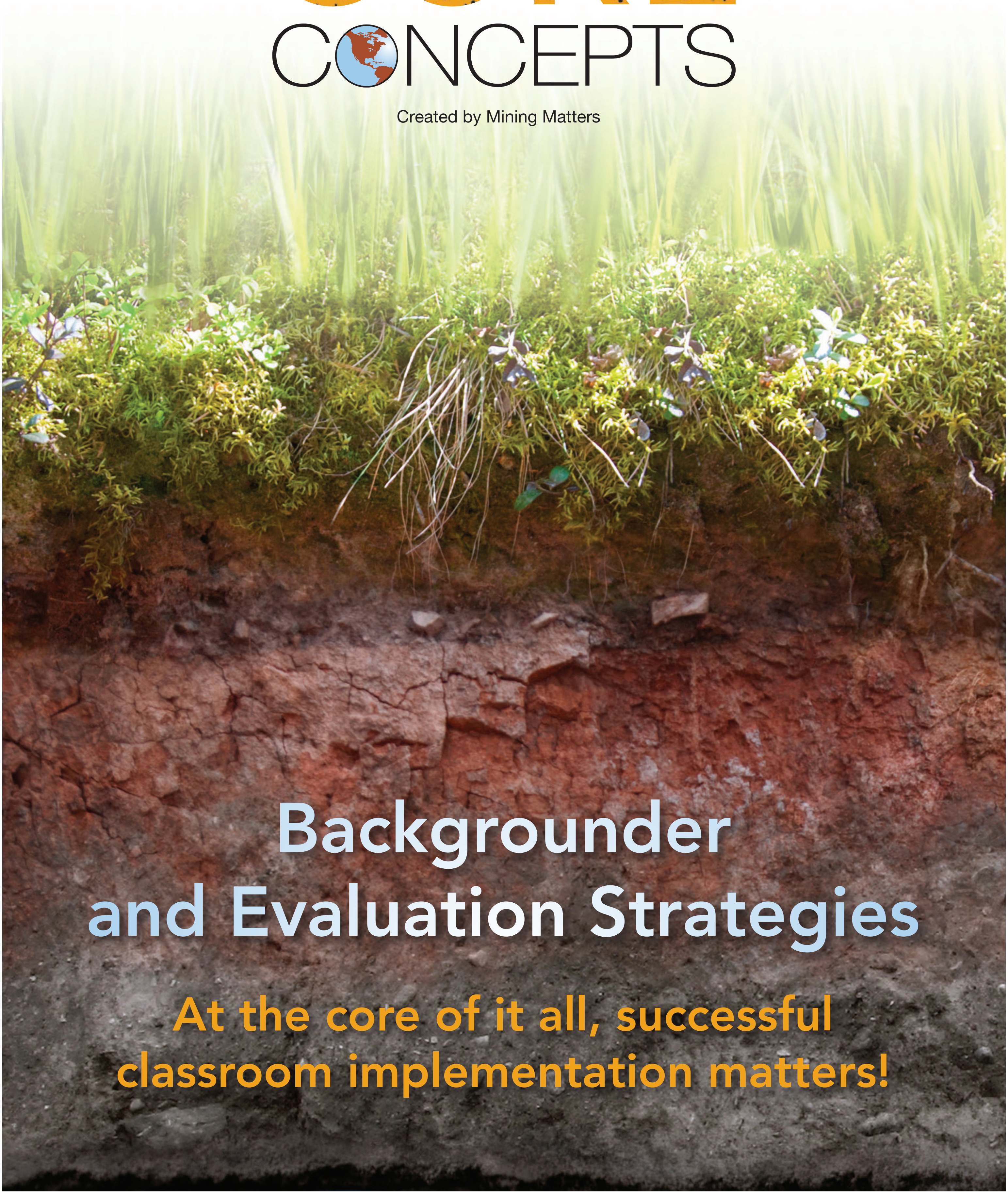
CORE CONCEPTS

Created by Mining Matters



Backgrounder and Evaluation Strategies

At the core of it all, successful classroom implementation matters!

BACKGROUNDER:

Mining Matters Core Concepts are standalone classroom ready activities that reflect key foundational ideas in Earth science. Sourced from our archives of curriculum-linked teacher resources, each activity reflects an integral part of many important concepts and theories in the various disciplines that comprise the Geosciences.

In an effort to be of service to all of our teacher-partners, these activities have been assembled as a way to support individual teachers without the need to attend a pre-requisite teacher training workshop. All the contents of the Core Concepts resource support current teaching practices that values hands-on experience where students take an active role in learning. Any rocks and minerals samples as well as print resources required for successful classroom delivery can be sourced through **Mining Matters**.

CURRICULUM STANDARDS AND EXPECTATIONS

The activities contained within are correlated to the National Science Foundation and the Earth Science Literacy Initiative (2009) entitled, Earth Science Literacy Principles. The document, which can be downloaded free of charge from the Earth Science Literacy Initiative website (www.earthscienceliteracy.org) outlines nine Big Ideas that represent the most important concepts of Earth science, and provide an excellent overview of what should be included in Earth Science curricula.

Here is a summary of the nine Big Ideas contained in the Earth Science Literacy document:

1. **Earth scientists use repeatable observations and testable ideas to understand and explain our planet.**
   Scientists learn about Earth using many different methods and techniques in both the laboratory and the field, such as radar, sonar, seismic waves, and magnetic fields.

2. **Earth is 4.6 billion years old.**
   Scientists use measurements of radioactive decay, analysis of rock and sediment structures and properties, an understanding of geologic processes and observations of other objects in the solar system to determine the age of Earth.

3. **Earth is a complex system of interacting rock, water, air, and life.**
   Earth's systems include the atmosphere, biosphere, geosphere and hydrosphere. Energy and matter cycle through these systems, and they are interconnected in a complex manner.

4. **Earth is continuously changing.**
   The geosphere is changed by many factors and processes including plate tectonics, weathering, erosion, and living organisms.

5. **Earth is the water planet.**
   Water is necessary for life, and is an important component of Earth's systems. Less that 3 percent of the surface water is fresh, and less than 1 percent is drinkable.

6. **Life evolves on a dynamic Earth and continuously modifies Earth.**
   Evolution is an ongoing process in which life adapts to changing habitats. Extinctions occur when conditions change more quickly than species can adapt. Living organisms cause changes in Earth's conditions, such as by producing oxygen and fossil fuels.

7. **Humans depend on Earth for resources.**
   Natural resources are limited and unevenly distributed. Water, soil and minerals are essential for agriculture and manufacturing, and oil and gas play a part in many components of modern life. Developing renewable energy resources will contribute to sustainability.

8. **Natural hazards pose risks to humans.**
   Natural hazards including earthquakes, volcanoes, floods, fires, hurricanes and tsunamis influence societies by driving migration and changing the size of populations. Human activity can increase the probability of some natural disasters such as landslides, floods and fires.

9. **Humans significantly alter the Earth.**
   Human activities impact Earth systems by causing climate change, altering land surface and water quality and availability, increasing erosion and causing habitat loss leading to decreased species diversity.

   Using the Big Ideas to shape instruction has been shown to be an effective way to build enduring understanding at the K-12 level. However, the Big Ideas of the ESLI are not meant to replace regional prescribed learning outcomes and while its aims are broader than K-12 education, its results will play an important role in shaping the future of K-12 Earth science education.

Source: http://earthscienceliteracy.org/document.html

INSTRUCTIONAL MODEL USED TO PRESENT THE ACTIVITIES

The 5 **E's** is an instructional model based on the constructivist approach to learning, which operates under the premise that learners build or construct new knowledge over older ideas. This model is an ideal framework for inquiry based learning.

Each of the 5 **E's** describes a phase of learning, and each phase begins with the letter **"E": Engage, Explore, Explain, Elaborate, and Evaluate.** The 5 **E's** allows students and teachers to experience common activities, to use and build on prior knowledge and experience, to construct meaning, and to continually assess their understanding of a concept.

Engage: This phase of the 5 **E's** starts the process. It should involve an activity which will focus student's attention, stimulate their thinking, and access prior knowledge.

Explore: This phase of the 5 **E's** provides students with a common base of experiences. They identify and develop concepts, processes, and skills. During this phase, students actively explore their environment or manipulate materials.

Explain: This phase of the 5 **E's** helps students explain the concepts they have been exploring. They have opportunities to verbalize their conceptual understanding or to demonstrate new skills or behaviors. This phase also provides opportunities for teachers to introduce formal terms, definitions, and explanations for concepts, processes, skills, or behaviors.

Elaborate: This phase of the 5 **E's** extends students' conceptual understanding and allows them to practice skills and behaviors. Through new experiences, students can expand and solidify their thinking and/or apply it to a real-world situation.

Evaluate: This phase of the 5 **E's** encourages learners to assess their understanding and abilities while providing an opportunity for the teacher to assess student performance and/or understandings of concepts, skills, processes, and applications.

Sources: WGBH Boston. (2002). Enhancing Education: The 5 E's. Retrieved from http://enhancinged.wgbh.org/research/eeeee.html
Eisencraft, A. (2003). Expanding the 5-C Model. *The Science Teacher,* 70. National Science Teacher Association.

CONTACT INFORMATION FOR COMPLEMENTARY RESOURCES

If you are interested in placing an order of any products featured in this resource, you may place your order by contacting **Mining Matters.**

Please state, **"Core Concepts order request"** in the subject line of the email/fax.

Telephone (416) 863-6463
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Core Concept	Activity	Task	Evaluation content *new
1.0 Structure of the Earth	**1.1** Tectonic Plates – The Moving Foundations of the Earth's Crust	• Read Information Bulletin (IB) • Look at world map, map of plates • Cut out continents, combine as pangea	• Written **questions:** - Describe plate tectonic theory - Locate two spreading boundaries - Definitions
	1.2 Heat – A Powerful Force in the Earth	• Read IB • Observe and record convection with oil and food colour • Written questions • Layers of Earth • Definitions	• Draw a **diagram** illustrating convection in their daily lives
	1.3 Earthquakes	• KW(L) for earthquakes • Stick slip experiment • Map 16 global events • Read IB • Watch animation on wave propagation and global events • Overlay plate boundary map with event map • Map events over 2 -3 weeks	• ***Exit question*** *index card: What is the most important information about earthquakes that you think someone living in Canada should know?*
	1.4 Volcanoes: The Rumblings Within	• KW(L) for volcanoes • View video of Hawaii • Discuss impact of volcanoes • Map global volcanoes • Read IB • Chart & describe shield, composite, cinder cone • Visit Volcano Virtual Fieldtrips	• *In* ***peer*** *group, complete "L" in KWL chart.* • ***Compare*** *the responses to the volcano chart, identifying and clarifying any differences with reference to the lesson material.* • *Make any* ***amendments*** *necessary.*
	1.5 Folding and Faulting	• Build Play-Doh layers and folds • Build popsicle stick and Play-Doh faults • Read IB	• Compare and contrast **chart** for folding and faulting • **Identifying** folded rocks and mountains in photos
2.0 Rocks and Minerals	**2.1** Mineral Identification	• Learn 8 tests • Apply tests to identify mystery mineral	***Teacher observation of lab skills using rubric*
	2.2 Minerals – The Building Blocks of Rocks	• Observe granite and its components • Learn definition of rock and mineral	• Compare and contrast chart for rocks and minerals • Concluding statement about rocks and minerals
	2.3 The Rock Cycle and the Three Rock Groups	• Observe rock samples and brainstorm formation • Study diagram and IB of rock cycle and three rock groups • Complete labels on their own diagram • Written questions on rock types	**Create analogy or diagram of products, processes and pathways in rock cycle, with given criteria that can be used to assess.*

Core Concept	Activity	Task	Evaluation content *new
	2.4 Rock Strata and Fossils	• Look at dolostone • Discuss dating • Read IB • Complete passage on geological history • From fossil photos, fill in sketch & ages of 8 main types • Written questions on timescale and life forms	**One minute report to panel discussion: what evidence is there that the Earth has changed through time*
	2.5 Rock Classification Challenge	• Review rock cycle diagram from 2.3 • Observe 13 rock samples • Match observations to given properties and ID rocks • Written interpretation questions	**Design an instruction card from someone to tell if a rock is sedimentary, metamorphic or igneous.*
3.0 Soil and Erosion	**3.1** Weathering and Erosion	• 3 Demonstrations: - Freeze thaw with balloon in plaster - Crush chalk in ice - Steel wool oxidise - Complete prediction of results • 2 Activities: - Vinegar and chalk - Pencil line and eraser • Read IB • Match activities to which kind of weathering • Answer written questions	***Design an experiment to test what increases or decreases the amount of one type of weathering.*
	3.2 Soil Formation	• Observe results of demonstration from 3.1 • Record observations next to predictions • Read IB • Explain how each experiment is related to soil formation	**Discuss as plus, minus, interesting points "What if we could stop all erosion?"*
	3.3 Characteristics of Soil	• Investigate: - Components of soil - Water holding capacity - Presence of air - Capillary action	**Chart each soil type and rank for water holding, air content and capillary action.*
	3.4 Types and Uses of Soil	• Read IB • Research soils in their area	Match type of soil to use
	3.5 Importance of Soil Conservation	• Review soil and process of erosion • Observe demonstration of mulch above soil to retain water • Observe demonstration of wind erosion on dry & wet sand, peat mix, and sand with grass • Complete crossword puzzle	**Create a public service announcement convincing people what they can do to reduce soil erosion and why it is important.*

Core Concept	Activity	Task	Evaluation content *new
	3.6 Glaciers and Landforms	• Review weathering and erosion • Observe ice abrasion • Read IB on glaciers & answer questions • Research glacial features • Complete two concept overview charts	**Concept definition charts for two glacial landforms*
4.0 Mining Cycle	**4.1** Mine Types and Technology	• View posters • Read IB • Compare and contrast discussion underground & surface mines • View Command for Underground • View Ground Rules	***Pros/cons grid for surface and underground mining*
	4.2 Reclamation and Rehabilitation	• Brainstorm impact of mines • Look at before and after photos • Read rehabilitation brochures • Create rehabilitation plan for local mine/quarry	**Self-evaluation responses of their presentation*
	4.3 The Mine Discovery Process	• 1 in 100 demonstration • Read IB • Answer written questions on IB • Watch careers video. • Research career of choice	**Sticky note response: what are the most important ideas related to the mine discovery process?*
	4.4 Recycle and Reuse	• Read IB • Write song, poem, anagram, etc about recycling • Survey community about recycling activities	**Design an evaluation tool*
5.0 Social and Environmental Responsibility	**5.1** Operating a Surface Mine	• Read IB • Look at surface mine poster • Model surface mine: draw, extract, reclaim • Questions on impact of mining model	*Before/after Photo interpretation: write 3 things done*
	5.2 Wakima – A Case Study	• Look at town map • Read IB • Written questions	**Vote with your body: how would you feel if a mine operation were proposed close to where you live?*
	5.3 Wakima – Research and Roles	• Role play to develop opinion and strategy towards mine proposal • Present point of view in role • Prepare solutions to issues raised	*(*Carried over into 5.4)*
	5.4 Wakima – Debate and Decision	**Plan debate presentation based on evaluation criteria* • Classroom debate with presentations from each role group • Individuals vote yes/no for mine	• Teacher assessment of debate performance based on given criteria

Interpret data	• 1.5 (photo) • 4.1 mine types pros and cons • 5.1 (photo) reclamation
Design an experiment	• 3.1 weathering and erosion
Questions on lab done	• 3.3 soil characteristics
Ongoing diagnostic process through 5E cycle	
Rubric	• 2.1 mineral testing
Teacher observation of performance	• 2.1 mineral testing • 5.4 Wakima debate
Student interview	
Portfolio	
Problem based learning product	• 5.1 reclamation photos to interpret
Video segment	
Journal	
Drawing	• 1.2 convection in life (record) • 2.3 rock cycle diagram (devise)
Performance task	• 1.5 interpret photos, label model • 3.5 public service announcement
What do you think about …	
Why do you think …?	
What evidence do you have ..?	• 2.4. evidence that the Earth has changed throughout time
What do you know about the problem ..?	
What is the most important ….	• 4.3 …. Ideas related to discovering a mine?
How would you decide about …	
What criteria would you use to assess …?	
How is …. a good model for this concept?	
Writing	
Test	
Exit questions (quick)	• 1.3 earthquake info
Respond to analogy	
Explain in own words	
Explain similarities and differences between analogy and target	
Detail limitations of analogies & models	
Create analogy or model following given rubric	• 2.3 rock cycle: analogy or diagram
Debate	• 3.2 soil formation: debate what if we could stop all weathering? • 5.4 Wakima mine
Make a [booklet] to convince others Write letter	• 2.5 rock type instructions • 3.5 public service announcment
Find other examples of ….	
What would you tell …. About this?	• 1.3 earthquakes
Explain …	

Panel discussion	• 2.4 evidence that the Earth has changed throughout time
Present your view	• 5.2 Wakima town map
Poster	
Record most confusing point	
Index card	
minute paper	• 2.4 rock strata evidence of change
Clicker question	
Brainstorm new investigations	
Compare personal ideas to given theory/articles	
Evaluate own progress and peers	• 1.4 volcano chart
Develop a scoring tool or rubric	• 4.4 recycle poem/song evaluation (done before they write)
Design a question that needs evaluate phase	
Self evaluation	• 4.2 rehabilitation plan
Peer review	• 1.4 volcano chart
Make a presentation	• 4.2 rehabilitation plan
Discuss conclusions with evidence	
Compare and contrast graphic organizer	• 1.5 Folding and faulting • 2.2 Rocks and minerals
Concept definition graphic organizer	• 3.6 glacial features

Mining Matters is a charitable organization dedicated to bringing knowledge and awareness about Canada's geology and mineral resources to students, educators and the general public.

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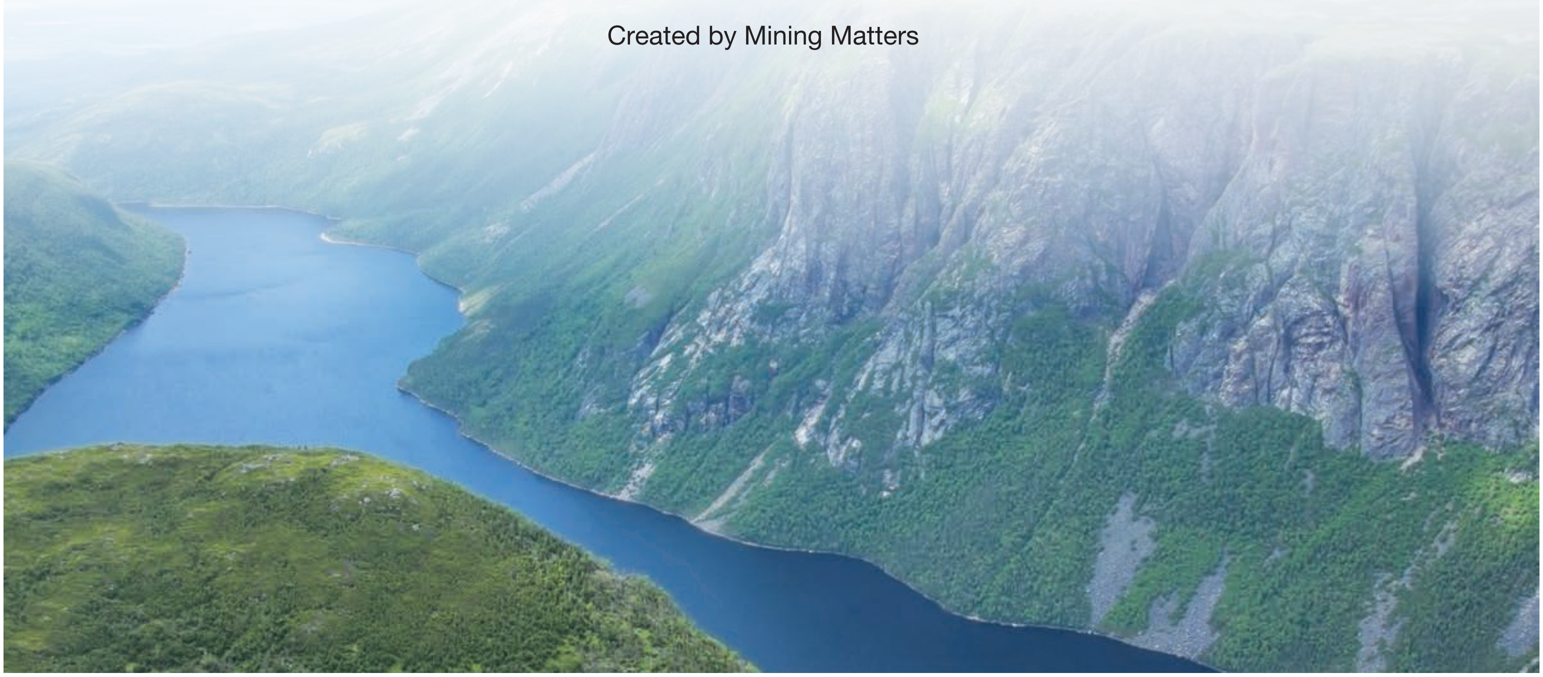

Structure of the Earth

Did you know that there are complementary and additional resources that will facilitate with the delivery of this topic? Please contact Mining Matters and we'd be happy to assist. Be sure to state, "Core Concepts order request" in the subject line of the email and/or the fax cover sheet.

Mining Matters:
T: (416) 863-6463
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TABLE OF CONTENTS

MATERIALS

- World map
- Craft knife
- Pens and pencils
- Figure: *Tectonic Plates* (Displayed on available classroom projection technology)
- Handout: *Diagram of Tectonic Plates*
- Handout: *Diagram of Tectonic Plates – The Moving Foundation of the Earth's Surface*
- Handout: *Tectonic Plates – The Moving Foundation of the Earth's Surface Information Bulletin*
- Handout: T*ectonic Plates – The Moving Foundation of the Earth's Surface Activity*
- Optional online book: *ROCK Ontario book*

  Available Here!
  http://www.mndm.gov.on.ca/en/mines-and-minerals/geology

Consumables:

- Thick Cardboard (side of an old cardboard box)
- Tracing paper

SUMMARY OF TASK

Students will:

- Understand and be able to describe the processes involved in mountain formation and in the folding and faulting of the Earth's surface.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 1	Earth scientists use repeatable observations and testable ideas to understand and explain our planet.
BIG IDEA 3	Earth is a complex system of interacting rock, water, air, and life.
BIG IDEA 4	Earth is continuously changing.

OBJECTIVES

1. Participate in teacher-led discussion about plate tectonics based on the Information Bulletin.
2. Answer questions based on a sight passage.

INSTRUCTIONS

Engage

1. Distribute and review the handout: *Tectonic Plates – The Moving Foundation of the Earth's Surface Information Bulletin.*

Explore

2. Have students examine the world map and examine how the continents could have once fit together.

Explain

3. Distribute the handouts: *Diagram of Tectonic Plates – The Moving Foundation of the Earth's Surface* and *Diagram of Tectonic Plates* and discuss student observations.
4. Display the figure: *Diagram of Tectonic Plates.*

Elaborate

5. Have students copy a map of the world onto tracing paper with a red pen. Then turn the paper over and rub the pencil firmly back and forth across the back of the red line.
6. Turn the tracing paper back onto the right side and place it on the piece of thick cardboard.
7. Draw over the outline of the world map again, pressing down firmly. The pencil on the back of the right side of the tracing paper will transfer onto the cardboard.
8. CAREFULLY, using the craft knife, cut around the continents.
9. Using the continental jigsaw pieces, arrange the continents so that they fit together as a single land mass (i.e. create Pangea).

Evaluate

10. Have students answer the questions on the handout: The Moving Foundation of the Earth's Surface Activity.

    To further student learning and inquiry, encourage students to visit, The Dynamic Earth: The story of plate tectonics, http://pubs.usgs.gov/gip/dynamic/dynamic.html

SUPPORTING INFORMATION

Key Words:

Basic Terms: Pangea, continental drift, convection, plate tectonics, hot spot, Mid-Atlantic ridge, divergent, hypothesis, convergent

Secondary Terms: paleontologists, meteorologists, geologists, subduction zone

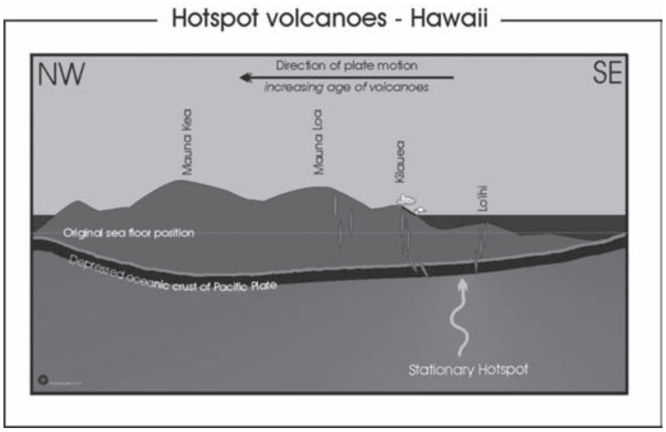
SAFETY

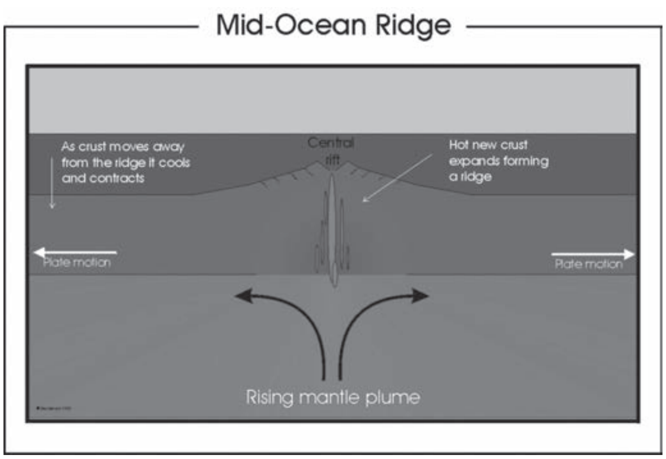
- When using a craft knife always cut away from you and hold the cardboard firmly. Make sure you are using a sharp knife.

Source: http://pubs.usgs.gov/publications/text/dynamic.html - US Geological Survey. This site provides a very comprehensive and excellent source of information and diagrams regarding the theory of plate tectonics.

THE MOVING FOUNDATION OF THE EARTH'S SURFACE

When we look at a map of the world or a globe we can see that the Earth has seven continents. However, when we look more closely we can see that the eastern coastline of South America and the western coastline of Africa fit together like pieces of a jigsaw puzzle – if the Atlantic Ocean were removed and the continents were put together. There are other matching outlines where Canada would piece together with Greenland if the Atlantic Ocean did not separate them. Is it possible that at one time the continents were actually a single land mass with no oceans between them?



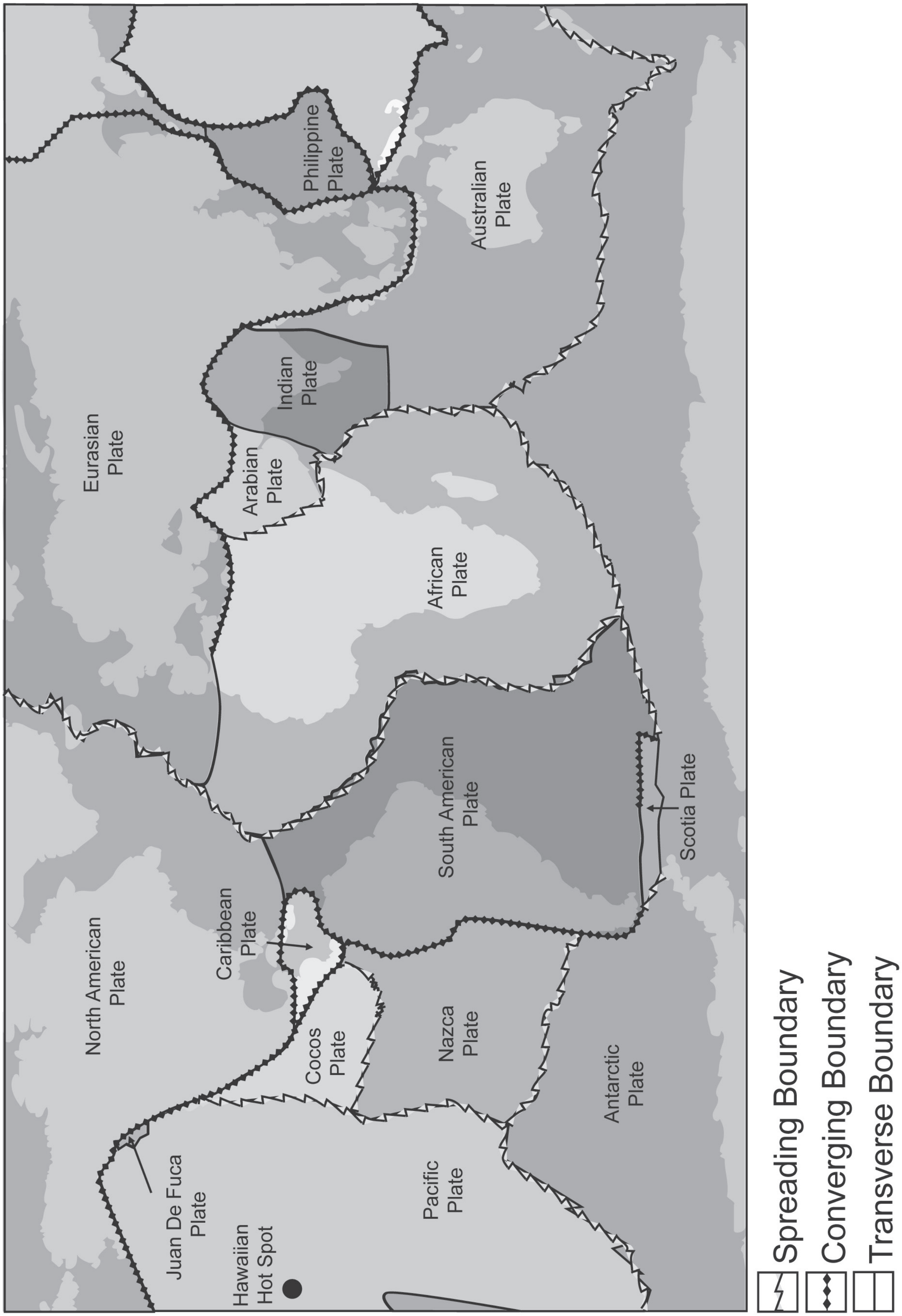


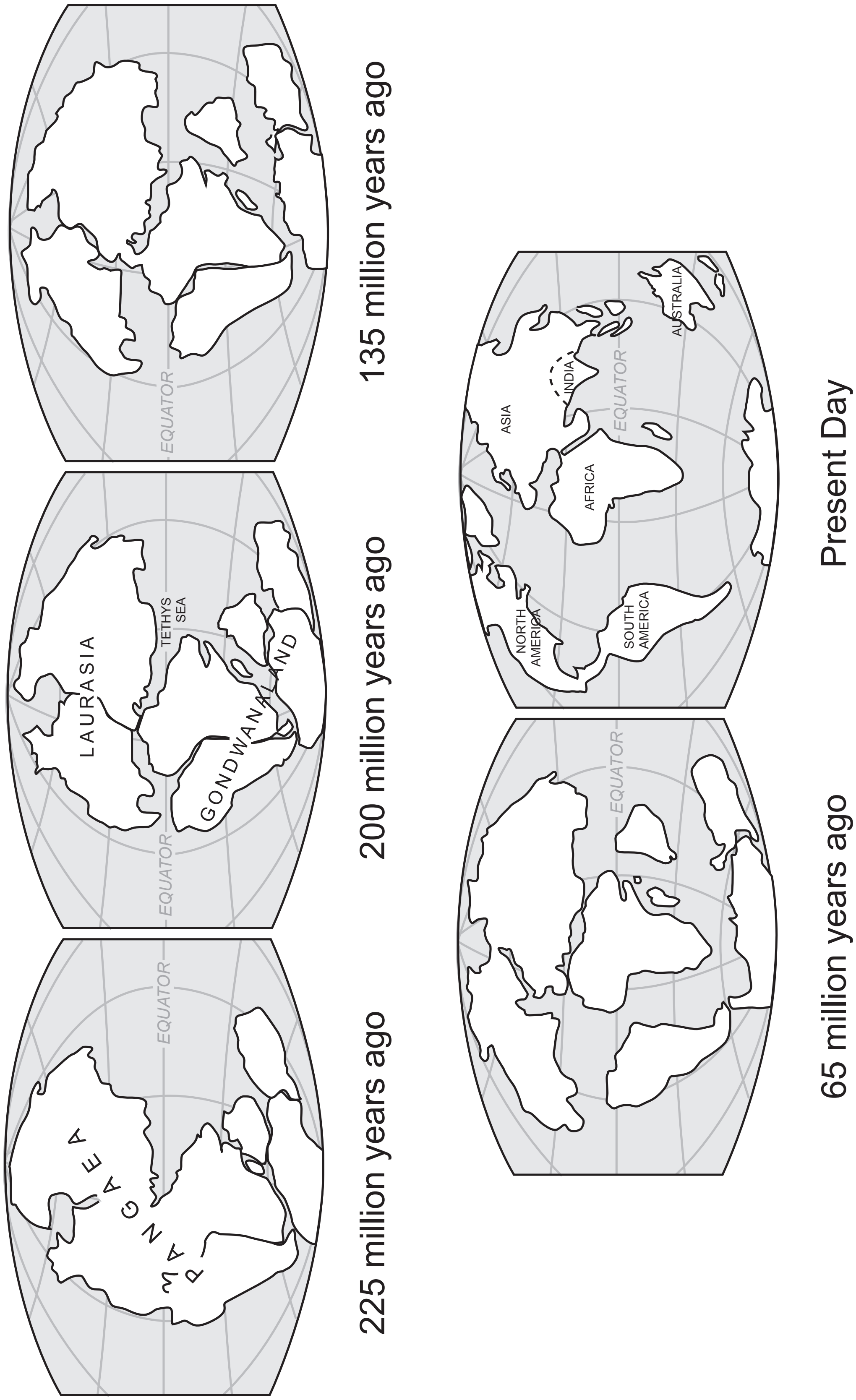
Alfred Wegener, a German *meteorologist*, believed that the continents fit together in the past. *Paleontologists* found the same type of fossils in both South America and Africa, and guessed that the continents were once connected. Wegener had always wondered about the jigsaw-puzzle fit of the continents and this together with the paleontologist's findings led him to come up with a **hypothesis** or scientific idea called **continental drift**. Wegener's theory proposed that at one time all of the continents had been united – a supercontinent – which he named **Pangaea** – and that about 200 million years ago it had begun to break into individual pieces, or continents, slowly moving into their present position, the gaps between the continents becoming oceans.

In 1928, a British *geologist* named Arthur Holmes published an article that discussed a force that could explain how the continents were driven apart. Holmes proposed the presence of thermal **convection** currents, or currents of heat, in the interior of the Earth. According to Holmes, these currents rose from the interior of the Earth to the base of the continents, stretching and breaking the continental masses apart.

