2019 – 2020

groundWORK

Building Mineral Literacy
through STEM Education

Sustainable Development and Geoscience

In 2015, the United Nation's General Assembly adopted Agenda 2030 for Sustainable Development, which incorporates 17 Sustainable Development Goals (SDGs), or calls for action by all countries in a global partnership. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Interconnected and designed to include all, they address global challenges, including quality education, industry innovation and infrastructure, responsible consumption and production, environment and climate action, poverty eradication, good health and well-being, and clean water and sanitation. To learn about the SDGs and track progress made in attaining them, go to sustainabledevelopment.un.org. Consider engaging your students with the World's Largest Lesson, which introduces the SDGs to children and young people to unite them in action. worldslargestlesson.globalgoals.org

SDG 9, titled Industry, Innovation, and Infrastructure, aims to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. Canada's minerals industry is on board. In 2017, the second International Mines Ministers Summit, held in Toronto, Canada, brought together 25 government leaders responsible for mining in their countries with leaders of industry, civil society, non-governmental organizations, and Indigenous communities. Participants agreed that innovation is imperative for the mining sector, not only to ensure that mines of the future are economically viable and environmentally sustainable, but also to ensure the sector's potential contribution toward achievement of the United Nations SDGs.

Understanding geoscience is critical to the achievement of the SDGs. For example, it can help to ensure the development of Sustainable Cities and Communities. Geoscience can serve to enhance the built environment through urban infrastructure planning, and knowledge of natural hazards like earthquakes, volcanic eruptions, tsunamis, landslides, floods, and subsidence can lead to safe, resilient, and sustainable communities. Regarding Climate Action, it can suggest adaptations to climate change, and provide solutions to flooding, drought, and pollution. To attain Clean Water and Sanitation, geoscience can aid in the development of and access to groundwater resources, waste management, and landfills. Achieving Affordable and Clean Energy would be informed by geoscience, with demand for batteries, solar panels, and wind turbines driving demand for many minerals and metals. Geoscientists can also serve to achieve Gender Equality through educational and professional practice. The engagement of the geoscience community is necessary to achieve all the UN SDGs.

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Celebrating 25 Years

In 2019, **Mining Matters** celebrated 25 years of supporting teachers with classroom resources and training in mineral resources education. In 1994, recognizing the lack of school curriculum or age appropriate resources for Earth science education, a small group of dedicated people committed to broadening students' understanding of Earth science and the vital role rocks, minerals, and metals play in everyday life, and to increasing awareness of the many career opportunities in the minerals industry.

Having started off with one teacher-designed, activity-based resource about minerals, metals, and rocks for Ontario grades 6 and 7, we have since developed multiple teaching resources, from curriculum-based units on rocks and minerals to original publications and posters in English, French, and some in Ojibway, Oji-Cree, Cree, Inuktitut, and Inuinnaqtun, for use across the country. In 2002, we began offering Indigenous Communities Education and Outreach Programs, in which we delivered our first program specifically designed for Indigenous youth. We now send instructors annually to numerous Indigenous communities to conduct tailored programs related to Earth science and the mining and minerals sectors, developed with sensitivity to the importance Indigenous communities play in resources stewardship, management, and development. We also host the national WHERE Challenge, which asks students to creatively answer the questions "What on Earth is in your stuff?" and "Where on Earth does it come from?"

We showcase the mining world to teachers, students, and the public at events such as the PDAC International Convention, teacher conferences, Mining Week celebrations, and gem and mineral shows. We are proud to help educators excite their students about Earth science and the world of mining. **Mining Matters** has reached an estimated 750,000 teachers and students with our unique resources. We look forward to reaching hundreds of thousands more in the future!

The Canadian Minerals and Metals Plan

THE CANADIAN MINERALS AND METALS PLAN

Released in March 2019, the Canadian Minerals and Metals Plan is a document that outlines a vision, principles, and strategic direction that federal, provincial, and territorial governments; industry; and stakeholders can pursue to support the competitiveness and long-term success of the mining sector.

The goals of the Plan are to foster a minerals and metals industry that is competitive, sustainable, and responsible. The Plan involves six strategic directions, including economic development and competitiveness; participation of Indigenous Peoples; the environment; science, technology, and innovation; communities; and global leadership.

Broadly, the Plan will serve to increase awareness of the importance of the minerals and metals sector to the economy and society, drive innovation in response to ongoing and emerging challenges, and help to position Canada for the opportunities afforded by an evolving economy. minescanada.ca/en

This is Mining

To celebrate the 100th anniversary of the Ontario Mining Association, the OMA has created #THISISMINING, a campaign that takes a fresh look at the role of mining in our lives and in the province of Ontario.

Explore and discover modern mining, including its scientific and engineering advancements, its legacy, and the career paths that it provides. For more information on the campaign, visit the Ontario Mining Association website and follow the campaign on social media.

oma.on.ca/en/this-is-mining.asp
#THISISMINING
@This_Is_Mining
youtube.com/watch?v=UNsI8Cf6CBw&feature=youtu.be

WHERE challenge

Sponsored by Teck

Water Hazards Energy Resources Environment

Are you in search of an interesting and innovative way to help students learn about geoscience and natural resources? If so, encourage them to take the WHERE Challenge!

The Challenge is a national contest, endorsed by the Canadian Earth Sciences Community, open to students aged 9 to 14. Students can use the contest to demonstrate their knowledge of Earth's non-renewable resources by completing fun research projects. They can complete their projects as individuals or in a team and can produce them in English or French. The Challenge makes an excellent culminating activity.

The WHERE Challenge encourages students to discover the importance of non-renewable resources by relating them to objects they use in their daily lives, including gold in electronics, iron and nickel in stainless steel, copper in plumbing and wiring, and limestone in concrete.

Entries can be submitted online until March 5, 2020 at earthsciencescanada.com/where. The contest features cash prizes totaling $10,000. Please visit the WHERE Challenge website for a comprehensive list of 2019 winners and to see their winning entries.

Contact WHEREChallenge@miningmatters.ca for more information.

Save the Date

PDAC Convention

2020 marks the 87th year of the Prospectors & Developers Annual Convention (PDAC), the world's leading convention for people, companies, and organizations in, or connected with, mineral exploration.

March 1–4
Toronto Convention Centre

PDAC 2020

Rocks + Kids = Opportunities

Mining Matters continues to provide specialized learning to students and teachers in underserved schools in the Greater Toronto Area. 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. Workshops can be customized, providing teachers with the opportunity to select from a series of 14 hands-on learning activities. **Mining Matters** continues its formal partnership with the Toronto District School Board to offer this program to its Model and Priority Schools. The program is available to all school boards in the GTA with priority schools. To learn more about *Rocks + Kids = Opportunities* or to request a workshop, contact schoolprograms@miningmatters.ca.

