mining MATTERS
2016
groundWORK

Aggregates: Foundation of Society

Sand, stone, and gravel are not glamourous. Plain and simple, they attract little attention from the general population, yet they make up the foundations of our society. Used for roads, buildings, bridges, sewers, sidewalks, railways, even paint and paper, and more, they are extracted from pits and quarries near cities and towns across Canada.

Canadians use a lot of aggregates, between 10 and 14 tonnes per person per year. About 160 tonnes of aggregate go into the construction of a typical single family home. Building a school or hospital requires approximately 14,000 tonnes and constructing one kilometre of four-lane highway uses about 35,000 tonnes.

Before aggregates can come out of the ground, years of planning must go in. In Ontario, the aggregates industry is among the most highly regulated industries. Natural environment reports, species at risk permits, hydrogeological assessment reports, cumulative impact assessments, environmental monitoring, municipal planning, traffic engineering, and rehabilitation plans must all be in place. When operations are finished, the land must be left safe, environmentally stable, usable, and appropriate to the surrounding area. See the regulatory process at ontario.ca/page/aggregate-resources

Between 2010 and 2014, Ontario Stone, Sand & Gravel Association (OSSGA) researchers examined 701 rehabilitated pits and quarries across southern and eastern Ontario. Site examinations continue, but conclusions to date recognize that pits and quarries are being successfully rehabilitated and reintegrated into rural or urban landforms in a variety of final land uses. Researchers hope to further examine previous and current rehabilitation, and they recommend further strengthening of rehabilitation practices and industry standards.

Correcting the Past

With the establishment of Ontario's Aggregate Resources Act (ARA) in 1990, aggregate resource companies were given a new set of rules. Before that time, pits and quarries were allowed to operate differently. The new rules strengthened requirements for progressive and final rehabilitation and made licensing more controlled. Operators who wouldn't conform to the new rules were no longer legally allowed to operate, their sites deemed abandoned. Those sites started to naturalize on their own. As many as one third are now unrecognizable as old pits and quarries. Others need a helping hand. The Management of Abandoned Aggregate Properties (MAAP) Program, created in 1997 (formerly administered by the Ministry of Natural Resources before being transferred to the Aggregate Resources Trust) and funded by aggregate company annual license fees, works to rehabilitate these properties. While some just need leveling and seeding, others require more involved plans. MAAP provides $400,000 to $600,000 annually for this purpose. As of December 2015, approximately $8.5 million has been spent on rehabilitating 720 hectares of land, covering 453 sites.

To learn more about MAAP go to toarc.com/maap-1/about-maap.html

Photos courtesy of the MAAP Program

Elderslie Township legacy pit

Over 31,000 m³ of material moved to create a relatively gentle 8:1 slope for farming

One year following rehabilitation

From Sand to Soy

Near Lakefield, Ontario, we can see what has gone into one piece of land to produce non-GMO soybeans. That land, agricultural until 1950, became a gravel and sand producing pit. CBM Aggregates, the pit operator since 2005, has worked with a local farmer since 2013 to rehabilitate 20 acres, aiming to make it even better than adjoining, non-mined farmlands. Grading the land and adding topsoil were just the beginning. Over 600 tonnes of manure and multiple fertilizer applications of nitrogen, phosphorus, potassium, and magnesium were tilled into the soil. Crop rotations of buckwheat, oats, rye, and clover, combined with constant soil testing, made the field ready for its 2015 soybean crop. Perhaps some of that crop ended up on your plate.

The Lakefield Pit rehabilitation earned CBM the OSSGA Progressive Rehabilitation Award (2014), for outstanding progress in the rehabilitation of extracted portions of active pit or quarry sites. CBM plans to transfer these best practices to other sites in Ontario.

It can be hard to recognize skillfully designed rehabilitation. Pits and quarries are transformed into wetlands and habitat for wildlife, farmland, parks, fruit orchards, vineyards, subdivisions, golf courses, and recreational fishing areas. Few people likely remember that places such as Evergreen Brick Works and Christie Pits in Toronto, Erindale College in Mississauga, the Royal Botanical Gardens in Hamilton, Lakeland Estates in Nepean, Carburn Park in Calgary, and Butchart Gardens on Vancouver Island, are former quarries or pits. For some of the best, see ossga.com/multimedia/55/report_to_ontarios_communities_2014.pdf

Rolling agricultural land is even harder to picture as a former pit or quarry. Agricultural uses account for approximately 21 per cent of rehabilitated land. An OSSGA 2015 Rehabilitation Tour visited Bruce County to look at some of the nearly 40 sites rehabilitated to agricultural use. The tour included drone demonstrations and soil sampling, emphasizing the importance of data collection, especially before extraction, so that a benchmark soil composition can inform rehabilitative efforts. To inquire about future tours, go to ossga.com/contact_us

As good neighbours, aggregate companies also try to minimize environmental impact during operations and contribute to the surrounding communities by donating resources, staff time, and funding to projects and charitable causes. Many welcome the community to tour their sites. Take a look at tinyurl.com/ossga-tours

According to the Ontario Geological Survey 2016 Recommendations for Exploration, Ontario's consumption of aggregates is expected to average about 186 million tonnes per year over the next 20 years, 13 per cent higher than in the past 20 years. Aggregate pits and quarries are with us to stay. Fortunately, the industry is well aware of its responsibility to the land and surrounding communities as it provides the foundation for growing cities, transportation networks, and more.

Contents

The Buzz on Drones

Queen bee's idle mate, lazy human being, monotonous hum: what do these have in common? They are all meanings attributed to "drone." They are, however, a far cry from the most recent meaning, developed in the mid-20th century: an unmanned aerial vehicle (UAV), a device that seems to be anything but idle, lazy, or monotonous. An increasingly useful tool, drones are being put to work in such varying fields as research, forestry, search and rescue, film making, police work, military operations, real estate, farming, and mining.

Visitors on the 2015 Rehabilitation Tour offered by the Ontario Stone, Sand & Gravel Association (OSSGA) saw drones performing tasks valuable to both farming and mining. Huron Geomatics and High Eye Aerial Imaging showed participants how drones are used to survey progress in the rehabilitation of agricultural land using low-altitude, high-definition aerial imaging, including photography and videography.

In fact, using drones in the mining and aggregate industries offers endless possibilities, cutting costs and increasing productivity, most welcome in a time when the sector has to tighten its belt. Tasks that used to take days or even weeks can now be done in hours. In the aggregate industry, drones can measure aggregate stockpiles, even odd-shaped ones, providing perimeter and volume, and automatically calculate weight from aggregate material density.

Drones also prove extremely useful in mapping mineral exploration targets. Shawn Ryan, credited with discovering the multi-million-ounce White Gold deposit in the Yukon Territory, is a principal in GroundTruth Exploration, and is known for his innovative approach to mineral exploration. In an interview at the 2015 PDAC convention, Ryan described how GroundTruth adopts and adapts technology, including drones, in the Yukon.

The company uses drones to generate a 3-D blueprint of a potential site that geologists can use to identify structures that can't be seen from the ground. Ryan said that the small environmental footprint of the drones and other minimally invasive machines eliminates the need for permits (in the Yukon) as well as the need for land reclamation. He stated that work can carry on year-round—no more need to shut down during the winter—and claimed to have cut costs by approximately 80 per cent with the new methods.