In 1963, the idea of continental drift was further developed into the concept of **plate tectonics** by Canadian Earth scientist Tuzo Wilson who taught at the University of Toronto and was the director of the Ontario Science Centre until his death in 1993. His main contribution to the theory of plate tectonics was the recognition of hot spots in the mantle. The chain of Hawaiian islands formed a **hot spot** in the Pacific ocean. Wilson's idea is regarded as one of the main advancements in thinking about how the Earth works.

The Earth's surface is divided into about 10 rigid sections, called **tectonic plates**. Convection forces move the plates relative to each other. As the plates move, their boundaries behave in two general ways – **divergent** (spreading) and **convergent** (colliding). New rock is generated at divergent plate boundaries as the plates pull apart. An example of this is the **Mid-Atlantic ridge** in the middle of the Atlantic ocean floor which behaves like two giant conveyor belts slowly moving in opposite directions as they transport newly formed oceanic plate away from the ridge crest at about 3 cm per year. The size of the Earth has not changed implying that the tectonic plate must be destroyed at about the same rate as it is being created. Such destruction (recycling) of rock takes place along convergent plate boundaries where plates are moving toward each other, and sometimes one plate sinks under another. The location where sinking of a plate occurs is called a *subduction zone*. Volcanoes are often located on the surface of the Earth above a subduction zone. Other times when plates collide they crumple up along their edges, creating mountains. An example of a convergent plate boundary is along the west coast of Canada where the Pacific plate is sliding under the North American plate.


Eurasian Plate
Philippine Plate
Australian Plate
Indian Plate
Arabian Plate
African Plate
South American Plate
Scotia Plate
North American Plate
Caribbean Plate
Cocos Plate
Nazca Plate
Antarctic Plate
Juan De Fuca Plate
Pacific Plate
Hawaiian Hot Spot
Spreading Boundary
Converging Boundary
Transverse Boundary


135 million years ago
EQUATOR
200 million years ago
LAURASIA
TETHYS SEA
GONDWANALAND
EQUATOR
225 million years ago
PANGAEA
EQUATOR
Present Day
ASIA
INDIA
EQUATOR
AUSTRALIA
AFRICA
NORTH AMERICA
SOUTH AMERICA
65 million years ago
EQUATOR

1 ACTIVITY QUESTIONS

1. In a short paragraph (4-6 complete sentences) describe the development of the Plate Tectonic theory from its origins in the hypothesis of Continental Drift.

2. What is a spreading boundary? Describe the location of two examples of this type of boundary.

3. Define in complete sentences:

Pangaea

continental drift

tectonic plates

subduction zone

4. What two land masses did Pangaea break-up into and how many years ago was it?

2 HEAT – A POWERFUL FORCE IN THE EARTH

MATERIALS

- Shallow clear heat proof dish
  – approximately 23 cm x 23 cm (9” x 9”)
- Wooden blocks (2) - 20 cm long pieces measuring, 5 cm x 10 cm (8” long, measuring 2” x 4”)
- Eye dropper
- Globe or world map
- Handout: *Heat – A Powerful Force In the Earth Information Bulletin*
- Handout: *Heat – A Powerful Force In the Earth Activity*

Consumables:
- Cooking oil
- Food colouring
- Votive candle

SUMMARY OF TASK

Students will:
- Understand and be able to describe the processes involved in convection currents.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 4 Earth is continuously changing.

OBJECTIVES

1. Participate in Teacher led discussion about the Earth’s formation.
2. View and explain convection experiment.

INSTRUCTIONS

Engage

1. Engage students in an introductory discussion of plate tectonics by looking at the globe and how the continents appear to ‘fit’ together. Have students think about how this movement could occur.
2. Run the Convection Experiment and have students take notes.
   a. Place two wooden blocks on a level surface, a little less than the width of the dish. Put a votive candle between them and light it.
   b. Half-fill a heatproof dish with cooking oil. Position it firmly on the blocks. Fill an eyedropper with food dye. Place the eyedropper in the oil, near the bottom of the dish. Squeeze a little food dye from the dropper into the bottom of the dish.
   c. As the oil at the bottom of the dish heats, it will rise, carrying the food dye to the surface. Once at the surface, the food colouring is forced to spread out as the currents keep pushing up from below. As the blobs cool, they get heavier and sink back down to rejoin the pool of food colouring on the bottom. *Source: John Farndon’s How the Earth Works (1992).*

Explore

3. Distribute and review the handout: *Heat – A Powerful Force In the Earth Information Bulletin.*

Explain

4. Discuss student observations and knowledge from the Information Bulletin as a group.

Elaborate

5. Once all the observations have been noted, have students complete handout: *Heat – A Powerful Force In the Earth Activity.*

Evaluate

6. Ask students to research and draw a labelled diagram illustrating an example of convection observed in their daily lives.

SUPPORTING INFORMATION

Key Words:

Basic Terms: inner core, outer core, mantle, lower mantle, upper mantle, transition zone, lithosphere, asthenosphere, convection, lava, magma, tectonic plates, fault, crust

Secondary Terms: convection current, conduction, geothermal, gradient

SAFETY

- The convection demonstration with the wooden blocks and heatproof dish must be performed on a very steady and level surface. It must also be remembered that this demonstration involves heated oil and a lit candle – and CAUTION must be used. REMEMBER – the oil must only be heated – it should under no circumstances be allowed to boil – it is to ensure this, that the heating source used is small – do not substitute another heating source for the votive candle.

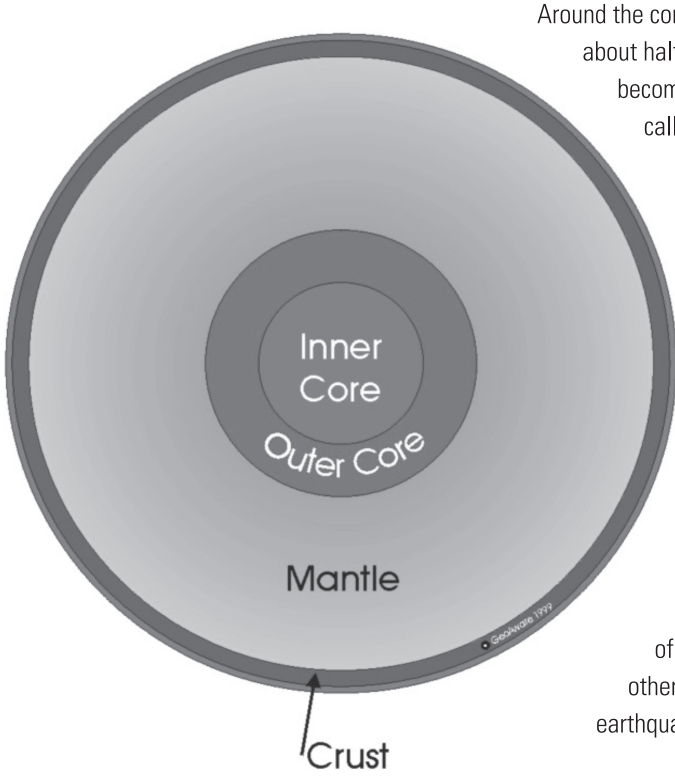
HEAT – A POWERFUL FORCE IN THE EARTH

If you were to go deeper and deeper down into the Earth, it gets hotter and hotter. You can see how hot the interior of the Earth is when you watch videos of volcanic eruptions around the world – such as in Hawaii or Mount Etna in Sicily, Italy. Red-hot molten rock from inside the Earth erupts out of the Volcano. The tremendous heat inside the Earth melts the rock. We call molten rock **magma**. When magma emerges on the surface during a volcanic eruption it is called **lava**.

You may think the Earth beneath your feet is solid and unchanging. In fact, it is constantly moving. Just as water and air rise when heated, magma rises too. The enormous temperature in the Earth's interior melts and mixes the magma, driving it upwards. The hot magma cools as it rises toward the Earth's surface. As it cools, it becomes denser and eventually sinks back down again deeper into the Earth. This circular flow of magma is known as **convection**. We can see convection in everyday life when a liquid is heated. However, unlike heating water, the convection in the Earth is very slow because the rock and magma are very dense.

The Earth is made up of different layers which each play a different role in this convection. The centre of the Earth is approximately 6400 km below the surface. At the centre is the **inner core**, a mass of iron with a temperature of 3870°C. Although such temperatures would normally melt iron, immense pressure on it keeps it in a solid state. The inner core is approximately 2400 km in diameter.

Next is the **outer core**, a layer about 2200 km thick surrounding the solid inner core. It is slightly cooler than the inner core, yet still hot enough to keep the iron it is made of molten.



Around the core is the **mantle**, a rock layer about 2850 km thick that reaches about half the distance to the centre of the Earth. Parts of this layer become hot enough to liquefy and become slow moving molten rock called magma.

The outside layer of the Earth is the **crust**, a layer of rock varying from 12 km thick under the oceans to 100 km thick under mountains. The rocks and minerals we are familiar with on the surface are unique to the crust, which has a different chemistry to the mantle.

When scientists look at convection in the Earth, they see that the outer layer is very rigid. This rigid layer is about 100 km thick and is the crust and the top of the upper mantle. Called the **lithosphere**, it is this layer that has broken and cracked making the tectonic plates. Convection in the mantle causes these tectonic plates to move sideways over the surface of the Earth. Sometimes the tectonic plates collide into each other, crumpling and folding and forming mountains, volcanoes and earthquakes, all evidence of the active, changing Earth.

2 ACTIVITY QUESTIONS

1. Record your observations during the convection experiment. Draw and label a picture showing the movement of the food colouring when heated.

   Title:

2. What is the movement of the heated liquid called? Describe the process.

3. In a brief paragraph, explain how convection affects the Earth's tectonic plates.

4. List the layers of the Earth starting from the centre.

5. What causes the constant movement in the Earth's mantle? Why can't we feel this movement?

6. Write definitions for the following terms.

inner core

outer core

mantle

lithosphere

magma

lava

convection

3 EARTHQUAKES

MATERIALS

- Figure: *Tectonic plates with Earthquake overlay* (Displayed on available classroom projection technology)
- Folded Rock Photos from the CD
- Handout: *KWL Chart*
- Handout: *1.3A Earthquakes Information Bulletin*
- Handout: *Earthquakes Activity*
- Handout: *Map of the world*
- 80 grit sandpaper – 28 cm x 23 cm ~11″ x 9″ (2/ group)
- A block of wood – 28 cm x 5 cm x 11 cm ~ 11″ x 2″ x 4″ (1/ group)
- Rubber bands (2/group)
- Tack (1/group)
- Ruler or measuring tape

Consumables:

- Masking tape
- Coloured pencils

SUMMARY OF TASK

Students will:

- Explain the causes of natural events that occur on or near the Earth's surface (e.g. earthquakes).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4 Earth is continuously changing.

BIG IDEA 8 Natural hazards pose risks to humans.

OBJECTIVES

1. Demonstrate through the use of mapping techniques that earthquakes occur along the boundaries of the Earth's tectonic plates.
2. Investigate the relationship between earthquakes and tectonic plates.
3. Describe the process that causes earth displacement and earthquakes.
4. Participate in an experiment/demonstration of energy release.

INSTRUCTIONS

Engage

1. Introduce the topic of earthquakes through the use of a Know-Wonder-Learned (KWL) Chart graphic organiser.
2. Ask students what they already know about earthquakes, then write questions about what they wonder (or want to learn) about earthquakes.

Explore

3. Students carry out Earthquakes Activity A: Model of an Earthquake, an experiment that provides a clear visual of how the concepts of displacement, **seismic activity**, **friction** and **elastic** energy work together to cause earthquakes.
4. Students will take notes including materials used, the process and the result using the proper scientific method procedures.
5. Students carry out Earthquakes Activity B: Mapping Earthquakes.

Explain

6. Students complete the final column of their handout: *KWL Chart,* describing the motion of the wooden block during the experiment, and relating it to movement on plate boundaries that causes earthquakes, using handouts: *Earthquakes Information Bulletins 1.3A and 1.3B*

Elaborate

7. Students answer the questions on handout: *Earthquakes Activity* using the information that they plotted on the map and the map of tectonic plate boundaries.
8. As a class, review the information contained in the first paragraph of handout: *Earthquakes Information Bulletin.*

9. Visit the online animation “This Dynamic Planet” from the Smithsonian Institute Global Volcanism Program http://volcano.si.edu/learn_dynamicplanet.cfm.
10. Use the Figure: Tectonic Plates with Earthquake overlay to summarize how most of the Earth’s seismic activity happens along plate boundaries.
11. Have students monitor the news reports for earthquakes around the world for a period of time (2-3 weeks) then place these occurrences on the world map (by magnitude and date). Alternately students can collect that data for the same time period using the IRIS Seismology in Schools website https://www.iris.edu/hq/sis.

Evaluate

12. At the end of the session, provide each student with an index card and have them complete a response to the Exit Question: What is the most important information about earthquakes that you think someone living in Canada should know? Use their responses to measure understanding of the concepts presented.

SUPPORTING INFORMATION

The Activity provides a model of how the two sides of a fault stick together when pushed. The stored energy builds up along the fault until the pushing force exceeds the frictional force between the two pieces of rock. There is a sudden release of energy, resulting in the two plates slipping past each other.

Key Words:

Basic Terms: subduction zones, seismic activity, displacement, fault line, earthquake, friction, elastic, focus, epicentre, body waves, primary wave, secondary wave, magnitude

Secondary Terms: collision, brittle, Richter scale, seismic, seisometer, seismic wave

SAFETY

- Have students keep track of the tacks that are provided and return them at the end of the lesson.
- Elastic bands should only be used as described in activity instructions.

3 KWL CHART

Topic: ______________________________

What I Know	What I Wonder	What I Learned

EARTHQUAKES

Think about how you might spend an ordinary day at home. Maybe, you're watching TV, reading a book or having some lunch. All of a sudden, things start to shake, dishes fall out of the cupboards, furniture topples over, the light from the ceiling crashes to the floor. It's an earthquake! The noise is tremendous. Suddenly, it's over. You look around at the damage and begin to wonder what happened?

The surface of the Earth consists of tectonic plates. These plates slide by each other along boundaries. The plates move past each other very slowly and steadily, perhaps moving only a couple of centimetres a year. However, some sections of the plates stick at certain points and are unable to move past each other. Resistance between the two stuck sections of the plates increases and energy builds up.

Although rocks appear to be solid and unbreakable, they are actually very flexible and can store energy much like a rubber band and release this energy in a sudden motion. Eventually, this energy is released and causes **displacement**. This means that there has been a movement in the Earth. A direct result of displacement is an earthquake. An **earthquake** is sudden shaking that has been caused by movement or volcanic activity within the Earth.

When earthquakes happen, the release of energy can be tremendous. Earthquakes vary in size and level of destructive force. Some events happen without being felt, while others continue for a number of seconds, with many aftershocks and affect a large area. Earthquakes occur in a number of areas around the world, including those that sit on top of tectonic boundaries. Many of these areas are heavily populated so understanding how an earthquake happens is important to those who study and attempt to reduce damage from these events, as well as to those who live with the possibility of experiencing an earthquake. Earthquakes can be very serious seismic events. These dramatic natural events are excellent examples of the dynamic and powerful nature of the Earth's crust.

Sources:

http://www.earthquakescanada.nrcan.gc.ca/index-eng.php
An excellent site for Canadian earthquake information and links to other sites.

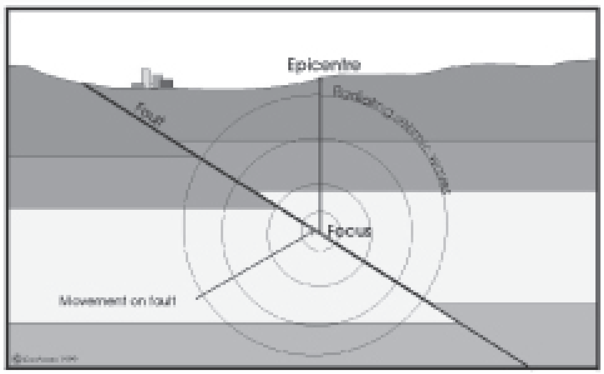
http://www.discoveryeducation.com//teachers/
Lesson plans about earthquakes and related subjects.

(Be advised, you may need to create an account with Discovery Education to have full access)

3b INFORMATION BULLETIN

EARTHQUAKES - TERMINOLOGY AND TECHNOLOGY

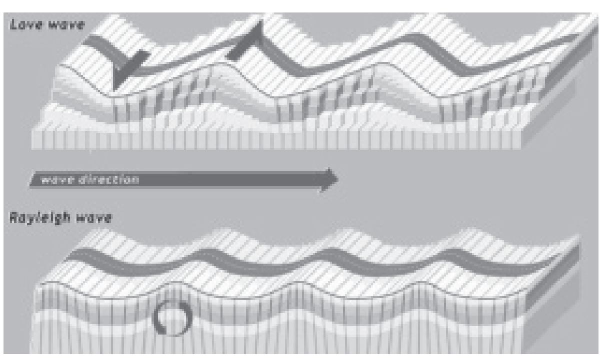
An earthquake occurs when there has been a release of stored energy within the earth's crust. Earthquakes take place along fault lines and when they happen they trigger a number of events. To understand these events and the accompanying results some terms need to be understood.



When an earthquake occurs there is a point at which a break or rupture begins deep inside the earth, this is called the **focus** of the earthquake. When the stored energy along the fault line is released, it spreads out from the focus like a wave. The shaking movement that occurs during an earthquake results from the passage of the waves that move through the earth from the focus.

When the waves move deep inside the earth they are known as **body waves**. The first type of wave is the fast moving P-wave or **primary wave**. These waves are commonly referred to as Push-Pull waves. Imagine a stretched Slinky lying on the ground. Hold one end in place and pull and push the other end of the Slinky in and out like an accordion. The waves that travel up and down the Slinky act like P-waves. The second type of wave is the S-wave or **secondary wave**, which travel more slowly but are more powerful and destructive. These waves shake the ground back and forth perpendicular to the direction in which the wave is moving. Picture the up and down hills of a roller coaster.

There are also two types of waves that occur at the surface of the earth. The first type of wave is the Rayleigh wave, which move the surface of the earth around in a circle, forward and down then back and up. This is the same as the motion in an ocean wave. The second type of wave is the Love wave, which moves in a circular fashion such as when you rub lotion on your skin. This shakes the surface of the earth side to side. These waves move more slowly than P-waves or S-waves but are more destructive, especially Love waves, which are often responsible for the collapse of buildings during an earthquake.



In order to better understand how earthquakes work, instruments to measure earthquakes have been developed. A *seismometer* measures the shaking caused by an earthquake by recording the ground movements. The *Richter scale*, which was developed by Dr. Charles Richter, is used to compare the *magnitude* of earthquakes. The magnitude is calculated by using several seismometers to measure the maximum amplitude of the waves and applying corrections for distance to the **epicentre**, which is the location on the surface of the earth directly above the focus of the earthquake. The Richter scale is open-ended, with common values in the range 1 to 9, but the scale is not even. Each number is 10 times as powerful as the last. For example, a magnitude 6 earthquake is 10 times greater than a magnitude 5 earthquake. It is important to understand that the Richter scale measures the magnitude of shaking, not the total energy released. A one point increase in the Richter scale value equals approximately a 32 times increase in the earthquakes energy.

RICHTER SCALE MAGNITUDE AND TYPE OF DAMAGE
Value: Type of Damage

1 - 2:	Movement recorded on local seismometers, but generally not felt.
3 - 4:	Often felt, but generally no damage.
5:	Felt widely with slight damage near the epicentre.
6:	Damage to poorly constructed buildings/structures within 10 km of the epicentre.
7:	Major earthquake; causes serious damage up to 100 km from the epicentre.
8:	Great earthquake; causes great destruction and loss of life over several 100 km.
9:	Rare great earthquake; causes major damage over a large region of 1000 km.

Sources:
http://www.earthquakescanada.nrcan.gc.ca/index-en.php
Up to date information on Canadian earthquakes and related events.

A. Model of an Earthquake

MATERIALS
- 2 pieces of 80 grit sandpaper - 28 cm x 23 cm sheet (11" x 9")
- A block of wood approximately 28 cm piece of 5 cm x 10 cm (11" piece of 2x4)
- 2 rubber bands (1 thick and 1 thin)
- A tack
- Masking tape
- Metre stick or measuring tape
- Information Bulletin – Earthquakes
- KWL Chart

PROCEDURE:

1. Attach one piece of 80 grit sandpaper to the top of a desk with the rough side facing up. Use masking tape to secure the edges of the sandpaper to the desk. Place the ruler or measuring tape alongside the sandpaper.
2. Wrap the other piece of 80 grit sandpaper (rough side out) around the sides of the wooden block. Use the thick elastic band to secure the sandpaper around the sides
3. Push a tack into one end (not the top and bottom) of the wood and tie the thin elastic band to the tack.
4. Place the sandpaper covered wooden block at one end of the sandpaper attached to the desk.
5. Slowly pull on the wooden block with the elastic band measuring the length of the elastic in 1 cm intervals.

   Notice how the force of your pulling builds up in the elastic band causing it to stretch while the block remains in place. The elastic continues to stretch until the force exceeds the friction between the two pieces of sandpaper and the wooden block moves in a sudden jerking motion.
6. Record the stretch length at which the block moves and measure the displacement that occurs between the block and the sandpaper.
7. Repeat several times and compile data.
8. Read Earthquakes - Information Bulletins 1.3a amd 1.3b. On the final column of your KWL Chart then complete the third column stating what you learned about the contribution of the movement of the tectonic plates to earthquake occurrence.

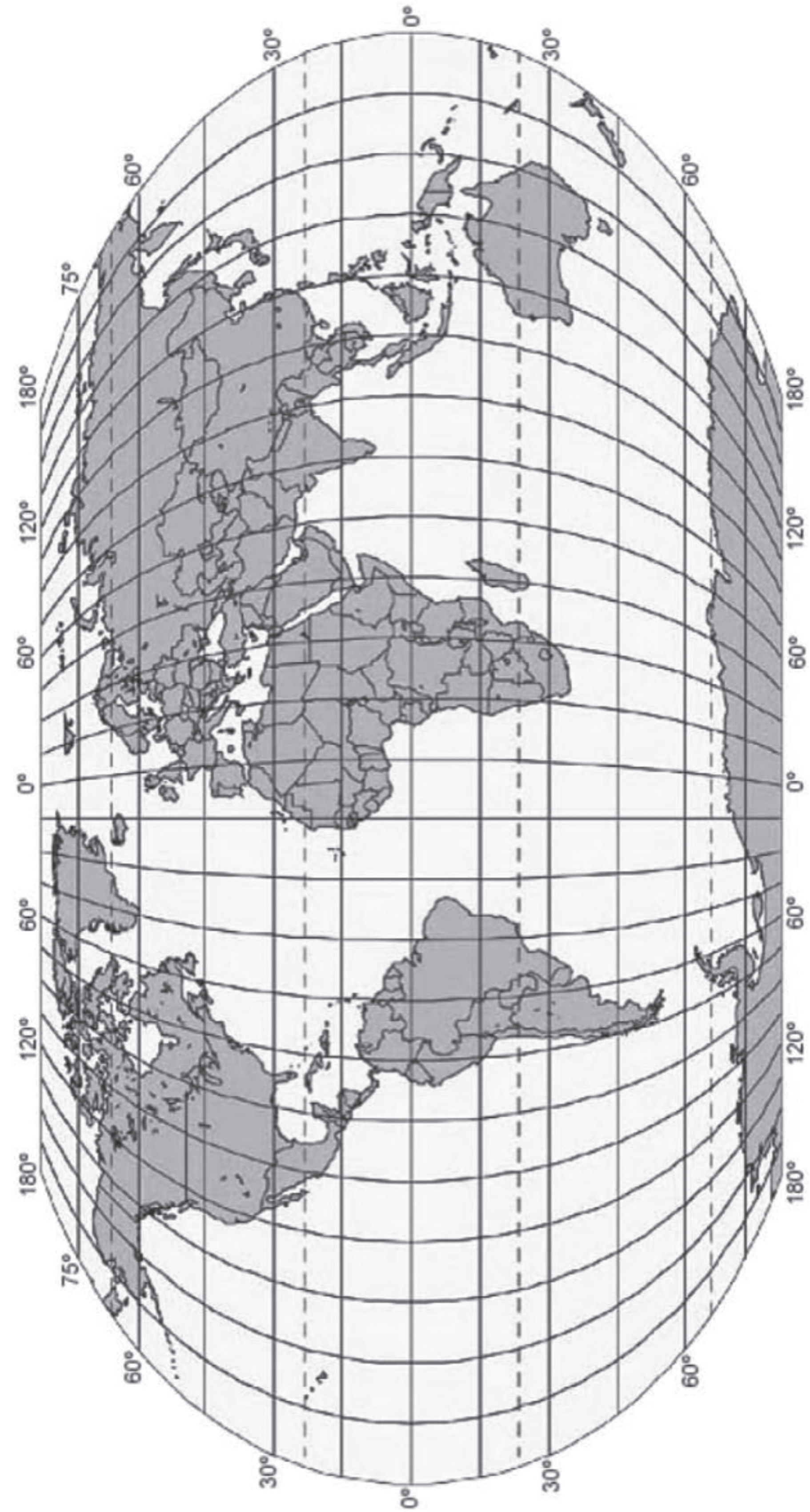
B. Mapping Earthquakes

MATERIALS
- Map of the world
- Table of major earthquakes
- Colored pencils
- Map of the Tectonic Plates (from lesson on Tectonic Plates)

PROCEDURE:

1. On the map of the world, and using the data table provided, find the location of the earthquakes.
2. With a colored pencil, mark a star on the map at the location of all 16 earthquakes. Remember that longitude marked is across the top and latitude is marked along the side of the map.
3. Based on your map of earthquakes and the map of tectonic plates, answer the following:
   a. Where are most of the major earthquakes in relationship to the tectonic plates?
   b. Are there any major earthquakes not located on the edge of a tectonic plate?

EARTHQUAKES	LOCATION	LONGITUDE	LATITUDE
1	China	110E	35N
2	India	88E	22N
3	Pakistan	65E	25N
4	Syria	36E	34N
5	Italy	16E	38N
6	Portugal	9W	38N
7	Chile	72W	33S
8	Chile	75W	50S
9	Equador	78W	0
10	Nicaragua	85W	13N
11	Guatemala	91W	15N
12	California	118W	34N
13	California	122W	37N
14	Alaska	150W	61N
15	Japan	139E	36N
16	Japan	143E	43N


0°
30°
30°
60°
60°
75°
180°
180°
120°
120°
60°
60°
0°
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60°
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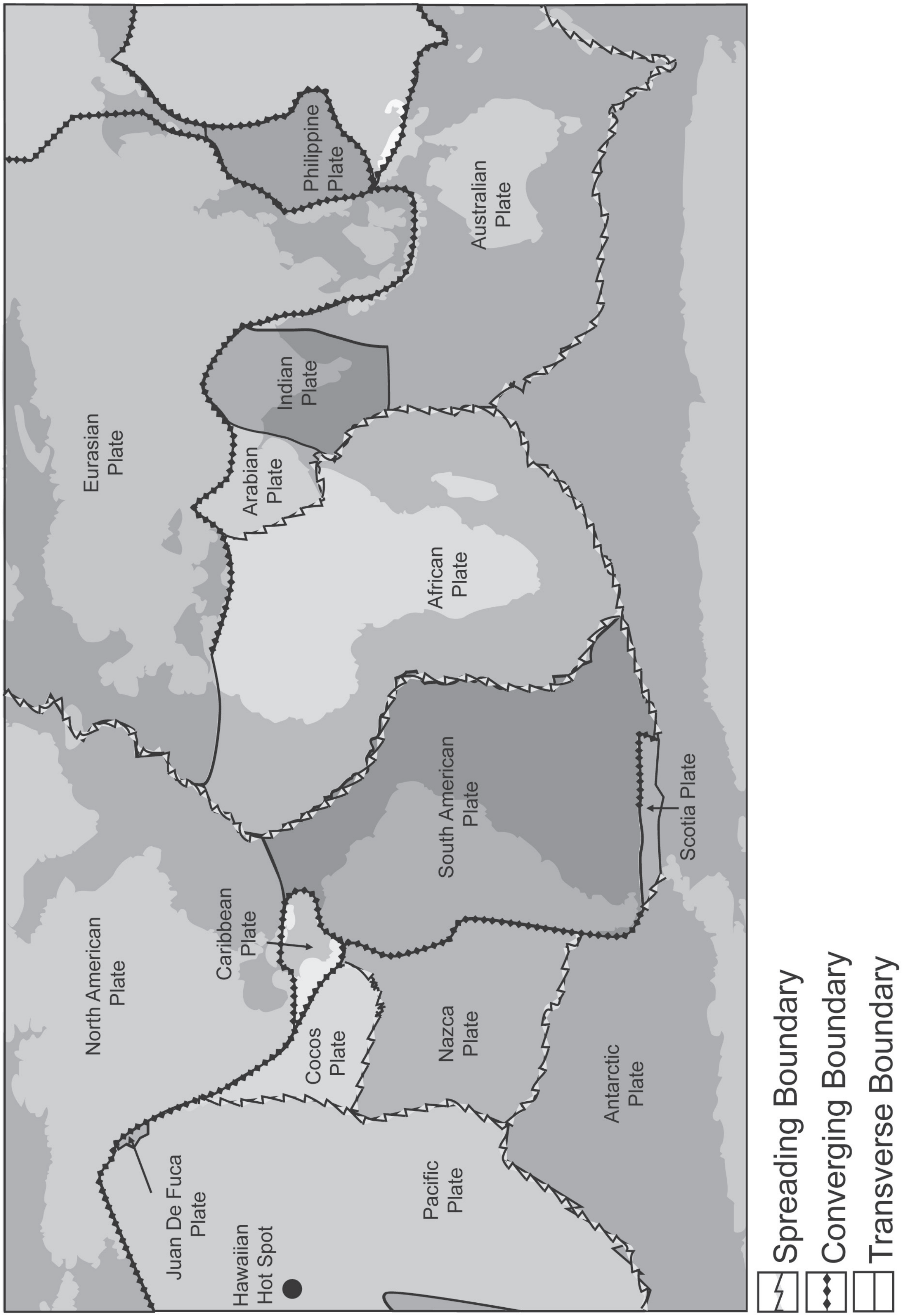
30°
30°
0°

Print overlay on on acetate (transparent film)


Philippine Plate
Australian Plate
Indian Plate
Eurasian Plate
Arabian Plate
African Plate
South American Plate
Scotia Plate
North American Plate
Caribbean Plate
Cocos Plate
Nazca Plate
Antarctic Plate
Juan De Fuca Plate
Pacific Plate
Hawaiian Hot Spot
Spreading Boundary
Converging Boundary
Transverse Boundary

4 VOLCANOES – THE RUMBLINGS WITHIN

MATERIALS

- Figure: *Tectonic plates with overlay Areas of Volcanic Activity* (Displayed on available classroom projection technology)
- *Violent Hawaii Full Documentary* Available here: https://www.youtube.com/watch?v=n_IUIW8--Ak
- Handout: *KWL Chart*
- Handout: *The Rumbling Within Information Bulletin*
- Handout: *The Rumbling Within Activity A*
- Handout: *The Rumbling Within Activity B*

SUMMARY OF TASK

Students will:

- Explain the causes of natural events that occur on or near the Earth's surface (e.g. volcanic eruptions).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4 Earth is continuously changing.

BIG IDEA 8 Natural hazards pose risks to humans.

OBJECTIVES

1. View and comment on the video segment "Violent Hawaii" (Up to 15 min.:50 sec.).
2. Read Information Bulletin and answer questions.

INSTRUCTIONS

Engage

1. Introduce the topic of volcanoes through the use a handout: *KWL Chart.*
2. Have students complete the first two columns: what do they know and what would they like to know about volcanoes.

Explore

3. The class will view a 5 minute video segment *"Violent Hawaii" (Up to 15 min.:50 sec.)* showing footage of volcanic activity and lava flow in Hawaii.
4. After viewing the video segment ask the students for descriptive words about the film they have viewed. These answers may be written down on the board, or overhead. Ask the students what effect volcanoes have on the surrounding physical environment and on both the human and wildlife populations.

Explain

5. Hand out the handout: *The Rumblings Within Activity A*. This activity is a continuation of the handout: *Earthquakes Activity B: Mapping Earthquakes* from Activity 1.3. The completed earthquake map will be needed to plot the volcanoes on and help answer the questions that follow this activity.
6. Share the Figure: Tectonic Plates with overlay Areas of Volcanic Activity. Revisit the overlay Earthquake Zones from Activity 1.3. Review student responses to the questions in Activity A. The Rumblings Within.
7. Hand out the handouts: *Information Bulletin* and *Volcanoes – The Rumblings Within Activity Sheet B.*
8. Students will use the information bulletin to complete the chart on volcano types in handout: *The Rumblings Within Activity B.*

Elaborate

9. Explain to the students that while the basic process by which volcanoes erupt is the same for all volcanoes, not all volcanoes are the same. Divide the class into pairs or groups, with each pair/group at their own computer.

Direct the student pairs/groups to the Virtual Volcano Fieldtrips website (http://volcano.oregonstate.edu/fieldtrips) where they will join a team of volcanologists as they explore and photograph the worlds volcanic areas.

Evaluate

10. In small groups, have students compare their responses in the chart “The Rumblings Within Activity B.” Identify any differences, and clarify responses based on material in the lesson. Students make amendments as needed to their charts.
11. Have students collaborate to complete the final column of the KWL chart with information learned about volcanoes.

SUPPORTING INFORMATION

Key Words:

Basic Terms: lava, magma, shield volcano, cinder cone, composite volcano, crater, vents, volcano, volcanism, conduit system

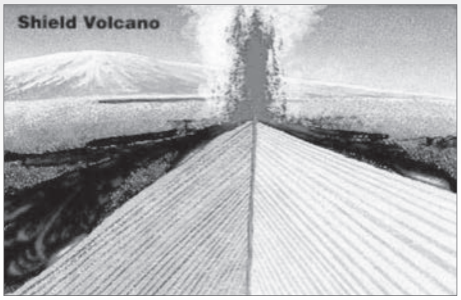
Secondary Terms: caldera, fumaroles, volcanologist, volcanic mountain, stratovolcanoes, tephra

4 KWL CHART

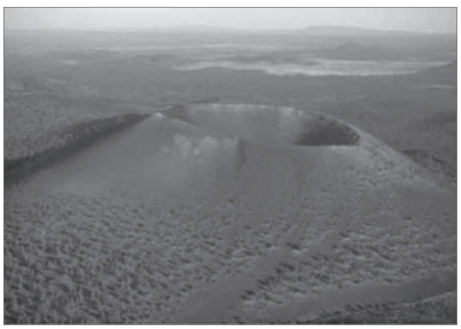
Topic: ____

What I Know	What I Wonder	What I Learned

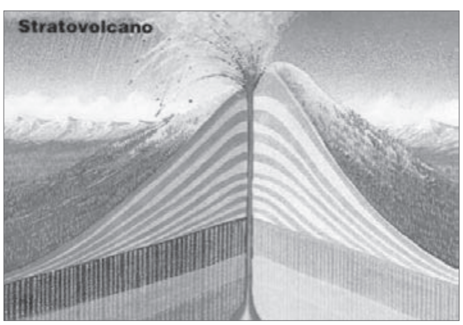
THE RUMBLING WITHIN



Volcanoes result from one of the world's most powerful natural forces shaping our dynamic Earth. A **volcano** is a vent or fissure through which molten and solid materials and hot gases pass upward to the Earth's surface. There are three different types of volcanoes. **Shield volcanoes**, the largest type of volcano, are built almost entirely of solidified **lava** flows. The lava, which is molten rock that flows down the side of the volcano, erupts through **vents** or openings that develop along the sides and base of the volcano. Thousands of highly fluid lava flows spread over great distances and cool in thin sheets. This builds a gently sloping cone. Some have compared it to a warrior's shield, and therefore the name of shield volcano. Hawaiian volcanoes are examples of shield volcanoes.