Field Trip Subsidies

The **Mining Matters** Field Trip Subsidy Program provides support to teachers for experiential Earth science learning. Available across Canada, the subsidies serve to offset some of the costs associated with transportation and entrance fees to venues. Site visits to outdoor facilities like sand and gravel pits, rock quarries, and rehabilitated mines, and to indoor facilities like science centres and museums are meaningful ways in which to reinforce geoscience concepts taught in the classroom. A limited number of subsidies are awarded annually, and applications are considered on a first-come, first-served basis. For more information, visit MiningMatters.ca and enter Subsidy Application Procedures in the Search box.

Field Trip Ideas

UNESCO World Geopark of Percé

UNESCO World Geopark of Percé, on Québec's Gaspé Peninsula, showcases sites and landscapes of international geological significance, managed to promote protection, education, and sustainable development. The Geopark includes 23 terrestrial and coastal geosites along with geosites on the territory of Bonaventure Island and Percé Rock National Park. The rocks that are present are of sedimentary origin and represent five distinct geologic periods: Cambrian (542-489 Ma), Ordovician (489-443 Ma), Silurian (443-418 Ma), Devonian (418-359 Ma), and Carboniferous (359-299 Ma). A visit offers self-directed and guided hiking tours; interpretive signage; a suspended glass platform; and the TEKTONIK Interactive Adventure, which introduces the diverse geology of Percé through a multimedia experience. With experiential and hands-on learning, Geopark of Percé is an excellent location for science, history, and Indigenous studies class trips. geoparcdeperce.com/en/new-website-for-the-pier-geoparc

Boom! A Live Action Experience in the Historic Britannia Mine

At the Historic Britannia Mine, near Squamish, British Columbia, BOOM! introduces audiences to the story, sights, and sounds behind the architectural marvel with an immersive live-action experience inside Mill No.3. The experience involves multiple screens, over 30 speakers, and physical and special effects, bringing all 20 storeys of the historic mill rumbling back to life. britanniaminemuseum.ca/pages/boom

Flower Pot Rocks

Hopewell Cape, New Brunswick, features some of the most famous sea stacks found along the Bay of Fundy coastline. Carved through time from Fundy's sandstone sea cliffs, the Flower Pot Rocks—otherwise referred to as sea stacks—showcase the vertical variance of the Bay of Fundy's great tides. From late-May until mid-October, visitors can walk on the ocean floor at the base of the giant formations, three hours before and after low tide. A guided sea kayaking excursion in and around the sea stacks provides a completely different perspective of the Rocks. bayoffundy.com/articles/flower-pot-rocks

Blue Beach Fossil Museum

The Blue Beach Fossil Museum, located near Hantsport, Nova Scotia, has the largest collection of fossil bones and tracks in Eastern Canada and claims to contain the oldest footprints on Earth. These 350-million-year-old discoveries, and others from this location, shed light on one of the most important and vexing puzzles of evolution, the transition from water to land, from fish to amphibian. Three tours explore different parts of the fossil shoreline, each with unique geology, fantastic fossils, and an amazing story. bluebeachfossilmuseum.com

The Ottawa-Gatineau Geoheritage Project

The Ottawa-Gatineau Geoheritage Project promotes greater public knowledge and appreciation of the geology and related landscapes in and around Canada's National Capital Region. It features four self-guided tours around the area. ottawagatineaugeoheritage.ca/field-trips

- **Geology of the Ottawa Area**: Rock exposures in the Ottawa area show geologic features typical of the local Precambrian and Paleozoic rocks. tinyurl.com/Ottawa-geo
- **Introduction to the Geodiversity of Perth**: The relationship between the people who settled this area and the local geology tells the story of how this community evolved, illustrated through the landscape of the outdoor museum in Perth, Ontario. tinyurl.com/Perth-geo
- **One Billion Years of Geology**: Explore the diverse geology and resulting landforms of the greater Ottawa area. Over time it has featured high mountains, warm and cold seas, huge rivers, and major earth movements, and it holds some of the earliest fossils. tinyurl.com/billionyearsgeo
- **Geoheritage of Eganville**: Bonnechere Museum in Eganville, also known as the Ordovician Fossil Capital of Canada, presents both the natural and cultural history of life as it developed along the Bonnechere River. A geologically rich trail leads to an exhibit of rock types, a limestone quarry, a dug trench, a river-view walk, and fossils. bonnechere.ca/fossils-geological-history

McAbee Fossil Beds

The McAbee Fossil Beds, near Kamloops, British Columbia, contain a biologically diverse collection of 52-million-year-old plant, insect, and fish fossils of global significance, preserved in extraordinary detail. The fossil beds, awarded Heritage Site status, were closed to the public in 2012, but reopened in June 2019. Admission is free, and guides can show visitors around Thursdays through Mondays. kamloopsthisweek.com/news/mcabee-fossil-beds-re-open-to-public-1.23872116

Miguasha National Park and UNESCO World Heritage Site

This UNESCSO World Heritage Site, located on the Gaspé Peninsula, Québec, features fish, invertebrate, and plant fossils representing a 370-million-year-old ecosystem. The fish fossils are considered to be the world's most outstanding example of the Devonian Period. Miguasha is home to the highest number and best-preserved fossil specimens of "lobe-finned fishes" which gave rise to the first terrestrial vertebrates. Discover the "Evolution of Life" trail and a Natural History Exhibit that displays fish and plant fossils collected on site. School groups are welcome, and park warden interpreters are also available to make classroom visits. sepaq.com/pq/mig

August 2020
SAVE THE DATE

Mineral Resources and Mining Education Tours for Educators

Mining Matters, the Canadian Ecology Centre, the Ontario Mining Association, and the Canadian Institute of Mining, Metallurgy and Petroleum partner to deliver the Mineral Resources and Mining Education Tours, an experiential professional learning program for educators. The tours are delivered annually, in August, or by request, during the academic year. The 2020 program marks a decade since the tours were introduced and will include three tours:

Life in a Mining Camp

Tour underground and surface operations, and stay overnight at the North American Palladium's Lac des Iles Mine, located near Thunder Bay. Visit geological and mining sites of interest in the region.

Mine Life Cycle

Learn about all of the phases of the mine life cycle and explore the geology and history of the Timmins area, known globally for its gold production. Visit an underground gold mine and reclamation sites, engage with industry professionals, and participate in hands-on workshops about Earth science and mineral resources.

Mineral Resources and Mining Education Foundations

Develop your 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.