Not only can the technology decrease costs through efficiencies and be more environmentally friendly, but it can also provide increased safety. The Ontario Aggregate Resources Corporation (TOARC) uses drones to survey abandoned pits and quarries, particularly when doing a survey on foot would be dangerous or difficult due to inaccessibility.

Commercial drone use is on the rise. In Canada, industrial or commercial applications are subject to Transport Canada regulations, meaning operators must apply for a flight certificate before taking off. But it would seem to be well worth it, when this not-so-idle busy bee offers such new possibilities and benefits as it does to the aggregate and mining industries.

Mining Matters New Poster

Medicine: From the Ground Up

Mining Matters has released a fourth original poster in our line of Mining Makes It Happen resources: *Medicine: From the Ground Up.* From head to toe, skin to bone, brain to heart, the human body is made up of complex systems. Learning about them, looking after them, and enhancing them challenges the medical world daily. Ancient healing practices, modern medicine, and tomorrow's discoveries rely on our world's natural resources. Essential dietary elements, care regimes, surgical instruments, medical devices, diagnostic aids, and life-saving treatments use the metals and minerals of the Earth. Mining Makes It Happen.

Order your poster today! Send your request to info@miningmatters.ca

The Wonders of Clay

Ooey gooey clay—a precious mineral? Well, perhaps not precious in the typical sense, like gold, silver, or sparkling gems, but this stiff, sticky fine-grained earth, made up of tiny particles of many minerals, is precious as a workhorse of civilization, past and present.

Clay has the marvellous property of being plastic when wet, allowing it to be shaped into an endless variety of objects. Once dry, it retains its shape unless soaked at length. Once dry and fired at high heat, it cannot be returned to its plastic state. From prehistoric times, clay has been indispensable in architecture, industry, agriculture, food preparation, and art.

As a building material, it goes into bricks [sun-dried (adobe) or fired], wall and floor tiles, and drainage and sewage pipes. The major use of clay, after brick manufacture, is in the manufacture of cement.

In agriculture, clay contributes essential water retention and mineral richness to soils to make them ideal for growing. For food preparation and serving, people have long depended upon ceramics such as clay cooking pots and porcelain, china, and earthenware dishes. Ceramics grew into an art form, demonstrating human creativity and chronicling local needs, beliefs, and traditions: from the oldest known work of terracotta sculpture in the world, the Dolni Vestonice, through fine Greek vases, Italian Renaissance masterpieces, Chinese terracotta soldiers, and Inca ceremonial pottery, the list goes on.

Clay is found in medicine as well. Indigenous cultures have long used the healing powers of mud rich with clay minerals. In Australia, the Andes, and Central Africa, people ingested clays to cure diarrhea and stomach upsets or prevent poisoning from toxins. In Canada, the Heiltsuk First Nation has used mineral-rich clays for centuries for both external and internal medicine. Natural medicine today suggests bentonite clay, made up of weathered volcanic ash, for many internal and external uses.

In religions around the world, clay is cited as the medium from which humans were made by a supreme being. Egyptian, Sumerian, Chinese, Greek, and other mythologies, along with the Bible and the Qur'an all include statements that man was fashioned from clay. Whether or not true, the beliefs demonstrate the value given to clay in history.

But What is Clay?

Found in a variety of colours—grey, white, brown, red—clay is made up of mineral particles smaller than 0.004 mm. Its composition depends on the rocks it was created from. Chemically, clays are hydrous aluminum silicates, usually containing impurities such as potassium, sodium, calcium, magnesium, or iron. Depending on which mineral particles they contain, clays fall into three main groups, each with its own particular properties: kaolinite, illite, and montmorillonite.

Clays occur around the world as residual or sedimentary deposits. Residual clay has formed in place, a product of surface weathering, which causes chemical decomposition of rocks, such as granite, containing silica and alumina; solution of rocks, such as limestone, containing clayey impurities, which, being insoluble, are deposited as clay; or disintegration and solution of shale. Sedimentary clay has been removed from the rock sources by erosion and deposited in a new and possibly distant position.

Kaolinite

Named after the Kao-ling mountain in Jiangxi Province in China.

Kaolinite, the most abundant clay mineral, has been used in China since early times for pottery and ceramics. It is also used in the production of paper and in pharmaceuticals as an ingredient in some medications. Kaolinite is also used as an ingredient in some cosmetics, soaps, paint, and toothpastes.

Illite

Named for the locality where it was first found, Illinois, USA.

Illite is a widespread component of sediments from minerals in the mica family. It is one of the main clays used to make traditional ceramics.

Montmorillonite

Named after Montmorillon, France, where it was first reported.

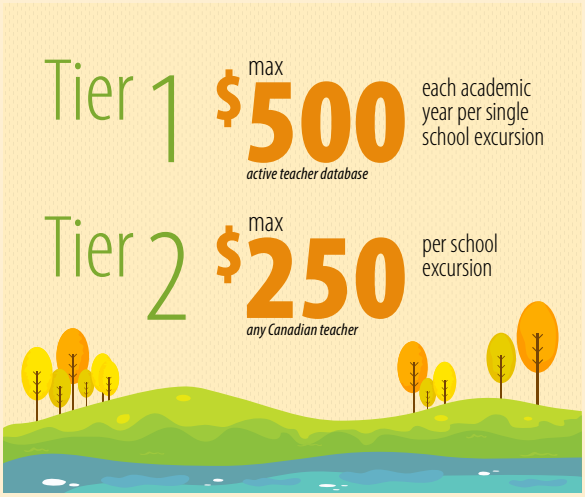
Montmorillonite comprises extremely small particles produced by volcanic and hydrothermal activity. It is the principal constituent of bentonite and fuller's earth. Bentonite is used in foundry work, refining petroleum, and in drilling muds used to protect cutting bits. Other uses are in the construction industry; in clarifying water and wine; in purifying sewage; in the paper, ceramics, plastics, and rubber industries; and in natural health practices. Fuller's earth is used to adsorb impurities or colouring bodies from fats, grease, or oils.

Field Trip Subsidies: New Funding Model

Mining Matters has long offered a highly successful Field Trip Subsidy Program to enrich Earth science learning. To allow even more teachers and students to benefit from the subsidies, we have changed and expanded the program's scope.

Field Trip Destinations: The subsidies have been intended to help offset the cost of transportation and entrance fees to geoscience venues as well as stone, sand, and gravel operations. We now welcome applications for trips involving Earth materials, processing, and manufacturing. We encourage both active outdoor field exploration, such as rock walks and visits to quarries and rehabilitated mine sites, as well as indoor excursions to museums and science centres to experience and reinforce geosciences concepts.

Who Qualifies: In the past, *Mining Matters* accepted funding requests from teachers who have completed an in-service workshop and use a *Mining Matters* resource kit in the classroom. These teachers, registered in our active teacher database, are assigned Tier 1 status and are eligible to apply for funding up to a maximum of $500 each academic year per single school excursion. In addition, we now offer Tier 2 funding: up to $250 per school excursion available for any Canadian teacher wishing assistance with a qualifying field trip. All applications will be considered on a first-come, first-served basis. For complete details, visit MiningMatters.ca



Mining Matters thanks Canadian Securities Exchange, our 2016–2017 Field Trip Subsidy Sponsor, for their generous support in making these educational experiences available.