The next type of volcano is a **cinder cone** (or tephra cone). They are the simplest type and often the smallest. They are formed when lava is quickly expelled from the main vent of the volcano. Gas dissolved in the lava blows it into the air and the lava solidifies into small fragments that fall as cinders/tephra around the outside of the vent and form a circular cone. Most cinder cones have a well formed bowl-shaped **crater** at the summit of the volcano. Cinder cones range in size from 10 to several hundred metres high. There are many examples of cinder cone volcanoes along the western coast of North America, like Mount Shasta in California and Sunset Crater in Arizona.



The third type of volcano is a **composite volcano**. These volcanoes, sometimes also called *stratovolcanoes*, are typically steep, symmetrical cones of large dimensions that have been built from alternating layers of lava flows, cinders, ash and other volcanic material. A central vent is located within the crater at the top of the volcano. One of the essential features of a composite cone is a **conduit system** through which **magma** rises to the top of the volcano from an underground reservoir deep in the earth's crust. With each eruption, the cone grows larger. Some composite volcanoes reach heights of 2,800 metres. Mount St. Helens is an example of a composite volcano.

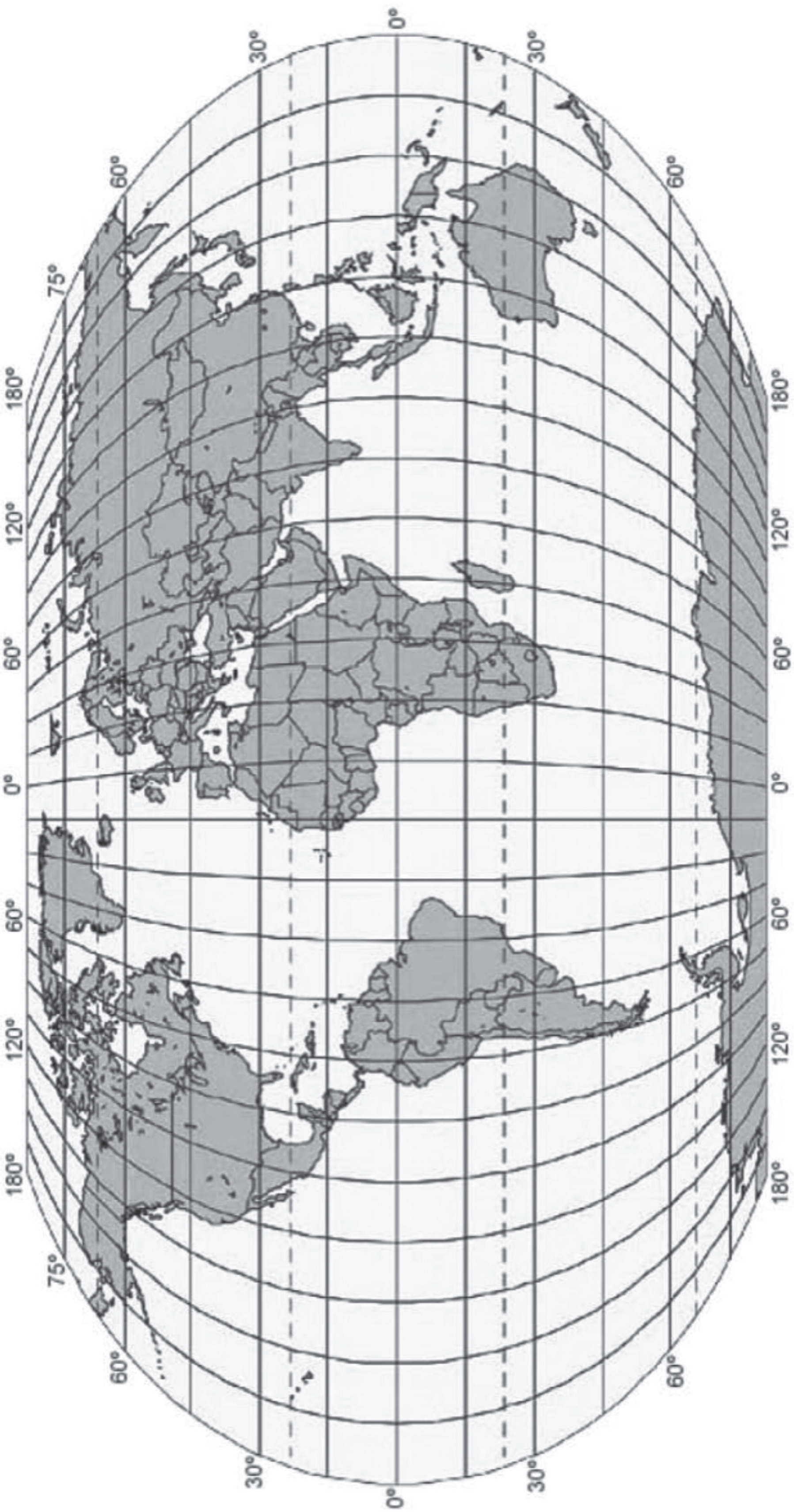
There are many more volcanoes beneath the surface of the sea than we can see on land. Volcanoes on the seafloor build cones from the ejection of lava and *tephra* just like volcanoes on land but submarine eruptions are different in two ways – the composition of the lava is not the same and the pressure of the seawater results in the creation of some products not found on land. Submarine **volcanism** creates new islands. One of the world's newest islands is Surtsey which first formed in 1963, just off the south coast of the island of Iceland in the Atlantic Ocean.

Sources:

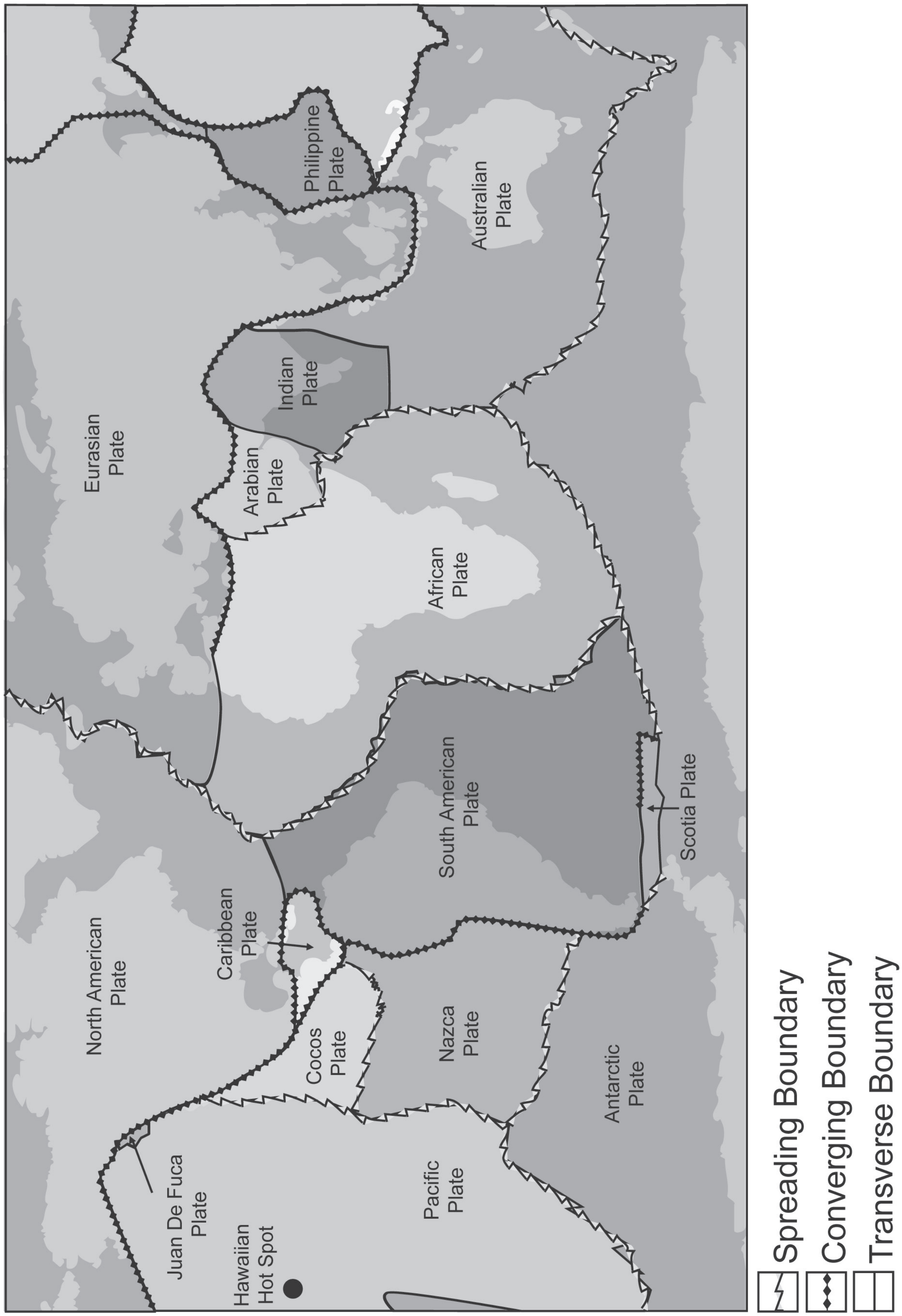
http://pubs.usgs.gov/gip/volc/types.html
Good site for describing various types of volcanoes.

http://www.learner.org/interactives/dynamicearth/index.html
General information to support volcano lessons.

4 MAP OF THE WORLD



Print overlay on on acetate (transparent film)


Eurasian Plate
Philippine Plate
Australian Plate
Indian Plate
Arabian Plate
African Plate
South American Plate
Scotia Plate
North American Plate
Caribbean Plate
Cocos Plate
Nazca Plate
Antarctic Plate
Juan De Fuca Plate
Pacific Plate
Hawaiian Hot Spot
Spreading Boundary
Converging Boundary
Transverse Boundary

MATERIALS
- Map of the world
- Table of major volcanoes
- Colored pencils
- Map of the tectonic plates (from lesson 1.1 Tectonic Plates)

A. The Rumblings Within

In this activity you will locate where some of the major volcanic activities have occurred. You will examine the relationship between the location of these volcanoes and the lithospheric plates.

PROCEDURE:

1. Using the data table provided, find the location of the volcanoes on the map.
2. With a colored pencil (a different one than already on the map), mark a triangle on the map at the location of all 17 volcanoes. Remember that *longitude* is marked across the top and *latitude* is marked along the side of the map.
3. Compare the locations of the volcanoes to the location of the earthquakes that you plotted on your map.
4. On a separate sheet of notebook paper, copy and answer the questions listed below
   a. Which ocean has a ring of volcanoes around it?
   b. Where are most of the volcanoes located in relationship to the tectonic plates?
   c. Which volcanoes are not located on the edge of a tectonic plate? What might account for the location of these volcanoes?
   d. What is the relationship between the location of the major volcanoes and the location of the major earthquakes?

VOLCANOES	NAME	LONGITUDE	LATITUDE
A	Aconcagua	70W	35S
B	Tungurahua	80W	0N
C	Pelee	61W	15N
D	Tajumulco	90W	15N
E	Popocatepetl	100W	20N
F	Lassen	122W	40N
G	Rainier	122W	47N
H	Katmai	155W	60N
I	Fujiyama	139E	35N
J	Tambora	120E	10S
K	Krakatoa	108E	5S
L	Mauna Loa	155W	20N
M	Kilimanjaro	37E	3S
N	Etna	15E	38N
O	Vesuvius	14E	41N
P	Teide	16W	28N
Q	Laki	20W	65N

B. The Rumblings Within

Use the information contained in the Information Bulletin to complete the chart:

	Shield Volcano	Cinder Cone Volcano	Composite Volcano
Size			
Composition			
Method of formation			
Interesting fact(s)			
Sketch			

5 FOLDING AND FAULTING

MATERIALS

- Figure: *Folding and Faulting* (Displayed on available classroom projection technology)
- Folded Rock Photos from www.sciencephotos.com or search the World Wide Web for free images to use as examples
- Handout: *Compare and Contrast Chart*
- Handout: *Folding and Faulting Information Bulletin*
- Handout: *Folding and Faulting Activity (A1 and A2)*
- Fishing line with a washer tied to each end ("cutting device")
- Small, transparent, plastic box
- Cardboard to fit tightly in box

Consumables:

- Play-Doh (or plasticine) - 4-6 different colours
- Popsicle sticks
- Sand
- Flour
- Chocolate powder

SUMMARY OF TASK

Students will:

- Explain geological processes and events using the theory of plate tectonics.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4 Earth is continuously changing.

OBJECTIVES

1. Model folding and faulting using "Playdoh," sand and flour, and popsicle sticks.
2. Complete the *Compare and Contrast Chart* on folding and faulting.

INSTRUCTIONS

Engage

1. Show students some pictures of highly defined folds and ask them to think of ways they could have formed. Remind them of the characteristics of rocks (hard, brittle, rigid, etc.).
2. Have them visualize some of their suggestions and predict what patterns they might expect.

Explore

3. Distribute handout: *Folding and Faulting Activity (A1 and A2)* – these are best done as hands-on activities for groups of students, but may also be a demonstration.
4. Have students work through activity A1, observing how Play-Doh bends and the popsicle stick breaks.
5. Read through the handout: *Folding and Faulting Information Bulletin* with the class, having them highlight the important information.
6. Have students work through activity A2: Play-Doh faults, modelling and sketching the three types of faults.

Explain

7. Present Figure: *Folding and Faulting* and discuss with the class the new terms related to folding and faulting.

Elaborate

8. Have students work through activity A3: Geological Squeeze Box: Folds and Faults, drawing a sketch and answering questions on the activity sheet.
9. Look back at the folded rock photos and have the students explain how these patterns were caused.

Evaluate

10. Have students complete handout: *Compare and Contrast Chart* for folding and faulting.
11. Visit, http://www.teachingboxes.org/mountainBuilding/resources/indexbox.jsp, search the online resources and lessons section for the Mountain Photo Archive pdf file. Observe and discuss which mountains appear to be made of folded layers.

SUPPORTING INFORMATION

Folded mountains are formed as the result of compression or squeezing of the Earth's surface. These forces cause the rocks to bend (fold) and break (faulting). If the compression exceeds the rock's strength and it can no longer withstand the strain, it will break. One result of this is large blocks of the Earth's crust riding up and over the top of adjacent blocks in a process called thrust faulting.

Key Words:

Basic Terms: strata, sedimentary, fold, fault, anticline, syncline, normal fault, reverse fault

Secondary Terms: compression, shearing, dip-slip faults, hanging wall, foot wall, strike-dip faults, folded mountains, fault block mountain

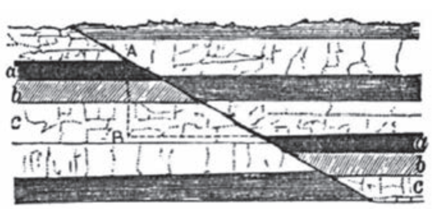
SAFETY

- When using the fishing line, students should be careful not to apply pressure to anything but the instructed material. Fishing line can be sharp.
- The popsicle stick will have sharp edges when broken. Handle by the un-broken ends only.
- Students should wash their hands thoroughly after handling sand and flour.

FOLDING AND FAULTING

The Earth is a dynamic planet and the enormous forces within the planet play a central role in forming the landscape we live in. Canada is home to spectacular land formations such as the Rocky Mountains and the Canadian Shield. In the last lesson we saw how tectonic activity (the movement of tectonic plates) can lead to violent upheavals in the form of mountains. In addition to this, as we have learned, tectonic forces deform rocks in the Earth's crust. The evidence for such activity is thousands of kilometres of rock layers that are bent, rumpled and fractured. The Earth's major mountain belts contain fossils of marine animals thousands of metres above sea level. Massive rock formations are folded as if they were made of modeling clay. These findings point to the tectonic activity forming the Earth's landscape. It is very important to study rock structures when we are selecting sites for bridges, hydroelectric dams, nuclear power plants and of course homes and communities. The knowledge of how a certain geographical area formed geologically – understanding the process of folding and faulting among others – allows us some understanding of the potential dangers of certain landforms.

Most rocks originally form in flat layers called **strata**. Some layers are **sedimentary**, which means they are created from rock particles (sand and mud) settling together. Others are volcanic, meaning there were formed due to volcanic processes. When these strata are compressed (squeezed), folding occurs. A **fold** is a bent layer, or series of layers, of rock that were originally horizontal and have become deformed (pushed out of shape). Folds come in different shapes and sizes from a few millimetres to tens of kilometres. The bending can be gentle or severe depending upon the amount of force. An arch shape fold is called an **anticline** and a down warp fold is called a **syncline**. Folding generally makes the rock units shorter and thicker.



Faults are fractures along which movement has occurred on either side of the crack. Faults can be caused by different forces such as *compression* (squeezing), *extension* (pulling) or *shearing* (tearing). Small faults consist of single breaks. Large faults, like the San Andreas fault in California, consist of many interconnecting faults. Sudden movements along faults are the cause of most earthquakes.

Faults in which the movement is mainly vertical are called *dip-slip faults* because the slip, or displacement, is parallel to the dip of the fault plane. The rock surface that is immediately above the fault is called the hanging wall and the rock surface below is called the footwall. These names have an interesting history, since they were given by miners who sometimes excavated tunnels along faults containing important minerals, such as gold. The miners would walk on the rocks below the fault (the *footwall*) and hang their lanterns on the rocks above (the *hanging wall*)! Dip-slip faults are classified as either *normal faults*, caused by pulling forces, where the hanging wall moves down relative to the footwall; or *reverse faults*, caused by squeezing forces, where the hanging wall moves up relative to the footwall.

Strike-slip faults are faults in which the movement along the fracture is horizontal, and parallel to the strike of the fault surface. Strike–slip faults result from tearing forces and generally consist of a zone of parallel fractures. The earliest records of strike-slip faulting were made after examining the surface ruptures produced by large earthquakes, such as the famous San Francisco Earthquake of 1906.

Folding and faulting have affected and continue to affect the landforms we find on Earth. Knowledge of folding and faulting has real importance for everyday life. It allows us to better understand the dynamic forces within the Earth that can be applied to decisions as to how and where we build our homes, communities, bridges and dams. It also helps us to know where to search for mineral and petroleum resources which sustain our economy.

A1: Folding and Faulting

Play-Doh Folds

1. Make a flattened pancake of each colour of Play-Doh (about 15 cm in diameter and 1 cm thick). The greater the diameter, the thinner the layers and the more easily the model can be folded.
2. Stack the layers on top of each other in any colour order to make a block.
3. Use colouring pencils that closely match the Play-Doh, sketch the side view of this model in the space labelled, **Diagram A**.
4. **To simulate compression -** place your hands, one on either end of the play dough block. Gently push your hands together so that you squeeze it along its longer axis. This will cause the play dough block to fold and buckle. Try to make at least one upward fold (anticline) and one downward fold (syncline)
5. Use colouring pencils that closely match the Play-Doh, sketch the side view of this model in the space labelled, **Diagram B**.
6. **To simulate surface erosion-**Take your cutting device (fishing line and washers) and cut the top off of your folded model.
7. Use colouring pencils that closely match the Play-Doh, sketch the side view of this model in the space labelled, **Diagram C**.
8. Discuss what you observe with your group members. Repeating bands of sedimentary layers, such as in this model, when found at the surface of the Earth tell a geologist that they have found an eroded fold.

Popsicle Stick Faults

1. Take one Popsicle stick. Hold it in both hands and bend it. What happens? Instead of folding, the Popsicle stick is brittle, and breaks. This is how a fault is produced in rocks.

A2: Play-Doh Faults

1. Cut your play dough block model in a vertical direction – add a little bit of an angle if you like.
2. Use this new model to demonstrate a normal fault, a reverse fault, and a strike-slip fault.
3. Use colouring pencils that closely match the Play-Doh, sketch the side view of this model in the space labelled, **Diagram D**.

Diagram A	Diagram B	Diagram C

Diagram D		
Normal Fault	Reverse Fault	Strike-Slip Fault

MATERIALS
- Transparent plastic box*
- Thick cardboard

Consumables:

A variety of substances of varying colour and similar particle sizes
- Sand
- Flour
- Chocolate powder

A3: Geological Squeeze Box: Folds and faults

1. Cut a piece of card to size to fit tightly and stand up in one end of the plastic container.
2. Pour in a thin (a few millimetres) layer of sand. Sprinkle a thin layer of flour on top of the sand. Continue to alternate layers of sand, flour, and chocolate powder until box is about one third full
3. Hold the piece of cardboard firmly and move it slowly and gently toward the opposite end of the box. Try to keep it vertical.
4. As the cardboard moves, watch the layers of sand and flour carefully to see what happens.
5. Stop moving the card when it is about halfway along the box.
6. Make a sketch of the side of the box identifying the folds and faults in the sand and flour layers.

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*For a visual reference visit:
http://www.earthlearningidea.com/PDF/Himalayas_in_30_seconds_final_071029.pdf

Instructions to build a more sophisticated model can be found at:
http://www.di-mac.com/Peg1.JPG
https://www.boreal.com/store/catalog/product.jsp?catalog_number=800302

Watch:
https://www.youtube.com/watch?v=t3T69vMK8OI

How to make :
http://www.exo.net/~emuller/activities/The_Squeeze_Box.pdf

Sketch

1. What causes similar compression to occur to the Earth's crust?

2. Where does this occur on the Earth's surface?

3. How does the model you made simulate the processes at work in the Earth?

5 COMPARE AND CONTRAST CHART

Theme: ______________________ **Topic:** ______________________

COMPARE
How are ______ and ______ alike?

CONTRAST
How are ______ and ______ different?

Write a statement to compare and contrast two terms, concepts or events.

CORE CONCEPTS

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Rocks & Minerals

Did you know that there are complementary and additional resources that will facilitate with the delivery of this topic? Please contact Mining Matters and we'd be happy to assist. Be sure to state, "Core Concepts order request" in the subject line of the email and/or the fax cover sheet.

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TABLE OF CONTENTS

1 MINERAL CHARACTERISTICS

MATERIALS

- Mineral samples: *Quartz, Magnetite, Barite, Gypsum, Calcite, Hematite, Amethyst, Chalcopyrite*
- Handout: Mineral Characteristics - Reference Chart
- Handout: *Mineral Characteristics Activity*
- Mohs Scale of Hardness
- Magnet
- Copper coin
- Nail
- Streak plate (unglazed porcelain tile)
- Magnifying glass
- Electronic balance or electronic balance
- Eye dropper
- Graduated cylinder or graduated beaker
- Safety goggles
- Rubber gloves
- Lab coat

Consumables:

- Dilute hydrochloric acid (10%)

SUMMARY OF TASK

Students will:

- Classify minerals, using their observations, according to their characteristics.
- Follow standard procedures for applying scientific tests.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 1 Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

OBJECTIVES

1. Understand the concept that all minerals have characteristic properties.
2. Undertake 8 geological tests and use observations to identify minerals.
3. Develop skills in using scientific equipment and tests to make observations and draw conclusions.

INSTRUCTIONS

Engage

1. Review the concepts of physical and chemical properties.
2. Brainstorm ways in which to test these properties using standard scientific equipment.

Explore

3. Distribute the handout: *Mineral Characteristics Activity*. Read the instructions for each test with the students, demonstrating techniques if necessary. Have students conduct the 8 scientific testing methods (Density, Hardness, Streak, Cleavage, Conductivity, Magnetism, Lustre, Colour, Chemical Reaction), recording their observations on the activity sheet. Test 8 - Chemical Property of Minerals may be best performed as a teacher demonstration due to safety requirements for handling dilute hydrochloric acid.

Explain

4. Discuss characteristics of minerals and how they are used to determine mineral type.

Elaborate

5. Provide the handout: *Mineral Characteristics - Reference Chart*. In small groups or individually, have students take one specimen. Use the 8 scientific tests, their observations, and the reference chart to identify the mineral name.

Evaluate

6. Through observation or individual student conference, evaluate each student's mastery of applying the tests, making observations, and identifying minerals.

Rubric

The student:	Level 1	Level 2	Level 3	Level 4
used equipment safely and appropriately:	rarely	occasionally	frequently	consistently
identified the physical properties of the sample:	with many errors	with some errors	mostly correctly	correctly
Identified the name of the mineral using the reference chart based on their observations:	with limited reasoning	with some reasoning	with considerable reasoning	with highly effective reasoning

PREPARATION AND SET-UP

The following instructions will help to prepare the samples before conducting this activity.

1. Make an instructor copy of the Mineral Characteristics – Reference Chart. This will be the "Answer Key."
2. Number the mineral samples using correction fluid and a fine tip permanent marker. For durability paint over the dry number with clear nail polish. Make sure to randomize the numbers so that the order does not correspond to the reference chart, e.g. do not label amethyst #1, barite #2, etc.
3. Record each sample number beside the appropriate mineral name on the Answer Key.
4. For the Mineral Characteristic Activity, prepare labels for each mineral name. Collect the equipment needed for each test station as described below.

SUPPORTING INFORMATION

Key Words:

Basic Terms: density, specific gravity, Mohs Scale of Hardness, streak, cleavage, conductivity, lustre, minerals, magnetism, magnetic

Secondary Terms: pure substance, mixture

SAFETY

- Care should be taken with glassware in test one. Broken glassware should not be used and should be disposed of properly if it is found.
- Test eight calls for the use of dilute acid (10% HCl). Teachers and students need to be very careful with the acid. Rubber gloves, safety goggles and a lab coat should be worn.

Test One - Density and Relative Mass

Teaching Notes: Some minerals are heavier than other minerals, which allows geologists to distinguish between them. Geologists use Specific Gravity (S.G.). However, since Specific Gravity is a complex and difficult test, density and relative mass have been substituted here as a comparable test. **Specific Gravity** is the ratio of the mass (weight) of a substance to the mass (weight) of an equal volume of water at 4ºC. The average specific gravity of most minerals is between 2.65 and 2.75. Quartz is 2.65, Feldspar is 2.65, Magnetite is 5.18, Gold is 15.0.

Equipment: balance, graduated beaker or cylinder, water, mineral samples (Magnetite, Barite, Quartz)

Observation:

Lightest - - - Quartz	S.G. 2.65
Middle - - - Barite	S.G. 4.5
Heaviest - - - Magnetite	S.G. 5.18

Test Two - Physical Property of Hardness

Teaching Notes: Scratch tests allow geologists to test the hardness of minerals. The **Mohs Scale of Hardness** was developed as a standard to help identify minerals in relation to each other. The resistance that a smooth surface of a mineral offers to scratching is its hardness which is determined by the observed ease or difficulty with which one mineral is scratched by another, or by a copper coin, knife or file.

Equipment: Mohs Scale of Hardness, copper coin, nail, mineral samples (Quartz, Talc, Calcite)

Observation: Talc is the softest mineral and can be scratched by the fingernail. Calcite is in the middle and may be scratched with the copper coin. Quartz is the hardest of all minerals in the kit.

Test Three - Physical Property of Streak

Teaching Notes: The **streak** of a mineral is its colour when it is ground into a fine powder. To grind a mineral into a fine powder, rub it against a streak plate. Although the colour of a mineral may vary, the streak is usually constant and is useful in mineral identification.

Equipment: paper, streak plate, mineral samples (Magnetite, Calcite, Hematite)

Test Four - Physical Property of Cleavage

Teaching Notes: **Cleavage** is the tendency of minerals to break parallel to their atomic planes. Not all minerals show cleavage. Some minerals break along their planes of cleavage which appear as lines or flat surfaces on minerals. Usually they will break easily along these lines. Cleavage surfaces shine brightly such as those on a diamond. Diamonds are cut along their cleavage lines to produce their sparkling appearance. Cleavage may be well developed as in mica, or fairly obscure as in apatite, or absent as in quartz.

Equipment: magnifier, mineral samples (Mica, Halite)

Observation: Halite is cubic and has 3 lines of cleavage at right angles. Mica is layered and has only 1 line of cleavage, parallel.

Test Five - Physical Property of Conductivity

Teaching Notes: **Conductivity** determines how well a mineral carries electricity. Certain minerals are more conductive than others, while others are not conductive at all.

Equipment: conductivity tester, mineral samples (Quartz, Chalcopyrite)

Observation: Chalcopyrite is conductive and will set off the buzzer. Quartz is not conductive and will not set off the buzzer.

Test Six - Physical Property of Magnetism

Teaching Notes: The degree of **magnetism** of a mineral is determined by how well a mineral attracts a magnet. Some minerals are highly **magnetic** while others are not. Knowing the degree of magnetism helps geologists identify mineral samples.

Equipment: magnet, mineral samples (Quartz, Hematite, Magnetite)

Observation: Quartz is not magnetic and will not attract the magnet. Magnetite is magnetic and will attract the magnet. Hematite is weakly magnetic.

Test Seven - Physical Properties of Colour and Lustre

Teaching Notes: Two important physical properties that geologists use are colour and lustre. The colour of a mineral is one of the first things that we notice. **Lustre** is the way in which light is reflected and scattered off the surface of a mineral. Words such as vitreous, dull, waxy, earthy, metallic, greasy, silky and pearly describe the lustre of a mineral.

Equipment: mineral samples (Amethyst, Quartz, Talc, Chalcopyrite)

Observation: Amethyst is purplish in colour and has a vitreous lustre. Quartz is clear to white in colour and has a vitreous lustre. Talc is grey to white in colour and has a pearly or silky lustre. Chalcopyrite is yellow-gold in colour and has a metallic lustre.

Test Eight - Chemical Property of Minerals

Teaching Notes: Geologists use dilute hydrochloric acid - (HCl) to determine whether or not a mineral will effervesce (bubble) when the acid touches it. The bubbles show the release of the gas carbon dioxide (CO_2) that occurs during the chemical reaction:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Calcium carbonate + acid → calcium chloride + water + carbon dioxide

Note: quickly rinse with water and dry samples after the test. See the *Safety* section for precautions and First Aid when working with hydrochloric acid.

Equipment: dilute hydrochloric acid, rubber gloves, safety goggles, mineral samples (Calcite, Chalcopyrite, Quartz)

Observation: Calcite effervesces strongly. Chalcopyrite does not effervesce. Quartz does not effervesce.

1 CHARACTERISTICS OF MINERALS

Amethyst ([Mn]SiO_2)
Manganese (Mn) + Silicon (Si) + Oxygen (O)

Colour: purple
Hardness: 7
Streak: white/colourless
Lustre: vitreous (glassy)
Cleavage: none
Fracture: conchoidal
A variety of quartz
Uses: Gemstones, mineral specimens

Barite ($BaSO_4$)
Barium (Ba) + Sulphur (S) + Oxygen (O)

Colour: white
Hardness: 3-3.5
Streak: white
Lustre: vitreous (glassy), pearly
Cleavage: perfect tabular crystals
Fracture: conchoidal
Special property: High specific gravity (very heavy)
Uses: carpets, barium ore

Calcite ($CaCO_3$)
Calcium (Ca) + Carbon (C) + Oxygen (O)

Colour: colourless/white, orange, blue, yellow, etc.
Hardness: 3
Streak: white
Lustre: vitreous (glassy)
Cleavage: rhombohedral
Fracture: conchoidal
Uses: cements, mortars, lime production, chemical uses

Chalcopyrite ($CuFeS_2$)
Copper (Cu) + Iron (Fe) + Sulphur (S)

Colour: brassy yellow/green
Hardness: 3.5-4
Streak: green-black
Lustre: metallic
Cleavage: rare
Fracture: conchoidal
Special property: Conductive
Uses: copper ore, electrical wires

Feldspar ($KAlSi_3O_8$)
Potassium (K) + Aluminum (Al) + Silicon (Si) + Oxygen (O)

Colour: pink
Hardness: 6
Streak: white/colourless
Lustre: vitreous (glassy)
Cleavage: 90°
Fracture: conchoidal, uneven
Uses: porcelain, mineral specimens

Halite (NaCl)
Sodium (Na) + Chlorine (Cl)

Colour: colourless/white, can be: blue, gray, red or brown
Hardness: 2
Streak: white
Lustre: vitreous (glassy)
Cleavage: cubic
Fracture: conchoidal
Special property: Tastes salty
Uses: road salt, table salt, glass, mineral specimens

Hematite (Fe_2O_3)
Iron (Fe) + Oxygen (O)

Colour: gray-black, red-brown
Hardness: 6-6.5
Streak: brick red
Lustre: metallic or dull
Cleavage: none
Fracture: conchoidal
Uses: iron ore, pigment, mineral specimens

Magnetite (Fe_3O_4)
Iron (Fe) + Oxygen (O)

Colour: black
Hardness: 5.5
Streak: black
Lustre: metallic, dull
Cleavage: imperfect cubes (rare)
Fracture: conchoidal
Special property: Magnetic
Uses: iron ore, mineral specimens

Mica ($KAl_3Si_3O_{10}[OH]_8$)
Potassium (K) + Aluminum (Al) + Silicon (Si) + Oxygen (O) + Hydrogen (H)

Colour: dark brown (biotite), colourless (muscovite)
Hardness: 2.5-3
Streak: white
Lustre: pearly, vitreous (glassy)
Cleavage: hexagonal
Fracture: laminar
Uses: industrial heat insulator, mineral specimens

Quartz (SiO_2)
Silicon (Si) + Oxygen (O)

Colour: clear, white or gray
Hardness: 7
Streak: white/colourless
Lustre: vitreous (glassy)
Cleavage: none
Fracture: conchoidal
Uses: glass, electrical components, optical lenses, abrasives

Talc ($Mg_3Si_4O_{10}[OH]_2$)
Magnesium (Mg) + Silicon (Si) + Oxygen (O) + Hydrogen (H)

Colour: colourless, white, greenish, yellowish
Hardness: 1
Streak: white
Lustre: pearly, greasy
Cleavage: monoclinic
Fracture: splintery, uneven
Uses: talcum powder, counter tops, carvings, heat, acid and electrically resistant stone (soapstone), an ingredient in paints, rubber, roofing materials, ceramics and insecticides

1 MINERAL IDENTIFICATION ACTIVITY

Test One: Density and Relative Mass — *Magnetite, Barite, Quartz*

Procedure:

- Pick up each mineral and estimate its weight.
- Use the scale to determine exact mass in grams.
- Partly fill graduated beaker with water. Record the level.
- Place each sample, one at a time, into the graduated beaker.
- Record the new water level and calculate the difference in mL (cm3).
- Dry samples and calculate the density of the sample (mass/volume).

Observations/Descriptions:

Densest		Least dense

Notes:

Test Two: Physical Property of Hardness — *Quartz, Talc, Calcite*

Procedure:

- Use your fingernail and scratch each of the minerals.
- Use the penny and scratch each of the minerals.
- Use the nail and scratch each of the minerals.
- Record your observations.