The Tours are fully sponsored and available for a fee of $50, per Tour. Registration includes transportation, accommodation, and meals. Participants are responsible for expenses incurred travelling to and from Tour locations. Visit the Canadian Ecology Centre website for additional details and to complete your registration. canadianecology.ca/professional-development/miningtour

Professional Learning Opportunities

In 2020, two Canadian cities will host geoscientific conferences that will feature geoscience education content, including technical sessions and outreach programming for teachers. Please visit the websites for details.

- GeoConvention 2020 will be co-hosted by six geoscientific organizations and take place May 11–13, 2020, in Calgary. geoconvention.com
- The Geological Society of America will host its annual conference October 25–28, 2020, in Montreal. geosociety.org

25–28 October
GSA 2020
Montréal, Québec, Canada

Canada's Science and Technology Awareness Network (STAN)

Canada's Science and Technology Awareness Network (STAN) exists to strengthen science and technology culture across Canada. It aims to enhance the profile and influence of the science and technology education and public awareness sector. STAN members include individuals and institutions, including government ministries, school boards, corporations, museums, and science centres. In March 2019, STAN hosted a conference built around Canada's role in advancing the Sustainable Development Goals (SDGs) set out by the United Nations. Individuals who are enthusiastic about, or engaged in, STEM literacy are encouraged to join. stanrsst.ca

2019 – International Year of the Periodic Table of Chemical Elements

In December 2017, the United Nations General Assembly proclaimed 2019 as the International Year of the Periodic Table of Chemical Elements (IYPT 2019). IYPT 2019 commemorates the 150th anniversary of the discovery of the Periodic System in 1869 by Russian scientist Dmitri Mendeleev. The Periodic Table of Chemical Elements is considered one of the most significant achievements in science, capturing the essence of chemistry, physics, medicine, Earth sciences, and biology.

Dmitri Mendeleev's Periodic Law states that if chemical elements are arranged in the order of increasing atomic numbers, their chemical properties go through cyclical changes, with elements of similar properties recurring at intervals. Only 63 elements were known in 1869, and the first table charts included gap cells predicting future discoveries of new elements.

The IYPT 2019 is an opportunity to reflect upon many aspects of the periodic table, including its history, the role of women in research, global trends and perspectives on science for sustainable development, and the social and economic impacts of this field. iypt2019.org

Oldest known periodic table chart, St. Petersburg State University, Russia

Going Underground: Electric Innovation in the Minerals Industry

Climate change, caused by increasing concentrations of greenhouse gases (GHGs) in the atmosphere, is one of the most important environmental issues of our time. According to Canada's National Inventory of GHGs, CO_2 makes up 79 per cent of GHGs emitted in Canada, largely from burning fossil fuels for stationary and transport energy. Canadian mining operations are working to reduce their CO_2 output, innovating with electric-powered technology that results in cleaner, more sustainable mining practices. Electric vehicles (EVs) are proving to be a big part of the solution.

"Artisan Z50". Photo courtesy of Artisan Vehicles.

EVs have no GHG emissions and are cheaper to operate than oil-fueled vehicles. They are slowly being embraced by the general public, but in the underground mining world, they are proving to be invaluable. As mines go ever deeper, ventilating fumes from diesel-run machinery requires costly ventilation shafts and systems that could threaten the economic viability of a project. Using zero emission EVs and other electronically run equipment, ventilation needs are reduced. In addition to reduced GHG emissions, EV use results in better underground air environment, lower noise levels, less heat emitted, and reduced operating costs.

Kirkland Lake Gold discovered earlier than some the advantages of using EVs. In 2012, the company began using electric haul trucks at its deep Macassa and South Mine Complex in Ontario. In 2017, the company and Artisan Vehicles, a manufacturer of zero emission battery powered mining vehicles, celebrated the launch of the first-ever all-battery powered 40-tonne underground haul truck.

After testing EVs at its Musselwhite Mine, Goldcorp Inc. made the leap. In 2018, the company was awarded C$5 million from Natural Resources Canada's Clean Growth Program for its new Borden gold project, Canada's first fully electric operation. Using battery EVs, Goldcorp expects to cut approximately 50 per cent of the total GHGs emitted on site, or 5,000 tons of CO_2 per year.

Other mining giants are following suit. Glencore plans to go electric with its entire fleet of underground vehicles at their Onaping Depth nickel/copper deposit in Sudbury, Ontario. Vale will transition its Creighton mine to an EV fleet and is designing its Copper Cliff Phase 2 project, as well as its ultra-deep Victor deposit, as fully electric mines.

The movement is in its infancy, but like a snowball rolling down a hill, the use of EVs in mining is gathering momentum and strength, promising big changes in the mining industry.

The R200 battery powered electric vehicle used by Goldcorp. Photo courtesy of Prairie Machine/Roikon

Mining Matters Resources

Posters

Mining Matters Mining Makes It Happen posters are excellent resources for information about the use of minerals, metals, and elements in medicine, manufacturing, alternative power generation, sports, and music. The posters are available in English, French, and Indigenous languages, including Ojibway, Cree, and Oji-Cree. tinyurl.com/mm-MMIH-posters

Resource Kits and Publications

Mining Matters teaching resources for classrooms, developed by teachers for teachers, meet provincial Earth science and Geography curriculum mandates and guidelines.

Three resource kits are available: Junior/Elementary: **Deeper and Deeper: Discovering Rocks and Minerals**, Intermediate/Middle: **The Earth's Crust** (Manitoba only), and Senior/Secondary: **Discovering Diamonds**. Resource kits are available in English or French through a prerequisite in-service workshop. Workshops can be arranged for between 10 and 24 teachers, anywhere in Canada, with four weeks' prior notice. Learn more about these resources and how to get them at miningmatters.ca/school-programs/teachers

Mining Matters Core Concepts are stand-alone classroom-ready activities that reflect the 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. Professional development workshops and resource kits are available.

The **Mining Matters Activity Book** for youth ages 9 to 13 years is packed with puzzles, including codes to crack, things to spot, word searches, crosswords, Sudoku, and more. Available in English, French, Inuktitut, and Spanish, it encourages kids to learn about rocks, minerals, metals, mining, and minerals industry careers.

Mining Matters, with the Ontario Ministry of Northern Development and Mines, created the **Rocks of Ontario Guide** and the **Fossils of Ontario Guide**. The first features rocks commonly found in Ontario and the processes that shaped them. The second features fossils commonly found in Ontario and how life, even millions of years old, has been preserved. Both posters are available in English, French, Cree, Ojibway, and Oji-Cree.