Field Trips

Canada's National Parks: Free to Discover

In 2017, Canadians will have the best chance ever to discover some of the natural jewels of our country—our national parks. The federal government has mandated that, to mark the 150th anniversary of Canada's Confederation, entry into our national parks and historic sites will be FREE! Annual passes bought in 2016 are good for two years from the time of purchase. In 2018, children 18 and under and new citizens will have free access as well. Learn about all there is to see at pc.gc.ca

Also, check out *My Parks Pass*, which allows all grade 8/secondary students in Canada to visit over 200 Parks Canada places for free. Teachers are encouraged to order passes for their entire class. Pass holders have until April 30, 2017 to choose among 44 national parks, 167 national historic sites, and four national marine conservation areas across the country. Students with a *My Park Pass* can also get family members an instant discount on a daily family or group pass. Check out locations to visit and enter a contest to win an iPad mini or other prizes. See myparkspass.ca/your-pass

Georgian College Engineering and Environmental Technologies students tour Uhthoff Quarry, Orillia, Ontario, September 2015

Waterfalling

People are fascinated by waterfalls. Some "go waterfalling," searching out those special spots where water flows over a precipice or down a hillside, eroding rock and carving out spectacular natural wonders. The World Waterfall Database offers 2,733 Canadian waterfalls to explore, listed alphabetically, or by province and territory. worldwaterfalldatabase.com/country/Canada

The database, while extensive, doesn't cover them all. For another list of good Canadian locations, see gowaterfalling.com/waterfalls/maps

The Best Waterfalls to Visit in Canada, written by Jackie Hamilton for *Cottage Life*, lists 10 of the best to see, from British Columbia and Northwest Territories to Newfoundland and Labrador. cottagelife.com/canadiana/canadas-10-most-incredible-waterfalls

Ms. Hamilton's article also cites Hamilton, Ontario as "the waterfall capital of the world," having more than 100 waterfalls in an area just over 1,000 sq. km. The website *Cascades and Waterfalls of Hamilton* lists over 90. waterfalls.hamilton.ca

Another Ontario resource is day-trips.ca/content/top-10-waterfalls-southwestern-ontario

On the Ground Field Trips

Stone, Sand & Gravel Associations

Most provinces and territories have stone, sand, and gravel operations. A few have associations. Try contacting an individual business or an association about a school tour. Here are some suggestions:

Ontario Stone, Sand & Gravel Association (OSSGA) has a list of companies offering group and school tours of stone, sand, and gravel mining operations around the province. tinyurl.com/ossga-tours

Alberta Sand & Gravel Association asga.ab.ca

British Columbia Stone, Sand & Gravel Association gravelbc.ca

Greig's Caves

greigscaves.ca

On the Bruce Peninsula, the Georgian Bay shoreline features magnificent overhanging cliffs formed over 7,000 years ago by Lake Algonquin's post-glacial wave action, which eroded soft limestone from beneath harder dolomite. Inland, where erosion cut more deeply, caves were created, such as Greig's Caves, which feature 10 limestone caves once located at water level but now 76 m above Georgian Bay.

Scarborough Bluffs

tinyurl.com/bluffs-scar

Forming much of Toronto's eastern waterfront, Scarborough Bluffs are a geological attraction where 12,000 years of sedimentary rock have been eroded by Lake Ontario. At their highest (at Cathedral Bluffs), they rise 90 m above the lake. The Bluffs feature hiking and walking trails, picnic tables, and fire pits.

Niagara Glen Nature Reserve

tinyurl.com/niagara-glen

Along the Niagara Parkway, access a climb down into the natural beauty of the Niagara Gorge. Four kilometres of trails wind through the reserve's incredible natural features, including flora, fauna, and remarkable rock formations.

Mining Heritage Tour

tinyurl.com/klgeotour

Kirkland Lake, Ontario, strung out along the "Mile of Gold," has been home to seven major mines that yielded extraordinary wealth for over 80 years from one of the world's largest gold deposits. Explore fascinating geology and mining history through six stops in the downtown area, including an historic mine, the outcrop where gold was first discovered, and the Museum of Northern History, which features over 5,000 pieces of local mining history.

Heritage Silver Trail

tinyurl.com/silvertrail

The Heritage Silver trail traces a map around Cobalt Lake and surrounding area, with perfect vantage points of several mines from Cobalt's silver rush, including the Right of Way Mine. The Heritage Silver Trail map, available at the Mining Museum, will guide you through mines, glory holes, and heritage buildings from yesteryear.

Rattlesnake Point Conservation Area

tinyurl.com/rattlesnake-point

Rattlesnake Point Conservation Area is a natural haven located in Milton, Ontario. Trails wind through 264 hectares of hidden caves, glacial deposits, and spectacular scenery. This is a perfect stop to discover first-hand the geography that makes up Ontario.

Bonnechere Caves

bonnecherecaves.com

Eganville, Ontario, is home to the Bonnechere Caves. Tours provide a wealth of knowledge and experience as participants learn about the different types of rocks, the process of fossilization, the impact of glaciers on our landscape, the formation of caves, and more.

Flowerpot Island

flowerpotisland.ca

Off the tip of the Bruce Peninsula lies Flowerpot Island, a natural attraction famous for its natural sea stacks or "flowerpots," caves, historic light station, and variety of rare plants. Accessible only by boat, Flowerpot Island is the only island in Fathom Five National Marine Park with campsites and hiking trails.

Ouimet Canyon

ontarioparks.com/park/ouimetcanyon

Ouimet Canyon, a spectacular landscape northeast of Thunder Bay, Ontario, measures three km by 152 m. Two viewing platforms overlook the canyon's edge. On the canyon floor, 107 m below, grow arctic plants typically found 1,000 km north of the park. To protect this fragile plant community, access to the canyon floor is prohibited.

Scenic Caves

scna.wpengine.com

The Scenic Caves, near Collingwood, Ontario, were carved by glacial ice millions of years ago. Venture across the 126 m suspension bridge or zipline through the forest. A free education package for teachers and students, grades 4 to 8, meets Ontario curriculum expectations for Science and includes lesson plans, fun facts, and work sheets.

Giant's Rib Discovery Centre

giantsrib.ca

The Giant's Rib Escarpment Education Network (GREEN) is dedicated to providing public education about the Niagara Escarpment World Biosphere Reserve. Discover the wonders of the Reserve at the Discovery Centre in the Dundas Valley Conservation Area, the first of many Centres planned along the Escarpment. Find Teacher's Kits at giantsrib.ca/teachers-kits

Canadian Fossil Discovery Centre (CFDC)

discoverfossils.com

The CFDC, in Winnipeg, Manitoba, houses Canada's largest collection of marine reptile fossils including "Bruce" – the Guinness Record holding largest mosasaur on display in the world, at more than 13 m in length. The CFDC also houses the world's only publicly displayed vial of Woolly Mammoth blood and many other unique exhibits. Looking for a fun and educational field trip for your class? Consider the CFDC's popular School Fossil Dig Adventure Tour or a School Museum Tour.

Rock and Mineral Shows

Rock and Mineral shows are fascinating events for everyone, from those just getting started with a few pieces to seasoned collectors.