Observations - Mohs Scale Number

Fingernail	Penny	Nail

Notes:

Test Three: Physical Property of Streak — *Magnetite, Calcite, Hematite*

Procedure:

- Rub each mineral across the streak plate (gently).
- Record your observations.

Observations - Colour of powdered mineral

Magnetite	Calcite	Hematite

Notes:

Test Four: Physical Property of Cleavage — ***Mica, Halite***

Procedure:

- Pick up each mineral sample and observe how light is reflected off the surface of the mineral.
- Determine the number of lines of cleavage for each sample.
- Record your observations.

Observations: Planes of breakage

Mica	Halite

Notes:

Test Five: Physical Property of Conductivity — ***Quartz, Chalcopyrite***

Procedure:

- Check to ensure that conductivity tester is working.
- Test each sample for conductivity.
- Record your observations.

Observations:

Not Conductive	Conductive

Notes:

Test Six: Physical Property of Magnetism — ***Quartz, Hematite, Magnetite***

Procedure:

- Test each sample with the magnet.
- Record your observations.

Observations:

Non magnetic	Slightly magnetic	Magnetic

Notes:

Test Seven: Physical Properties of Colour and Lustre — *Amethyst, Quartz, Talc, Chalcopyrite*

Procedure:
- Observe the colour and lustre of each sample.
- Record your observations.

Observations:

Amethyst
Quartz
Talc
Chalcopyrite

Notes:

Test Eight: Chemical Property of Minerals — *Calcite, Chalcopyrite, Quartz*

Procedure:
- Slightly scratch the surface of each mineral sample with a penny.
- Using an eye dropper, place a drop 10% hydrochloric acid on each scratched mineral surface.
- Rinse and dry samples immediately.
- Record your observations.

Observations: reaction in presence of dilute hydrochloric acid

Calcite
Chalcopyrite
Quartz

Notes:

Questions:

Answer the following questions based on what you have learned about the physical and chemical properties/characteristics of minerals.

What is Mohs Scale of Hardness. When was it developed and by whom? (Clue: look at the information on the scale).

Why is colour not a reliable mineral identifier?

Name and describe four terms applied to minerals to describe their lustre.

2 MINERALS – THE BUILDING BLOCKS OF ROCKS

MATERIALS

- Rock sample: Granite
- Mineral samples: Mica (variety: *Biotite*), Quartz, Feldspar (variety: *Orthoclase*)
- Figure: *Minerals – The Building Blocks of Rocks* (Displayed on available classroom projection technology)
- Figure: *Compare and Contrast Chart* (copies for each student)

SUMMARY OF TASK

Students will:

- Distinguish between rocks and minerals and describe the differences in their composition (e.g. minerals, such as calcite, are components of rocks such as the sedimentary rock limestone).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 7 Humans depend on Earth for resources.

OBJECTIVES

1. Understand that rocks are formed from a combination of different minerals.
2. Understand that minerals are substances that occur naturally.
3. Understand that minerals are naturally occurring, crystalline solid substances.
4. Make observations about rocks and minerals.

INSTRUCTIONS

Engage

1. Show students a sample of granite, and brainstorm words to describe the sample.

Explore

2. Have students draw a 2.5 cm border around the edge of a blank page and put a title at the top of “Rocks and Minerals – Granite and its Components”.
3. Pass around samples of granite, mica, feldspar and quartz, and have students make a drawing of each of the four samples on their page and write a brief description of what they observe.

Explain

4. Using the Figure: *Minerals – The Building Blocks of Rocks* that shows the picture of granite and the three minerals that form granite (mica – black, quartz – white, feldspar – pink) have students label their own diagrams according to the illustration to identify a few of the minerals that comprises granite.
5. Ask the students what they think the difference is between rocks and minerals. Make a list of their responses so that they can read and review them. Clarify misconceptions.

Elaborate

6. Granite is an extremely hard rock. Brainstorm uses of granite (tombstones, floors in commercial buildings, countertops in kitchens).

Evaluate

7. Hand out the *Compare and Contrast Chart*. Lead the students in the completion of the similarities and differences while explaining the comparison between rocks and minerals.
8. Compose a concluding statement together about rocks and minerals using the students' suggestions.

SUPPORTING INFORMATION

The difference between rocks and minerals

Minerals are naturally occurring, inorganic (non-living) substances, usually with a definite **crystal** structure. The crystal structure is formed due to the way the atoms are arranged in a regular geometric shape. Some minerals are made up entirely of one **element** (e.g. Gold - Au or Silver - Ag) and others are made up of a mixture of elements (e.g. Quartz – One third Silicon – Si and two thirds Oxygen – O = SiO_2). Minerals usually have a specific chemical composition (i.e. is always made up of the same elements – such as SiO_2) and a highly-ordered atomic structure.

Rocks are usually a mixture of two or more minerals. The differences between rocks are due to the different combinations of minerals that they contain and the different methods of formation. As an example, granite has crystals with about 20% quartz, 75% feldspar and 5% mica. However these amounts can vary and there can be minor amounts of other minerals included.

Additional Information:

A mineral has four characteristics:

1. Naturally occurring - it occurs naturally on earth and is not man-made. There are over 3,000 minerals on the earth, 100 of which are considered common.
2. Inorganic homogeneous solid - it is not the product of plants or animals and is made of the same molecules throughout.
3. Definite chemical composition - each mineral has its own chemical formula.
3. Highly-ordered atomic structure - the atoms and molecules that make up the mineral are arranged and repeated in a set order.

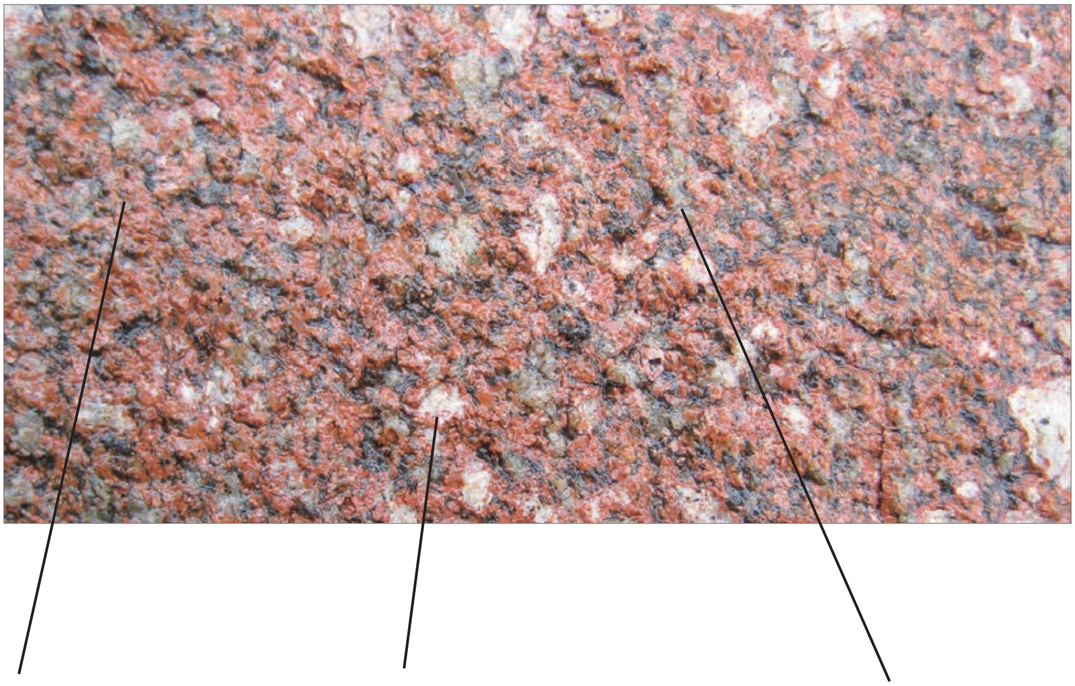
Over 100 chemical elements exist. These elements combine to make up all matter.

About eight of these elements make up most common minerals. These elements include: oxygen, silicon, aluminum, iron, calcium, magnesium, sodium, and potassium.

Key Words:
Basic Terms: mineral, crystal, element, rock

Granite

An igneous, coarse grained, intrusive rock composed of main minerals:
Feldspar (pink), Quartz, and Mica



Feldspar (pink)

A pink, hard mineral with a vitreous (glassy) lustre.

Quartz

A clear, white or gray, hard mineral with a vitreous (glassy) lustre.

Mica

A dark brown to black (may be colourless), soft, flaky mineral with a pearly, vitreous (glassy) lustre.

2 COMPARE AND CONTRAST CHART

Theme: ______________________ **Topic:** ______________________

COMPARE
How are   and   alike?

CONTRAST
How are   and   different?

Write a statement to compare and contrast two terms, concepts or events.

3 THE ROCK CYCLE AND THREE ROCK GROUPS

MATERIALS

- Samples: Granite, Rhyolite, Gabbro, Basalt, Limestone, Shale, Sandstone, Dolostone, Conglomerate, Quartzite, Gneiss, Marble, Slate
- Figure: *The Rock Cycle* (Displayed on available classroom projection technology)
- Handout: *The Rock Cycle Diagram*
- Handout: *The Rock Cycle and Three Rock Groups Information Bulletin*
- Handout: *The Rock Cycle and Three Rock Groups Activity*

SUMMARY OF TASK

Students will:

- Explain the Rock Cycle (e.g. formation, weathering and erosion, transportation, sedimentation and reformation)
- Use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use terms such as magma, crystallization, igneous rock, weather, transportation, sediments, and sedimentary rock when describing the rock cycle).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 1 Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4 Earth is continuously changing.

OBJECTIVES

1. Complete the rock cycle diagram and describe the key processes involved in rock formation.
2. Study the characteristics of the three rock groups and the interrelationships between them through the diagram and analysis questions.

INSTRUCTIONS

Engage

1. Review other natural cycles (e.g. the water cycle, biogeochemical cycles, etc) and explain to students that the rock cycle is a concept or a model that was developed by a scientist (James Hutton, 1727-1797) to help others understand the process of formation of rock.
2. Have students observe the rock samples and suggest ways they think those rocks could have formed. Record student hypotheses.

Explore

3. Display the Figure: *The Rock Cycle* and have students continue to suggest ways that rocks could form.

Explain

4. Distribute the handout: *The Rock Cycle and Three Rock Groups Information Bulletin* and the blank student version of *The Rock Cycle Diagram*
5. Explain that the rock cycle is like a giant recycling system. Nothing is created or destroyed. The same materials are transformed over time from one rock type to another due to surficial processes, melting, heat and pressure. Explain that you will examine this system using the diagram.

Elaborate

6. Have students fill in the blanks on their diagram as you go through the different processes that shape the formation of rock.
7. Have students read the information bulletin and answer the questions on the handout: *The Rock Cycle and Three Rock Groups Activity*

Evaluate

8. Have students demonstrate their understanding of the rock cycle by creating one of the following:
   a) written analogies from their everyday life for how each rock type is formed
   b) a diagram of their own design representing the rock cycle

   Share the following criteria for success with students prior to completing the task:
   - All three rocks groups included
   - Identifies each product of the rock cycle
   - Identifies the process by which each product is formed
   - Includes more than one pathway through the cycle

SUPPORTING INFORMATION

Explaining the Rock Cycle

Begin by explaining that the cooling of magma within the Earth forms **igneous** rocks which are called **intrusive** or *plutonic* (because they form inside the Earth). Explain that when magma reaches the surface of the Earth (e.g. through a volcano), it is called *lava*. Cooled lava also forms igneous rocks, however, these rocks are called **extrusive** or *volcanic* (because they are formed at the surface of the Earth). Extrusive lava cools more rapidly than intrusive magma (because it is exposed to the air), so the resulting rock contains finer-grained crystals.

Over time, all types of rock undergo transformations. On the surface of the Earth, rain, wind and snow break down (weather) the rock and small particles (or **sediments**) are transported to the river, lake or sea floor. These sediments form layers which eventually turn into rock under the weight of the overlying sediments. This process is called **lithification** and the result is **sedimentary** rock.

When either igneous or sedimentary rocks are exposed to extreme temperature and pressure due to being buried deep within the Earth over a period of millions of years, they are transformed into a new type called **metamorphic** rock. The extreme temperature and pressure change the appearance of the original rock.

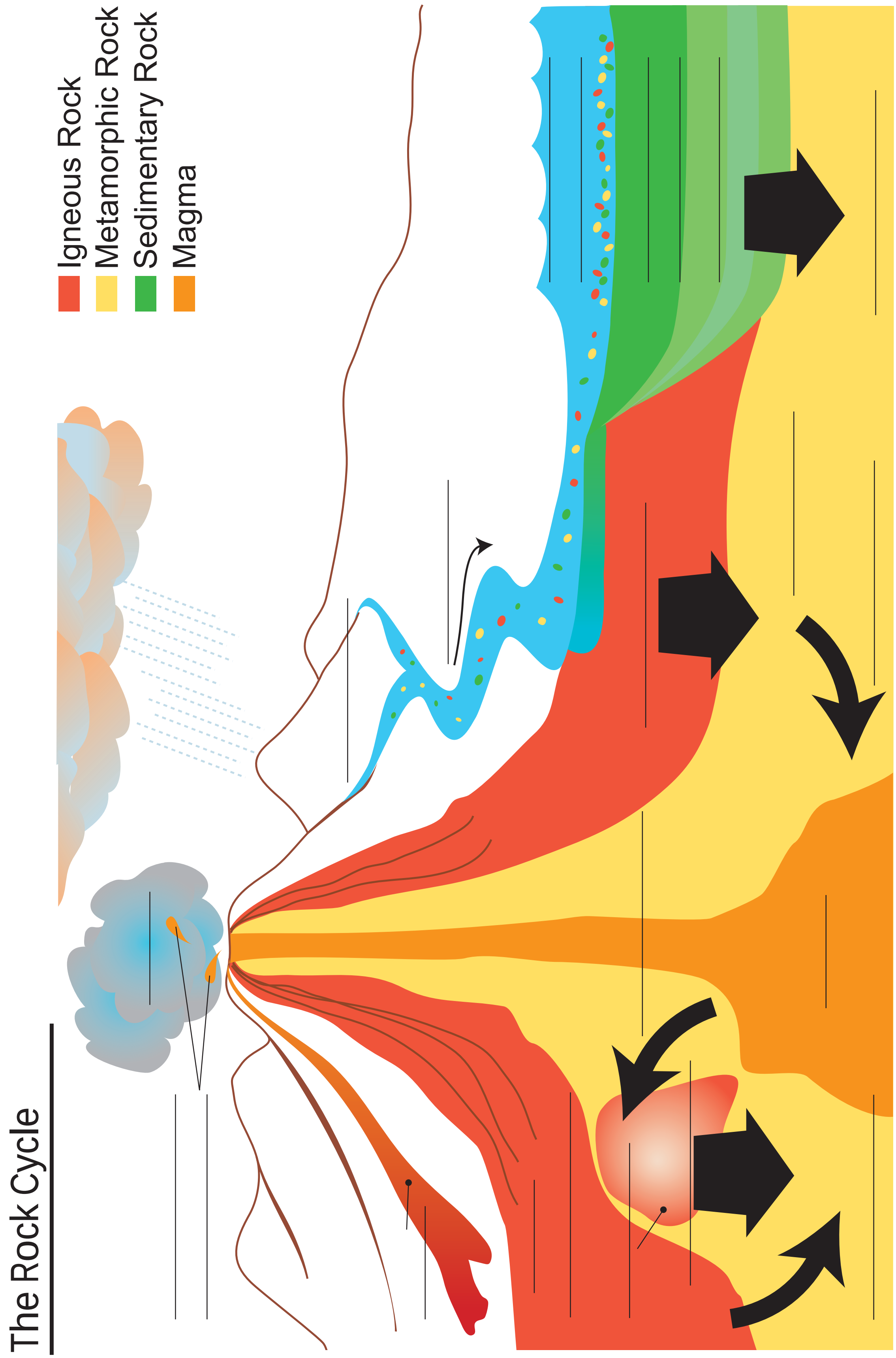
Key Words:

Basic Terms: igneous, rock cycle, intrusive, extrusive, eroded, sediments, lithification, sedimentary, fossils, metamorphic, metamorphism

Secondary Terms: plutonic, volcanic, granite, basalt, shale, sandstone, limestone, marble, slate, quartzite, gneiss

SAFETY

- Reinforce the need to handle the rock samples with care, as some are sharp while others are fragile.

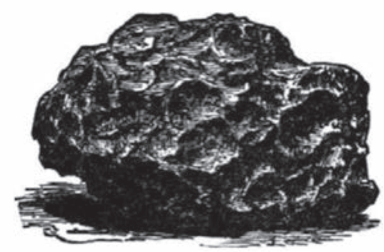

The Rock Cycle
Igneous Rock
Metamorphic Rock
Sedimentary Rock
Magma

THE ROCK CYCLE AND THREE ROCK GROUPS

Geologists classify rocks into three groups according to the major Earth process that formed them. The three groups are **igneous, sedimentary,** and **metamorphic.**

Igneous Rock

Igneous rocks are formed from molten material called magma or lava that cools and solidifies to form a new rock. The term "igneous" comes from the Latin word meaning "fire." Igneous rocks are formed as magma cools either within the Earth or as it flows out of volcanoes on the Earth's surface. When magma cools deep within the Earth, it does so very slowly, allowing large crystals to form. This type of igneous rock is known as an **intrusive** igneous rock. *Granite* is a common intrusive igneous rock. Magma that reaches the Earth's surface is called lava. Lava cools very quickly because it is suddenly exposed to cool temperatures on the Earth's surface or in ocean water. Therefore, crystals do not have time to grow and are very small. This type of igneous rock is called an **extrusive** igneous rock, or volcanic rock. The most common type of extrusive igneous rock is *basalt.*



Igneous rock often contains metallic minerals that include valuable metals such as nickel, copper, gold and silver. The Canadian Shield is partially composed of igneous rock, and consequently, contains large amounts of these minerals. In fact, the Canadian Shield is often referred to as Canada's "storehouse of metallic minerals".

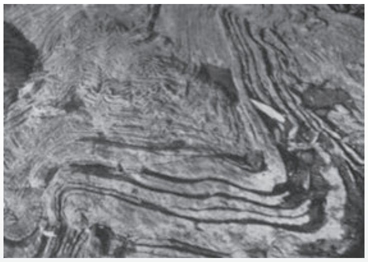
Sedimentary Rock

Sedimentary rocks form from existing rocks that have been **eroded** by wind, water or ice. Tiny pieces of rock and minerals (**sediments**) are eroded and carried by running water, ice or wind and deposited in seas, lakes and rivers. Over millions of years, these sediments are deposited in horizontal layers that can be thousands of metres thick. The weight of the sediments, compresses the layers into rock. If the sediments are composed of clay or mud, the resulting sedimentary rock is *shale*. If the sediments are sand, the resulting sedimentary rock is *sandstone.*

Under certain conditions coal, oil, natural gas, salt and potash may be found trapped in sedimentary rock layers. Over millions of years, dead plants and animals from the seas were deposited and compressed between layers of sediments. When the bodies of certain sea animals decayed and were compressed, oil and natural gas was formed. Wetland vegetation was compressed to form coal. The type of rock particles found today in sedimentary rocks depends on the type of sediments that were deposited millions of years ago. In other locations, the shells of marine animals form limestone or chalk. Sedimentary rocks can also include **fossils**, the remains and imprints of ancient life.

Metamorphic Rock

Sometimes igneous and sedimentary rocks, upon being deeply buried, are subjected to such very high pressures and temperatures that they are completely changed and become metamorphic rocks. The term metamorphic comes from the Greek word meaning "change of form". The process of **metamorphism** does not melt the rock, but instead transforms it into a denser, more compact and harder rock. Heat allows the chemical components of the rock to recombine to form new minerals. Pressure does the same, but only at great depths, typically greater than 10 kilometres. Metamorphism often occurs when hot magma is intruded into cracks and fractures in the surrounding igneous or sedimentary rocks. These surrounding rocks are changed to metamorphic rocks because of the high heat and pressure. *Marble* is metamorphosed limestone, *slate* is formed from metamorphosed shale, *quartzite* is metamorphosed sandstone. Some metamorphic rocks are strongly banded forming a rock called *gneiss* (pronounced "nice"). Metamorphosed granite commonly has a banded appearance.



As well as igneous rocks, The Canadian Shield contains many metamorphic rocks. These rocks contain a variety of deposits of metallic minerals e.g. nickel, copper, zinc, gold, and rare metals such as tantalum and niobium.

The three rock types can each be changed into another through the process known as the **rock cycle**. For example, magma when it cools forms igneous rocks. Igneous, sedimentary and metamorphic rocks exposed to water, wind and other erosional processes on the Earth's surface break down to form sediments. These sediments get transported, deposited and eventually buried forming sedimentary rocks. Sedimentary and igneous rocks that are exposed to high heat and pressure can form metamorphic rocks. If the heat becomes very high the metamorphic rocks can melt and become magma again.

Sources:

http://pubs.usgs.gov/gip/collect1/collectgip.html
Simple definitions of the three rock types.

http://www.cotf.edu/ETE/MODULES/MSESE/earthsysflr/rock.html
Diagram for the rock cycle and simple explanation.

3 ACTIVITY QUESTIONS

Use the Information Bulletin to answer the following questions:

1. Why is the rock cycle called a cycle?

2. What are the three rock groups?

3. How do igneous rocks become sedimentary rocks?

4. What forces are involved in the formation of metamorphic rocks?

5. How is lava different from magma?

4 ROCK STRATA AND FOSSILS

MATERIALS

- Sample(s): Dolostone
- Hand lens
- Common Fossils Cards
- Figure: *Rock Strata and Fossils – Geologic Time Scale* (Displayed on available classroom projection technology)
- Handout: *Rock Strata and Fossils Information Bulletin*
- Handout: *Canada's Tropical History Activity A*
- Handout: *Canada's Fossils Activity B*
- Handout: *Rock Strata and Fossils: Keys to our Geological Past diagram*

SUMMARY OF TASK

Students will:

- Analyze, through observation, evidence of geological change (e.g. fossils, strata)

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 1 Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

BIG IDEA 2 Earth is 4.6 billion years old.

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 6 Life evolves on a dynamic Earth and continuously modifies Earth.

OBJECTIVES

1. Understand how, where and why fossils are preserved and their value.
2. Become familiar with the terms absolute and relative ages.

INSTRUCTIONS

Engage

1. Review how sedimentary rocks are formed and generally how fossils are preserved within the rock layers.
2. Set out the dolostone rock and hand lens for the class to examine the samples for evidence of fossils.

Explore

3. Conduct a class-wide discussion to answer the question: "How do geologists determine the relative age or absolute age of sedimentary rocks?" To explain absolute dating, compare dating methods to the use of batteries (i.e. we can determine how long a flashlight has been on by counting the number of used batteries.)

Explain

4. Have students read the handout: *Rock Strata and Fossils Information Bulletin.*
5. Distribute handout: *Rock Strata and Fossils Activity A*, and have students read the passage and fill in the blanks. This can be done independently.

Elaborate

6. In groups of 2 or 3, have students work with the *Common Fossil Card* and the handout: *Rock Strata and Fossils: Keys to our Geological Past diagram* by sketching the fossil in the appropriate box and writing the relevant information and the fossil's relative time in the geologic past.
7. Using the diagram *Geological Time Scale*, students complete the questions on the handout *Rock Strata and Fossils Activity B*.

Evaluate

8. In small groups, have each student make a one minute report to discuss what evidence we have that the Earth has changed through time.

SUPPORTING INFORMATION

What are Fossils?

Fossils are any remains, traces (evidence of), or imprints of a plant or animal that has been preserved in the Earth's crust since some past geologic or prehistoric time.

Fossils range in size from huge dinosaur skeletons to tiny plants and animals that can be seen only under a microscope. Most fossils are formed from the hard parts of animals and plants, such as shells, bones, teeth, or wood. They may be virtually unchanged from their original state, but more commonly occur as a mineral replacement or simple impression in the surrounding rock. An impression is called a *trace fossil.*

The study of fossils, called *paleontology*, shows us that life originated on Earth at least 3,600 million years ago. Since then there has been a succession of animal and plant species. Most are now extinct, and only a tiny number have survived as fossils due to a lack of the correct environmental conditions for preservation. By studying these survivors, we can get a fascinating glimpse of ancient life on Earth. This is called the *fossil record.*

The oldest fossils known represent simple, microscopic bacteria-like organisms that were single-celled. In rocks of around 545 million years in age, the fossil record explodes with evidence of a diversity and abundance of life.

Key Words:
Basic Terms: fossil, mammoth, amber, trilobites
Secondary Terms: paleontology, trace fossil, fossil record, paleontologist

SAFETY

- Reinforce the need to handle the rock samples with care, as some are sharp while others are fragile.

4 ACTIVITY A: CANADA'S TROPICAL HISTORY

Read the following passage and fill in the blanks with the appropriate word from the list at the end of the passage.

Imagine stepping out the back door of your house and being transported back in time 570 million years ago… It would be some 200 to 400 million years BEFORE ________________ roamed the Earth! You would be visiting young Canada where the south (e.g Ontario, Manitoba, etc.), beheld a landscape of shallow, warm ______________________ much like the Caribbean we see today. At that time the land beneath the cities of Windsor, Goderich, and Winnipeg, were in fact under shallow saltwater lagoons that were full of tropical organisms like corals, and shelled critters. How do we know these areas were covered with water so long ago? The rocks and fossils tell the story, and over time geologists have learned how to read their story.

Many answers to the Earth's geological past lie within _________________________. As we have seen in the study of the ________________, sedimentary rocks form in bodies of water when the surrounding land is eroded by rain, wind and glaciers. These ________________ settle on the floor of the lake or sea forming a sedimentary rock layer. Southern Canada is formed largely of sedimentary rock, telling us that it was under water when those layers were deposited. The life forms and salt deposits that we find within the sedimentary rocks tell us that it was once a warm, tropical environment covered by salty sea water.

Geologists can determine the relative (approximate) age of rocks by studying the sedimentary formations. As studied in earlier sections, each layer of sedimentary rock is _______________ than the layer lying beneath it. Within the different layers of sedimentary rock (called strata) we may find a number of different _____________ (remains of organisms that lived long ago and that have been cemented and preserved in the layers of rock). Geologists carefully study the fossils in the different _____________to help them determine the relative age of the rock.

With new technology, __________________ can now determine the absolute age of rocks. They use a sophisticated scientific test that __________________ radioactive elements in the rock. Radioactive elements take a specific amount of time to release radiation. Knowing how long it takes for radioactive elements to give off radiation and by carefully studying the radioactive elements in a rock, geologists can determine its _______________ age.

Word Bank - Each word may only be used once

younger	**absolute**	**measures**	**tropical seas**
layers	**fossils**	**sediments**	**geologists**
sedimentary rocks	**rock cycle**	**dinosaurs**	

4 ACTIVITY B: CANADA'S FOSSILS

Using the *Rock Strata and Fossils diagram – Geologic Time Scale*, answer the following questions:

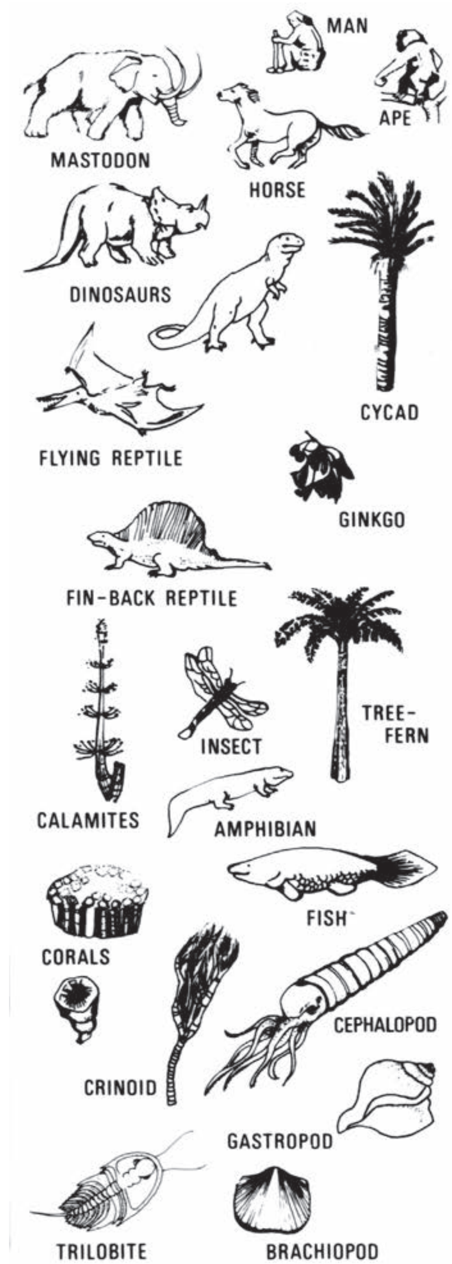
1. What is the name of the geologic time period when flying reptiles existed on Earth.

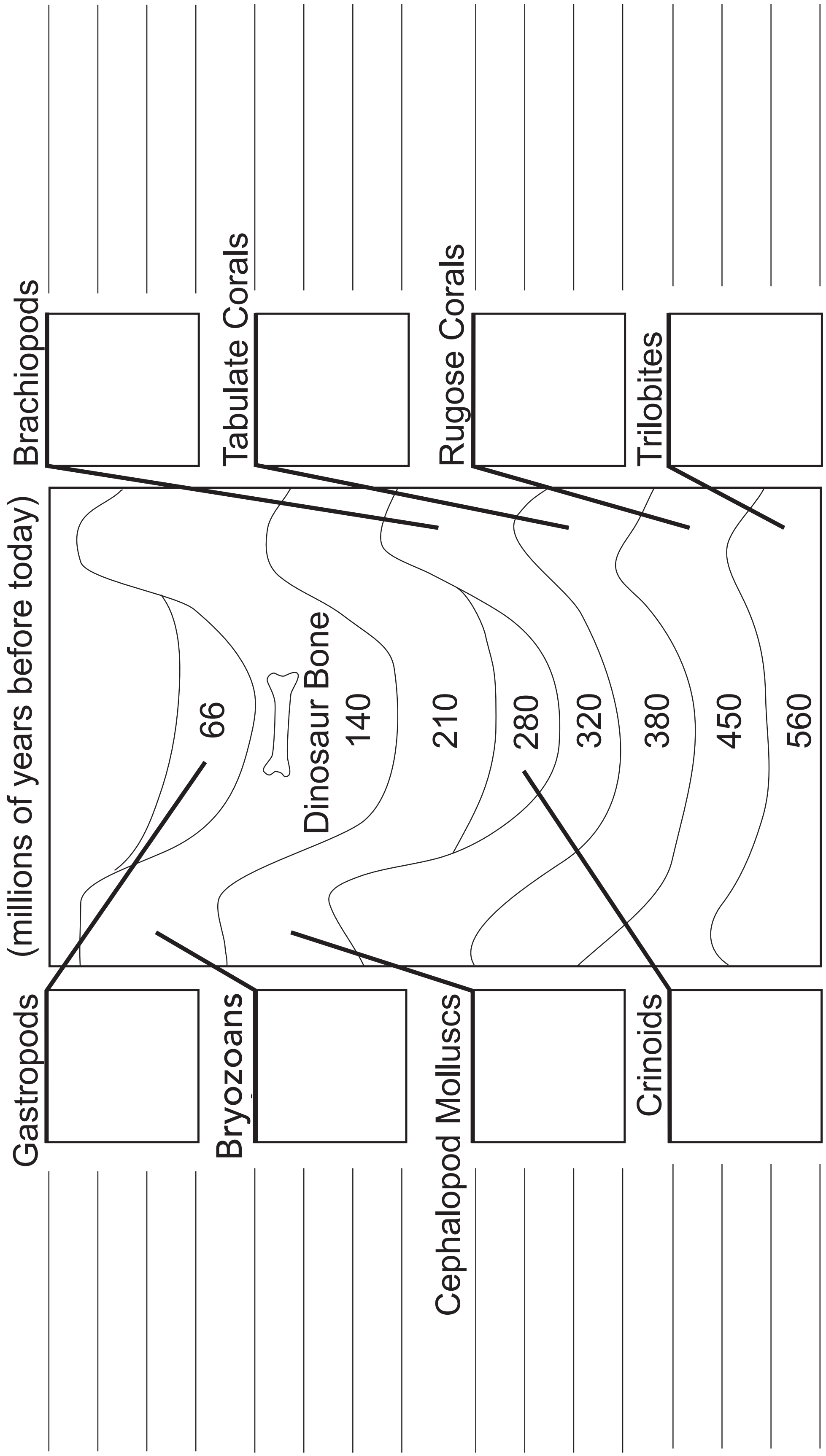
2. Insects are often considered "the most successful organism on Earth". How long have insects been present on Earth according to the geologic time scale?

3. During what geologic time period do you suspect the horses first roamed the Earth?

4. Referring to your Geologic Time Scale, what is the age of the oldest rock on Earth?

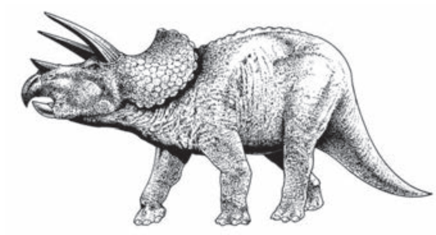
PERIOD	DATE IN YEARS	SUCCESSION OF DOMINANT LIFE FORMS
QUATERNARY		
TERTIARY	1.8 MILLION	
CRETACEOUS	65 MILLION	
JURASSIC	135 MILLION	
TRIASSIC	195 MILLION	
PERMIAN	245 MILLION	
PENNSYLVANIAN	280 MILLION	
MISSISSIPPIAN	310	
DEVONIAN	360 MILLION	
SILURIAN	400 MILLION	
ORDOVICIAN	440 MILLION	
CAMBRIAN	500 MILLION	
PRECAMBRIAN	545 to 4,500 MILLION	*LIFE HAD ITS EARLY BEGINNINGS IN THE LATE PRECAMBRIAM SEAS*



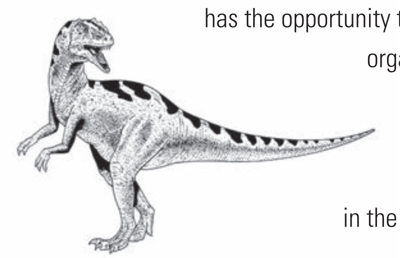

Age of Rock
(millions of years before today)
Brachiopods
Tabulate Corals
Rugose Corals
Trilobites
66
Dinosaur Bone
140
210
280
320
380
450
560
Gastropods
Bryozoans
Cephalopod Molluscs
Crinoids

A GLIMPSE AT THE HISTORY OF OUR EARTH

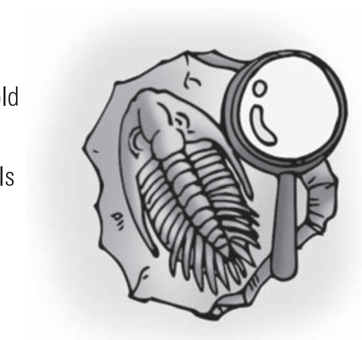
Fossils are the remains or traces of animals and plants that have been preserved in sedimentary rocks. Geologists that study fossils to determine the biology of these organisms and the environment and time in which they lived, are called **paleontologists**. These specialized geologists study fossils and fossil remains that may be billions of years old, ranging in size from microscopic one-celled organisms to huge dinosaur bones. Most fossils are formed from the hard parts of animals and plants, such as shells, bones, or teeth while the soft tissue of the organisms are commonly lost to scavengers or decomposed.