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

Other Resources

Learning Activities

Columnar Jointing

Combine a virtual field trip to the Columns of the Giants in California (designed for grades 6 to 12) with an easy experiment to create your own columns. This virtual field trip includes six stops and 3D samples that can be explored using Virtual Reality. For teachers, there is a demonstration on how to use the field trip, guided stop questions, a rock identification guide, and more. The experiment uses cornstarch and water, which, over time (and the correct environment), can dry to show the same hexagonal structures exhibited by the Columns of the Giants.

Field Trip sciencefriday.com/educational-resources/360-degree-expedition

Experiment lgoehring.com/Starch_columns_files/columns.pdf

Dig into Mining Careers

This 12-question quiz can help a person learn which mining career might suit them, based on their interests, skills, and values. When the quiz has been completed, several suggested careers are presented, along with career profiles. Information is based on the US Bureau of Labour Statistics.
digintomining.com/sites/default/files/career-exploration

Minecraft Education Edition – Mine Solar Car Lab

Students work together to gather materials and manufacture an electric car.
education.minecraft.net/lessons/mine-solar-car-lab

Websites

The Virtual Museum of Canada

The Burgess Shale, a UNESCO World Heritage Site, is a globally important fossil site. The Burgess Shale Virtual Exhibit, created by the Royal Ontario Museum, provides a portal to life on Earth after the Cambrian Explosion that occurred more than half a billion years ago. The exhibit features several scientific and historical themes and digital reconstructions of fossils, marine animals, and algae. Lesson plans are available for teachers. virtualmuseum.ca/virtual-exhibits/exhibit/the-burgess-shale

The Canadian Minerals and Metals Plan – Introduction to the Minerals of Mining

Learn about 11 minerals important to mining in Canada through a series of delightful character cards, suitable for an elementary school audience. minescanada.ca/en/content/introducing-minerals-mining

Mindat.org

Mindat.org, run by the not-for-profit Hudson Institute of Mineralogy, is the world's largest open database of minerals, rocks, and meteorites, and the localities they come from. The site features an extensive mineral collection and corresponding photos, audio clips of mineral pronunciation, 3D images of crystal forms, a map of significant localities, and much more. Mindat.org has expanded its repository to include information on meteorites, rocks, and other aspects of geology. Some interesting features include the Nearest Localities search, the Learning Centre, and the Chemical Elements and Mineralogy. mindat.org

Ancient Earth Globe

Explore the movements of the continents over time and the evolution of life using this virtual globe. Enter a location and follow that point through time; was the place where your house is built ever at a pole? The equator? The opposite hemisphere? Learn what the world looked like when coral reefs first evolved. Look at the colours of the Earth before and after the evolution of land plants.
dinosaurpictures.org/ancient-earth#750

Evolution 101

The Evolution 101 website provides foundational information about evolution, including what it is (and isn't) and how it works (and how it doesn't). It also provides examples of evolution in action and considers questions still requiring answers. The site also includes teacher resources.
evolution.berkeley.edu/evolibrary/article/evo_01

Open Science Laboratory

The Open Science Laboratory is an online learning platform that includes activities for exploring virtual mineral samples, examining thin sections with a virtual microscope, and sorting soils. Many investigations use on-screen instruments and real data. Access to additional activities is available with registration.
learn5.open.ac.uk/course/view.php?id=2

Mappt

Mappt™ is an offline Android Geographic Information System application for tablets and mobile phones. It is used to collect and manage geospatial data and includes tools that allow for the creation, editing, storing, and sharing of data. The app can work alongside ArcGIS by Esri, used in schools. Mappt's georeferencing tool marks out inclusion and exclusion zones to prevent students from wandering off in the field. When they have connectivity, they can easily send their data to Google Maps or Google Earth and then embed it into a website in just a few taps. The app is available free of charge to educational institutions. mappt.com.au

Planet Rocks Ontario

Planet Rocks Ontario is a guide to more than 500 Ontario sites of geologic interest, spanning three billion years. The guide features rocks, fossils, and natural attractions from the Canadian Shield in northern Ontario to the limestone plains and glaciated lowlands in southern Ontario. Navigate the Site List for geospatial information, photographs, and detailed descriptions. planetrocks.utsc.utoronto.ca

The Life of a Mine

The Life of a Mine is an interactive website where users learn how responsible mining companies try to limit the environmental impact of their operations throughout the stages of the mine life cycle, including exploration, evaluation, construction, production, and reclamation. oma.on.ca/en/resources/life-of-a-mine

Climate-Smart Mining: Minerals for Climate Action

In 2017, the World Bank published "The Growing Role of Minerals and Metals for a Low Carbon Future," which concluded that a lower-carbon future will result in increased demand for key minerals and metals necessary in cleaner energy technologies. Growing demand for minerals and metals provides economic opportunities for resource-rich developing countries and private sector entities, but challenges will likely emerge if the climate-driven clean energy transition is not managed responsibly and sustainably. The Climate-Smart Mining Facility will help resource-rich developing countries benefit from the increasing demand for minerals and metals, while ensuring the mining sector is managed in a way that minimizes the environmental and climate footprint. See the infographic and read the remainder of the brief at tinyurl.com/wb-climatesmart

Gemological Association of America – GemKids

This website is an excellent resource for information about minerals and gems. Its content includes processes of gem formation, the various uses of gems, and fascinating facts about gem history. The Story of a Gem section includes an excellent description of minerals and rocks. The website includes content directed toward teachers, including an Educators' Guide, presentations, and hands-on learning activities for the classroom gemkids.gia.edu

Books

Canada Rocks: The Geologic Journey 2nd Edition

by Nick Eyles and Andrew Miall (2018)

Canada Rocks is the fascinating story of how the Canadian landmass evolved—piece by piece—from a long-lost continent some four billion years ago into one of the most spectacular and geologically significant areas on Earth. *Canada Rocks* is the first book to present the entire sweep of Canadian geology to the general reader. This second edition contains updated and reassessed content, with major updates to chapters on plate tectonics, the formation of eastern Canada, and Canada's glacial heritage. It also contains new insights and material on climate change. The book also showcases many sites that are easily accessible from highways, making it an invaluable field guide for exploring our country.

Sedimentary Rocks

by Rebecca Pettiford (2018)

Readers will learn about the layers of sediment that compress and form sedimentary rocks. Vibrant, full-colour photos and carefully leveled text will engage readers as they learn more about the characteristics of sedimentary rocks and where on Earth they are found.

STEM Starters for Kids Geology Activity Book

by Jenny Jacoby (Author), Vicky Barker (Illustrator) (2019)

Little learners can learn about Earth and its life recorded in rocks by reading the simple explanations and doing the illustrated activities on each page. Children can experience the great gift of geology and begin a lifelong passion for STEM subjects.

