titanium, and graphite; green technologies like batteries, wind turbines, and solar panels that use cobalt, germanium, and Rare Earth Elements; and electronics like computers and smart phones that depend on copper, gold, and silver.

PURPOSE

- To provide learners with an enriching experiential learning opportunity that connects the classroom to the wider world
- To provide learners with a forum to explore the ways in which rocks and minerals are used in the built environment
- To help learners develop skills of observing and recording

MATERIALS

- Mineral and Rock Checklist
- Clip board, notepad, and a pencil or pen to record findings

Safety

An adult should supervise children when they are outside doing their scavenger hunt. Children should stay in a group and be careful when touching surfaces as they could be rough or sharp and pose a hazard.

INSTRUCTIONS

This activity will help children develop an understanding of how rock and mineral resources are used to create the human-made environment that provides the setting for human activity in their neighbourhood, backyard, or school yard. Using a checklist, students will complete a survey noting the kinds of mined materials that they discover on their scavenger hunt.

Each child should attach a copy of the Mineral and Rock Checklist to a clipboard and pack a pencil or pen. Discuss with the children some of the ways rocks and minerals are used in daily life. Define the term "built environment," and explain why understanding it is important to the task. Explain that they will be participating in a scavenger hunt of their neighbourhood, backyard, or school yard to look for rocks and minerals and the ways in which they are being used. Ask them to use the Checklist to guide them through the completion of the activity. Tell them that they might not locate all of the items included in the checklist, depending on where they do their scavenger hunt. Take the children outside and assign them 15 minutes to complete as much of the checklist as possible.

Conclude the activity by providing assistance to the children in filling out their checklists and addressing any questions that they may have about any of the rocks, minerals, or elements. Ask if anyone was surprised by any of their observations.

MINERAL AND ROCK CHECKLIST

	Object	Rock, Mineral, or Metal Used
Play Equipment		
☐	Slides	Iron, Aluminum
☐	Metal Swings	Iron, Aluminum
☐	Ladders	Iron, Aluminum
☐	Play Structures	Iron, Aluminum, Limestone, Gypsum, Clay
☐	Benches	Limestone, Gypsum, Iron Oxide, Clay
☐	Basketball Hoops	Iron, Aluminum
☐	Flag Poles	Iron, Aluminum
Building		
☐	Concrete	Limestone, Gypsum, Iron Oxide, Clay, Dolostone, Sand, Gravel
☐	Bricks	Clay, Shale
☐	Paint	Titanium Dioxide, Wollastonite, Sand
☐	Screws and Hinges	Copper, Iron, Zinc
☐	Steel Roofing	Iron, Limestone
☐	Metal Flashing	Iron, Aluminum
☐	Eavestroughs	Iron, Aluminum
☐	Roof Shingles	Sand, Gravel, Crushed Stone, Petroleum

	Object	Rock, Mineral, or Metal Used
Parking Lot		
☐	Asphalt	Crude Petroleum, Sand, Gravel, Crushed Stone
☐	Street Lamps	Limestone, Gypsum, Iron, Aluminum, Copper, Quartz
☐	Cars	Iron, Copper, Aluminum, Lead, Nickel, Sand, Silicon, Sulfur, Zinc
☐	Bicycle Racks	Iron, Aluminum
☐	Bicycles	Iron, Aluminum
☐	Garbage Cans	Iron, Aluminum
☐	Water Drain Grates	Iron, Aluminum
☐	Electrical Wires	Iron, Aluminum, Copper
☐	Sign/Traffic Signs	Iron, Aluminum
Yard		
☐	Artificial Grass	Barite, Petroleum products
☐	Metal Fencing	Iron, Aluminum
☐	Sandboxes	Sand
☐	Railings, Posts	Iron, Aluminum
☐	Landscaping Rocks	Natural Rock, Limestone
☐	Gravel	Natural Gravel, Crushed Stone
☐	Sand	Natural Sand

Secondary Activity: Conveyor Belt Challenge

BACKGROUNDER

Mining involves a host of engineered systems to efficiently move materials, including ore and waste rock. Ores and minerals are usually processed and partially refined close to a mine, then shipped elsewhere for further refinement. Moving those materials has been a challenge since people began mining.

To help launch this activity with your students, we created a Conveyor Belt Challenge video that can be shown to the class to provide an overview and inspiration. youtube.com/watch?v=OZMgAh94Jag


Underground coal mine conveyor system, site unknown. 1936. Wikimedia

PURPOSE

- To introduce students to the use of automated conveyor and transportation systems in mines
- To encourage students to explore simple engineering and mechanical ideas
- To introduce students to the application of mechanical engineering in mine operations
- To help develop students' design and problem-solving skills
- To illustrate how simple design challenges build both "soft skills," such as teamwork and creativity, and technical understanding