For a comprehensive list of shows across Canada, please see our website. pdac.ca/mining-matters/outreach-programs/rock-mineral-clubs-shows

Green Mining Initiative

The Green Mining Initiative (GMI), under the collaborative leadership of Natural Resources Canada (NRCan), brings together stakeholders to develop green technologies, processes, and knowledge for sustainable mining.

The GMI targets the development of innovative energy-efficient technologies required for mining to leave behind only clean water, rehabilitated landscapes, and healthy ecosystems. It aims to improve the mining sector's environmental performance, to promote innovation in mining, and to position Canada's mining sector as the global leader in green mining technologies and practices.

The GMI will help improve the competitiveness of the Canadian mining industry through research, innovation, and commercialization efforts. nrcan.gc.ca/mining-materials/green-mining/8178

WHERE challenge

Encourage your students to take the WHERE challenge this fall and discover what on Earth is in their stuff!

The *Mining Matters* WHERE Challenge is a national contest that promotes awareness of non-renewable Earth resources. WHERE stands for Water, Hazards, Energy, Resources, and Environment, the fields in which geoscientists work.

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

Launched each September, the WHERE Challenge welcomes entries, submitted online, until the following March. Judges select regional and national winners, awarding cash prizes! In the 2015–2016 WHERE Challenge, 462 students were involved, resulting in 13 regional winners, of which seven won national prizes. Some entrants have won multiple years! And, new this year, changes to the contest categories and prize allocations will make it even easier for students to participate and win!

You Be the Judge!

Volunteer to be a contest judge in the 2016–2017 WHERE Challenge. If you can spare just a few hours of your time and possess a degree in geosciences, education, environmental studies, or resource management, or work in a similar field, please consider contacting us. For more information about the contest, to see the rules, or to view winning entries, visit earthsciencescanada.com/where

2016 National Prize Winners

	Ages 9 - 11	Ages 12 - 14
Best Overall	L'al ou l'aluminium Jérôme Lavoie	Handwarmers Brooke Dirk Montgomery School
Best Creative	Se faire une beauté grâce aux minéraux Maude Carrier	Polymer Banknote Zainab Syed Craig Kielburger S. S.
Best Creative	What on Earth is glass made of? Tomasz Padiasek	
Best Research	L'halite Félix-Antoine Couture Jérémie Couture	Aluminium Vision Olivia Yip Dr. Norman Bethune C. I.

School Winners

Three school prizes were awarded, $750 each. School prizes are based on a combination of quality and quantity of entries from each school. See the complete list of winning projects at earthsciencescanada.com/where/results.html

Craig Kielburger Secondary School
Milton, ON
Entries 120+
National Winners 2 (includes honourable mention)
3 Regional Winners

Dr. Norman Bethune C. I.
Toronto, ON
Entries 36
National Winners 2 (includes honourable mention)
3 Regional Winners

Montgomery School
Saskatoon, SK
Entries 28
National Winners 2 (includes honourable mention)
3 Regional Winners

Water Hazards Energy Resources Environment

Hands-on Minds-on Student Workshops

Mining Matters now offers student workshops that will have your students working collaboratively to identify properties of Earth materials while they engage in discussions to better understand where and how these resources form. *Mining Matters* student geoscience workshops include local and regional perspectives by showcasing samples that are sourced in Ontario. There are over a dozen workshop options to choose from! There is a nominal fee associated with this service.

Contact our Education Team at schoolprograms@miningmatters.ca to book a student geoscience workshop today!

Student workshops are now available to schools in the Greater Toronto Area. The workshops can be designed with one of three goals in mind:

1 ***Set Induction***

an introduction to activate prior knowledge

2 ***Reinforcement***

an extension to stretch students and engage them in critical thinking

3 ***Concept Exploration***

reinforcement of concepts, topics, and/or theories already covered about the subject matter by the teacher

Indigenous Peoples and Canada's Mineral Resources

Indigenous peoples, the First Peoples of Canada, have a history rich with language, culture, and traditional knowledge. Through the years, they grew to understand the Earth and its processes and developed ways to care for their health, lifestyles, and economies, while respecting the environment. Among other resources, they gathered metals; they have much to offer and gain as partners in Canada's present and future resource development.

What does that development look like at present? The mineral exploration and mining industry is a driving force in Canada's economy. According to the Canadian Mining Association's 2015 Facts and Figures publication, the industry contributed $57 billion to Canada's gross domestic product in 2014, including $24 billion in mineral extraction, and $33 billion in mineral processing and manufacturing.

Canadian companies are gaining strides in learning how to meticulously plan exploration and mining activities with consideration for the environment and the surrounding communities, many of which are Indigenous. The companies can offer these communities economic and employment benefits. In turn, those communities can offer insight into the land, traditional knowledge, employees, and business partnerships. To ensure this, Indigenous Economic Development Corporations have been, and continue to be, established in many communities, pursuing valuable partnerships and opportunities, and "re-teaching the business sector how to operate on a community basis and how to actually deliver socially responsible outcomes to the community itself." (*Muskrat Magazine*, Nov. 10, 2015, muskratmagazine.com/the-role-of-aboriginal-economic-development-corporations-in-canadas-business-paradigm-shift)

Produced in May 2013, the *Aboriginal Canada and the Natural Resource Economy Series*, available to download at macdonaldlaurier.ca/10303/, provides thought-provoking insights into the history and potential of Indigenous involvement in natural resource development. One report, *New Beginnings: How Canada's Natural Resource Wealth Could Re-shape Relations with Aboriginal People*, discusses involvement efforts being employed today, including revenue sharing; impact and benefit agreements between Indigenous groups and mining corporations; development corporations (Indigenous-run, community-based, collectively owned commercial enterprises); education and employment opportunities for youth; and support for culture, language, and traditional practices.

Mining Rocks Earth Science Program

Since 2001, *Mining Matters* has supported the meaningful involvement of Indigenous communities in the mineral exploration and mining industry through the delivery of education programs. Our *Mining Rocks* Earth Science Programs offer interactive Earth science and mining education activities for children and youth, and often include the broader community. In 2015–2016, we delivered a record 33 *Mining Rocks* Programs in communities across Canada, and we are on track to meet this number in 2016–2017.

Tailoring our *Mining Rocks* Programs to individual communities, we lay the foundations of core Earth science concepts and the modern mining cycle, from exploration to reclamation. We collaborate with community leadership and educators to design and deliver material that features local geology and mineral exploration. Over the years, we have developed respected and supportive relationships with the communities in which we have delivered programs. We are warmly welcomed and frequently invited to return.

Mining Matters School Programs at the PDAC Convention

Since 2007, *Mining Matters* has presented a two-day, hands-on learning school program for elementary and secondary students at the Prospectors and Developers Association of Canada (PDAC) International Convention, Trade Show and Investors Exchange in downtown Toronto, Ontario. The four-day annual Convention, held at the Metro Toronto Convention Centre, is the world's largest annual mineral exploration convention.

This learning opportunity, generously sponsored by IBK Capital Corp., is beneficial to all students, but might appeal most to those interested in geology, engineering, geography, natural resource management, mining, and environmental practices related to land use. Students will visit the Trade Show and chat with some of over 1,000 exhibitors, exposing them to the immense scope of the mineral exploration and mining industry.