Why Do Tectonic Plates Crash and Slip? Children's Earth Sciences Books

by Baby Professor (2017)

The outermost part of Earth's structure is divided into tectonic plates, which affect everything on land and sea. When they crash, new mountains are formed. When they slip, valleys are found. And when all these happen, earthquakes shake cities and towns. Understanding fundamental information about tectonic plates will make it easier for children's knowledge of geology to grow.

Geology Lab for Kids: 52 Projects to Explore Rocks, Gems, Geodes, Crystals, Fossils, and Other Wonders of the Earth's Surface

by Garret Romaine (2017)

Geology Lab for Kids features 52 simple, inexpensive, and fun experiments that explore the Earth's surface, structure, and processes. This family-friendly guide explores the wonders of geology, such as the formation of crystals and fossils, the layers of the Earth's crust, and how water shapes mountains, valleys, and canyons. There is no excuse for boredom with a year's worth of captivating STEAM (Science, Technology, Engineering, Art, and Math) activities.

Rock Collecting for Kids: An Introduction to Geology

by Dan R. Lynch (2018)

Experience the excitement of finding, collecting, and identifying rocks and minerals with this children's introduction to our amazing Earth. The book includes geology basics, an identification guide for 75 types of common and collectible rocks and minerals, and a "how to" section on what to look for, where to look, what to bring, and safety considerations.

Videos

One Strange Rock

Executive Producer Darren Aronofsky (2018)

National Geographic's 10-part "One Strange Rock" series, narrated by actor Will Smith, seeks to convey the interconnected story of life and survival on Earth. The series looks at our planet from the unique perspectives of eight astronauts, including Canada's Chris Hadfield, who have spent time on the International Space Station. Filmed in space and across 45 countries on six continents over the course of more than a year, "One Strange Rock" reaches beyond being a nature documentary by weaving in the astronauts' personal and emotional experiences to shape how the planet is shown. Also available on Netflix.

Blog

Where Does It All Go?

Crushed stone, sand, and gravel are part of our daily lives. They are used to manufacture the buildings in which we live and work and the roads on which we drive. The Ontario Aggregates Resources Corporation (TOARC) website blog includes infographics that illustrate the use of crushed stone, sand, and gravel in urban, suburban, and rural environments.
toarc.com/blog/where-does-it-all-go

Infographic

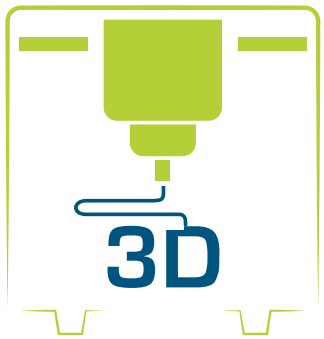
Smart Solutions for Smart Mines

Modern mines incorporate digital connectivity and a wide range of technology to optimize their operations. Created by Visual Capitalist, this infographic provides a comprehensive overview of the innovations used to improve productivity, safety, accountability, the environment, and community in the mine life cycle.
visualcapitalist.com/potential-smart-mining

Activity Booklet

Geoscience Aware Challenge

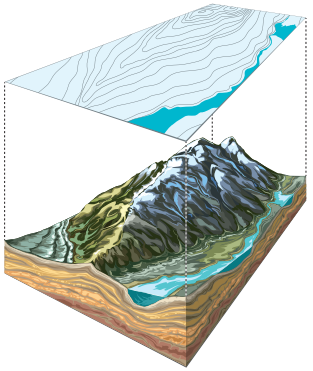
Mining Matters, the Government of Manitoba, and the Canadian Geoscience Education Network collaborated to create the "Geoscience Aware Challenge" for the Girl Guides of Canada, Manitoba Chapter. The Challenge explores Geoscience Literacy Principles through more than 30 hands-on learning activities. The Challenge is for use by teachers and can be accessed on the **Mining Matters** web site.
miningmatters.ca/docs/default-source/mining-matters---resources/geoscience-aware-challenge.pdf?sfvrsn=5ad3ba98_2



3D Printing: Taking Printing to the Next Level

3D printing (3DP), also known as additive manufacturing, creates a solid object from a digital file by laying down successive thin layers of a material. Originally conceived of in 1981, early 3D technology built objects a single layer at a time. Technological advances allowed for simultaneous printing of multiple layers, making the printing of large parts feasible, and increased printer speed and accuracy allowed for parts to be created as required. The technology now produces everything from human body parts and industrial parts to unmanned aircraft and modular homes.

While 3DP began with plastics, metals and metal composites increasingly are being used in industry, further expanding the capabilities of parts that can be printed. Metal powders now being used include aluminum, cobalt derivatives, stainless steel, and titanium. Powdered gold and silver allow for applications across the jewellery sector. 3DP plastics embedded with carbon fibre offer particularly high strength- and stiffness-to-weight ratios, and graphite or aluminum powder combined with plastics offer other properties.