Where do we find fossils? Fossils are most commonly found in sedimentary rocks such as shale, sandstone and limestone. They are very difficult to recognize in metamorphic rocks, and are non-existent in igneous rocks (they would melt at the high temperature that forms magma). Anyone who finds layers of unaltered sedimentary rock has the opportunity to discover fossils hundreds of millions years old. In order for fossils to be preserved, the organisms have to be buried quickly by layers of sediment so that their skeletons can remain undisturbed through the ages, until uncovered by man or erosion (by rain, wind, or ice). Some fossils are relatively unchanged from when the organisms were alive, such as **mammoths** frozen in ice, and insects preserved in **amber**, such as the mosquitoes shown in the Jurassic Park film.



Fossils are important to us today because they help explain the evolution of many different types of species over time. The oldest known fossils are simple single-celled microscopic bacteria-like organisms. They are found in rocks approximately 545 million years old and they mark the beginning of life on Earth. From that time onwards the number of fossilized organisms increased as organisms evolved into more complicated forms. Organisms grew shells for protection allowing them to live longer and adapt to their surroundings.



Many fossils have the general shape of modern animals and plants. A fossil snail (gastropod) looks very similar to the snails we see today except the fossil is only the shell and not the soft bodied animal inside. Many groups of fossils such as **trilobites** and dinosaurs no longer exist and are now only known as fossils.

Paleontologists have determined, through years of study, exactly when certain organisms lived on the Earth. This is valuable for us because we can identify the relative age of a rock layer by identifying the fossils within it. This is particularly useful in the search for fossil fuels such as oil and gas. Using the fossils found in sedimentary rocks, paleontologists can date the rocks that contain the fossils and determine what the past environment was like at that time and whether oil or gas are likely to be buried in the area.

5 ROCK CLASSIFICATION CHALLENGE

MATERIALS

- Samples: Granite, Rhyolite, Gabbro, Basalt, Limestone, Shale, Sandstone, Dolostone, Conglomerate, Quartzite, Gneiss, Marble, Slate (Use the Preparation and Set-up document to label the samples)
- Figure: *The Rock Cycle* (Displayed on available classroom projection technology)
- Handout: *Rock Classification Challenge Activity A - Observations*
- Handout: *Rock Classification Challenge Activity B - Analysis of Observations*
- Handout: *Rock Classification Challenge, Rock Description Chart*
- Hand lens
- Correction fluid
- Fine tip permanent marker

Consumables:
- Dilute 10% hydrochloric acid

Online reference:
- Rocks: Igneous, Metamorphic and Sedimentary **www.geology.com/rocks**

SUMMARY OF TASK

Students will:
- Classify rocks, using their observations, according to their characteristics and methods of formation

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 1 Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4 Earth is continuously changing.

OBJECTIVES

1. Make observations on the characteristics of 13 different unidentified rock samples using an observation table.
2. Answer questions based on their observations.

INSTRUCTIONS

Engage

1. Briefly review the rock cycle and characteristics of the three rock groups using the figure: *The Rock Cycle* (Displayed on available classroom projection technology).

Explore

2. Explain to the students that they will observe the characteristics of 13 different rock samples that have been set out.
3. Distribute the handout: *Rock Classification Challenge Activity A - Observations table*. Read the table headings together and stress the importance of complete observations, being concise and using scientific vocabulary where appropriate. Suitable words are included in the column headers of the chart. At this point, they leave the last column, *Rock Type blank*. Students must also understand that the sample numbers correspond to the table (i.e. if the first sample they observe is #5, they must record their observations in the #5 row).
4. Model the study of one rock sample to reinforce the use of the correct row and to introduce the type of observations to make and possible terminology to use.
5. Conduct the hydrochloric acid test on the limestone. Indicate to the students which sample number you are testing and while the students watch; place a drop or two of 10% HCl on the limestone. Have the students record the result in the appropriate row on their charts. Repeat the test for dolostone and marble, and students should observe and note that the reaction is not as strong.
6. Divide your class into 3 groups in order to allow all students to work with the rock samples. Distribute a set of the 13 rocks to each group (one rock going to each student). Students are to quickly make observations on their rock sample, and then carefully pass it to the next student in their group, following a rotation until all samples have circulated through the group. They will need about 2 minutes with each sample.

Explain

7. Once all the observations have been noted, have students complete handout: Rock Classification Challenge Activity B - Analysis of Observations.
8. After activity B has been completed, students are to complete the Rock Type column on the observation chart: Rock Classification Challenge Activity A - Observations.

Elaborate

9. After students have successfully identified the rock type (sedimentary, igneous or metamorphic) for each sample, provide them with the handout: Rock Classification Challenge - Rock Description Chart. Based on their rock type classification and observations and reference characteristics, have them attempt to give a name each rock sample.

Evaluate

10. Have each student design an instruction card for someone to identify whether a rock is sedimentary, metamorphic, or igneous.

PREPARATION AND SET-UP

The following instructions will help to prepare the samples before conducting this activity.

1. Make an instructor copy of the Rock Description Chart. This will be the 'Answer Key'.
2. Number the rock samples from 1 to 13. Make sure to randomize the numbers so that they don't correspond to the list on the Rock Description Chart (e.g. don't label granite #1, rhyolite #2…). Ensure that rocks of the same type have the same number.
3. To label the rocks, dab each sample with correction fluid and write the number in permanent marker on top of the correction fluid (ensure the correction fluid is completely dry). For durability, paint over the dry number with clear nail polish.
4. As you give each sample a number, record that number beside the appropriate rock name on the 'Answer Key'.

SUPPORTING INFORMATION

Hydrochloric acid test

The acid will react with the calcium in the limestone and will bubble (*effervesce*) strongly. The bubbles show the release of the gas carbon dioxide (CO_2) that occurs during the chemical reaction:

$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$ calcium carbonate + acid → calcium chloride (salt) + water + carbon dioxide

If no reaction occurs, scratch the surface with a tack or paper clip and place an additional drop or two of acid on the rock. This should produce slight bubbling. Immediately rinse with water and dry off the test rocks and place them back in the set they came from.

Key Words:

Basic Terms: sample, coarse-grained, fine-grained, igneous, sedimentary, metamorphic, plutonic rock, volcanic rock, vesicles

Secondary Terms: clast, effervesce, foliated

SAFETY

- Care should be taken with glassware in test one. Broken glassware should not be used and should be disposed of properly if it is found.
- This activity has the teacher use dilute hydrochloric acid (10% HCl). Rubber gloves, safety goggles and a lab coat should be worn.

5 ROCK DESCRIPTION CHART

Igneous	**Formed from cooling magma under the Earth's surface (plutonic) or lava at the Earth's surface (volcanic).**
Granite	• **Coarse** (1-10mm) interlocking **grains** show that this is a **plutonic rock**. • The three main minerals are orthoclase (pink feldspar), quartz (clear, white or-gray, glassy) and mica (black and flaky). • Sometimes the mineral hornblende (black and hard, not provided in this kit) is also present.
Rhyolite	• **Fine grains** (less than 1mm) show that it is a **volcanic rock**. • Based on mineral composition this is the extrusive equivalent of granite. • The samples provided are dull, red and are very hard with sharp edges.
Gabbro	• Coarse (1-10mm) interlocking grains show that this is a plutonic rock. • It is composed of dark minerals such as plagioclase (white, calcium-rich feldspar), pyroxene, olivine and amphibole.
Basalt	• Fine grains (less than 1mm) and **vesicles** show that this is a volcanic rock. • Crystals (green or beige) have formed in some of the vesicles. • Basalt is the extrusive equivalent of gabbro. • The samples in the kit are a deep brown-red colour.
Sedimentary	**Formed by erosion of existing rock by water, wind or ice and the transportation, deposition and lithification of rock particles.**
Limestone	• Composed mainly of calcium carbonate (calcite). • Typically a dull gray to beige colour. • Limestone can be fine-grained or coarse-grained. • *Effervesces* (bubbles) strongly in the presence of dilute HCl.
Shale	• Composed of clay-sized particles and as a result looks like hardened clay. • Samples range in colour from brick red to gray-green. • In some samples layers can be seen.
Sandstone	• Composed of sand-sized particles of quartz, feldspar and rock fragments. • The samples in the kit are beige colour. In some samples bedding (layers) can be observed.
Dolostone	• Composed of calcium magnesium carbonate (dolomite). • Limestone samples are turned into dolostone when rain or groundwater adds magnesium. • Dolostone samples effervesce (bubble) slightly in the presence of dilute HCl (make sure the sample is clean, sometimes carbonate dust will react with the HCl). • Samples are dull and can be beige or gray. They may look identical to limestone.
Conglomerate	• Rounded rock fragments of varying size (clasts) held together by a silica or calcium carbonate cement (matrix). • *Clast* size ranges from 1mm to several cm. • Fine grained and a magnifier is necessary to see individual grains. • Some of the clasts can be identified as feldspar, quartz and granite. Be on the lookout for smooth indentations where the clast has been 'plucked out'.

Metamorphic	Previous rock changed by heat and/or pressure into a different rock.
Quartzite	• Metamorphosed sandstone. • Most of the samples in the kit are gray although the occasional sample might be pink-red. • Fine granular texture, looks as though it is wet.
Gneiss	• Metamorphosed granite. • Banding is characteristic with orthoclase (pink feldspar) and quartz forming together and mica and hornblende forming together. • Some samples have fine-grained crystals while others have coarse-grained crystals.
Marble	• Metamorphosed limestone that has been exposed to low levels of metamorphism will have small (calcite) crystals. The crystals become larger as the level of metamorphism progresses. • The samples in this kit are white or pink and coarsely granular. • Sparkly • Will effervesce (bubble) in the presence of dilute HCl.
Slate	• The alteration of shale by low-grade regional metamorphism. • Fine-grained *foliated* appearance. • The colour (dull black, grey, red, and/or green) is often determined by the amount and type of iron and organic material present in the rock. • Some pieces can be broken easily.

5 ACTIVITY A – OBSERVATIONS

Sample #	**Shape** (massive, lumpy, thin, layered, banded, etc)	**Surface Texture** (smooth, rough, granular, flaky, etc)	**Grain Size** (very fine like powder, fine, medium like sand, coarse like gravel)	**Scratch Test** (Can you scratch the surface with your fingernail?)	**Sketch** (use colours to sketch the sample)	**HCl Test** (Bubbles Y/N Weak/Strong)	**Rock Type** (Igneous, Sedimentary, Metamorphic)
1							
2							
3							
4							

Sample #	Shape	Surface Texture	Grain Size	Scratch Test	Sketch	HCl Test	Rock Type
5							
6							
7							
8							
9							

Sample #	Shape	Surface Texture	Grain Size	Scratch Test	Sketch	HCl Test	Rock Type
10							
11							
12							
13							

Notes:

5 ACTIVITY B – ANALYSIS OF OBSERVATIONS

The following questions will help you analyze your observations. While answering the questions, try to predict the rock type for each of the samples in your table. Record your answers in pencil in the Rock Type column on the observation table. Do your best to provide an answer for each of the 13 samples.

1. According to the characteristics of each of the three rock groups, which type is made up of layers of compressed sand or clay?

2. Which samples from your observation table had a layered structure?

3. Sedimentary rocks are the softest of the three rock groups. Which samples from your chart were you able to scratch with your fingernail?

4. Which sample numbers were repeated in your last 2 answers (soft and layered)?

5. Igneous rocks that are intrusive or plutonic (formed when magma cools under the Earth's surface) are characterized by coarse, interlocking grains and are very hard. Which sample number(s) correspond to this description?

6. Igneous rocks that are extrusive or volcanic (formed when lava reaches the Earth's surface, cools and solidifies) are often characterized by very fine-grained crystals that are difficult to see with the naked eye. There are two extrusive rocks out of the 13 that you identified. Which two could they be?

7. As you know, heat and pressure inside the Earth can cause igneous and sedimentary rocks to change, creating metamorphic rocks. Rocks that have a layered structure for example, but that are much harder could be metamorphic rocks. Igneous rock that has been affected by heat and/or pressure is often characterized by bands or stripes. Which samples do you think could be metamorphic rocks?

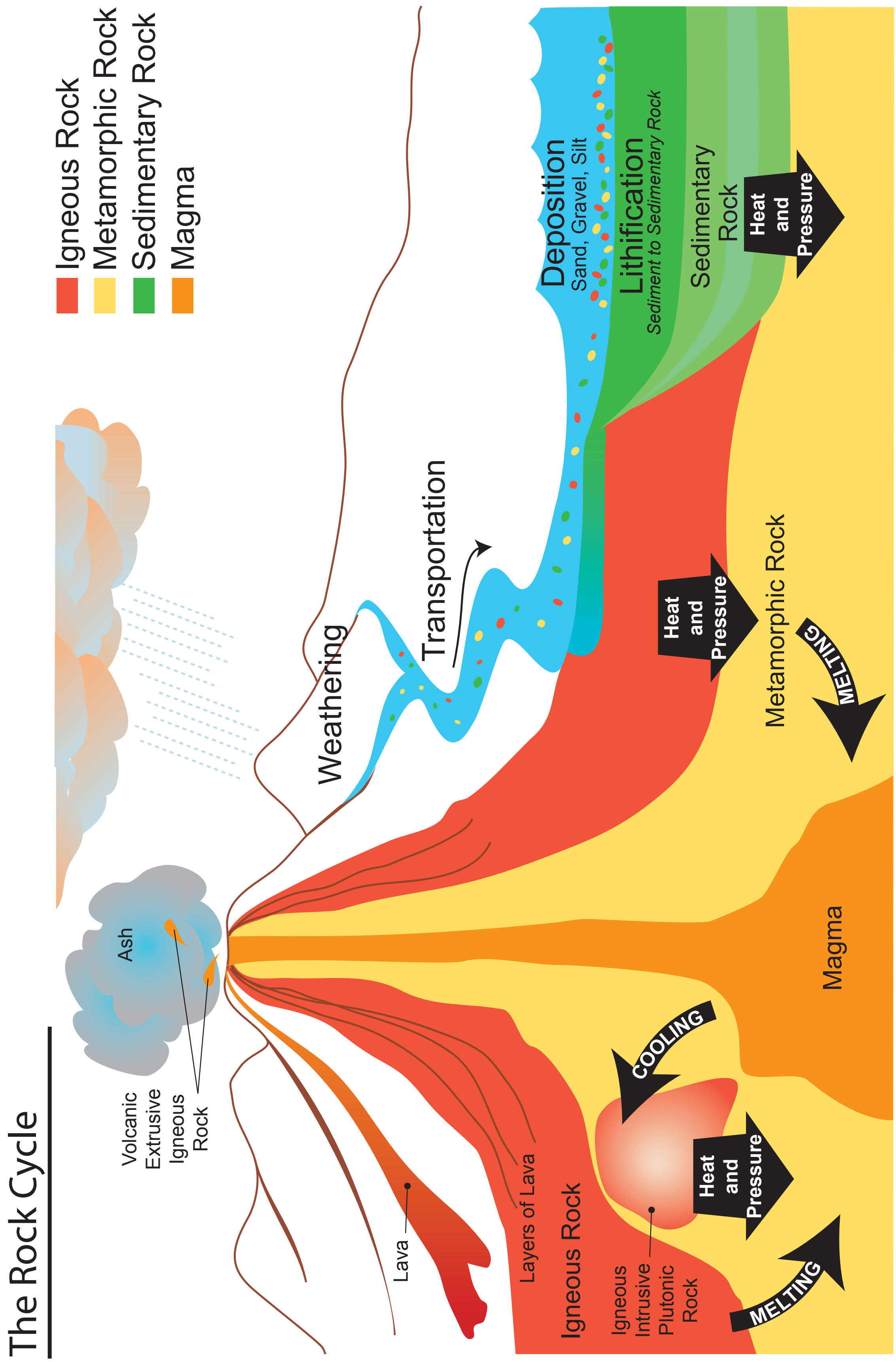
8. Which rock type(s) do you think is/are the easiest to identify? Why?

9. Which sample numbers were the most difficult to identify?

10. Choose one of rock samples that you believe is an igneous rock. Using descriptions from your observation table, explain why you believe that it is an igneous rock.

11. Choose one of your sedimentary choices, and explain why you believe it is a sedimentary rock using descriptions from your table.

12. Finally, choose one of your metamorphic choices and justify your choice using descriptions from your table.


The Rock Cycle
Igneous Rock
Metamorphic Rock
Sedimentary Rock
Magma
Ash
Volcanic Extrusive Igneous Rock
Lava
Layers of Lava
Igneous Rock
Igneous Intrusive Plutonic Rock
Weathering
Transportation
Deposition
Sand, Gravel, Silt
Lithification
Sediment to Sedimentary Rock
Sedimentary Rock
Heat and Pressure
Heat and Pressure
Heat and Pressure
Metamorphic Rock
MELTING
MELTING
COOLING
Magma

CORE CONCEPTS

Created by Mining Matters

Mining Cycle

Did you know that there are complementary and additional resources that will facilitate with the delivery of this topic? Please contact Mining Matters and we'd be happy to assist. Be sure to state, "Core Concepts order request" in the subject line of the email and/or the fax cover sheet.

Mining Matters:
T: (416) 863-6463
F: (416) 863-9900
E: schoolprograms@miningmatters.ca

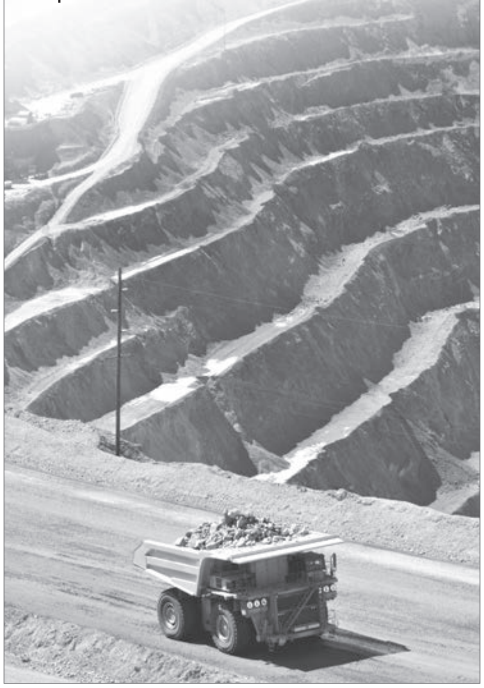
TABLE OF CONTENTS

1 MINE TYPES AND TECHNOLOGY

MATERIALS

- Handout: *Mine Types and Technology Information Bulletin*
- *Command for Underground*
  https://www.youtube.com/watch?v=8c9IGP1SmSs
  By Cat Mining
- Caterpillar's *"Ground Rules: Mining Right For a Sustainable Future"*
  https://mining.cat.com/groundrules
- NRCan Posters: Underground Mine and Surface Mine

  The mining posters: *Surface Mine, Underground Mine, Smelter, and Concentrator,* can be downloaded from the Mining Matters website at http://www.pdac.ca/mining-matters/resources/education/additional-posters



Key Words:

Basic Terms: mining, orebodies, surface mining, excavated, open pit, quarry, aggregate, pit, underground mining, shaft, smelter

Secondary Terms: front-end loaders, cage, skip, ventilation shaft, drift, scoop, reclamation, rehabilitation

SUMMARY OF TASK

Students will:

- Analyze modern mining techniques, and compare underground and surface resource extraction.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. Be familiar with the basic stages in the discovery and development of a mine.
2. Use terminology associated with the mining process.
3. Understand that exploration is dependent on technology.

INSTRUCTIONS

Engage

1. Have students examine the posters: Underground Mine and Surface Mine.
2. Review the facts indicating that mining is a large industry.

Explore

3. Give students handout: *Mine Types and Technology Information Bulletin.* Read the information with the class. Students should use highlighters to denote important points, terms and definitions. As you read the information, stop and elaborate on the material when you feel it necessary or a good opportunity to reinforce content.
4. Use the NRCan Posters: *Surface Mine and Underground Mine* to provide visual examples of how each mine is constructed or perhaps draw a simplified version on the board.

Explain

5. Identify the differences between the two types of surface mines – open pits for minerals such as copper which have kilometre-scale dimensions and are usually in remote areas; and open quarries used for crushed stone that are usually smaller and close to local populations. Contrast underground mining with surface mining and ask the students which they think is easier to develop and run and why.

Elaborate

6. View the You Tube video, *Command for Underground*. It is a short video showing one example of technology that is making underground mining easier and safer. *Command for Underground* allows operators to load, move and dump material via remote control. Using computers, cameras, lasers and software, the loading truck can even steer itself to avoid obstacles.
7. View video, *"Ground Rules: Mining Right For a Sustainable Future"* by Caterpillar, specifically the segments related to 'Mining'. This theme teaches students about open pit and underground mining, including safety and environmental considerations. It also introduces students to a wide range of mining careers.

Evaluate

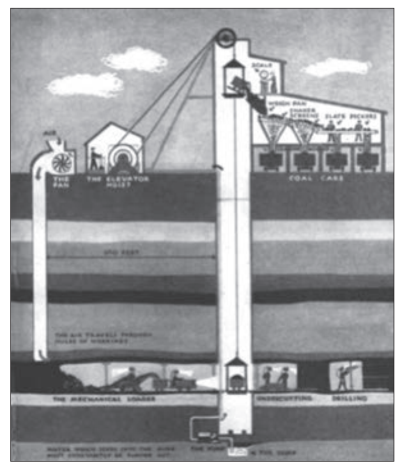
8. Have each student complete a grid with point-form statements for the positive and negative aspects of surface and underground mining. Allow students to include their personal opinions, so long as the factual content is from the material presented in this activity.

MINE TYPES AND TECHNOLOGY

Mining is the process of removing (extracting) valuable rock from the earth. Rocks that contain concentrations of valuable metals or minerals are called **ore bodies**. In some cases, the rock's value is its direct use as building material.

Surface mining is used when the orebody is close to the surface of the earth and can be **excavated** (dug out) forming a hole called an **open pit** mine. Explosives are used to break up the rock. The broken rock is loaded onto very large trucks, using *front-end loaders*, and taken away for additional processing. A **quarry** is an open pit mine where bedrock is extracted and crushed into **aggregate**, used to make buildings, bridges, monuments and roads. It is called aggregate because it is often mixed with cement to make concrete and tar to make asphalt. Other sources of aggregate are deposits of sand and gravel. These sediments can be extracted without blasting. Machines simply remove the material directly from the ground. When the source of aggregate is sand and gravel the operation is called a **pit**.

After mining, the hole can be filled with water to make a new lake or landscaped with rock and soil. Grass and trees may be planted to make a park or recreational area. If the surface mine was in an agricultural area, the land can be returned to agricultural use. These processes are called *reclamation and rehabilitation*.



Underground mining is used when the orebody is buried deep in the earth and miners must dig tunnels to reach it. The vertical tunnel that is used to reach the area of the orebody is called a shaft. Inside the **shaft**, an elevator, or **cage**, is used to transport the miners and equipment from the surface to the underground workings and a bucket or **skip** is used to lift the broken rock and ore from underground. Other vertical tunnels called **ventilation shafts** bring fresh air to the mine. Horizontal tunnels, called *drifts*, provide access from the shaft to the orebody. Once again, explosive is used to break up the rock. Broken rock is loaded into a *scoop* which is a combination *front-end loader* and truck. It is driven back to the shaft where the ore is dumped and lifted to the surface in the skip.

Once the rock is broken from the orebody it must be processed to extract the valuable minerals or metals (copper, zinc, gold, silver, nickel, etc.). First the rock is crushed into a fine powder then combined with water and various chemicals to "free" the valuable minerals from the waste rock. The valuable minerals have to be collected and concentrated before being processed further at a **smelter** or refinery to obtain the final metal product.

After underground mining is completed, the reclamation process includes filling all the opened areas with sand, concrete or waste rock. The shafts are capped (plugged) and the buildings on the surface are removed. The small areas used for the buildings are replanted with grass and trees so that very little evidence of the mine remains.

2 RECLAMATION AND REHABILITATION

MATERIALS

- Figure: *Reclamation and Rehabilitation* (Displayed on available classroom projection technology)
- Handout: *Reclamation and Rehabilitation Information Bulletin*
- Handout: *Reclamation and Rehabilitation Activity*
- Aggregate Producers Association of Ontario Brochures

  The hole story
  https://www.ossga.com/primer/

  https://www.mineralseducationcoalition.org/store/aggregates-poster

SUMMARY OF TASK

Students will:

- Identify environmental impacts of geological resource extraction, and describe techniques used to address these.
- Identify environmental, social, and economic factors that should be considered in making informed decisions about land use.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. Examine the environmental concerns that can accompany mining.
2. Discuss the importance of aggregates and the concept of quarry rehabilitation.
3. Work in pairs to construct a realistic reclamation/rehabilitation plan for a site.
4. Display their plan in a creative fashion.

INSTRUCTIONS

Engage

1. Have students brainstorm the following questions:
   - Name the ways a mine may impact the surrounding environment?
   - How can impacts be minimized?
   - What are some of the other issues related to developing a mine site that may have an impact on the environment?

Explore

2. Distribute the *Reclamation and Rehabilitation Information Bulletin*. Give students sufficient time to read and ask questions in advance of the group discussion.
3. Discuss the issues around pit and quarry rehabilitation. Rehabilitation involves the return of land used in the pit and quarry operation to its former use or some other suitable use. It involves creating new landforms, replacing soils and establishing new vegetation. Once the land has been prepared, it can be used for conservation or recreation, developed into a golf course, or as a place to build a school or houses.
4. Show the figure: *Reclamation (Underground Mine) and Rehabilitation (Sand and Gravel Pit)*. Ask the students to give their thoughts on the projects and use this opportunity to discuss any relevant information.

Explain, Elaborate

5. Explain that one of the easiest mine types to rehabilitate is an aggregate pit or quarry. Using the provided brochures What is Aggregate? (https://www.ossga.com/faq/) and The Importance of Aggregate (https://www.ossga.com/primer/), explain that aggregates are very important in the building process and are usually mined close to populated areas. Because of this fact, ask the class why it might be important for old

quarries and pits to be rehabilitated. What kinds of uses might there be for these large mined areas? Use the provided brochure Environment and Rehabilitation to provide information and examples of rehabilitation projects such as parks, lakes, and wetlands.

Evaluate

6. Give students handout: *Reclamation and Rehabilitation Activity*. The assignment consists of designing a reclamation or rehabilitation plan that is creative but also has reasonable expectations. Students need to have a clear understanding of the purpose behind reclamation so that their design reflects the needs of the community and surrounding environment.
7. Provide students with the *Self-Evaluation* sheet for them to reflect on their presentation before completing the work.

SUPPORTING INFORMATION

Issues associated with rehabilitation can include the length of time that it can take to complete a project following resource depletion, ensuring that a site is safe, by removing any dangers, following a mine closure, and selecting an appropriate secondary land use for the land. Brainstorm with the class as to how to deal with these problems or avoid them all together.

Key Words:

Basic Terms: mining, reclamation, rehabilitation, reforestation, tailings, mineral resource

Secondary Terms: biologist, environmental specialist

RECLAMATION AND REHABILITATION

Mining is a temporary use of the land - no mine will last forever. It is an important goal of the mining or aggregate company to return the site to a natural and stable state, making it available for other uses. When a mine, quarry or pit is closed, the site needs to be restored to a useable state, or changed to another use or state that complements the surrounding landscape.

Mine Closure in Canada

Before mining ever begins a mining company must make sure that the environment will not be harmed by their mining practices. It is the priority of the mining company to conduct their business in an environmentally responsible manner. Long before the mine, the first rocks are broken in a mine and the mineral resources removed, *biologists and environmental specialists* research all aspects of the environment and collect huge amounts of data against which future test results will be compared. These specialists look at the soil, water, wildlife and vegetation and also the air quality and climate. It is very important to the mining company that the environment at the mine is left exactly as it was before the mining activity began.

In Canada, the provincial and territorial governments regulate the mining industry, and have all developed and enacted legislation and regulations for the administration of mining activities and mine closure. The federal government has also developed policies that govern mine closure, and is responsible for mine reclamation and closure in Nunavut, the Northwest Territories, and on First Nation Reserves. All the jurisdictions require that closure plans are put on file and funds for the cleanup and reclamation are provided by the mining company before mining operations can begin. Reclamation is completed according to the approved closure and reclamation plan, which must be continuously updated by the mining company and approved by the responsible government agency.

Mine Closure Plans

Mine closure plans are specific to each mine, and include details on how the mining company will close the mine site, how environmental protection will be achieved, and how the site will be returned to an acceptable state for a pre-arranged land use. The terms *reclamation, rehabilitation, remediation,* and *restoration* are all used to describe mine closure activities. The terms are closely linked, but refer to distinct steps in the preparation of the site for another use:

- **Reclamation:** The physical stabilization of the terrain (dams, waste rock piles), landscaping, restoring topsoil, and the return of the land to a useful purpose. This process usually occurs in northern Manitoba where zinc, copper and nickel mines are common. This process, like rehabilitation, also involves removing all the buildings or physical property, but also includes treating the mine tailings or wastewater, stabilizing the underground workings and closing the mine shafts and tunnels.
- **Rehabilitation:** The establishment of a stable and self-sustaining ecosystem, but not necessarily the one that existed before mining began. The process of rehabilitation includes removing, relocating or demolishing buildings and physical property (crushers, conveyor belts, etc), stabilizing the soil or slopes by recontouring or filling the pits, and revegetation and reforestation of the land. In many cases, complete restoration may be impossible, but successful remediation, reclamation, and rehabilitation can result in the timely establishment of a functional ecosystem. There are a number of excellent examples of rehabilitation; one of the most famous is Butchart Gardens in Victoria, British Columbia. In 1904, Butchart Gardens began as an effort to beautify a former limestone quarry. The Garden today has established itself as a world-renowned botanical garden.
- **Remediation:** The cleanup of the contaminated area to safe levels by removing or isolating contaminants. At mine sites, remediation often consists of isolating contaminated material in pre-existing tailings storage facilities, capping tailings and waste rock piles with clean topsoil, and collecting and treating any contaminated mine water if necessary.

- **Restoration:** The process of rebuilding the ecosystem that existed at the mine site (where applicable) before it was disturbed. The science of mine reclamation has evolved from simple revegetation activities to a discipline which involves using native plants to mimic natural ecosystem development over an extended period of time.

For more information about mine closure practices in your region visit your provincial or territorial government office website (e.g. Ontario Mining Association, Ontario Sand Stone and Gravel Association, Québec Ministère de l'Énergie et Ressources Naturelles, Saskatchewan Mining Association, Yukon Government Energy, Mines and Resources, etc.).

BEFORE AND AFTER RECLAMATION

Underground Mine

Photo of Quirke II Mine, Rio Algom Limited – Elliot Lake , Ontario prior to reclamation.

Photo of Quirke II Mine following removal of buildings and prior to reseeding and planting.

BEFORE AND AFTER REHABILITATION

Sand and Gravel Pit

Photo of the Fonthill Pit, Steed and Evans Limited, Fonthill Ontario during rehabilitation.

Photo of the Fonthill Pit showing final rehabilitation.

2 ACTIVITY: RECLAMATION AND REHABILITATION

STUDY THE FOLLOWING MATERIALS WHICH ARE AVAILABLE IN YOUR CLASSROOM:

Brochures from the Aggregate Producers Association of Ontario including What is Aggregate? Importance of Aggregate and Environment and Rehabilitation. In addition, your teacher has overheads of sites that have been reclaimed or rehabilitated. Look at these Before and After pictures and look at what has been done to the area when the operations closed.

Locate the closest mine, quarry or sand and gravel pit to where you live. After locating the operation, consider how you would either rehabilitate or reclaim the site, and the land the surrounds it, when the resource being mined or extracted has become depleted and the site closes. Prepare a presentation that includes an explanation of:

1. What the area will be used for, (e.g. golf course, community park, bird sanctuary, botanical garden).
2. What steps you will take in your rehabilitation or reclamation project, (e.g. filling in the area with soil to create hills for a golf course or leveling off the area in order to build a school or shopping mall).
3. What resources you will need and how they will be used (e.g. topsoil, trees, plants, sand and gravel for roads, etc).

Include two diagrams, one that shows how the area looks before and how it will look after reclamation.
Your presentation may be a report, poster, slideshow, or speech with visuals.

Use your imagination, be creative and have fun!

Other sources of information: http://www.mineralseducationcoalition.org/reclamation-stories

2 ACTIVITY: SELF-EVALUATION

Reflect on your presentation and evaluate how well you have completed the expected criteria described below.

Content – I have included:	Yes	No
Before diagram with labels and/or description		
Future use		
List of steps needed		
List of resources needed		
What each resource is used for		
After diagram with labels and/or description		

Comprehension – I have:	Not really	Partly	Very well
Designed an appropriate land use			
Identified and removed all hazards related to the mine			
Considered the needs of the natural environment (animals and plants)			
Considered needs of the local community			
Used creative ideas			
Designed a reasonable solution			

Presentation – I have:	Not really	Partly	Very well
Checked spelling			
Checked grammar			
Included visuals			

3 THE MINE DISCOVERY PROCESS

MATERIALS

- Handout: *The Mine Discovery Process Information Bulletin*
- Handout: *The Mine Discovery Process - Questions*
- Handout: *Investigate a Career in Mining*
- Video Careers in the Minerals Industry
- Opaque bag
- 99 plain popsicle sticks
- 1 red popsicle stick
- "Mining Explained" Publisher, The Northern Miner (Contact Mining Matters to request a copy of this book. Quantities limited. Subject to availability).

SUMMARY OF TASK

Students will:

- Identify past and present-day applications of technologies that have contributed to the study of geology (e.g. surface observation, core sampling, seismology, magnetometry, satellite technologies)

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. Be familiar with the basic stages in the discovery and development of a mine.
2. Use terminology associated with the mining process.
3. Understand that exploration is dependent on technology.
4. Investigate careers in the modern mining industry.

INSTRUCTIONS

Engage

1. Introduce to the class that mining is an industry with many aspects to it and that to keep in step with society's attitudes the mining business will continue to change to better integrate technology, environmental best practices and community needs.

Explore

2. Conduct the 1 in 100 Chance demonstration:
   a. Present a bag that you cannot see through. Inside you should place 100 plain Popsicle sticks with one of the sticks coloured red.
   b. Explain that the chances of discovering an economic orebody is very small (approximately 1 in 100) and that the plain Popsicle sticks represent mineral prospects and the red stick represents an economic orebody.
   c. Have each student reach in the bag a pull out a stick and see if anyone finds an economic ore body, i.e. red Popsicle stick.

Explain

3. Raed the handout: *The Mine Discovery Process Information Bulletin* and have students complete the handout: *The Mine Discovery Process - Questions* Material in the Information Bulletin can be supplemented with chapters 3, 4 and 5 from the book *Mining Explained*.
4. Explain that the process of discovering a mine site begins with exploration and evaluation and relate this back to the demonstration.
5. Share with students the video Careers in the Minerals Industry.

Elaborate

6. Have students complete the assignment *Investigate a Career in Mining* to research a career of their choice.

Evaluate

7. Hand each student a sticky note, and have them write their response to the question: What are the most important ideas related to the mine discovery process? Display and discuss their responses, looking for similarities, outliers, and connected themes. Correct any misinformation.