Teachers who use *Mining Matters* resources in their classroom and would like to give their students this unique opportunity should email inquiries to *Mining Matters* Manager of Teacher Training and School Programs at schoolprograms@miningmatters.ca

Save the Date 2017

Mining Matters Annual

- **5 March** Sunday ☑ Teachers' Day
- **6 March** Monday ☑ Elementary Students' Day
- **7 March** Tuesday ☑ Secondary Students' Day

School group reservation and pre-registration are required for these events. Contact schoolprograms@miningmatters.ca for more information.

Teacher Tested: Digging Deeper at St. Joseph's College School

Mining Matters recently received a very appreciative note from Mr. John Doucet, Department Head, Canadian and World Studies and teacher of 25 years at St. Joseph's College School, Toronto Catholic District School Board.

Mr. Doucet took the initiative to develop 11 activities for his grade 11 physical geography class, using material from the *Deeper and Deeper* kit. He was kind enough to pass them along to us to share with all of you! The complete unit is available for download from slideshare.net/MiningMatters

Thank you John Doucet!

On March 6, 2016, I was one of the very fortunate teachers who took part in the Annual Teachers' Day hosted by Mining Matters at the PDAC International Convention. My goal was to learn and incorporate new activities related to the mining industry and Earth science into the physical geography unit of the grade 9 geography of Canada course and into the grade 11 physical geography course.

It was during the workshop that I received training on Mining Matters "Deeper and Deeper" Earth science activity kit. Although this kit was designed for the elementary classroom, I found it absolutely adaptable to the secondary level. The beauty of the material is that it is so complete and teacher-friendly. It would literally take hours of work to assemble all the material provided in this kit.

My students truly appreciated the chance to get "hands-on" with the diversity of rock and mineral samples provided with the kit. They particularly enjoyed the chance to use the simple testing equipment to test the properties of the minerals. Their enthusiasm for the activities allows me to unequivocally endorse the material provided by Mining Matters.

John Doucet

Beyond Classrooms: Kingston Experience

"Why do people study geology?" "What are the environmental impacts of human uses of rocks and minerals?" "What can rocks, minerals, and fossils tell us about our past, and why are they important to us today?"

These are just a few of the questions inquiring students ask during their week-long stays at the Miller Museum of Geology in Kingston, Ontario, as part of their Beyond Classrooms Kingston experience. The Beyond Classrooms approach, based on the Open Minds program developed in Calgary, moves students into community spaces so that they can discover what happens there and why that space is important.

Part of the Department of Geological Sciences and Geological Engineering at Queen's University, the Miller Museum of Geology hosted the pilot of Beyond Classrooms in 2014. It has since hosted five classes and their teachers for full weeks of inquiry-learning, providing the unique opportunity to learn from one of Canada's most significant Earth science collections and also speak to leading experts in the field such as mineralogists, paleontologists, mining engineers, and archeologists. Working alongside these experts, teachers use the site's resources as a catalyst for learning. Students slow down their learning, look closely, and reflect through journal writing.

Mark Badham, Miller Museum curator, has been instrumental to the success of Beyond Classrooms and in creating hands-on, inquiry-based learning for students at the Museum. From fossil walks to extracting minerals from breakfast cereal, his activities make learning fun! Thanks to Mark, Beyond Classrooms, and some truly dedicated teachers, Kingston's students can learn more about the world beneath their feet than many of their peers. Learn more at beyondclassrooms.ca

The Miller Museum also features an assortment of educational programs available to the general public. These include interactive tours for students of all ages that look at Mineral Identification, Meteorites, Introduction to Geology, The Earth through Time, Earth & Space Systems, and their most recent addition, Dinosaurs. There is a charge of $70 per group (minimum of 10/maximum of 35). tinyurl.com/MillerMuse

Phyllis Lesnikov

Her motivation...

I believe in the contribution that young adults' perspective may have to solving the issues that are a part of today's world; this belief led me to an experiment related to environmental topics, specifically the remediation of vastly contaminated mine sites. I am interested in investigating the potential and ability of other remediation methods besides the ones I have investigated, and in the future, would like to research the implication of chemistry and genetic sciences in the environmental field. This novel and emerging field is one that I believe could truly help reduce the damage that heavy metal contamination has had on many ecosystems.

Student Tackles Mine Remediation... and Wins!

Students don't just learn. They wonder, they innovate, they think outside the box. Given resources and encouragement, they can tackle some of the world's problems in a whole new way. Phyllis Lesnikov, a grade 10 student at Stratford Hall in Vancouver, B.C., decided to do just that. She examined the problem of remediating contaminated mine sites, focusing on the Britannia Mine near Squamish, B.C., and came up with an award-winning solution.

Phyllis received a Gold Medal at the 2016 Greater Vancouver Regional Science Fair for her project on the Remediation of Britannia Mine through Phytoremediation and Chemical Washing. She went on to represent British Columbia in May at the Canada Wide Science Fair (CWSF) in Montreal, where she won a Silver Medal for Excellence and a $2,000 Entrance Scholarship to the University of Western Ontario, Faculty of Science.

Phyllis says of her work, "I compared two methods of remediation, phytoremediation and chemical washing, which use plants and chemicals, respectively. By imitating the remediation of Britannia Mine on a lab-sized scale, I was able to find the optimal concentration at which each method worked most efficiently and effectively."

Out of 500 projects at the CWSF, only Phyllis's was concerned with the mining industry, and yet hers is precisely the kind of creative thinking that Canada's mining industry—a global leader—encourages. Industry members constantly strive to improve their operations, with minimal impact on the environment, and welcome innovative approaches. Bureau Veritas Minerals was pleased to sponsor Phyllis with her research by doing a specialized mass spectrometry analysis on the products of her experiment. Golder Associates and the Government of British Columbia, Crown Contaminated Sites Program, Ministry of Forests, Lands and Natural Resource Operations were able to provide Phyllis with the Britannia Mine soil samples necessary for the experiment.

Mining Matters congratulates Phyllis, thrilled to see that one of the 2016 CWSF entrants decided to tackle an everyday problem related to the mineral exploration and mining industry. We sincerely hope that other inquiring young minds will follow her lead.

For more about the Britannia Mine environmental clean-up, see britanniaminemuseum.ca/environment

Resources

Publications

Canadian Shield: The Rocks That Made Canada by Nick Eyles

Fitzhenry & Whiteside (2010)
Canadian Shield: The Rocks that Made Canada looks at the geologic evolution of the Shield: its first tentative exploration by humans starting 11,000 years ago as the last great ice sheets withdrew, its changing economic fortunes as Europeans penetrated its remote rocky vastness for furs and metals, and its transformation in the 20th century into a national icon to Canadians. tinyurl.com/can-shield

From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury by Oiva W. Saarinen

Wilfrid Laurier University Press (2013)
From Meteorite Impact to Constellation City is a historical geography of the City of Greater Sudbury. The story that began billions of years ago encompasses dramatic physical and human events. Among them are volcanic eruptions; two meteorite impacts; the ebb and flow of continental glaciers; Aboriginal occupancy; exploration and mapping by Europeans; exploitation by fur traders, Canadian lumbermen, and American entrepreneurs; the rise of global mining giants, unionism, pollution, and re-greening; and the creation of a unique constellation city of 160,000. tinyurl.com/GeoSudbury

Rockscapes of Georgian Bay by Ed Bartram (Author), Joan Murray (Contributor)