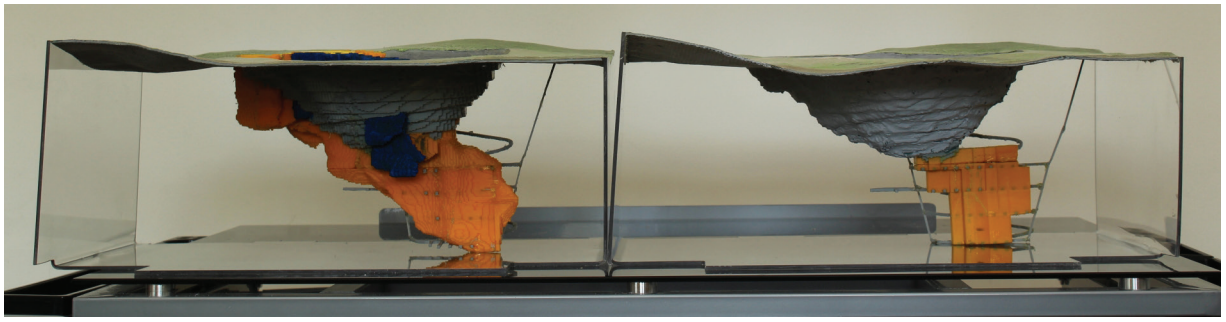


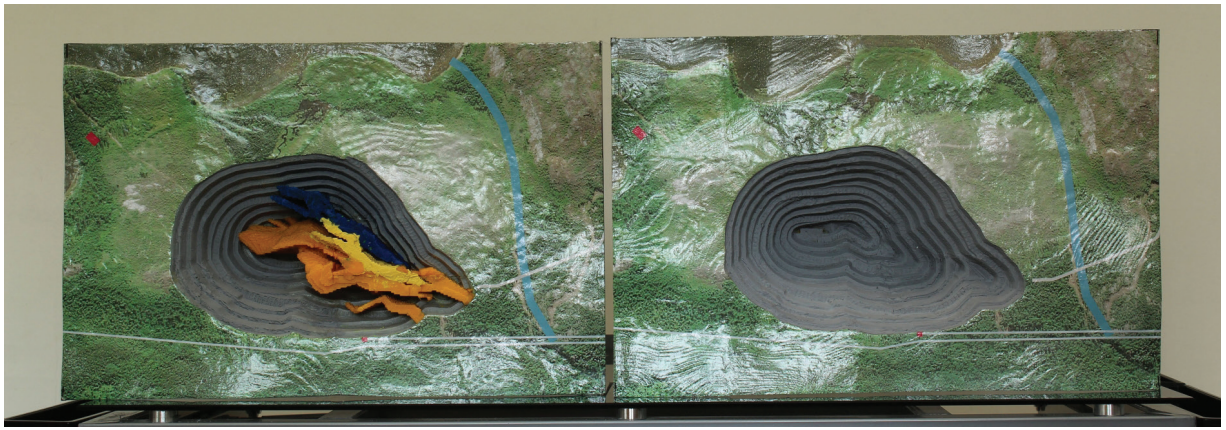
The minerals industry, with mines often set in remote locations, is taking full advantage of 3DP. The process enables on-site, on-demand production of parts and tools, allowing for the quick replacement of parts that tend to wear out quickly. Mining operations no longer have to warehouse spare parts or go through costly downtime waiting for parts to ship. 3D printing also allows for customized parts, redesigned and replicated on site to adapt to a particular job or to be made more robust.

Mining and exploration companies can use 3D printers with multi-coloured printing capability to create models of their properties, delineate ore locations, and project areas of development. A 3D representation can show how future plans will affect properties without the risk of motion sickness that might occur with Virtual Reality.

3DP could have positive environmental impacts for the mining industry, and industry overall. The energy-efficient process would reduce the energy needed to produce parts, and on-site production would reduce the need to ship parts long distances. It would also reduce manufacturing waste. The 3D process can also reduce the weight of and amount of materials needed for parts, able to create items with mostly hollow interiors, where traditional methods such as injection molding and milling produce solid pieces. A lighter car, truck, or haul truck would save in fuel in the long term.

It's been nearly 40 years since that first concept of 3DP. Technological advances have taken the process from producing simple plastic gadgets to fabricating complex real-world parts for a variety of uses, but the technology is still young. Whether on the mining industry or on the global economy, the full effects of 3D printing remain to be seen. It's going to be an interesting journey.





3D models of the PAK Project, located 175 km north of Red Lake. The open pit portion of the proposed lithium mine is about 200 metres deep and 400 metres wide. The model illustrates what the open pit will look like after the ore close to the surface has been mined out, the underground mine workings (black) to about 450 metres, and the ore body (orange) at depth. Photos courtesy of Frontier Lithium.

Tourmaline and quartz crystals

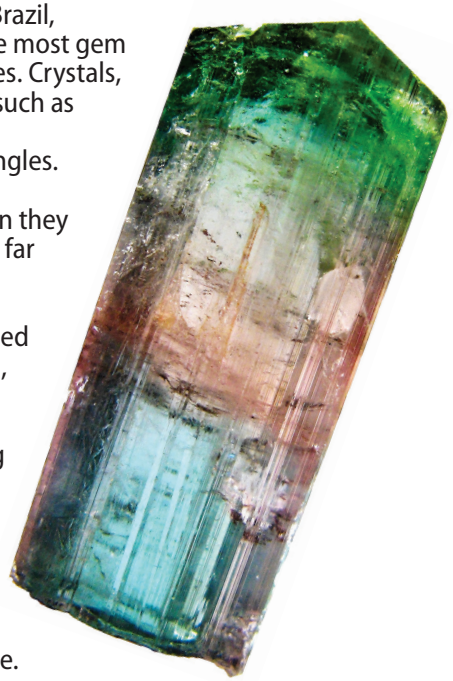
Photo Credit: R. Weller/Cochise College

Tourmaline: The Rainbow Mineral

Tourmaline, a group of minerals valued as gemstones, collectible specimens, and for their industrial uses, has been appreciated and utilized for centuries. Occurring in a rainbow of colours, including pink, red, orange, yellow, green, blue, brown, black, and even bi- and tri-coloured crystals, it offers the largest colour range of any gemstone.

What gives tourmaline minerals their incredible range of colours? While members of the mineral group share a common crystal structure and similar physical properties, they vary tremendously in their chemical composition. They share the elements silicon and boron but contain a complex mixture of other elements such as aluminum, sodium, lithium, calcium, magnesium, manganese, iron, chromium, vanadium, fluorine, and copper. The International Mineralogical Association recognizes 33 varieties of tourmaline based on chemical composition.

Tourmaline minerals are found across the continents. South America, specifically Brazil, produces the most gem quality stones. Crystals, usually triangular or six-sided and often striated along their length, most commonly occur in igneous rocks, such as pegmatities, and are also found in metamorphic rocks such as schist, marble, and skarn.



Coloured tourmaline gems display pleochroism, meaning their colour changes when viewed at different angles. Tourmaline has other interesting physical properties, including piezoelectric and pyroelectric properties. A piezoelectric mineral develops a charge with applied stress, and pyroelectric minerals develop a charge when they are heated or cooled. These and other physical properties, like spontaneous polarization and emission in the far infrared region of the electromagnetic radiation spectrum, make tourmalines useful in manufacturing.

Tourmaline has long been used for carving and as a decorative material. In the 1700s, the Dutch used the pyroelectric property of tourmaline to collect and remove ash from smoking pipes. In the 1800s, chemists used tourmalines to create polarized light. In the 1940s, demand for tourmaline as an industrial material increased, as it was important in the manufacture of submarine instrumentation pressure gauges and other military equipment. Tourmaline has been used as a calibration standard for the manometer and as a standard to measure effects of water-soluble boron in fertilizers. Current industrial uses of tourmaline include hair styling products like dryers and flattening irons.

Scientific and engineering research is focusing on evaluating powdered tourmaline for use in environmental applications. These include water purification systems and in special concrete and asphalt road surfaces that are used to capture harmful components of automobile exhaust. While not as well known to the buying public as gemstones like emerald, sapphire, and ruby, tourmaline offers a special fascination and mystique to collectors and jewellers worldwide. And with new discoveries about its use in industrial and environmental applications, demand for this unique mineral family will most certainly continue.