MATERIALS

Suggested Building Materials

- Bamboo skewers
- Utility baking or roasting pan (large)
- String/butcher twine
- Toothpicks
- Mini balls (plastic golf balls or hockey balls)
- Small cups
- Paper towel/toilet paper tubes
- Roll Kraft paper
- Rubber bands pack
- Binder clips
- Wood clothespins
- Duct tape
- Paint rollers
- Packing tape
- Double-sided tape
- Wooden dowels
- Shelf paper/liner
- Cardboard boxes
- Bicycle tire inner tubes

Suggested Equipment

- Stapler
- Mini glue gun
- Small wire cutters/pliers
- Utility knife
- Measuring tape
- Metal ruler/straight edge
- Cutting mat or cutting surface (scrap cardboard works well)
- Saw
- Scissors

Suggested "Ore"

- Toy blocks
- Gravel
- Individually wrapped candies
- Nuts and bolts

Space Requirements

- Ample workspace for construction and testing, possibly for a long period of time
- Cutting area for the use of the handsaw/utility knives (adult supervision required)
- Centralized "supply depot" for materials
- Electrical outlets for a glue gun

INSTRUCTIONS

Introduction and Context

Conveyor belts and systems are used frequently to move materials, objects, and people over distance. In this activity, students will work in teams of four to design simple conveyor belt systems to move "ore."

For this engineering and construction challenge, students use tools, problem-solving skills, cooperative and communication skills, and design thinking. They will need to understand the project requirements, devise strategies, create preliminary designs, and experiment with their prototypes. They will make mistakes and should understand that making mistakes is part of the process. Teachers can assist by allowing students to recognize their mistakes and guiding them in developing their own solutions.

There are a few crucial concepts students need to understand:

- Conveyor belts move because they are being pushed (or pulled) by a powered roller
- The belt follows a loop; driven by one roller, it loops past another that acts like a pulley
- The belt and rollers need a structure to support them, keeping the belt tight and allowing the rollers to turn freely

Design and Ideation

Lay out all the materials in a central place to allow students to inspect and handle them. Advise students to think about their challenge in a three-dimensional way. Ask them to consider the following:

- How do they want to drive the belt? (there are three ways: by hand, using a cordless drill to rotate an axle, or using a small motor/gearbox combination–or all three, depending upon student skill levels)
- How far do they want to go? (they can build conveyor belts that feed each other–this could introduce a cooperative challenge for the entire class)
- What materials do they need?

Option: Challenge advanced students to move the "ore" uphill or over a larger distance.

Students then develop a system design and title it "Design Proposal." The proposal should include a drawing, a list of potential materials, and their intended construction method. Only when they present a complete Design Proposal should students be allowed to start building. Ask them to identify at what point they will test their concepts.

Build a Prototype

Once their Design Proposals are approved, students can start building their prototypes. This will take the bulk of the class time and require plenty of space.

Encourage students to test their ideas at different stages, e.g., test that the rollers can turn before adding the belt or that the belt/roller combination moves by hand before using power. Suggest that they design a simple version, such as a small conveyor belt in an aluminum roasting pan, before applying their ideas to a larger scale project.

Key elements needed in building prototypes that you can watch for (and guide students to):

- A rigid support structure: cardboard boxes or roasting pans work well
- Rollers that turn freely, attached to axles that are supported by the structure: dowels and bamboo skewers make good axles, but need to be attached to the rollers (glue works)
- Axles positioned in the middle of the roller (alternative types of rollers, such as pool noodles or paint rollers, might need some sort of end piece or "plug")
- Support rollers (or balls) for long belts to prevent sag but still allow movement
- Tightly fitted belts; rollers pull the belt by friction, so the tighter the contact, the better
- Testing with disposable materials, e.g., paper or shelf liner (easier to cut, more forgiving for mismeasurements), to make a belt before using material like bicycle inner tubes
- Careful cutting of paper tubes with a mitre saw or utility knife
- Careful cutting of bicycle inner tubes (these make great belts, but need careful cutting down the middle, making them easier to staple or glue)
- Building a hand-driven prototype first, then use a cordless drill (fit the nub to the dowel/axle and gently pull the trigger to start the belt moving)
- Careful fitting of the motor/gearbox between the axles and gears (a challenging task)

Presentation

Allow about 15 to 20 minutes for the finale; students might make last-minute adjustments. Be sure to approach this as a celebration; even if some of the belts don't work as expected, highlight positive elements. Emphasise that all designs fail at certain stages and that failure is part of the process.

During the presentation, connect it back to a mining context; highlight the challenges of moving ore over large distances or doing it 24/7 in difficult environments. Student understanding of the engineering and problem solving involved is an important outcome of the activity.

Ask students to reflect on their learning with questions such as:

- What made you think of...?
- What happened when...?
- What surprised you?
- What did you do when something didn't work the way you expected?
- What else would you like to have tried?

These types of questions help students frame their learning and better articulate how the design process is done, particularly from an engineering perspective, where they incorporate their observations and learning from the testing.

Mining Matters is a charitable organization dedicated to educating young people to develop knowledge and awareness of Earth sciences, the minerals industry, and their roles in society. Since 1994, **Mining Matters** has reached an estimated 780,000 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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