Fitzhenry & Whiteside (2014)
Ed Bartram, printmaker, photographer, and painter, transforms his vision of Georgian Bay into graphic images that reflect the land, particularly the rock face of this region of Canada's Precambrian Shield. His powerful works, often luxuriously physical, have an abstract dimension with richly coloured and textured surfaces. fitzhenry.ca/Detail/1554553482

Road Rocks Ontario: Over 250 Geological Wonders to Discover by Nick Eyles

Fitzhenry and Whiteside (2013)
More than 200 Ontario field sites illustrate the province's rich geologic history, from Timmins in the north to Windsor in the south. These include the Sleeping Giant near Thunder Bay; Agawa Canyon; the Sudbury meteorite crater; Niagara Escarpment, Falls, and Gorge; numerous caves; the mineral-rich Bancroft area; and the high lakeshore cliffs at Scarborough Bluffs. Some sites are sacred to First Nations and feature spectacular rock art. tinyurl.com/RoadRocks-Ont

Geology of the Manitoba Legislative Building by Jeff Young, Graham Young, William C. Brisbin (2013)

The Manitoba Legislative Building is a distinctive Winnipeg landmark, visible from many places in this city. It is such a common sight that most Winnipeggers probably barely think of it, but it is a gem, both architecturally and geologically. tinyurl.com/GeoManLeg

Geology of the Ottawa Area compiled by Quentin Gall (2010)

This self-guided field trip takes you to rock exposures in the Ottawa area that show geologic features typical of the local Precambrian and Paleozoic rocks. As the field trip progresses, it attempts to work through the local stratigraphic succession; that is, it starts with the oldest Precambrian rocks and progresses to the younger, overlying Paleozoic rocks units. tinyurl.com/GeoOttawa

Minerals and Metals Factbook – 2015

This resource provides key information, in an easily understood format, related to Canada's exploration, mining, and mineral manufacturing industries in 2014. It also includes historical information spanning nine years (2005–2014). For a copy, email Natural Resources Canada's Minerals and Metals Sector at info-mms@nrcan.gc.ca or call 343-292-8683. nrcan.gc.ca/mining-materials/markets/17686

Websites

Earthwise

Earthwise, part of the Manitoba Rocks website, gives examples of Indigenous Peoples approach to interacting with the Earth. manitoba.ca/iem/min-ed/kidsrock/earthwise/index.html

K-5 GeoSource

Elementary school teachers will appreciate this comprehensive online support from the American Geosciences Institute. Packed with usable content, activities, resources, and services, it covers topics such as climate, fossils, rocks, soil, water, and weather, as well as literacy strategies and virtual field trip ideas. k5geosource.org

Investigating Earth Systems (IES)

This middle school Earth science curriculum leads students through a complete and thought-provoking exploration of Earth systems and how they are all connected. IES

was developed by the Education Department of the American Geosciences Institute, with support from the National Science Foundation and AGI Foundation. It has been field tested and content reviewed and meets the evolving standards of Earth science education reform. americangeosciences.org/education/ies

EarthScope

EarthScope, sponsored by the National Science Foundation, explores the North American continent, as well as our entire Earth, to better understand its composition, formation, and processes. Data collected from seismic waves, crustal movements, Earth's magnetic field, rock and soil samples, and aerial images helps better explain geological phenomena, protect against natural hazards, and locate necessary resources.
Educators can look at
earthscope.org/resources/educators
Students can explore
earthscope.org/resources/students

Visualizing Earth Systems NASA

Graphically presented data using images, animations, and videos promotes deeper understanding and insight into Earth systems. Students and teachers can explore data, phenomena, and behavior and examine large scales of time and space and "invisible" processes (e.g. flows of energy and matter). This comprehensive online resource, with lessons for grades K to 12, encourages student questioning and conversation. svs.gsfc.nasa.gov/forEducators/Start_Here.html

Encyclopaedia Britannica

Is the Grand Canyon two billion years old? Can you find magnesium in the sea? Test your knowledge of rocks and minerals in this quiz. britannica.com/quiz/rocks-and-minerals-fact-or-fiction

4kids.com

A series of sites to excite and inform kids about chemistry, geography, space, and physics. chem4kids.com
geography4kids.com
cosmos4kids.com
physics4kids.com

Uncovered

Diamond Discoveries

In August 2015, a 187.7 carat diamond was discovered at the Diavik mine in the Northwest Territories. Given the name Foxfire, the stone is the largest gem quality diamond ever found in North America and is considered a very rare find. The stone was almost discarded by the company's ore processor, not calibrated to accept stones of that size, but it slipped through the filtering screen because of its unusual shape.

In November 2015, the world's second largest diamond was found in Botswana, the world's largest producer of diamonds, by Canadian mining company Lucara Diamond Corp. Called Lesedi La Rona, which means "our light" (in the Tswana language), the stone measures 1,111 carats—about the size of a tennis ball—and is second in size only to the Cullinan diamond in the British Crown jewels.

New Elements in the Periodic Table

In January 2016, the International Union of Pure and Applied Chemistry (IUPAC) verified the discoveries of four new chemical elements, completing the seventh row of the Periodic Table of Elements. The new elements, all man-made, have temporarily been named Element 113 (ununtrium), Element 115 (ununpentium), Element 117 (ununseptium), and Element 118 (ununoctium). They exist for only a fraction of a second, created by bombarding heavy metal targets with beams of ions, and detected by measuring the radiation and other nuclides produced as they decay.

World's Longest Mountain Range

To find the world's longest mountain range, look underwater. Called the mid-ocean ridge, the underwater chain of volcanoes spans some 65,000 km. It rises an average of 5.5 km above the bottom of the sea. As lava erupts from the seafloor, it creates more crust, adding to the mountain chain, which stretches around the globe.

Backgrounder Intermediate/Senior

Activity: Looking Inside Rocks

Microscope Use in Geology

Rocks are made up of two or more different minerals. The study of mineral properties is fundamental to the identification of rocks and the interpretation of the environment in which rocks—igneous, sedimentary, and metamorphic—are formed. The study of minerals and textures in a rock is called *petrography*. Thin section petrography is the study of microscopic features using a *polarizing* or *petrographic microscope*, a basic tool in the field of geology.

A polarizing or petrographic microscope operates under similar principles as the light microscope used by biologists; however, its function is based not only on the properties of light, but also on the optical properties of the solid materials under observation, in this case, minerals.

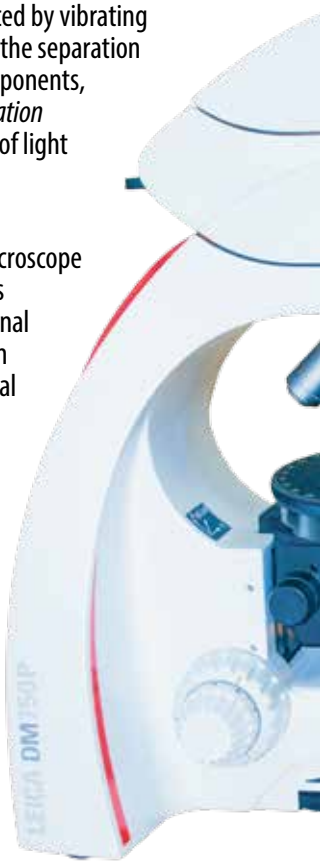
When examining a rock at the microscopic level, a geologist can see the many minerals that make up the rock. Since minerals are natural crystals, the geological world at the microscopic level is mostly crystalline. The polarizing microscope allows geologists to observe the micro-textures of rocks as well as such features as *mineral shape, colour, grain size, refractive index*, and *cleavage* and may even provide evidence of the chemical content of minerals.