Junior Activity

Starburst Rock Cycle

The Rock Cycle is a model describing the formation, breakdown, and reformation or restructuring of rock as a result of sedimentary, metamorphic, and igneous processes. There are three types of rock, each formed by a different process:

granite

basalt

Igneous Rock

The word igneous comes from the Latin word ignis, meaning fire. Igneous rock forms from the cooling and solidification of molten rock (magma or lava) and may form with or without crystallization. Intrusive (plutonic) rocks solidify slowly from magma under the Earth's surface. They exhibit large, visible crystals. Granite is a common example. Extrusive (volcanic) rocks solidify, from lava, at the surface of the Earth. The lava solidifies quickly, creating fine-grained rocks, with small crystals. Sometimes the crystals can be seen only with the aid of a microscope! Basalt is a common example.

metaconglomerate

gneiss

Metamorphic Rock

The word metamorphic derives from the Greek words meta (meaning change), and morph (meaning form). Metamorphic rocks form from the transformation (metamorphism) of existing rock. Existing rocks are changed physically or chemically as a result of exposure to heat and pressure. Examples of metamorphic rocks include metaconglomerate, gneiss, slate, marble, schist, and quartzite.

conglomerate

limestone

Sedimentary Rock

The word sedimentary comes from the Latin word sedimentum, meaning to settle. Sedimentary rocks are formed from deposits that accumulate on the Earth's surface. Sediment is the term for the particles that accumulate to form sedimentary rocks, which can be classified into three categories: clastic, biochemical, and chemical.

- Clastic sedimentary rocks comprise eroded Earth materials—gravel, sand, silt, and clay-sized particles—that have been transported by gravity, water, wind, or ice to where they are deposited and slowly become cemented and lithified. Examples include conglomerate, sandstone, siltstone, and shale.
- Biochemical sedimentary rocks are created when organisms use materials dissolved in air or water to make their tissues. Examples include limestone and dolostone.
- Chemical sedimentary rocks form when minerals in solution precipitate. Common examples include limestone and rocks composed of evaporite minerals, like gypsum and halite.

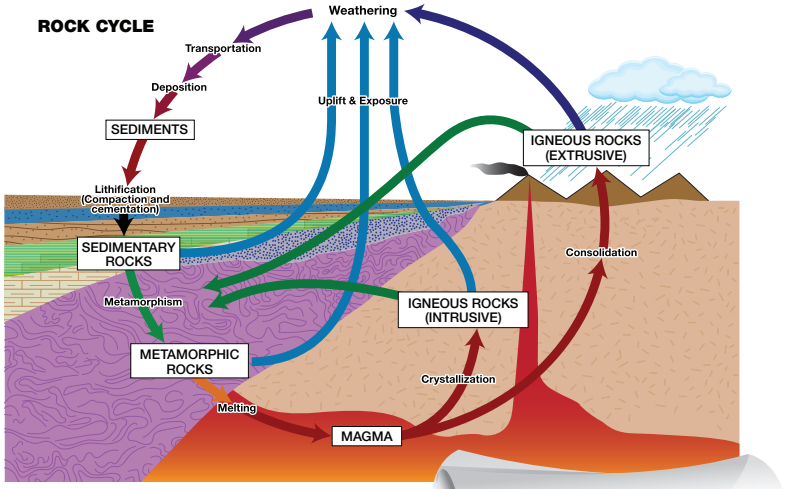
Activity Purpose

In this activity, students create "sedimentary rocks," transform them into "metamorphic rocks" with the application of heat and pressure, and then transform their "metamorphic rocks" into "igneous rocks" by melting and cooling them. This activity can be completed before or after students have learned about the three rock types and the rock cycle.

Program Note: To complete this activity, students will require the support and assistance of a teacher, throughout.

Supplies

- Starburst Minis® candy (assorted colours)
- Scissors
- A source of heat (e.g., toaster oven, hot plate, blow dryer)
- Tongs
- Waxed paper (cut into 15 – 20 cm squares, one for each group)
- Aluminum foil (cut into 20 – 25 cm squares, with edges folded up like a dish)
- Rolling pin or heavy book
- Rock Cycle Chart manitoba.ca/iem/min-ed/kidsrock/mrocks/files/rockcycle.pdf



Instructions

1. Discuss or review the three rock types and the rock cycle.
2. Place the students in small groups.
3. Have each group unwrap four Starburst Minis® candies, each of a different colour. Instruct them to use scissors to cut each piece of candy into four small pieces. Assist if necessary.
4. Have students mix up the candy pieces, advising them that this would be similar to wave action mixing pebbles on a rocky beach.
5. Have students rub the palms of their hands together quickly for several seconds to warm them, then instruct them to pick up their piles of candy and push the pieces together to form balls. The balls should appear lumpy, with visible candy pieces. At this stage, students have created a type of **sedimentary** rock, like **conglomerate**. Ask students to record the pattern of colours of the arranged pieces.
6. Have student groups use a heat source to slightly warm their "sedimentary rocks," but not to the point of melting. When the "rocks" have been warmed, ask students to place them on one half of their waxed paper sheets and fold the other half over top.
7. Have students apply pressure to the covered candy by using a rolling pin or placing a book on top and pressing down on it. After pressure has been applied, they should remove their flattened candy lumps from the waxed paper, fold them in half, place them back in the waxed paper, and repeat the process of applying pressure. At this stage, the students have created **metamorphic** rocks, a metaconglomerate rock, in particular. Ask students to observe their "rocks." What do they look like now? Ask them to describe the colour, texture, and pattern.
8. Have students shape their aluminum squares, turning up the edges to make dishes. They can then place their "metamorphic rocks" in the aluminum foil dishes.
9. Using a heat source, assist students to melt the flattened lumps of candy until completely liquified.
10. Advise students to use tongs to remove their foil containers from the heat source and place them somewhere out of reach to let them cool. Caution them not to touch the aluminum dishes or hot candy with their fingers.
11. Once the heated candy has cooled, have students carefully peel their "rocks" from the foil dishes. The students have created **igneous** rocks. Ask them to observe their "rocks." What do they look like now? Ask them to describe the colour, texture, and pattern.

Senior Activity

Activity – Concern – Solution

Mining can impact the environment. Examples of activities include clearing vegetation during mine construction; creating waste rock and dust through blasting; and using energy and water in mineral extraction, milling, and processing. Government regulations and mitigation measures, innovation, and technology serve to prevent, reduce, or control these impacts.

Activity Purpose

In this activity, students learn about impacts of mining activities on the environment. They match mining activities with environmental concerns and with innovative solutions used to minimize impacts on the environment.