SUPPORTING INFORMATION

1 in 100 Chance demonstration:

Although the red Popsicle stick may be chosen at anytime, the randomness of the exercise demonstrates that even with cutting edge technology the chances of finding a prospect that can become an economic orebody is very slim. These are the chances that mining companies take in the discovery of a mine.

Information Bulletin:

Emphasis should be on the technology that is used to make exploration more successful. Also, an important point to mention is that the process of finding, developing and closing a mine can take a number of years so the decision to build a mine must be based on sound information, good judgement, and proper knowledge of the mining process.

Key Words:

Basic Terms: orebody, aerial photographs, gravity, magnetism, radioactivity, conductivity, anomalies, geochemical, geophysical, prospecting, core, analysis, assayed

Secondary Terms: geologist, geological sciences

THE MINE DISCOVERY PROCESS

Concentrations of metals and minerals that can become a mine are rare and not easy to find. These concentrations have to be large enough and rich enough that a company can sell these metals or minerals at a profit after spending the money to build and operate a mine. If a concentration of metals and minerals can be mined at a profit, it is called an **orebody**. *Geologists*, individuals who have been trained in the *geological sciences*, have developed a number of techniques to help them find an orebody. Some of these techniques are described briefly below.

1. Finding a promising mine area

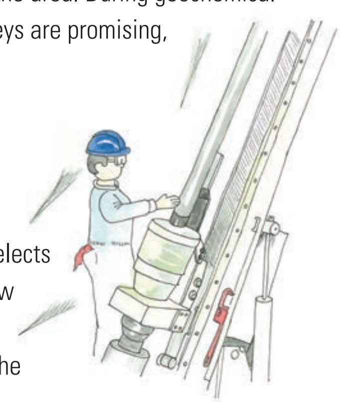
Geologists learn what geologic environments and rock types are favourable for hosting valuable mineral deposits. The first step in the mine discovery process is identifying areas where the rocks are likely to contain a valuable mineral deposit. Geologists will study aerial photographs, photographs taken from satellites, maps published by governments and previous work completed by other mining companies to help them find an area that might host an orebody. Depending on these studies, an area may be selected for further work.

2. Aerial Surveys

Concentrations of metals and minerals sometimes create areas of unusual **gravity**, **magnetism**, **radioactivity** or **conductivity**. These unusual areas are called **anomalies** and can be found using measuring devices carried in airplanes or helicopters. If interesting anomalies are found, geologists proceed to the next step.

3. Ground Surveys

Before carrying out further work, the land covering the anomaly must first be acquired from the government or landowner. After acquiring the land, a location grid is made over the area. Detailed **geological mapping**, prospecting and sampling, **geochemical** and **geophysical** surveys are conducted over the grid on the ground. Geophysical surveys often use similar devices to those used in the aerial surveys. Geological mapping and **prospecting** is done to identify the different rocks in the area. During geochemical surveys, rock and soil samples are collected and analyzed for minerals. If the results of these surveys are promising, drilling is planned.



4. Drilling

A drilling machine bores small holes into the ground. These holes are only a few centimetres in diameter but sometimes they are as deep as one or two kilometres. As it makes the hole, the drill produces a continuous narrow cylinder of rock called a **core**. A geologist examines the core and selects interesting selections for **analysis**. Using chemistry, the core is **assayed** (analyzed) to find out how much metal or valuable mineral is present. If the results in a drill hole are encouraging many more holes are required to find out the size and shape of the body containing the metals or minerals. If the body is big enough and rich enough, a mine may be developed.

5. Developing a Mine

Millions of dollars may be spent constructing a mine. The mine is always designed to have the least possible effect on the surrounding environment. Once built, the mine will create jobs and produce metals and minerals needed for manufacturing the many products that you use in everyday life.

3 INVESTIGATE A CAREER IN MINING

Student Research:

- Choose whether you will use a paper copy of the Careers in Mining or allow students to access it through the internet. www.acareerinmining.ca/en/careers/index.asp
- Not every community has a mine right in its backyard, but every community will have some kind of career that can be related to the mining industry
- The Careers in the Minerals Industry supplement lists MANY careers that are tied to mining. Have students use the supplement to pick a career to investigate. They can choose from careers in Mining-Exploration, Mining-Extraction, Mining- Processing, Transport to Market, Smelting, Mining-Environmental Management and Reclamation, Mining-Suppliers, Contractors and Consultants, or Mining-Corporate Office.

Students will:

- Research their chosen career – including the education or training that would be necessary to work in that job
- Include which part of mining their job relates to –outline what this part of mining involves…eg, extraction – getting the minerals out of the ground
- Find pictures (at least 3) of people engaged in this occupation
- Include other people that you might have to work with – a geologist might work with a helicopter pilot and a mine consultant, etc.
- Find out how much these kinds of jobs pay each year
- Assemble their information in a brochure on their particular job
    - Brochures can be made by hand or through electronic means
    - Completed brochures can be displayed around the room
- BONUS: Some students may really be interested in some of these careers and may take the opportunity to interview someone currently working in that field.
- If a student chooses to interview an adult make sure that they generate a list of questions beforehand and check them to make sure that they are acceptable.
- Students will need to arrange to meet with the interviewee on their own time.

Additional Career Profiles: http://earthsciencescanada.com/careers/

3 QUESTIONS

Answer the following questions using the Information Bulletin-The Mine Discovery Process.

1. What is the first stage in the mine discovery process?

2. Name two methods that geologists use as a first step to identify an area of favourable geology.

a.

b.

3. ______________________ are areas where unusual results are detected and may be caused by concentrations of metals and minerals.

4. List three ground survey techniques used to investigate aerial anomalies?

a.

b.

c.

5. Why are geological mapping and prospecting carried out?

6. What happens during a geochemical survey?

7. ______________________ is a narrow cylinder of rock that is produced during drilling.

8. Drilling provides geologists with many pieces of important information. Explain this statement using examples from the text.

9. What are the benefits for developing a mine?

4 RECYCLE AND REUSE

MATERIALS

- Handout: *Recycling and Reuse Information Bulletin*
- Handout: *Recycling and Reuse Activity A – Let's Celebrate Recycling*
- Handout: *Recycling and Reuse Activity B – A Community Investigation*

Key Words:

Basic Terms: renewable resources, non renewable resources, recycling, sustainable, compost

SUMMARY OF TASK

Students will:

- Identify Earth resources used by humans to manufacture products and discuss what happens to the products when they are no longer useful.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. Understand the difference between renewable and non-renewable resources
2. Identify the various destinations of products and materials when their initial use is completed, e.g. reuse, recycle, and disposal.
3. Communicate with others the ideas of recycling and reusing to minimise our impact on natural resources.

INSTRUCTIONS

Engage

1. Ask the students what the words "Recycle" and "Reuse" mean to them.

Explore

2. Read and discuss the handout: *Recycle and Reuse - Information Bulletin*.

Explain

3. Have students complete the handout: *Recycling and Reuse Activity A – Let's Celebrate Recycling*. Use strategies such as brainstorming, discussion, or looking at samples of songs and poetry to help their creativity. See the Evaluate section below and create an evaluation tool before they produce their work.

Elaborate

4. Have students complete the handout: *Recycling and Reuse Activity B – A Community Investigation.* They may survey peers in the school, or family and friends outside of the school.
5. You may wish to compile the interviews from Activity B into a scrapbook. This can be a good way of highlighting community viewpoints and knowledge regarding recycling.
6. Have students collect media articles on recycling and reuse, and display in the classroom to further reinforce the subject.

Evaluate

7. As a group, design an evaluation tool for the "*Let's Celebrate Recycling*" product. Once consensus is reached, use this tool to guide their creativity and evaluate their work.

RECYCLE AND REUSE

The world around us depends on our responsible use of its natural resources. The quantity of some of these resources is limited and they cannot be replenished once they are used up. These kinds of natural resources are called **non-renewable resources** and examples of these include fossil fuels like oil and gas, metals like gold, silver, and lead, and minerals like gypsum and calcite. Once these resources are used, they are gone forever unless they are recycled or reused. These resources differ from **renewable resources** which naturally replenish themselves through everyday processes. Examples of renewable resources include forests, fish, and groundwater. When a forest is cut down (logged) for its lumber, it can be replanted to later produce more trees. Unfortunately trees grow very slowly, so we must limit our use of paper products to avoid over-harvesting the mature forests that we have now. Using and extracting only the resources we need from the Earth at a rate that will allow the renewable resources to replenish themselves, and the non-renewable resources to last for years to come, is called **sustainable** living.

Wasting our natural resources is a problem. People naturally produce waste and have done so for thousands of years. During the early days of civilization, people had little difficulty finding a place to dispose of their garbage, but as the population increased and became more sophisticated, waste disposal became a major problem. The solutions found to handle the growing amount of garbage were either incineration (burning of garbage) or burial in a local dump or landfill site. Recently, some cities and towns have tried to send their garbage to other communities for burial and incineration, but this method has been largely unsuccessful. The solution is not moving garbage to another place, but limiting the amount of garbage we create.

Recycling, the reuse of items in order to conserve non-renewable resources, is practiced by a growing number of individuals, communities and corporations around the world. The key to understanding recycling is found in the word itself. The term recycling contains the prefix “re” meaning “to do again”, and “cycle” which comes from the Greek word “kyklos”, which means “circle where events return to their starting point over and over”. Therefore, recycling means that products or items are returned to their starting point again and again. When you finish reading your newspaper or drinking your pop and recycle the paper or can, the products will be broken down to their original state (paper or aluminum) and reformed into a new newspaper or can.

Recycling can be broken up into three general categories depending on the material to be recycled. The first is reintegrating waste back into the cycle of nature. An example of this is **compost** - adding food waste (like banana peels and egg shells) and lawn clippings (like grass and leaves) to soil so that when they break down, the nutrients in them will be available for the plants that grow in your garden.

A second category of recycling is using materials after reprocessing for the same or similar purpose. This is what happens when you put your pop can, glass bottle or newspaper into the recycling bin at home or at school. Your municipality will come and get your items for recycling, take them to a plant that will break down your paper, aluminum (pop can) or glass and make it into new newspapers, pop cans and bottles.

The third category of recycling is reusing materials more than once as opposed to throwing them in the garbage. You can reuse yogurt containers for leftover food, or wash and reuse old glass bottles to store nails or small household items. You could use a broken plastic cup to hold pens or pencils by the phone. All these things will keep plastics and other materials out of our garbage and out of our landfill and can be done at home to reduce the amount of waste going to landfills or incinerators.

The Earth’s natural resources once seemed unlimited. However, with population growth and increased use of natural resources, we are in danger of running out of non-renewable resources, and we’re placing our renewable resources in danger. Careful management of our resources and techniques such as reducing the amount of waste created, reusing, and recycling will give us hope for a future where needed resources are still available to us and future generations.

4 ACTIVITY A

LET'S CELEBRATE RECYCLING

Write a song, poem, short story, create an anagram or limerick about recycling and reuse. You could also draw a picture or create a cartoon character that will encourage us to recycle and reuse.

Be creative! Student creations could be displayed or performed for the class.

Some words to think about and possibly include are:

- renewable and non-renewable resources
- recycle and reuse
- sustainable
- compost

There are many other words. These are only an example of the kinds of words that could be in your celebration.

Jot down a few ideas here:

A COMMUNITY INVESTIGATION

Every community has different recycling needs depending on the type and amount of garbage it produces and the size of the community. Investigate your own community's recycling and waste disposal facilities and see if you can find out where things go when you put them out on the curb in front of your house!

Interview your mom and dad, and use the internet (checking your local government municipality website) if necessary to find out about the recycling and waste disposal (landfill, dump, etc) facilities near you. Use the Interview Form below to collect the responses to your questions.

Interview Form "Where does all my garbage go?"

Name: Address:

What items does your community currently recycle? (i.e. newsprint, aluminum, etc).

Where is your local community landfill located? What items cannot be disposed of in a landfill?

Where in your community can you dispose of batteries, paint cans, motor oil or electronics?

What does your family do with old clothes?

What does your family do with yard waste (fall leaves, grass clippings, etc)?

Does your family compost kitchen scraps? Why or why not?

CORE CONCEPTS

Created by Mining Matters

Social and Environmental Responsibility

Did you know that there are complementary and additional resources that will assist with the delivery of this topic? Please contact Mining Matters and we'd be happy to assist. Be sure to state, "Core Concepts order request" in the subject line of the email and/or the fax cover sheet.

Mining Matters:
T: (416) 863-6463
F: (416) 863-9900
E: schoolprograms@miningmatters.ca

TABLE OF CONTENTS

1 OPERATING A SURFACE MINE

MATERIALS

- Information Bulletin - *The Mineral Resource Development Cycle*
- NRCan Surface Mine poster

  The mining posters: *Surface Mine, Underground Mine, Smelter, and Concentrator*, can be downloaded from the Mining Matters website at **http://www.pdac.ca/mining-matters/resources/education/additional-posters**
- Reclamation and Rehabilitation photo cards
- Reclamation Stories
  Canadian Land Reclamation Stories
  http://www.clra.ca/default.aspx?page=29
  photos included
- Teacher instructions on "Creating a Model Surface Mine Model."
- 1 plastic container (250 ml) for each group
- Approximately 4 litres of country rock material *(see Creating a Model Surface Mine for suggestions)*
- Approximately 300 ml of target mineral/rock material *(see Creating a Model Surface Mine for suggestions)*
- 6 squares of brown construction paper or fabric
- Tree and grass cut-outs or 6 natural habitat magazine pictures
- 6 plastic spoons
- 6 paper cups

SUMMARY OF TASK

Students will:

- Investigate the effects of resource extraction on the land, and the processes of reclamation and rehabilitiation.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. To operate a model surface mine model provided by the teacher.
2. Investigate how mining companies extract valuable minerals that are close to the surface of the Earth and then reclaim the land after the process.

INSTRUCTIONS

Engage

1. Distribute Handout *Information Bulletin - The Mineral Resource Development Cycle* and discuss and explain the stages.
2. Review the *Surface Mine* poster with the students. Show students how the overburden (surface soil and loose rock) is removed and how drilling and blasting breaks the rock. Large trucks and diggers move the rock to the crushers and processing plant where the valuable materials are separated from the host rock.

Explore

3. Explain to students that they will mine their model of a surface mine for either a valuable rock or mineral.
4. Ask students to draw a picture of their model and make a group list showing the steps they will follow to mine, and later reclaim, their model.
5. After the plan has been approved, have students start the extraction process:
   a. Extract the rock and mineral mixture and place it on the table.
   b. Separate the target mineral from the host rock. You will need to instruct students on the method to use, depending on the materials you chose for the models. Keep the mineral in a paper cup.
   c. Draw a picture of what their surface mine looks like during mining remembering to include the pile of rock that was taken out of the mine.

Explain

6. Have students answer the following questions:
   a. How has mining changed model the landscape.
   b. How could we use the pile of mined-out rock that was taken from the surface mine?

Elaborate

7. Have students reclaim the surface during and after mining is completed, returning the land to useful purposes. Emphasize the fact that even with the best technology, reclaimed mine lands may never be returned to its pre-operation state.
8. Students should draw a picture of the land after mining.

9. Ask each group to share their extracted valuable rocks/minerals with the class. Discuss with students the steps of their mining and reclamation operations and any differences between the original model and the model after reclamation. It is important to note that the reclaimed pit may not look exactly the same as the original model. For example, students may note that there is a depression due to the missing minerals that were extracted. Discuss whether the animals, trees, and plants can be returned to the area immediately, as well as the time factor involved in restoring a landscape.

Evaluate

10. Show students the Reclamation and Rehabilitation photographs of mine sites before and after the land has been reclaimed.
11. Students will write three things that have been done to reclaim the land used for mining.

SUPPORTING INFORMATION

The Surface Mine poster shows the characteristics of a surface mine and the stages used in a typical surface mine operation.

Two common procedures used to separate minerals from rocks take advantage of the physical properties of the sought materials. When mixed with liquid, heavier or denser minerals sink, and therefore can be separated from lighter minerals. This procedure is called **heavy media separation**. This process could be used to separate heavier chalcopyrite from lighter quartz when mining for copper and nickel. If the valuable minerals are magnetic, they can be separated from other rock and minerals by passing the crushed ore under a powerful magnet. This procedure is called **magnetic separation**.

When reclaiming a surface mine, even if all the remaining rock (called “waste” rock, meaning rock devoid of valuable mineralization) were replaced into the surface mine, the depression formed by mining would not be refilled completely. However, the wall of the depression can be contoured to gentle slopes, the surface can be covered with topsoil, and grass and trees can be planted to create a naturalized landscape or environment. In some cases, mined-out surface mines and rock quarries have been made into recreational lakes, public parks, rock gardens, and farmland.

Mining companies use grass to stabilize slopes and reduce soil erosion, and they plant seeds and seedlings to encourage the establishment of plant and tree communities. As the plants and trees mature, animal species diversity increases in the area. The habitat reclamation process is highly monitored by scientists from many disciplines.

Key Words:

Basic Terms: heavy media separation, magnetic separation, rock, mineral, mineral resource development cycle, mining cycle, mineral exploration, staking a claim, mineral evaluation, surface mine, open pit, tailings, separation process, refined, processing

Secondary Terms: geologists, underground mine, environmental specialists

SAFETY

- If food is used as the target rock/mineral or country rock/waste, ensure that there are no allergies before proceeding. Students should be encouraged to wash their hands after manipulating the models.

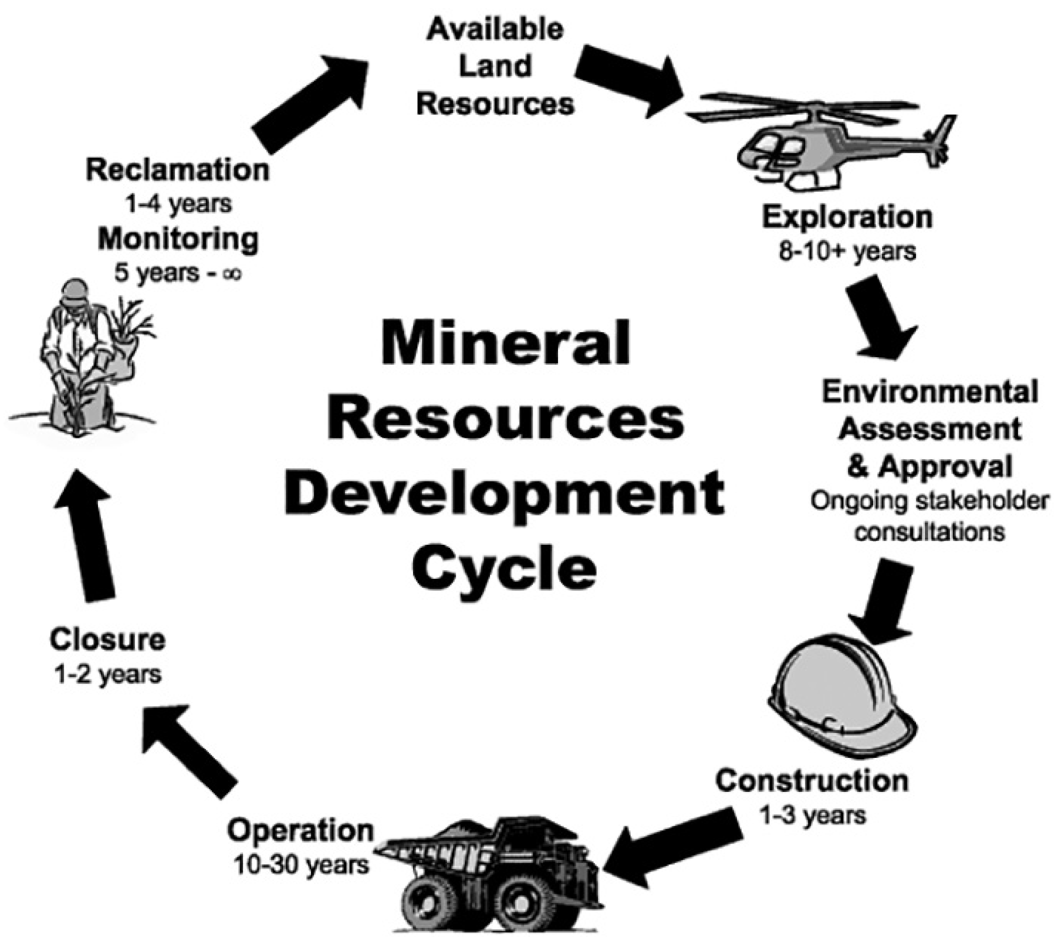
THE MINERAL RESOURCE DEVELOPMENT CYCLE

Mining is an industrial activity that removes **rock** from the Earth's crust and processes it to remove valuable **minerals** for us to use. We need mineral resources to make many of the things we use in our daily lives, from toothpaste to buildings, computers to cars.

The **mineral resource development cycle (mining cycle)** is very complicated and generally involves five stages:

- looking for minerals;
- evaluating a mineral discovery;
- building a mine;
- mining and processing minerals;
- and closing the mine and reclaiming the land.

From start to finish, a mining company has to think about how its activities will affect the environment and any nearby communities. The mining process can take a very long time and cost millions of dollars.



Minerals Education British Columbia. (2016). Mineral Resources Development Cycle.
Retrieved from http://www.mineralsed.ca/s/MinDevCycle.asp#ReclaimMonitor

Looking for Minerals

Looking for minerals is called **mineral exploration**. Geologists use many different methods to look for valuable minerals. They study satellite images of the Earth and use airplanes or helicopters to measure things, such as the magnetism in the land. Maps also help them choose an area to explore.

Before a mining company can explore more closely, it must get the exclusive rights to a piece of land. This is called **staking a claim**. The company can then use special equipment to look more closely for mineral deposits. Geologists do field work to identify different rocks and collect rock and soil samples to study in a laboratory. If the results are good, the company drills holes in the ground to take out long, thin cylinders of rock called cores, which can be studied to find out how much valuable mineral they contain.

Evaluating a Mineral Discovery

Once a mining company finds a mineral deposit, the next step is to decide if it will be worth spending the millions of dollars needed to construct a mine. A **mineral evaluation** looks at how much it will cost to construct and operate the mine, to sell the minerals, to take care of the environment, and whether or not the company will make any money. Finding a good mineral deposit is rare. Very few mineral exploration properties actually make it to the mineral evaluation stage of the mining process.

Constructing a Mine

Mineral deposits close to the surface of the Earth can be mined by digging a **surface** or **open pit** mine. This means using huge diggers to scrape away the surface material and blasting the solid rock with explosives to reach the valuable minerals. Mineral deposits buried deep in the Earth have to be mined using an underground mine. This means digging tunnels into the Earth to reach the valuable minerals.

Mining and Processing Minerals

Actual mining can begin once construction of a mine is complete. Miners use drills and explosives to break up the rock and large scoops and machines to move the rock to the processing plant.

Mined rock contains valuable minerals as well as worthless ones, all mixed together. **Processing** separates out the valuable minerals from the waste. Usually, the rock is first crushed into a fine powder. Then, a **separation process** captures the small amount of valuable minerals from the large amount of powdered waste rock. Some minerals are then refined to produce pure metal in a process called smelting. A mining company has to deal with the leftover waste materials, called **tailings**, which are rock fragments, dust, and chemicals. They must be stored in safe areas to avoid polluting the air or water.

Closing a Mine and Reclaiming the Land

No mine will last forever. When a mine closes, the mining company has to reclaim the land, making it safe, usable, and a natural part of the surrounding environment. It must remove the buildings, make sure mine waste doesn't harm the environment, make any pits or tunnels safe, and replant the land with grass and trees.

Protecting the Environment and Connecting with Communities

At every stage of the mining process, environmental specialists study the soil, water, wildlife, and vegetation, as well as the air quality and climate, to make sure an area remains safe and can be returned to usable land when mining is complete. The company also goes to local communities to learn about the area, explain the mining plans, answer questions, and talk about work opportunities.

BEFORE AND AFTER RECLAMATION

Underground Mine

Photo of Quirke II Mine, Rio Algom Limited – Elliot Lake , Ontario prior to reclamation.

Photo of Quirke II Mine following removal of buildings and prior to reseeding and planting.

BEFORE AND AFTER REHABILITATION

Sand and Gravel Pit

Photo of the Fonthill Pit, Steed and Evans Limited, Fonthill Ontario during rehabilitation.

Photo of the Fonthill Pit showing final rehabilitation.

1 CREATING A SURFACE MINE MODEL

1. Create one model of a surface mine for each group of students. There is considerable flexibility in the materials that may be used: the general principle being to have a valuable mineral or rock that must be separated from a waste or county rock component. Look at the suggestions in the table below; you can substitute the different valuable target minerals/rocks into alternate country rock.

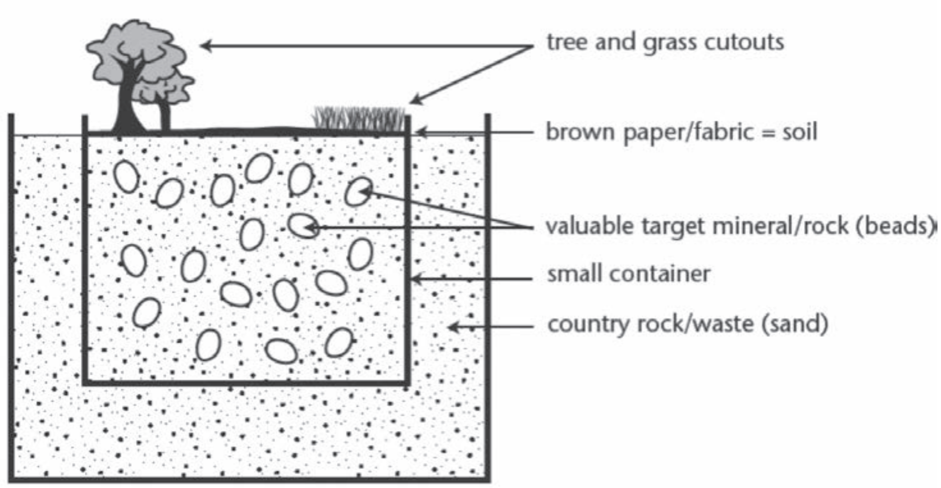
Valuable Target Rock/Mineral	Separation Process	Country Rock/Waste
Magnetic beads	Using a magnet	Sand or gravel
Paper clips	Using a magnet	Potting soil
Dried beans	Physical picking with fingers or tweezers	Pasta
Large sunflower seeds	Sieving, physical picking with fingers or tweezers	Small-gran bird seed
Coloured beads	Sieving, physical picking with fingers or tweezers	Rice
Peanuts in shells	Crushing and sieving	Peanut shells

2. Build the target rock body or mineral ore.
   a. In a small container (~250 ml), mix a 4:1 ratio (200 ml: 50 ml) of country rock/waste material and valuable target rock/mineral.
   b. Lay brown construction paper or fabric on top of the rock to represent soil.
   c. Place tree and grass cut-outs or magazine pictures of natural habitats on top of the soil.

3. *(Optional)* Put the target rock body or ore in a wider environment.
   a. Rest the smaller container inside a larger container (750 ml or 1 litre). Fill the area around the inner container with the same country rock material as it contains, making sure that the rim of the inner container can be seen after filling.

   OR

   b. Submerge the small containers in a sand table, making sure the rims can be seen.



MATERIALS

- Figure: *A Discussion on Development - Town of Wakima* (Displayed on available classroom projection technology)
- Handout: *Wakima – A Case Study Information Bulletin*
- Handout: *A Case Study Questions Activity*

Natural Resources Canada's Minerals and Metals Sector develops and distributes a number of information products on Aboriginal participation in exploration and mining.

https://www.nrcan.gc.ca/mining-materials/aboriginal/bulletin/7817

SUMMARY OF TASK

Students will:

- Identify the factors that must be considered in making informed decisions about land use (e.g. environmental impact, jobs, present and future values of natural resources).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. Become familiar with the Wakima – *A Case Study Town Map*.
2. Use the map information for informed participation in the class debate.

INSTRUCTIONS

Engage

1. Review map reading skills with students (use of legend, scale, etc.)

Explore

2. Have student examine figure: *A Discussion on Development - Town of Wakima.*

Explain

3. Distribute the handout: Wakima – *A Case Study Information Bulletin.*

Elaborate

4. Have students answer the questions on the handout: *A Case Study Questions Activity.*

Evaluate

5. Have students present their views using a *vote with your body* strategy. Set up signs at 4 sides of the room: For, Against, Unsure or Don't Know, Not Interested or Don't Care. Pose the question to students: "How would you feel if a mining operation were proposed near to where you live?" Give students 1 minute to consider their view, and then they move to stand by the appropriate sign. Ask a few students in each group to share more about their point of view. All responses are valid, so long as the factual basis is correct. The distribution of students between each point of view may be used as a baseline on which to consider changing opinions as the following activities are completed. This evaluation task can be repeated at relevant times.

SUPPORTING INFORMATION

Answers to Questions Activity

1. 750 m (0.75 km) northwest
   1,500 m (1.5 km) northwest
   1,200 m (1.2 km) north
   700 m (0.7 km) west
2. 425 m
3. Beaver dams
4. Airport, railway and major highway

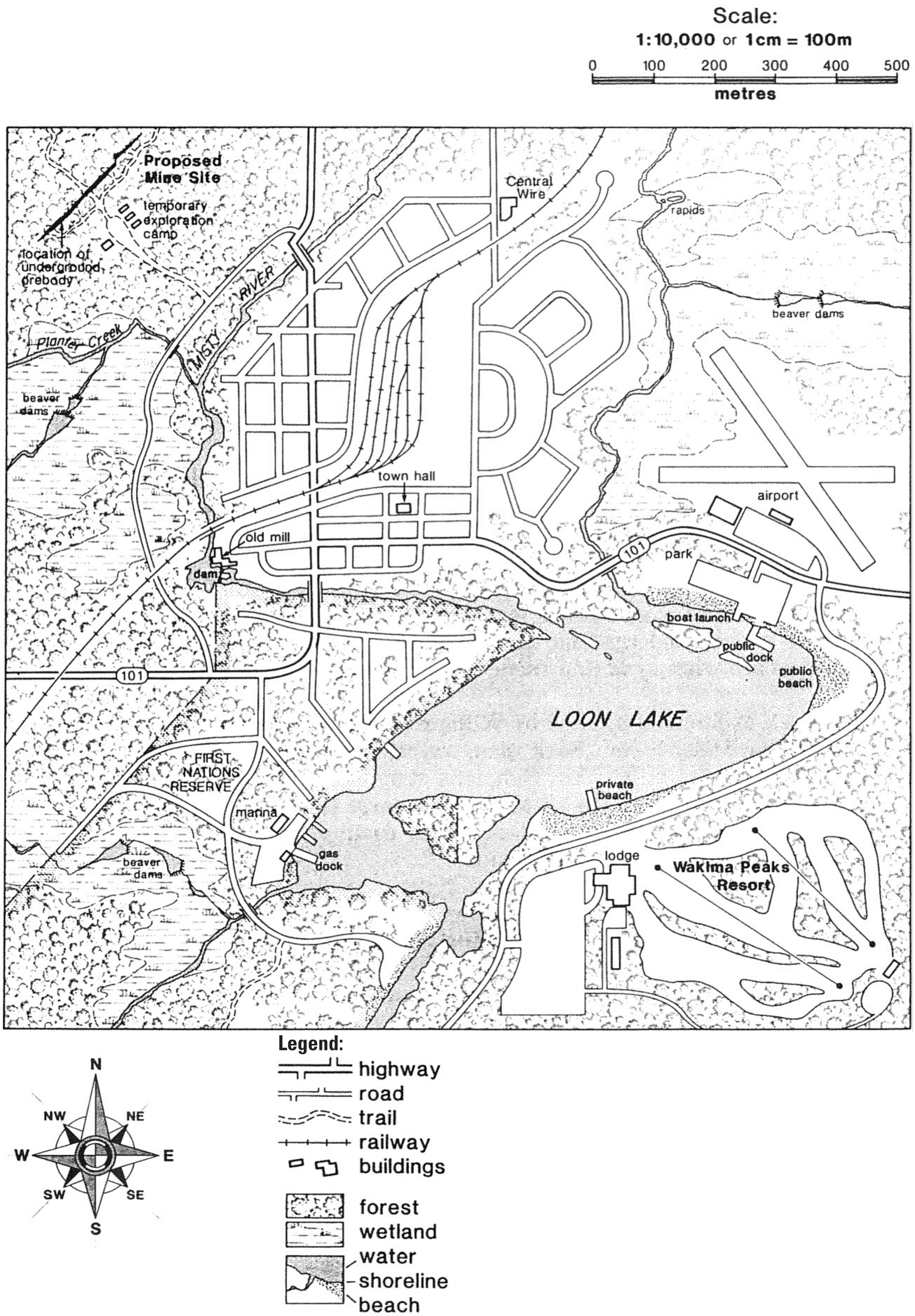
WAKIMA – A CASE STUDY

Wakima is a fictitious town in the northern part of your home province or territory. Trillium Mines is proposing to open a new underground nickel mine, based on the discovery of a large orebody close to the town. The building of a large mine near any community prompts questions and discussion and the town of Wakima will experience a debate that brings together many of the interested groups from within the community and beyond.

William Simmons founded Wakima in 1846. Mr. Simmons built a sawmill at a waterfall on the Misty River and supplied lumber for use in the gold mines, 10 kilometres to the east, until the early 1900's. Since then, Wakima has become a well-established community with a regional rail maintenance yard and switching site. Although it is a strong community, Wakima has experienced a slow down in its economy in the last few years. Some businesses have had to close and many young people have had to leave Wakima in order to find employment. A ski resort has been developed nearby, which has attracted some seasonal business. Tourists like to come to the town because there is very little industry and the surroundings are still natural and attractive.

Trillium Mines has made a proposal to the local town council to build an underground mine on its forested property just outside of Wakima. The mine would create 200 direct jobs and 450 additional spin-off jobs. The town population of 5,000 would increase to 6,000 and new services would be needed to meet the demands of the new residents. Some people favour the mine, as it will bring development and resources to the town while others are concerned about the altering of the local environment or a possible increase in pollution.

The town council is ready to debate the issue of whether or not the mine should be built. You will be assigned a role within an interest group that brings a particular point of view to the discussion. You need to help research the group's viewpoint and form an argument that supports, with examples, this point of view. Make sure that you can respond to opposing group's arguments, as well. Once the debate has been concluded, all debate participants will vote, according to their personal opinion, as to whether or not Trillium Mines should be allowed to go forward with their project.


Scale:
1:10,000 or 1cm = 100m
0 100 200 300 400 500
metres
Proposed Mine Site
temporary exploration camp
location of underground orebody
Central Wire
rapids
beaver dams
Planter Creek
MISTY RIVER
beaver dams
town hall
airport
old mill
dam
101
park
boat launch
public dock
public beach
101
LOON LAKE
FIRST NATIONS RESERVE
private beach
marina
gas dock
lodge
Wakima Peaks Resort
beaver dams
Legend:
highway
road
trail
railway
buildings
forest
wetland
water
shoreline
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2 QUESTIONS AND ACTIVITY

1. Considering the map's scale and using a straight line, how far and in what compass direction is the proposed mine site from:

   The town hall

   Wakima Peak's Ski Lodge

   The gas dock at Loon Lake Marina on the First Nations Reserve

   Central Wire Building

2. How long is the east-west runway of the airport?

3. What signs of wildlife are there in the area?

4. What facilities are already present in Wakima that would be useful to industry in the area?

5. If the mine were built, how might the area and life in the town be affected? Answer in 4 or 6 sentences. Be sure to consider both potential benefits and potential problems. What actions could be taken to reduce the potential problems?