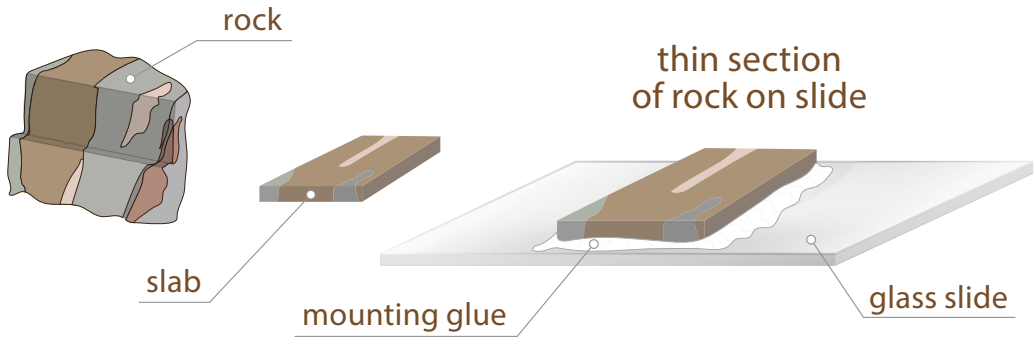
Visible Light Spectrum

Light is a form of *radiant energy*, but only a small part of the spectrum is visible. Our eyes are sensitive to a very narrow band of wavelength located to the right of the infrared region and to the left of the ultraviolet regions. This narrow band of wavelength that humans see is referred to as the *visible light spectrum*, which is in fact composed of *electromagnetic waves* produced by vibrating electric charges. In the field of *optical mineralogy*, the separation of the electromagnetic spectrum into its two components, electric and magnetic—referred to as the *polarization phenomenon*—is used to explain the interaction of light with minerals.

Thin Section

A *thin section*, in geology, is a standard glass microscope slide upon which a very thin slice of rock sample is mounted. The sample of rock is so thin (conventional standard, ~ 30 microns/0.03 mm), *petrologists* can see through the cross sections of individual mineral crystals. Thin sections are used by petrologists to identify the minerals present and their textural relationship, to classify rocks, and to locate minerals for further analysis.

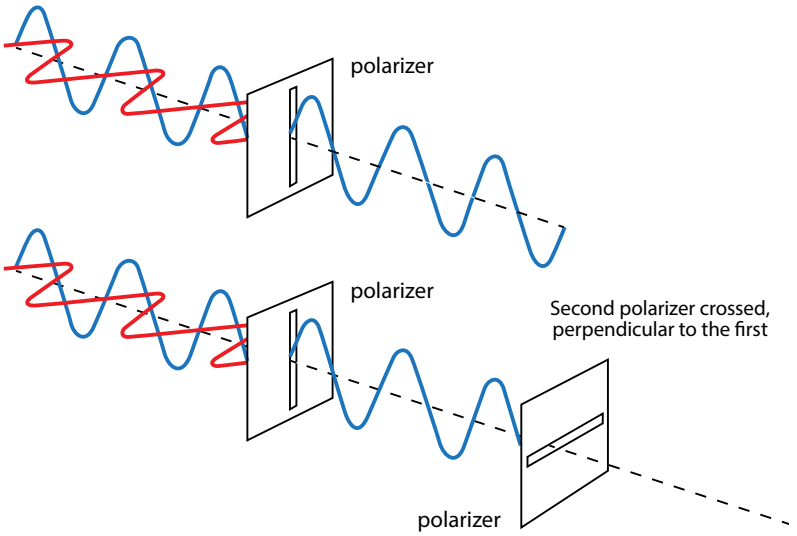




Optical Mineralogy

To identify the optical properties of minerals found in rocks, geologists use a polarizing microscope. As in all light microscopes, the rays emitted vibrate in randomly oriented directions. A rotatable prism (polarizer), mounted below the microscope stage, filters the light rays so that only those vibrating in one specific plane pass through the prism. This is called *plane polarized light (PPL)*. A thin section placed on the microscope stage and viewed from above will show the true colours of the minerals present; most will be colourless, some will have distinctive colours, and some, like metallic minerals that do not transmit light, will be opaque or black.

If two polarizers are placed at right angles to each other in the light path, essentially crossed (*cross polarized light, CPL*), all the light will be blocked. If a thin section is placed on the microscope stage between crossed polarizers and viewed from above, some minerals will alter the direction of the light such that some light can pass through the upper polarizer. Minerals that are *birefringent*, or *refract* light into two light rays with differing wavelengths, create interference when they pass through the upper polarizer.
This effect is observed as extraordinary colours, referred to as "*interference colours*." The colours are determined by the path distance between the two wavelengths as they exit the upper polarizer, which directly correlates to the mineral's composition, the thickness of the section, and its orientation. Interference colours can provide important clues to the identity of a mineral or even the orientation of the crystal in the section.



Activity

In this activity, students use a Smart Device microscope and two pieces of polarized film to view thin sections, exploring rocks at a microscopic level and capturing photos of their crystalline worlds.

Materials*

- ☐ Smart Device microscope, includes light source
- ☐ 2 pieces of linear polarized film
- ☐ 3 thin sections (igneous, sedimentary, and metamorphic rocks)
- ☐ HB pencil and eraser
- ☐ Colouring pencils
- ☐ Ruler

Preparation

A. Copy the table on page 15 into your notebook.

B. Assemble the Smart Device microscope using the materials provided by the supplier.

Notes: A petrographic microscope is not required to carry out this activity. Magnification is unknown, and for the purposes of this activity, is not important.

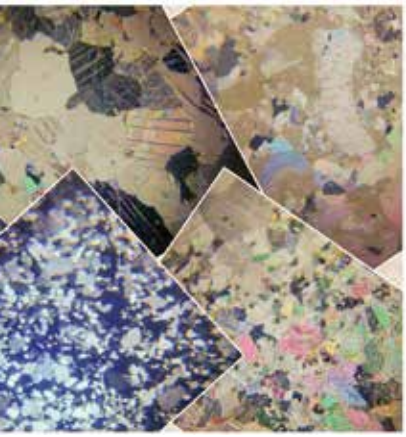
Instructions

1. Complete A and B under Preparation.
2. With your "microscope" assembled, set the microscope stage: the narrow Plexiglas underneath the top platform at a level that allows for placement and removal of specimens.
3. Switch on the light source under the stage, directly below the lens in the device support platform. Line up the Smart Device camera lens directly on top of the micro lens embedded in the device support platform. This is most easily done by holding the Smart Device a few centimetres above the micro lens to centre the camera lens on top and then lowering to the stage.
4. Place the two linear polarized films one on top of the other on the stage and check the orientation of the polarizing film. Slowly rotate the top film until you see the background between the two polarizers appear dark.
5. Remove the upper film, place the thin section on top of one polarizer, and then place them—polarized film and thin section—together onto the stage. Position the slide so that the sample fills the field of view of the Smart Device screen. You may want to enlarge the image on your Smart Device camera to fill the field of view. Adjust the stage height and the light as needed.