Supplies

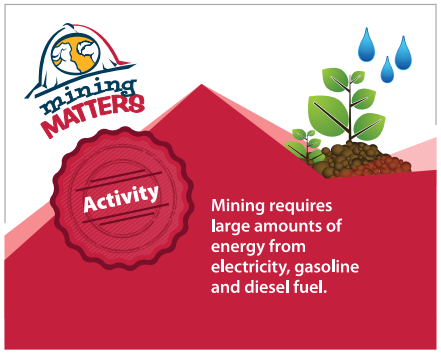
- A class set of Activity – Concern – Solution cards (8 sets of 3, total of 24) included in this publication.

Instructions

1. Shuffle the cards and distribute them among the students. Each student receives one card.
2. Ask students to seek out classmates with the two corresponding cards so that their Activity – Concern – Solution set is complete.
3. When students have formed their groups of three, ask them to share their Activity – Concern – Solution with their peers, orally.

Discussion

Ask the students their impressions of the mining activities and the associated concerns and solutions that are presented. What did they learn about activities, concerns, and solutions? Were they surprised by any of them?



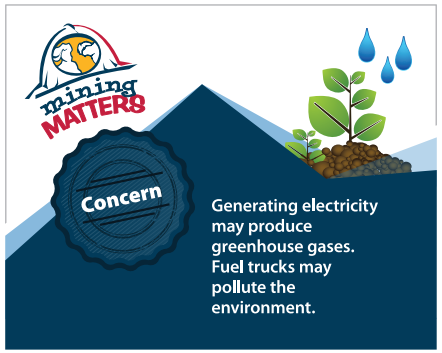

Concern
Mining may create water shortages for animals, plants and people in the region. Water costs may rise for other users.


Concern
Mines may return contaminated water to the environment.


Concern
Changing natural habitats may cause harm to wildlife in the area.


Concern
Safety and environmental impacts from mining are a long term concern.


Concern
Air quality can be affected around the mine.


Concern
Generating electricity may produce greenhouse gases. Fuel trucks may pollute the environment.


Concern
Mine waste rock can react with air and water to create environmental contaminants.


Concern
Mines could cause significant hazardous environmental spills.


Solution
Mines can reduce water use, and reuse and recycle water. Mines can use alternative sources such as seawater or municipal waste water.


Solution
Mines can treat and monitor waste water and make sure it is returned to the environment clean.


Solution
Mines can plan to minimize the area cleared, and replace plants as soon as possible.


Solution
Monitor and manage the risks at closed mine sites on a long term basis.


Solution
Mines can plan to improve their energy efficiency. Mines can consider alternative energy sources.


Solution
Mines can monitor air quality, and adjust mining practices to reduce dust.


Solution
Mines plan to minimize the risk of a spill and any effects on the environment.


Solution
Mines have storage areas to separate waste rock. Mines can use waste rock in reclamation.

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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 750,000 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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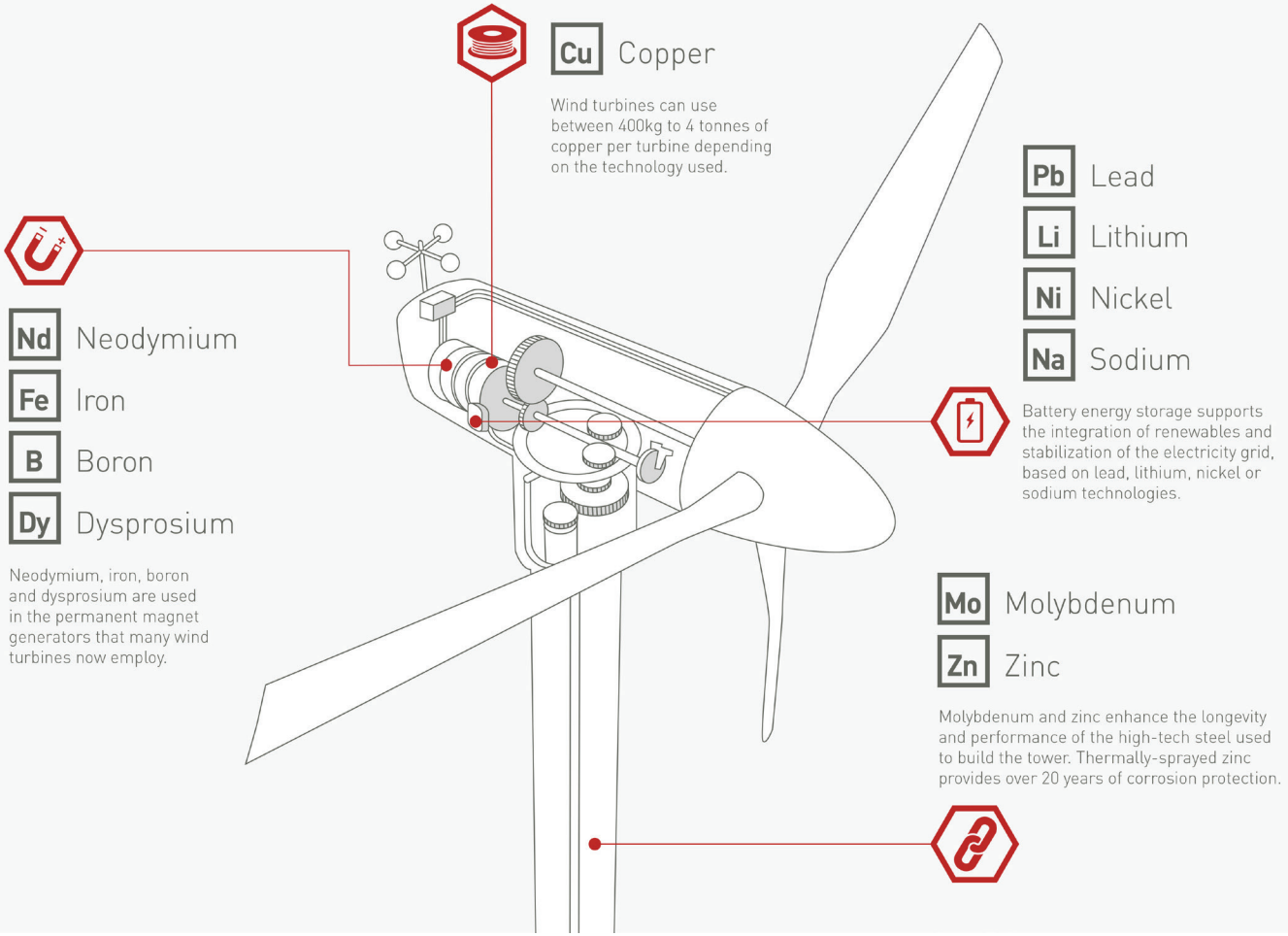

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