3 WAKIMA – RESEARCH AND ROLES

MATERIALS

- Figure: *A Discussion on Development - Town of Wakima* (Displayed on available classroom projection technology)
- Handout: *Wakima – Research and Roles*

Natural Resources Canada's Minerals and Metals Sector develops and distributes a number of information products on Aboriginal participation in exploration and mining.

https://www.nrcan.gc.ca/mining-materials/aboriginal/bulletin/7817

Towards Sustainable Mining (TSM) is the Mining Association of Canada's (MAC) commitment to responsible mining. It is a set of tools and indicators to drive performance and ensure that key mining risks are managed responsibly at our members' facilities.

http://www.mining.ca/towards-sustainable-mining

SUMMARY OF TASK

Students will:

- Identify the factors that must be considered in making informed decisions about land use (e.g. environmental impact, jobs, present and future values of natural resources).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. Work in small groups to develop a point of view and points for discussion and debate based on information provided and research.
2. Discuss both the positive and negative aspects that can come with a mine being opened in a community.
3. Be familiar with the social, cultural and economic aspects required for full participate in the class debate.

INSTRUCTIONS

Engage

1. Review with students the activity 2: *Wakima – A Case Study*.
2. Review with students the concept of a debate and its purpose in governance.
3. Clarify the steps of getting ready for debate and how the voting process will proceed.

Explore

4. Divide students into 6 groups and give each group a handout with a role from the handout: *Wakima – Research and Roles.*
5. Students will meet with their group and discuss their situation clarifying any terms or aspects of the assignment.

Explain

6. Students will prepare strategies with which to present their point of view.
7. A spokesperson should be appointed from each group. These students will then present their group's specific situation to the class, the fellow citizens of Wakima.
8. All groups will listen carefully to other's point of views so that the group can develop its responses to any issues that will arise in the debate.

Elaborate

9. Each group will meet again to discuss the information presented by other groups and prepare solutions to the issues that were raised.

Evaluate

10. Explain to students the next step in this case study: Activity 4 Debate and Decision. Provide them notice of the evaluation criteria that will be used then for their contribution to the debate.

SUPPORTING INFORMATION

The town debate will decide if Trillium Mines Incorporated will be allowed to open up an underground mine on its Planter Creek Claims in Wakima. Wakima town council will soon debate the issue whether the mine should be built and under what circumstances. Six groups are going to present their point of view at the local meeting on this issue.

Key Words:
Basic Terms: orebody, reclamation plan, tailings, concentrate, emissions, milling, contamination, headframe, viable

3 STUDENT ROLES

ROLE 1
Trillium Mines Incorporated

Your company, Trillium Mines, has been in the mining business for 15 years and specializes in nickel mining. Four years of exploration work on the Planter Creek Claims, in the Wakima area, has resulted in the discovery of a significant **orebody** of nickel. It is estimated that the amount of nickel found can be mined for at least 20 years. There is currently a shortage of nickel in the world, and in view of the profitability of this operation, you would like to get started on your mine immediately. Recognising the environmental concerns of the town, you have an excellent **reclamation plan** ready to present to the community. When your project shuts down in 20 years, the buildings will be removed, the property landscaped and the **tailings** pond site treated and seeded.

Your mine will create 200 direct high paying jobs. The average miner salary will be approximately $50,000. In addition, you have negotiated with the Wakima First Nations people to provide training and employment to some of their members to fill 10% of the direct jobs. New homes, schools, restaurants and services will be built if your mine is given the go ahead and 450 spin-off jobs will result in the province.

You will be mining and producing a nickel **concentrate** at the site and you will ensure that emissions are kept to industry and government standards. Should you be given permission to build a mine, you are prepared to build a Sports-Community Centre for Wakima including an arena and an indoor pool.

ROLE 2
Provincial Government Ministries

(1) Ministry of the Environment

The Ministry of the Environment's job is to protect the environment. You are concerned about the proposed Trillium mine for the following reasons:

- Trillium Mines is proposing to build a mine in a forested area where moose travel regularly. The noise caused by the mine may affect mating patterns and disrupt the moose of the area. You need to review the environmental impact studies carried out by the company.
- You need to know from Trillium Mines whether or not there will be any dust and other airborne **emissions** from machinery and processes used by the mining company.
- You want to make sure that none of the chemicals used in the **milling** process will leak into the streams of the area and that no **contamination** of groundwater occurs from the tailings disposal area.

(2) Ministry of Northern Development and Mines

The Ministry of Northern Development and Mines' job in this case is to assist Trillium Mines with advancing their mining project. You want to assist Trillium Mines for the following reasons:

- Your Ministry is concerned with the economic development and wellbeing of communities. Mining is an important economic activity.
- The Government has developed a set of rules for the safe construction, operation and rehabilitation of mines. You ensure that Trillium Mines follows these rules.
- Other Ministries and groups have concerns and questions and are sometimes opposed to mine development. You help Trillium Mines deal with these concerns by suggesting solutions to the issues.

ROLE 3
The Economic Development Commission of Wakima

The Economic Development Commission of Wakima is composed of business people. You are in favour of allowing Trillium Mines to mine for the following reasons:

- The mine will create 200 direct jobs and 450 indirect ones. New people will be attracted to the town sparking more economic activity.
- If the project goes ahead, Trillium Mines will build a new $3 million community centre with a pool, arena and auditorium/theatre. Cineplex Odeon will build a cinema. Your members hope to get construction contracts.
- You have heard rumours that Central Wire, a small 50-employee company in the town, may close. If the new mine opens, the effect of the job losses at Central Wire may be lessened. Possible wire sales to the new mine may even keep Central Wire in business.

ROLE 4
"Life Without a Mine is Just Fine" Committee

Upon receiving word that Trillium Mines was seeking to open a mine in the Wakima area your group formed the "Life Without a Mine is Just Fine" committee. Your group is very concerned that mining will not only destroy the property value of area homes, but will ruin the environment. Your concerns are:

- The mine will lead to the construction of new homes and businesses and a more crowded town life.
- The mine site will be very ugly and the forest will be destroyed to make way for this project.
- The pollution that the tailings may generate could affect animal, plant and even human life in the area. Many people like life in Wakima because there is currently no air pollution.
- The moose population in the area will be driven away and some of the aboriginal people won't be able to practice traditional winter moose hunting. As well, moose mating habits may be affected by the mining operation.
- The mine may create noise pollution. Heavy trucks and equipment may cause unwanted noise.
- Skiers who use the ski hills in the area would not like to see a mine **headframe** and cleared area as they ski down a hill that at this moment has a beautiful panoramic view.

ROLE 5
The First Nations Cultural Protection Committee

Your group represents the aboriginal people living on the Wakima First Nations Reserve. Your people have been living on the reserve for over 80 years. Your people go moose hunting in the winter and depend on this activity to supplement their annual food supply. You have formed a committee to protect aboriginal concerns for the following reasons:

- The construction of the mine may bring noise, dust and pollution to an area immediately north of the inhabited section of your reserve.
- The moose population may be affected by mining and this would directly interfere with the hunting tradition of some of your community members.
- The protection of plant and wildlife is very important to your culture and further destruction of it will result in your way of life being negatively affected.
- You are worried that if the tailings pond is not properly monitored, certain substances may leak into local streams and affect the fish and wildlife.
- Certain commununity members conduct nature tours of the local forest area. They show the local wildlife to tourists. If the mine is built they are concerned that the wildlife will flee and their jobs will be eliminated.
- Some of your band members would like to get a job at the new mine so you must be careful to ensure the concerns of all of your members are met.

ROLE 6
Concerned Citizens for Progress

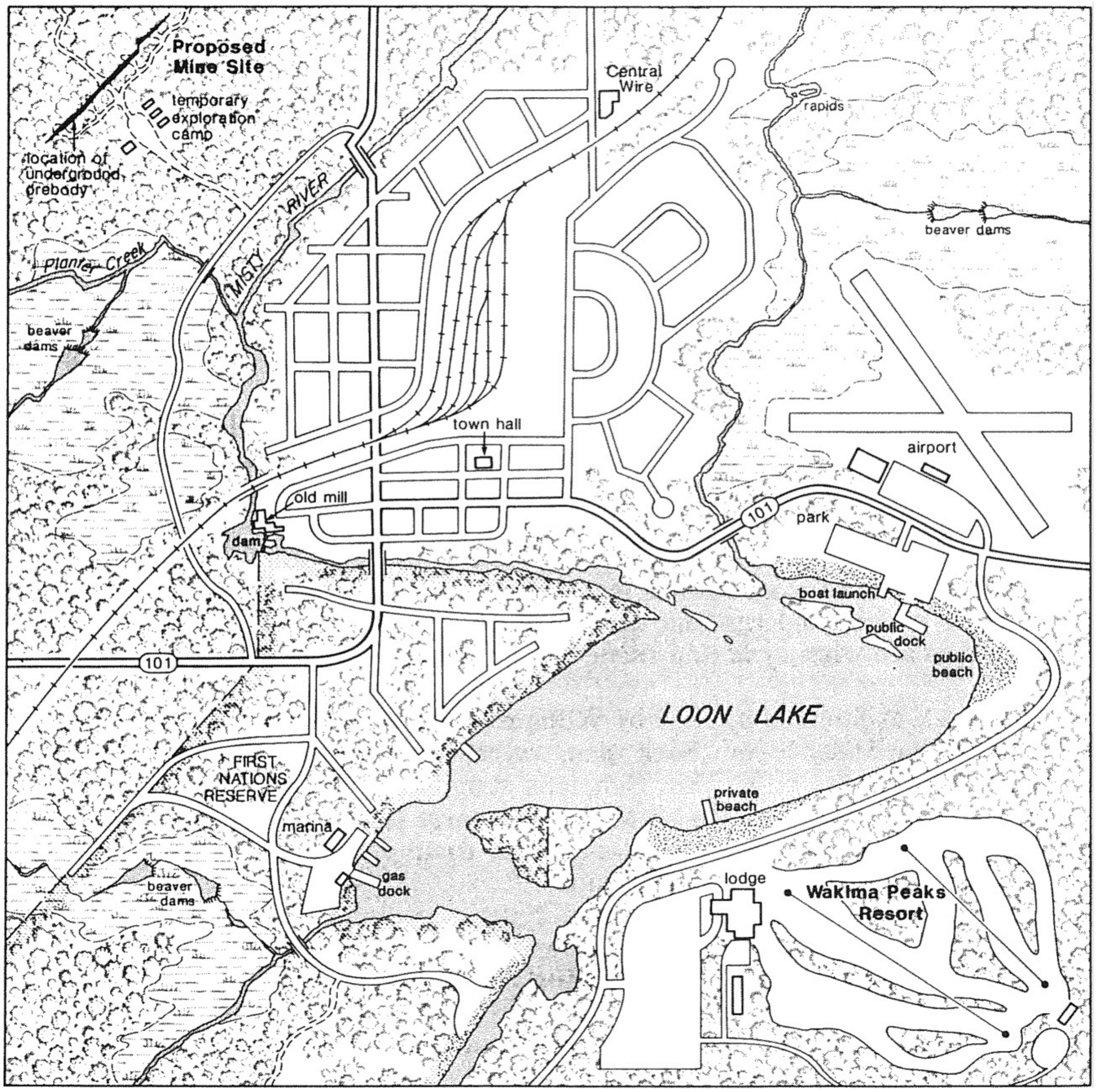
Your group represents the Concerned Citizens for Progress, and was formed to support the mining project because you believe that:

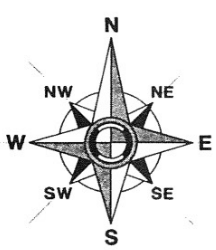
- If the mining project goes ahead, there will be new industry and jobs in the town. New restaurants and shops will be built making town life more interesting.
- Trillium Mines has promised to build a new sports complex and community centre if it receives permission to mine in the Wakima area. The local theatre group has no locale at present and has plans to convert the scenic old mill site into a centre for the performing arts. Increased population and resulting taxes in the town would make the project economically **viable**.
- Many parents in the community, along with students at local schools, would like a sports complex. At present, Wakima lacks an arena and indoor pool. Young people would be better served with a sportsplex and would be kept off the streets during their teenage years. As well, with more restaurants and shops, there would be more part-time jobs for the town’s youth.
- Lack of facilities prevented touring groups from visiting the town. If the old mill site is converted, travelling theatre and dance groups could perform in town.

WAKIMA TOWN MAP

Scale:
1:10,000 or **1cm = 100m**

0 100 200 300 400 500
metres





Legend:

- highway
- road
- trail
- railway
- buildings
- forest
- wetland
- water
- shoreline
- beach

4 WAKIMA – DEBATE AND DECISION

MATERIALS

- Student-generated research and material from Activity 3 relevant for the debate presentation.

SUMMARY OF TASK

Students will:

- Identify the factors that must be considered in making informed decisions about land use (e.g. environmental impact, jobs, present and future values of natural resources).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. To work in small groups to write and present a point of view based on information provided.
2. Discuss both the positive and negative aspects that can come with a mine being opened in a community.
3. Be familiar with the social, cultural and economic aspects required for full participation in the class debate.
4. Demonstrate communication and debating skills.

INSTRUCTIONS

Engage

1. Set-up the room as a meeting hall where a debate will take place. This requires a speaking area, a waiting area and a head table for those responsible for managing (adjudicating) the debate.
2. Discuss with the class the rules that will be followed during the debate. Explain that even though they may disagree with some aspects of their assigned role, it is their job to present the most positive elements of their position as they can. Clarify what the role of a moderator will be and how the voting process will proceed. It should be mentioned that after all the points of view have been presented and discussed there will be a class vote on whether or not the mine will proceed. Each vote should be cast as an individual based on the information discussed in the debate and does not have to be according to the student's group stance.

Explore

3. Provide students with the evaluation criteria for their performance in the debate (see #8 below). Allow groups time to prepare their presentation according to these criteria and their previous research from activity 3.

Explain

4. The debate moderator is introduced, the mayor of Wakima (the great grandchild of William Simmons) and will be represented by the teacher.
5. Rules of the debate are stated for the record and meeting is started.

6. During the group debate, the spokesperson for each group reads the group's position as to "yes" the mine should go ahead or "no" it shoud not and the reasons why. This debate can be done in two forms where:
    a. All groups first present their information without outside interaction and then an open question period can be conducted or
    b. Groups are put against an opposing side and then allowed a uniform time limit with which to present their case.

Elaborate

7. At the end of the debate, the mayor will ask everyone to vote. For the purpose of the vote everyone will be a town councillor and will vote individually whether or not the mine should be permitted. When deciding how to vote remind the students to consider the concerns of each group and what their proposed solutions were. The majority will decide if Trillium Mines gets to build the mine or not.

Evaluate

8. Use the following criteria to evaluate each group's communication and debating skills.
    1. Was the presentation well organized and effective?
    2. Did the team present plenty of empirical evidence to defend its position?
    3. Were the arguments presented in a logical and coherent way?
    4. Did the team use the allotted time well?
    5. Did the team recognize the weak points of the other sides and ask questions strategically?
    6. Did the team appear to know well both sides of the debate?

SUPPORTING INFORMATION

The town debate will decide if Trillium Mines Incorporated will be allowed to open up an underground mine on its Planter Creek Claims in Wakima. Students are expected to clearly identify the key factors; environmental, social, economic, etc that should be considered in order for the town council to make an informed decision.

CORE CONCEPTS

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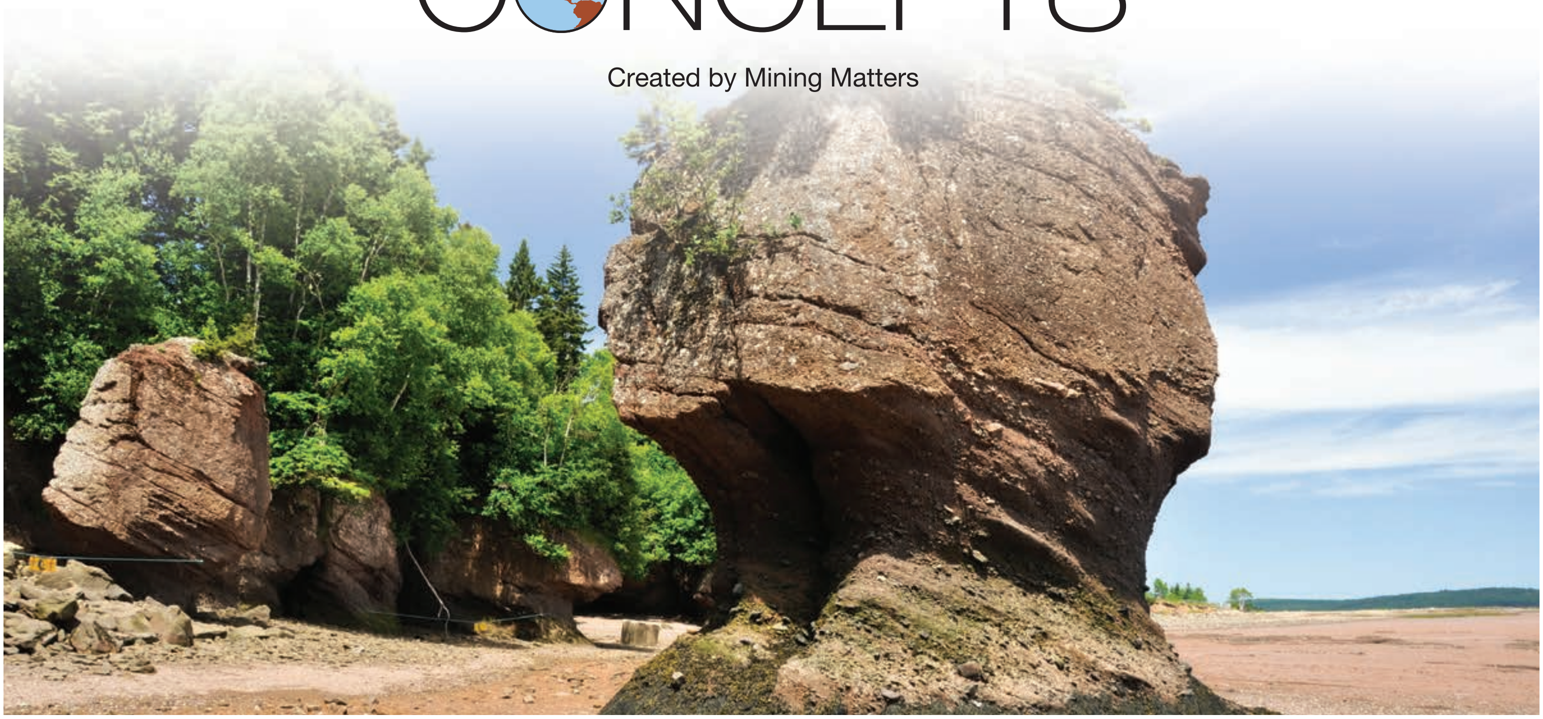
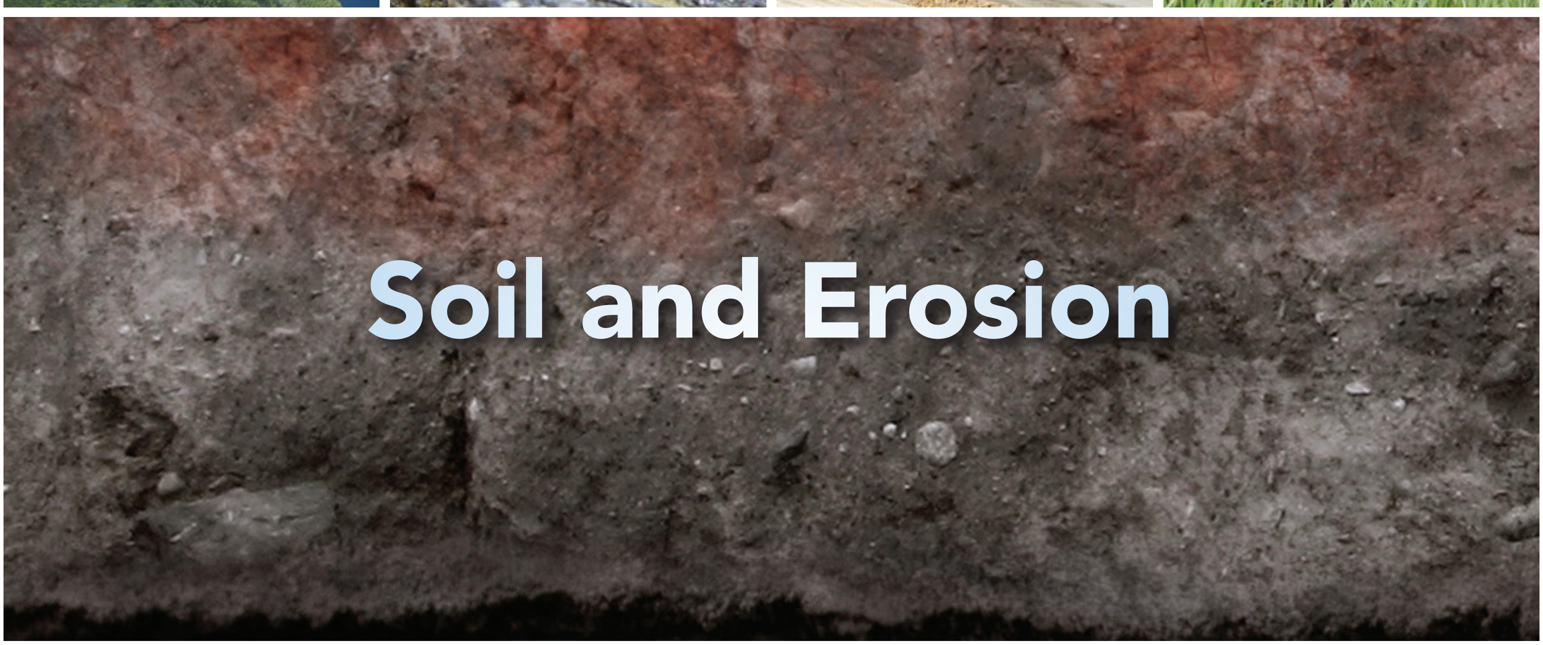




Soil and Erosion

Did you know that there are complementary and additional resources that will assist with the delivery of this topic? Please contact Mining Matters and we'd be happy to assist. Be sure to state, "Core Concepts order request" in the subject line of the email and/or the fax cover sheet.

Mining Matters:
T: (416) 863-6463
F: (416) 863-9900
E: schoolprograms@miningmatters.ca

TABLE OF CONTENTS

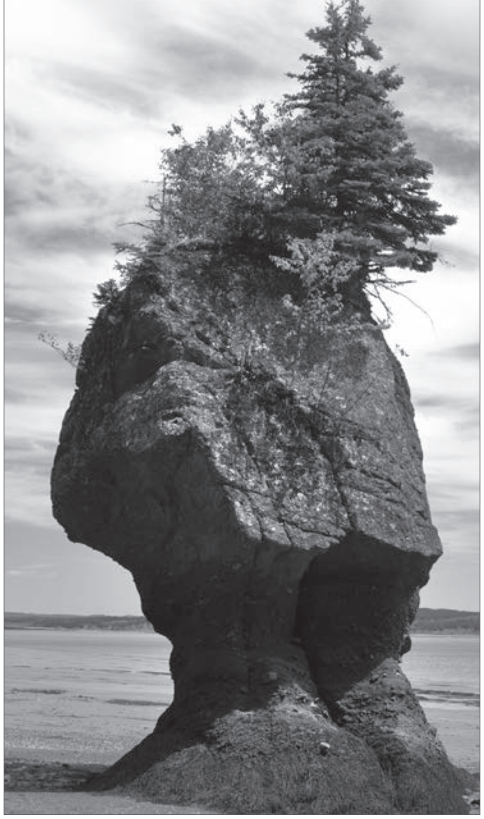
1 WEATHERING AND EROSION

MATERIALS

- Handout: *Weathering and Erosion Information Bulletin*
- Handout: *Weathering and Erosion Activity*
- Rubber Gloves
- Small transparent plastic glass
- Small plastic plate
- Mason jar with tight fitting lid
- Plastic container
- Freezer

Consumables:

- Steel wool (without soap)
- Water
- Vinegar
- Chalk
- Writing paper
- Pencil
- Eraser
- Water
- Balloon
- Plaster of Paris



SUMMARY OF TASK

Students will:

- Investigate the effect of weathering on rocks and minerals.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

OBJECTIVES

1. Understand the effects of weathering on rocks and minerals.

INSTRUCTIONS

Engage

1. With students, set-up the three demonstrations of weathering (see Preparation and Set-up). These experiments take up to 3 days to produce results.
2. Have students make predictions about what will happen in each experiment.

Explore

3. Have students complete the two experiments on *Weathering and Erosion Activities*.

Explain

4. Read and review the main points of weathering as discussed in the handout: *Weathering and Erosion Information Bulletin.*
5. Have students complete the question on the handout *Weathering and Erosion Activities*, identifying the weathering process in each demonstration and activity.

Elaborate

6. Have students answer the questions on the handout: Weathering and Erosion Questions.

Evaluate

7. Have students design an experiment to investigate what factors may increase or decrease the amount of one type of weathering. If appropriate, have them carry out their investigation.

Preparation and Set-up

Demonstration 1: Effects of Water and Air on Rock

1. Use a piece of steel wool about the size of a lemon.
2. Moisten the steel wool with water and place on a small plate.
3. Allow steel wool to sit for three days.
4. Put on the rubber gloves and rub the steel wool between your fingers.

Demonstration 2: Effects of Ice on Rock

1. Place a piece of blackboard chalk in a rigid jar with a tight fitting lid.
2. Completely fill the jar with water so there is no air space.
3. Freeze the jar until the water is solid, at least overnight depending on the size of the jar.
4. Remove from the freezer and observe the piece of chalk.

Demonstration 3: Effects of Freezing on Rock

1. Put water into a balloon, just enough to fill the balloon slightly beyond flat. Squeeze out any air and seal the balloon.
2. Mix plaster of Paris and put approximately 2.5 cm in the bottom of a plastic container.
3. Place the balloon on the plaster and then cover the balloon with another 2.5 cm layer of plaster.
4. When the plaster has completely set, place the container in the freezer, at least overnight, preferably 48 hours.
5. Remove the container from the freezer and observe the plaster.

SUPPORTING INFORMATION

Explanation for Demonstration 1: Chemical Weathering by Oxidation

Oxygen combines with the iron in the steel wool pad forming iron oxide or rust. Rocks with streaks of yellow, orange or reddish-brown contain iron. The iron at the surface of the rock forms iron oxide when exposed to moist air and eventually crumbles away as did the steel wool.

Explanation for Demonstration 2: Mechanical Weathering through Crushing by Ice

The water in the jar expands as it freezes, crushing the piece of chalk.

Explanation for Demonstration 3: Mechanical Weathering by Freezing

Water in the balloon expands when it freezes, cracking the plaster around it. If the container is allowed to thaw and is re-frozen, the plaster should crack even more.

Explanation for Activity 1: Chemical Weathering by Acids

Vinegar is an acid and acids slowly react chemically with the chalk. The piece of chalk is made of a type of limestone, a mineral that quickly changes into new substances when touched by an acid. One of the new substances is the gas seen rising in the vinegar, which is carbon dioxide. Acids affect all minerals – but very slowly. The slow deterioration of statues and buildings is caused by weak acid rain falling on the statue or building. If the building or statue is made of a type of limestone it will deteriorate quickly. Other rocks are more resistant.

Explanation for Activity 2: Mechanical Weathering by Wind

Pencils are made of graphite. Graphite is a mineral found in many rocks. Pencil erasers are made of high-friction materials. Pushing the eraser across the pencil markings rubs the particles of graphite and some of the paper off. When wind blows sand particles against rocks, the grinding of the sand against the rock acts like the eraser and removes small pieces of the rock. Over a period of time, more and more of the rock is rubbed away, and instead of a solid rock, only sediment is left behind.

Key Words:
Basic Terms: weathering, mechanical weathering, chemical weathering, erosion

SAFETY

- The jar for Demonstration 2 must very solid (can use glass, but be careful since the glass may break).
- Exercise caution when using plaster of Paris in Demonstration 3. There is the potential for burns since it gives off heat while setting.

WEATHERING AND EROSION

We have now seen how the landscape of the Earth is continually being shaped by natural forces that began millions of years ago and still continue today. Many geological processes have created new landforms or acted on existing ones, like mountains, canyons, caves and lakes. Rocks may seem solid and unchanging but in reality they are always changing. Rocks on the Earth's surface are exposed to the air, sun, rain and ice and gradually they will start to change. This process of change is called **weathering**. Weathering is the breaking down of rocks into smaller particles. Weathering is a slow, continuous process that affects all substances exposed to the Earth's atmosphere. There are two major types of weathering, mechanical and chemical. **Mechanical weathering** causes the rock to break into smaller pieces without changing the composition of the rock. **Chemical weathering** is the process of changing the composition of the rock through chemical reactions. Most landscapes we see are the result of a combination of both mechanical and chemical weathering processes.

Mechanical weathering is caused by changes in temperature, frost action, the growth of crystals, plant activity, and grinding. Temperature variations over a period of time can cause rock to expand and contract repeatedly resulting in pieces breaking off. Frost action occurs as water seeps into cracks in the rock. The water expands upon freezing and breaks the rock. This process also happens when salts dissolved in water crystallize. Organic activity occurs as plant roots slowly pry apart the rock as the plant grows. Grinding occurs when rock surfaces come together. Collision between rock surfaces normally occurs through the movement of material by wind, water, or ice.

Most chemical weathering is caused by water. Water can dissolve most minerals that hold rocks together. Minerals such as halite (salt) and gypsum dissolve very easily in water. Over time, water can also break down most minerals, except quartz and a few others, to form clay. Oxygen in the atmosphere will react with rocks which contain iron (basalt and gabbro) to form rusty coatings. Human industrial activity can result in increased chemical weathering from acid rain. Acid rain breaks down rocks, metal, and other materials.

How would granite break down? The following shows the simplified weathering process of granite and the end result.

Granite	Weathering	Result
Orthoclase feldspar (pink)	Water	Clay
Quartz (clear to white)	Grinding	Quartz grains
Biotite (black)	Water	Clay

Granite breaks down by both mechanical and chemical processes. Quartz is resistant to chemical weathering but will break down physically to form tiny quartz grains. Orthoclase feldspar and biotite both break down chemically in the presence of water to form clay.

Once the weathering process has broken down a rock into smaller particles, these particles are transported from one place to another by wind, water or ice. **Erosion** is the general term that describes the physical breakdown and chemical dissolution of rock <u>and</u> the simultaneous movement of material from one place to another on the Earth's surface.

One of the most spectacular landscapes resulting from erosion is Niagara Falls. When a river flows over a rock ledge, the increased speed of the falling water sets up strong turbulence at the base of the falls. The lip of Niagara Falls consists of strong, resistant dolostone (sedimentary rock) on top of weak, easily eroded shale (sedimentary rock). As the shale is eroded back by the turbulent water, the dolostone lip is undermined and collapses, resulting in the retreat of the falls upstream. The long deep gorge downstream from the falls was created by this retreat over thousands of years at the rate of about 1.2 metres/year.

Weathering and erosion are processes that shape the Earth's landscape, creating dramatic features such as canyons, flood plains and caves. These two processes are also involved in soil formation. Erosion is sometimes detrimental to human needs, but can also be beneficial to us, such as when its products are deposited on rich flood plains. We can clearly say that both weathering and erosion play a part in the processes that sustain human, animal and plant life on Earth.

MATERIALS

- Chalk
- Vinegar
- Small transparent plastic glass

Activity 1: Effect of Acid on Rock

PROCEDURE:

1. Fill a glass one quarter full with vinegar.
2. Add a piece of chalk to the glass.
3. Observe the piece of chalk and the vinegar.

MATERIALS

- Writing paper
- Pencil with eraser

Activity 2: Effect of Wind on Rock

PROCEDURE:

1. Write your name on the paper with the pencil.
2. Rub the eraser back and forth over the writing.
2. Observe the pencil lines and the paper.

After reading the *Weathering and Erosion Information Bulletin*, identify which type of weathering is represented in each of the demonstrations and activities.

Demonstration 1: Effects of Water and Air on Rock

Demonstration 2: Effects of Ice on Rock

Demonstration 3: Effects of Freezing on Rock

Activity 1: Effect of Acid on Rock

Activity 2: Effect of Wind on Rock

1 ACTIVITY QUESTIONS

1. Describe the process of weathering and erosion in your own words.

2. How is weathered rock transported from one place to another? Give two examples.

3. Given the example in the Information Bulletin of how granite would weather, describe how you would expect the following rocks to weather and what the end result would be?

   Sandstone

   Gabbro

4. Describe another example of a spectacular landscape created by erosion like Niagara Falls. Be sure to explain how the erosional processes have worked to shape the feature.

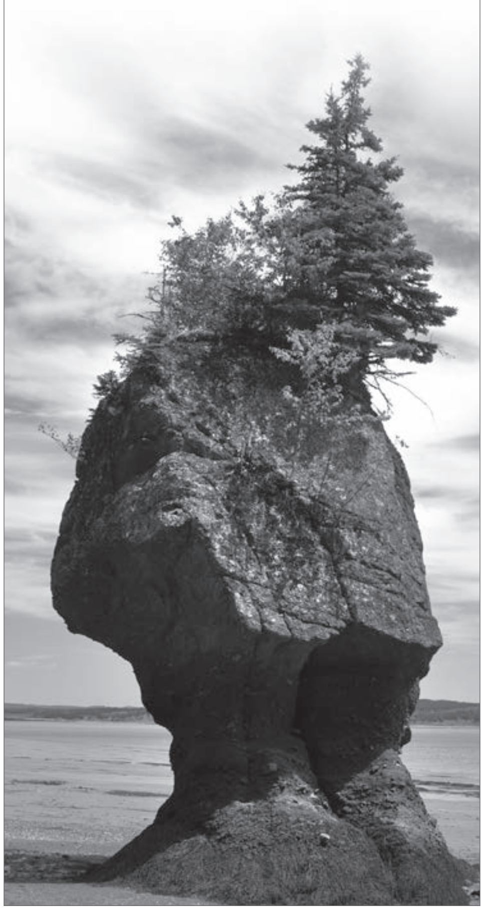
2 SOIL FORMATION

MATERIALS

- Handout: *Soil Formation Information Bulletin*
- Rubber Gloves
- Small transparent plastic glass
- Small plastic plate
- Mason jar with tight fitting lid
- Plastic container
- Freezer

Consumables:

- Steel wool (without soap)
- Chalk
- Water
- Balloon
- Plaster of Paris



SUMMARY OF TASK

Students will:

- Describe the process of soil formation by relating the various meteorological, geological and biological processes involved.
- Recognise that soil is a natural resource.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

OBJECTIVES

1. Understand the processes related to soil formation.

INSTRUCTIONS

Engage

1. Have students observe the results of the three demonstrations set-up in Activity 3 *Weathering and Erosion*.

Explore

2. Alongside students predictions they made for the demonstrations, record their observations.
3. Review the types of weathering represented by each demonstration.