A petrographic microscope commonly used in the geology lab

A Smart Device microscope

Igneous rock thin section as viewed with Smart Device microscope



Rock Cycle Mash-Up Challenge: Can you identify the rock types presented in the images?

6. Observe. Draw, colour, and describe what you see under plane polarized light (PPL). You may want to capture an image under PPL to support your description and drawing.
7. Place the second polarizing film on top of the thin section at 90° (crossed) to the film underneath the thin section, making what looks like a thin section sandwich. When correctly oriented, the outer edges of the linear polarized film should appear dark, with colourful grains showing in the central field of view.
8. Observe. Draw, colour, and describe what you see under cross polarized light (CPL). You may want to capture an image under CPL to support your description and drawing
9. Remove the sample under observation. Repeat steps 5 to 8 for the other specimens.
10. Complete the "Check your Understanding" questions.

Check Your Understanding

1. Compare and contrast the drawings (and/or images) of the samples when viewed under PPL versus CPL. Consider how much detail you were able to gather related to shape, cleavage, texture, colour, and opacity.
2. Why would it not be a sound scientific practice to bypass the PPL viewing and proceed directly to observing the thin section under CPL?
3. Based on what you have observed, determine if grain or crystal size provide clues about the rock type. Explain your answer by citing at least two observations.
4. Igneous rocks can be classified in many ways; one way is based on their chemical composition.
   - Felsic: light-coloured minerals (quartz and orthoclase feldspar)
   - Mafic: dark-coloured minerals (amphibole, pyroxene, olivine, and biotite)

   Based on this information, is the igneous rock sample felsic or mafic? Explain your choice.
5. Understanding chemistry and physics plays an important part in pursuing studies in geosciences. Identify and briefly describe two different phenomena exhibited in this activity that are attributable to (a) chemistry and (b) physics.

Digging Deeper

1. Why does magnification not matter for this activity?
2. What information could you gather if magnification were known?
3. How would you determine magnification?

To learn more about petrography and to use a virtual petrographic microscope, visit Open University.

*Where to source materials

- Mining Matters, Kidder Design Technology and Science Education: Smart Device microscope
- Boreal Science: thin sections and polarized film
- Edmund Optics: polarized film
- Contact your local university Department of Earth Sciences for thin sections of rocks

References

Gladstone, C. (n.d.). *Minerals under the Microscope*. Department of Earth Sciences, University of Bristol. Retrieved July 25, 2016 from gly.bris.ac.uk/www/teach/opmin/mins.html#menu

Gunter, M. E. (n.d.). *Optical Mineralogy*. Department of Geology and Geological Engineering, University of Idaho. Retrieved July 25, 2016 from webpages.uidaho.edu/~mgunter/opt_min/article.pdf

Mogk, D. W. (2016, July 19). *Optical Mineralogy–Tutorials and Other On-Line Resources*. Department of Earth Sciences, Montana State University. Retrieved from serc.carleton.edu/NAGTWorkshops/mineralogy/optical_mineralogy_petrography.html

Table of Observations

Name _____

	Drawings / Observations	
Sample	Plane Polarized Light (PPL)	Cross Polarized Light (CPL)
Sedimentary		
Igneous		
Metamorphic		

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Mining Matters is a charitable organization dedicated to bringing knowledge and awareness about Canada's geology and mineral resources to students, teachers and the public. Since 1994, *Mining Matters* has reached an estimated 600,000 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.

Charitable Registration Number: 88775 6435 RR0001

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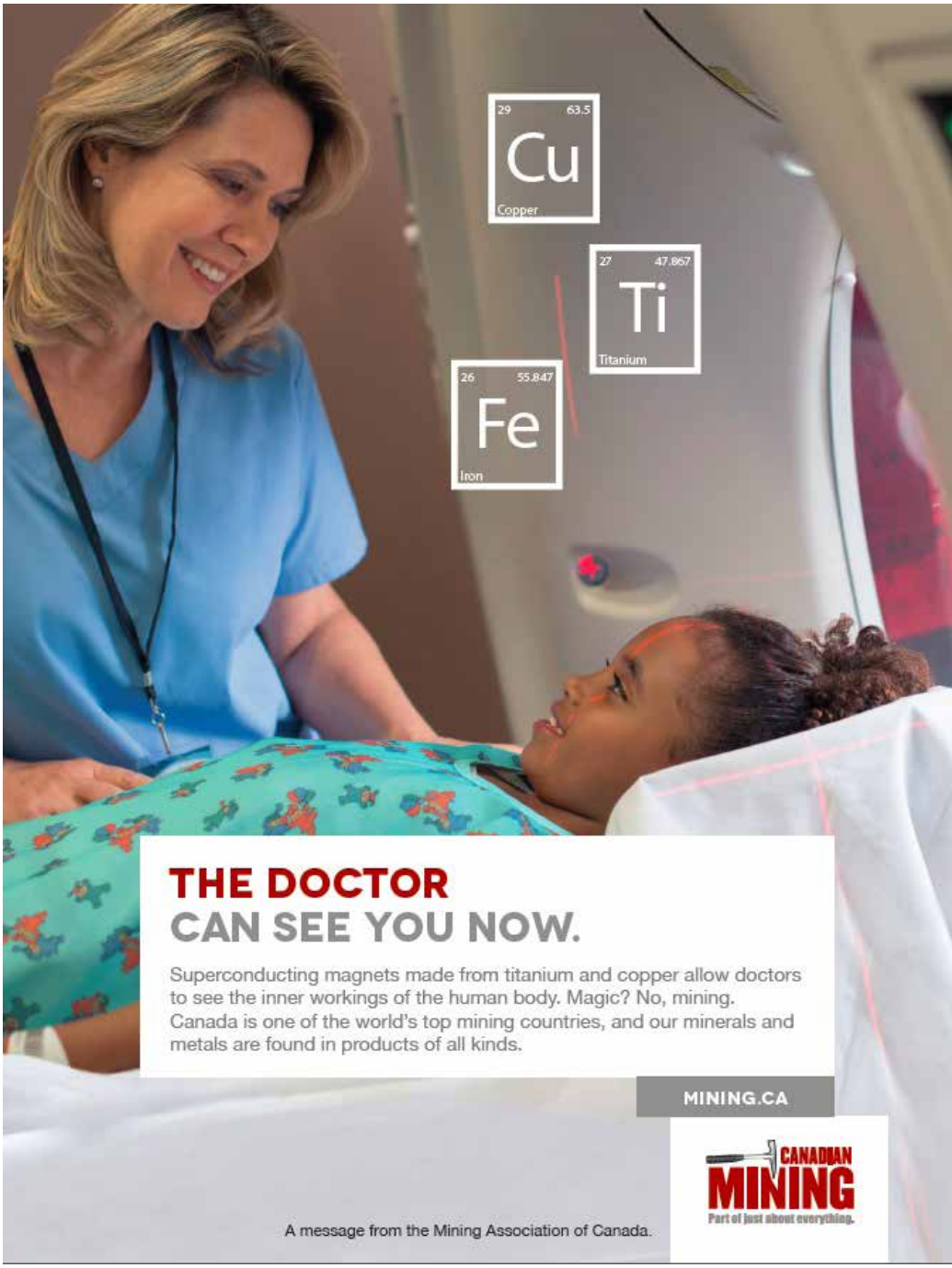
Mining matters to everyone!



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