Explain

4. Read and discuss the handout: *Soil Formation Information Bulletin*.

Elaborate

5. Have students write an explanation of how each demonstration relates to soil formation.

Evaluate

6. Lead a group discussion to respond to the question: "What would happen if we could stop all erosion?" Use a three column format to prompt their thinking: plus points, minus points, and interesting comments.

SUPPORTING INFORMATION

Key Words:

Basic Terms: soil, humus, gravel, sand, silt, clay, soil profile, A horizon, B horizon, C horizon, topsoil, parent material, loam, weathering, mechanical weathering, chemical weathering, erosion

Secondary Terms: pedology, regolith, pedologist, leaching, bedrock, mixture

SOIL FORMATION

One of the significant results of weathering is the creation of soil. **Soil** is the material that is the bridge between the non-living and the living. Soil is a complex **mixture** of mineral matter (gravel, sand, silt and clay), organic matter (like **humus** – that, incidentally gives the name to our species as being "human", or "from the soil"), water, air and living organisms. Mineral matter can be divided into separate components based on grain size.

These components include:

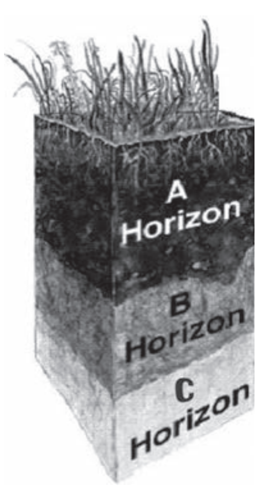
Gravel - particle sizes (2.0 - 10.0 mm) - *visible with naked eye*
Sand - particle sizes (2.0 - 0.02 mm) - *visible with the naked eye or hand lens*
Silt - particle sizes (0.02 - 0.002 mm) - *visible with a light microscope*
Clay - particle sizes (less than 0.002 mm) - *need electron microscope*

An "average" soil consists of about 45% mineral matter, 25% air, 25% water and 1-5% organic matter. A common soil texture is **loam**, which is a rich soil composed of a mixture of sand, silt and clay in more or less equal proportions and usually containing humus. Soil is a product of the environment - constantly changing, constantly evolving and developing over a long period of time. Soil is different from "powdered rock" or "dirt" in that it supports life - in particular, the growth of plants.

Pedology is the study of the origin, use and protection of soils. The word comes from the Greek "pedos" meaning "feet", or "under foot" (think of the word 'pedicure'). *Regolith* is the term used to describe the uncemented rock fragments and mineral grains derived from rocks by the weathering processes which overlie solid rock (bedrock) in most places.

The action of weathering and biological activity on regolith eventually leads to the formation of a **soil profile**. The kind of soil profile that develops depends upon many factors including parent material, climate, vegetation, topography, time and organisms. It is the characteristics of this soil profile that are used to classify soil types. Why are soils classified? The main reason is to allow *pedologists* to predict the behavior of soils. This knowledge would help people to understand which soils are susceptible to flooding or wind erosion, which soils are best suited for a landfill, or which soils are best for specialty crops.

An idealized soil profile can be thought of as having three horizons. From the surface downwards they are called A, B and C horizons. These horizons can usually be distinguished by colour differences, but there are also differences in chemical and physical properties.



A horizon is the top layer of the soil. The A horizon varies in thickness and is usually dark in colour because it contains organic matter. The organic matter is present because of the biological activity of soil organisms and the accumulation of plant materials. Organic matter makes this horizon fertile, meaning that it contains nutrients that make it suitable for plant growth. *Leaching* of materials can also occur in the A horizon.

B horizon is the soil layer underneath the A horizon. It is usually lighter in colour than the A horizon because it does not contain as much organic matter, making it less fertile. This layer can vary in thickness from a few centimetres to more than a metre. The B horizon shows accumulations of mineral particles such as clay, iron and salts due to leaching or movement from the A horizon.

C horizon is the soil layer which lies under the B horizon. It remains largely unchanged by soil forming processes. It may still resemble the sand, gravel, pebbles, boulders and rock from which the soil was originally derived.

Underlying the C horizon is the original material, also called the **parent material**, from which the soil developed. The original parent material could be sediments like till, gravel, sand and silt deposits or *bedrock* (solid rock).

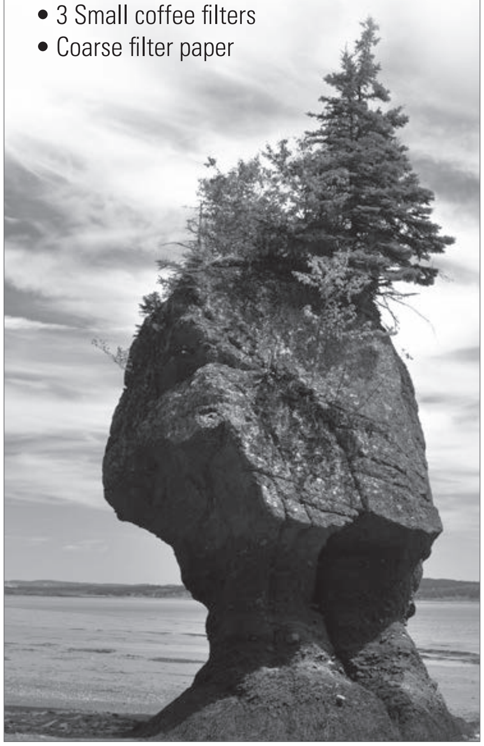
3 CHARACTERISTICS OF SOIL

MATERIALS

- Handout: *Activity A – Components of Soil*
- Handout: *Activity B – Water Holding Capacity of Soil*
- Handout: *Activity C – Presence of Air in Soil*
- Handout: *Activity D – Capillary Action in Soil: How Water Rises*
- 2 Magnifying glasses
- 3 Glass cylinders
- 3 Graduated beakers
- 5 Graduated cylinders
- 3 Elastic bands for coffee filters
- 3 Funnels
- 1 Large clear glass jar
- 1 Large flat pan (33cm x 23cm or 13”x9”)
- 2 Rulers
- 1 Tube for siphon

Consumables:

- 1 Small bag of sand
- 1 Small bag of clay
- 1 Small bag of potting soil
- Water
- 3 Small coffee filters
- Coarse filter paper



SUMMARY OF TASK

Students will:

- Investigate the characteristics of soil (e.g. water-holding capacity, size of particles, texture).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 5 Earth is the water planet.

BIG IDEA 7 Humans depend on Earth for resources.

OBJECTIVES

1. Understand that soil is primarily made up of fine rock and mineral particles plus some organic material or humus.
2. Understand that different soil types and textures exist.
3. Understand that different soils have different characteristics.

INSTRUCTIONS

Engage

1. Discuss the components of soil – gravel, sand, silt, clay, organic matter or humus.
2. Provide basic definitions of the basic soil textures.
3. Discuss how to create a table to chart observations. (This can be provided or have the students create some or all of them on their own).

Explore, Explain, Elaborate

4. Review the handouts for all 4 activities. Give particular attention to how to use a siphon in Activity A (see the Safety section). and have students complete these activities and record their observations.

Evaluate

5. Have students create a chart that ranks each soil type (sand, clay and potting soil) for the three characteristics: water holding capacity, air content, and capillary action.

SUPPORTING INFORMATION

There are several ways to classify soil types or textures for soils that are made primarily of mineral matter. One of the most common is based on particle size. Each type of particle is called a **soil separate**. Any soil composed mainly of mineral matter can be divided into soil separates such as gravel, sand, silt or clay.

A common type of soil texture is loam, a soil composed of a mixture of sand, silt and clay in more or less equal proportions. The stickiness of wet clay and silt is balanced by the gritty nature of the sand. Depending upon the dominant component of loam, various terms are used to describe a loam soil. These terms include sandy loam, silty loam, clay loam and variations like silty-clay loam and sandy-clay loam.

Key Words:
Basic Terms: capillary action, composition, soil separate

SAFETY

- Make sure that students wash their hands after handling soil and sand.
- Make sure that any water that is spilled is cleaned up immediately to avoid slips.
- Activity A uses a siphon. The siphon should NOT be started by sucking on the end of the tube. To correctly siphon, fill the tube completely with water and close both ends with thumbs. Insert one end into the water in the jar while holding the other end lower into a container to catch the water. Remove thumbs from the ends of the tube to start the siphon.
- Handle all glass jars, beakers and cylinders with care to avoid breakage.

MATERIALS

- Soil sample
- Large glass jar
- Water
- Ruler
- Tube for siphon
- Spoon or spatula
- Magnifying glass

Activity A: Components of Soil

Question: Is a soil sample a mixture of more than one component?

Hypothesis: Write a hypothesis for this activity.

PROCEDURE:

1. Examine the dry soil sample under the magnifying glass. Describe its colour.
2. Describe the different particles in the soil.
3. Pick up sample, rub the sample in your fingers and feel its texture. Record your observations.
4. Put approximately three-quarters of your soil in the glass jar and slowly add enough water to cover it. Keep one quarter dry for later comparison.
5. Watch carefully for bubbles to rise from the soil. Record your observations.
6. Fill the jar so that you have approximately half soil and half water. Add jar lid.
7. Shake thoroughly and set aside to settle. Allow at least 20 to 30 minutes.
8. Observe carefully to determine which layers contain the largest and smallest particles. Draw and label the jar and contents after settling is completed.
9. Siphon out all of the water being careful not to disturb the soil. See Safety Note.
10. Carefully remove the top layer with a spoon or spatula. Examine a small sample under the magnifying glass. Take another small sample and rub it in your fingers. Record your observations. Repeat this process for each layer.
11. Compare the wet and dry soil samples and record your observations.
12. Was your hypothesis correct? Explain your results.

MATERIALS

- Soil samples (sand, clay, potting soil)
- 3 Funnels (or 3 foam cups with small holes punched in the bottom)
- 3 Graduated beakers
- Graduated cylinder
- Coarse filter paper
- Ruler
- Magnifying glass

Activity B: Water Holding Capacity of Soil

Question: Are all soils capable of holding the same amount of water?

Hypothesis: Write a hypothesis for this activity.

PROCEDURE:

1. Examine each soil sample under the magnifying glass. Describe the colour.
2. Describe the different particles in the sample.
3. Pick up sample, rub the sample in your fingers and feel its texture. Record your observations.
4. Describe the differences between the samples.
5. Predict which sample will hold the most water.
6. Place coarse filter paper over the bottom of each funnel to stop the soil sample from moving out of the funnel.
7. Measure 50 mL of each sample and place into separate funnels without packing.
8. Place the graduated beaker under the funnel.
9. Put 50 mL of water in a graduated cylinder and slowly pour the water into the funnel and through the soil sample. Repeat for each sample.
10. Record the amount of water in the graduated beaker.
11. Was your hypothesis correct? Explain the results.

MATERIALS

- Soil samples (sand, clay, potting soil)
- 4 Graduated cylinders
- Water

Activity C: Presence of Air in Soil

Question: Is air present in soil? Do all soils have the same amount of air?

Hypothesis: Write a hypothesis for this activity.

PROCEDURE:

1. Put 50 mL of each soil sample into a graduated cylinder without packing.
2. Using the fourth graduated cylinder, slowly pour 50 mL of water into each of the graduated cylinders containing the soil samples.
3. Watch carefully for bubbles to rise from the soil. Record your observations.
4. Record the final volume of the soil and water.
5. Calculate the change in volume of the water and soil for each sample.

   Soil = 50 mL

   Water = 50 mL

   Initial volume = 100 mL

   Final volume = X mL

   Change in volume = Y mL
6. Was your prediction correct? Was your hypothesis correct? Explain your results. Which sample had the highest volume of air between the soil particles?

MATERIALS

- Soil samples (sand, clay, potting soil)
- 3 Tall glass cylinders
- Large pan
- 3 Small coffee filters
- Elastic bands
- Water

Activity D: Capillary Action in Soil: How Water Rises

Question: Will soil samples draw water up the glass cylinder? Why?

Hypothesis: Write a hypothesis for this activity.

PROCEDURE:

1. Fill each cylinder with dry soil to the same height (at least 15 cm).
2. With elastic bands, cover the end of each glass cylinder with a coffee filter.
3. Predict the height to which water will rise in each cylinder after it is placed in water.
4. Stand the cylinders, filter side, down in a pan containing at least 3 cm of water.
5. Allow to stand in the pan for at least 5 minutes.
6. Note carefully if the different soils become wet.
7. Record the height to which each sample absorbs water.
8. Was your hypothesis correct? Explain your results.

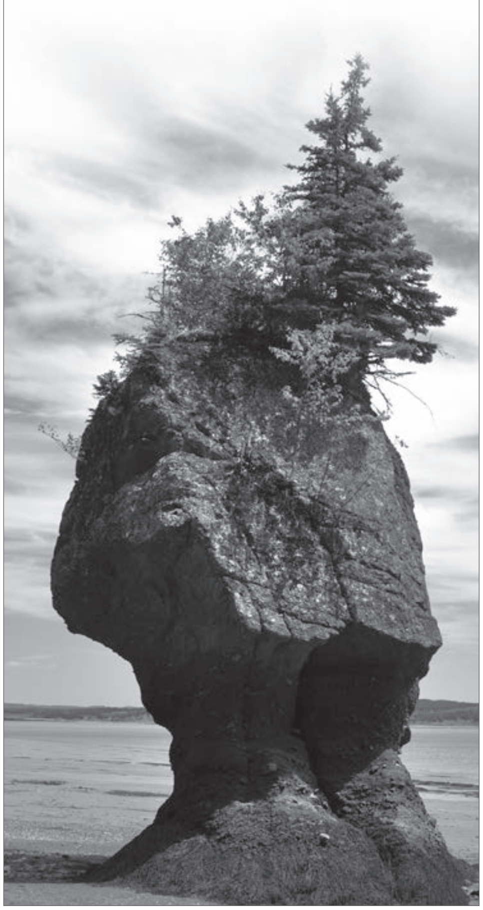
4 TYPES AND USES OF SOIL

MATERIALS

- Handout: *Types and Uses of Soils Information Bulletin*

Additional teaching tools:
"Teaching soil science" learning resource developed by Soil Science British Columbia
www.soilsofcanada.ca

This site provides and excellent overview of all aspects of soil in Canada and includes numerous pictures of various soil types.



SUMMARY OF TASK

Students will:

- Recognize that soil is a natural resource, and explain how the characteristics of soil determine its use.

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

OBJECTIVES

1. Understand that different soil types have the potential for different uses.
2. Understand that different agricultural products use different types of soils.

INSTRUCTIONS

Engage

1. Ask the class for the properties of soil.
2. Brainstorm ideas about why different soil types are used for different purposes. Make sure the idea of water holding potential is brought up.

Explore

3. Read and discuss the handout: *Types and Uses of Soils Information Bulletin.*

Explain, Elaborate

4. Have students research the types of soils in their region and their uses.

Evaluate

5. Put the following question to the students:

   What type of soils would one consider best for:
   a. Hazardous Waste Storage
   b. Landfills
   c. Conservation Projects (reforestation)
   d. Recreation (soccer pitch, baseball diamond)
   e. Vegetable Crops
   f. Cattle
6. In groups of two or three have students provide reasons for their answers. Have one student record the suggestions in point form.
7. Have students debate the pros and cons of the various uses.

SUPPORTING INFORMATION

What type of soil is best answer key:

a. Hazardous Waste Storage:
Answer - clay soils or rock without fissures because the material would be less likely to leach into the groundwater or beyond its storage area.

b. Landfills:
Answer - clay soils because the waste material would be less likely to leach into the groundwater.

c. Conservation Projects (reforestation):
Answer - less productive soils, sandy, gravelly soils.

d. Recreation (soccer, baseball):
Answer - less productive soils, old pits and quarries, soils with high sand content, because they would be well drained.

e. Vegetable Crops:
Answer - organic soils because of the higher nutrient content.

f. Cattle (grazing/pasture):
Answer - shallow, stony soils which are not useful for much else.

Key Words:
Basic Terms: texture, organic matter, forest soils, organic soils, mineral soils

TYPES AND USES OF SOILS

Like water, soil is a valuable resource for life forms. Green plants derive their energy from sunlight. Water, gases, mineral nutrients are absorbed by plant organs and are incorporated into plant bodies. Plants that are consumed by animals or humans are eventually converted into animal tissue. Decomposition of plant and animal bodies and their waste products in soil allows matter to be reused by living organisms. In this way, soil serves as an important interface or link between the living and non-living worlds.

Soils are made up of different things. Rocks are eroded by water, wind and ice. They are broken down by physical or chemical processes to form tiny mineral particles. The sizes of the mineral particles are important in determining the characteristics, especially **texture**, and classifications of soils:

- Clays have the finest particles, the largest total air space but the ability to soak up and hold much water.
- Sands and gravels have the largest particles and large pores but less total air space. They hold little water and allow water to pass through easily.
- Loams have particles of intermediate size and space. They have the ability to hold water more easily than sands and gravels.

Irregular spaces between the mineral particles (pores) allow water, and water vapour, and atmospheric gases, including oxygen, carbon dioxide, and nitrogen, to enter soils. Decaying **organic matter**, derived from vegetation and soil organisms, is added to soil over time. Organic matter is an important component of soils in that it provides nutrients, and influences soil structure and water holding capacity. Soil also contains living organisms, including microorganisms like bacteria, fungi, and protozoa, and macro organisms like insects. Organisms are an important soil forming factor.

The Canadian System of Soil Classification organizes soils into numerous types. These soil types can be grouped into three main categories that include forest soils, organic soils and mineral soils.

Forest soils are usually brownish in colour and contain a well developed B horizon. There are three categories of forest soils - luvisolic, brunisolic and podzolic which are differentiated based on the degree of soil development and characteristic soil horizons.

Mineral soils are usually gray in colour and are typically rich in mineral matter (sand, silt and clay) and contain little humus. These soils are generally wet and develop in low lying areas which are subject to periodic flooding and water saturation. The main category of mineral soil is gleysolic.

Organic soils are usually black in colour and composed mainly of organic matter making them very fertile. These soils are typically found in bogs, swamps and wetlands. There are three major categories of organic soils - fibrisol, mesisol and humisol which are differentiated by the amount of decomposed organic material.

Because soils have different characteristics from one place to another, the agricultural use and type of crop that the soil can support also differ. Shallow soil over bedrock is commonly used for extensive pasture and forest management. These soils are too shallow for cultivation of high-value crops. Organic soils are used for intensive production of high-value crops such as vegetables.
Sand plains are generally used for specialty crops such fruits, vegetables, and tobacco. These plains have clay enriched layers which improve moisture availability.

Many soils in Canada are under stress due to of intense cultivation and loss of productive land due to urbanization. Large areas have low levels of organic matter and soil health will decline in the future if conservation practices are not adopted.

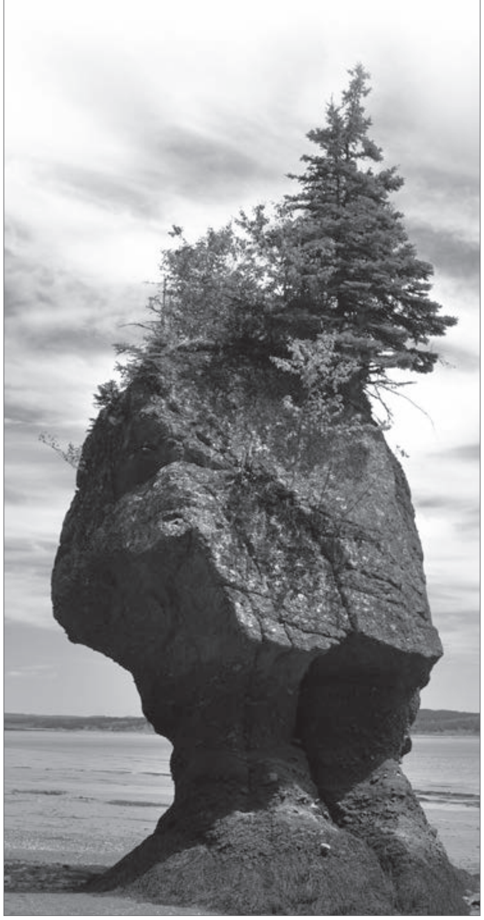
5 THE IMPORTANCE OF SOIL CONSERVATION

MATERIALS

- Handout: *Concept Overview Chart*
- 2 Flower pots (10cm or larger)
- Electronic balance or scale
- 4 Plastic garden flats/ seedling trays (approx. 22 x 45 x 6cm, no drainage holes)
- Hair dryer
- Large cardboard box (big enough to put the gardening flats into)
- Safety goggles

Consumables:

- Soil
- Peat moss
- Sand
- Quick growing grass seed



SUMMARY OF TASK

Students will:

- Assess the importance of soil conservation (e.g. economically important to agri-food industry, important for controlling the flow of water, necessary for plant growth).

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 7 Humans depend on Earth for resources.

BIG IDEA 9 Humans significantly alter the Earth.

OBJECTIVES

1. Observe two demonstrations that illustrate the importance of soil conservation, soil erosion and methods of soil conservation.

INSTRUCTIONS

NOTE: Mulch demonstration should be started three days prior. Wind Erosion demonstration should be started 14 to 20 days prior.

Engage

1. Review the uses of soil.
2. Review the concept of erosion.

Explore, Explain, Elaborate

3. Have students write a hypothesis about the following: What is the effect of putting a layer of peat moss on top of soil?
4. Conduct the *Mulch Demonstration* and have the students record observations and identify if their initial hypothesis was correct.
5. Have the students write a hypothesis for the following: How do different soils react to different wind speeds?
6. Conduct the *Wind Erosion Demonstration* and have the students record observations and identify if their initial hypothesis was correct.

Evaluate

7. Have students create a public service announcement to convince people what they can do to prevent soil erosion, and why it is important. Products may be a web page, animation, poster or brochure.

The Canadian Soil Information Service (CanSIS)

The Soil Landscapes of Canada (SLCs) are a series of GIS coverages that show the major characteristics of soil and land for the whole country. You will also find a photo gallery of SLC. http://sis.agr.gc.ca/cansis/index.html

SUPPORTING INFORMATION

Mulch Demonstration:

The act of covering the soil with a loose porous material such as peat moss is called **mulching**. Good mulch slows the process of evaporation of water from the soil by shielding the surface of the soil from the heat of the sun's rays. This is important for crop growth and for slowing erosion.

Wind Erosion Demonstration:

The dry sand should blow easily at low speed. Sand is easily eroded by both wind and water. The wet sand is more difficult to move because the water creates tension between the particles and holds them together. The sand and peat moss should also be more difficult to blow because of the water holding capacity of the peat moss and the surface area of the peat moss. This example should be compared to the *Mulch Demonstration* where the peat moss kept the soil damp. The grass and sand combination should remain in the pan even at high speed because the roots hold the sand particles in place. If the grass is well developed, pulling a small clump out should demonstrate the holding capacity of roots.

Key Words:

Basic Terms: erosion, mulching

SAFETY

- **Caution:** Dry sand blows easily, wear safety goggles.

5 ACTIVITIES - MULCHING AND WIND EROSION DEMONSTRATIONS

Mulch Demonstration

Question What is the effect of putting a layer of peat moss on top of soil?
Hypothesis Have students write a hypothesis.
Equipment 2 Flower pots, soil, peat moss, balance/scale.

Procedure

1. Divide a sample of moist soil into two equal parts.
2. Put each sample into a flower pot.
3. Cover the top of one sample with moist peat moss (moisten by soaking in water for approx. 10 minutes), but leave the top off the other.
4. Measure the mass of each pot with its contents.
5. Predict the outcome.
6. Set both pots in the same sunny place for 3 days.
7. Again carefully measure the mass of each pot with its contents.
8. After the mass has been recorded, carefully remove the peat moss from the one pot and compare the appearance (the degree of dryness or wetness) of the surface of the soil in each pot.
9. From the mass of the pots and their contents before and after exposure to the sun, find by subtraction the loss in mass of the contents of each pot.
10. Was your prediction correct?

Wind Erosion Demonstration

Question How do different soils react to different wind speeds?
Hypothesis Have students write a hypothesis.
Equipment Sand, peat moss, quick growing grass seed, four garden flats (no holes), hair dryer, large cardboard box (to put garden flats into)

Procedure
Four samples: (1) dry sand, (2) wet sand, (3) sand and damp peat moss in equal proportions, and (4) sand with grass growing.

Plant the grass seed in the sand 14 to 20 days before the demonstration. ⚠

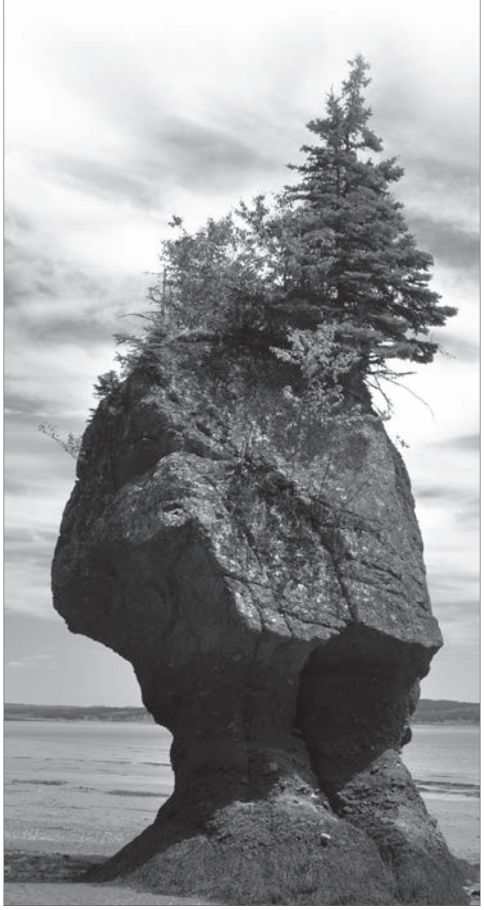
1. Place enough sand into each of the four garden flats to cover the bottom to a depth of approximately 2.5 cm.
2. The first flat of sand should remain completely dry.
3. Soak the sand in the second garden flat.
4. Mix an equal amount of wet peat moss into the second pan of sand.
5. Mix grass seed into the fourth flat of sand and gently water. Allow seed to germinate and begin to grow. Continue to add water as necessary. Try to have the sand reasonably dry by the time of this demonstration.
6. Before applying the hair dryer, (representing wind erosion) place each garden flat into a large cardboard box in order to control the blowing sand.
   Note of Caution: Dry sand blows easily. Use safety goggles.
7. Use hair dryer on low for each condition to demonstrate the effect of wind.
8. Use medium speed on any soil condition that does not react to the low.
9. Use the high speed if necessary.

6 GLACIERS AND LANDFORMS

MATERIALS

- Handout: *Glaciers and Landforms Information Bulletin*
- Handout: *Glaciers and Landforms Activity A – Questions Based on Reading*
- Handout: *Glaciers and Landforms Activity B – Investigating Glacial Landforms*
- Handout: *Concept Overview Chart* (2 per student)
- Handout: *Activity C – Crossword Puzzle*

Consumables:
- Ice cube
- Sand
- Softwood board



SUMMARY OF TASK

Students will:
- Investigate the effects of weather on rocks and minerals

EARTH SCIENCE LITERACY PRINCIPLE(S)

BIG IDEA 3 Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4 Earth is continuously changing.

OBJECTIVES

1. Participate in a teacher led discussion about glaciers.
2. Complete handout: *Glaciers and Landforms Activity A – Questions Based on Reading.*
3. Complete handout: *Glaciers and Landforms Activity B – Investigating Glacial Landforms.*

INSTRUCTIONS

Engage

1. Review weathering and erosion from activity 1.

Explore

2. Conduct the following demonstration:
   - Take an ice cube out of the freezer. Wait until it is just starting to melt, and then dip it in the sand.
   - Moving your hand in a circle, rub the sandy side of the ice cube on the wooden board. Keep dipping the cube in sand so that it stays sandy as you rub.
   - Look at the board surface after a few minutes have passed. The ice will have scraped the sand against the wood – just as a glacier scrapes against bedrock.

Explain

3. Read and discuss the handout: *Glaciers and Landforms Information Bulletin*.

Elaborate

4. Have students complete *Activity A: Questions Based on Reading.*
5. Have students complete *Activity C: Crossword Puzzle.*

Evaluate

6. Have students research glacial features and complete *Activity B and Concept Overview Chart.*

SUPPORTING INFORMATION

Demonstration highlights:

Glacier ice collects rock by picking up rock fragments loosened by the process of weathering. These pieces of rock can range from large boulders with jagged edges to tiny fragments of sand. The glacier scrapes this material across the bedrock, wearing it away and often leaving gouges on the surface of the land. In this way glaciers can cause a lot of erosion.

Crossword Solution

Across:
5 - winderosion
6 - erosion
7 - humus
11 - zoneofaccumulation
12 - glacier
13 - plasticflow

Down:
1 - drumlin
2 - gravity
3 - basalsliding
4 - zoneofablation
8 - moraine
9 - weathering
10 - kettle

Key Words:

Basic Terms: glacier, glaciation, firn, basal sliding, gravity, plastic flow, zone of accumulation, zone ablation, till, moraine, drumlin, esker, kettle

Secondary Terms: continental ice sheets, alpine glacier

SAFETY

- Make sure to clean up any excess water that may fall on the floor from the ice cube to prevent slipping.

GLACIERS AND LANDFORMS

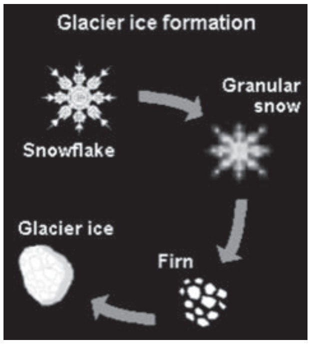
As we have learned in earlier lessons, tectonic activity deep within the Earth plays a major role in shaping the landscape (think back to folding and faulting). However, other processes have also formed the landscape we see around us. Throughout history, **glaciers** have changed the surface of the Earth. In some locations, this process continues at present. The term **glaciation** refers to the formation and movement of glaciers. This includes the accumulation of snow that leads to the eventual formation of the ice mass, and to the advance and retreat of the glacier that forms different erosional and depositional landforms. Sharp mountain peaks, grooved rocks, and vast till sheets and are all examples of the impact of glaciers.

Glaciers are enormous, thick blocks of ice which cover about 10% of the Earth's land surface. They are found on every continent except Australia. The biggest glaciers are called continental ice sheets which consist of huge slabs of ice several kilometres thick which cover very large areas. *Continental ice sheets* cover Antarctica and parts of Greenland, Iceland, Russia, Alaska and Canada. The ice sheet on Greenland is approximately 3 kilometres thick! A smaller but more common type of glacier is called a mountain or *alpine glacier*. There are more than 100,000 examples of this type of glacier worldwide.

Glaciers hold almost 75% of the world's fresh water supply. If all of the existing glaciers in the world were to melt, world sea levels would rise more than 55 metres. To get a better idea of what this would actually mean, imagine coastal cities, like Vancouver, New York, Halifax and London under water.

Glaciers form in places where the air temperature never gets warm enough to completely melt the snow in the summer. Over the years, snow accumulates and becomes deeper and deeper. As new snow falls its weight compacts the snow beneath, slowly changing it to **firn** – which is a dense, tightly packed snow. Repeated melting and freezing, combined with increased pressure from the overlying snow turns the firn into clear, hard glacial ice.

Glaciers are not stationary chunks of ice, but rather, are constantly on the move, and this movement affects the surface of the Earth. Glaciers usually move quite slowly – perhaps only 2.5 to 5 centimetres a day, but some have been known to move up to several metres per day. There are two basic ways that glaciers move. The first is called **basal sliding** which occurs when the force of **gravity** pulls the glacier down a hill. The glacier slides on a thin layer of water at the base of the glacier which allows it to slide over the rock surface below. The water beneath a glacier forms when the ice is melted by the heat produced from *friction*. (Friction is created when two objects rub against each other). In addition to producing heat, friction also slows the movement of the glacier. Basal sliding occurs along the bottom of a glacier – we can see evidence of this movement in the scratches and grooves left in rocks after the ice has melted away. **Plastic flow** is the second way that a glacier moves. This movement occurs inside a glacier and results from great pressure. The enormous weight of the ice forces individual ice crystals to line up in such a way that they slide along each other. This constant movement causes the ice to bend and flow. You see an example of the process of plastic flow when you squeeze a tube of toothpaste. When you apply pressure to the tube you cause the paste inside to bend and flow. But, the moment you stop squeezing, the paste remains in its new shape, until you squeeze it again. Just like the toothpaste, the glacial ice also acts as a plastic material. All glaciers move by one of these two methods. However, glaciers in very cold areas, like Antarctica, tend to move by plastic flow rather than basal sliding because it is so cold there is no water at the base of the glacier to slide on, the glacier is frozen to the ground.



It is also important to remember that glaciers are constantly losing and gaining ice, (like all parts of nature, they are constantly changing – though we may not easily notice these changes). New snow is added to a glacier in an area called the **zone of accumulation**, which is at the highest part of the mountain where it is the coldest. As new snow falls, a glacier continues to grow and move forward. The area where glaciers lose snow and ice is called the **zone of ablation**, which is at the leading edge of the glacier. Melting or evaporation causes the loss of a glacier's ice and snow.

A glacier has a scouring effect (like a steel cleaning pad on a kitchen counter) as it moves across the Earth's surface, dramatically changing and shaping the landscape. The shape of mountain peaks, valleys and other amazing landforms are some of the effects of glacier movement. There are several glacial landforms that can be found throughout Canada. The types of glacial landforms in an area result from different processes, influenced by the local and regional geology at the time of glaciation. The sediment that glaciers carry and deposit is a mixture of sediment and rock called **till**. Glaciers, acting like enormous bulldozers, push the till into ridge-like deposits called **moraines**. Moraines form along the outside, inside and front of a glacier. Another landform created by glaciers is a rounded upside-down spoon shaped hill of glacial sediment called a **drumlin**, examples of which can be seen throughout Canada. **Eskers** are long winding ridges of sediment deposited by streams (made by melt water from glaciers) that flowed in tunnels inside and under glaciers. **Kettles** are bowl shaped areas in the ground that form after blocks of ice that had been buried in sediment, later melt. Some kettles later fill with water and become small round lakes. We can see that the movement of glaciers thousands of years ago, have shaped and continue to shape our landscape, as they, scour and groove the surface of the Earth and move sediment and rocks.

6 ACTIVITY A - QUESTIONS BASED ON READING

1. Explain in your own words the statement “glaciers have had (and still have) an important impact on the Earth’s landscape”.

2. Define the terms glacier and glaciation in your own words.

3. Explain how a glacier is formed and how it moves.

4. Discuss the terms basal sliding and plastic flow.

5. Describe three of the landforms created by glaciation.

6. Define the following:

firn

zone of accumulation

zone of ablation

6 ACTIVITY B - INVESTIGATING GLACIAL LANDFORMS

Glacial landforms are related to the movement of glaciers. Some landforms caused by glaciation are eskers, drumlins, moraines, kettles and tills. Though we reviewed these landforms in the lesson, your job is to investigate TWO of the landforms in detail.

A. You will complete two "Concept Overview Charts" – one on each type of glacial landform that you choose.

B. Your investigation should include information on where your chosen landforms are found, especially if they are in your region.

C. You should use at least two resources. Make sure you reference your source.

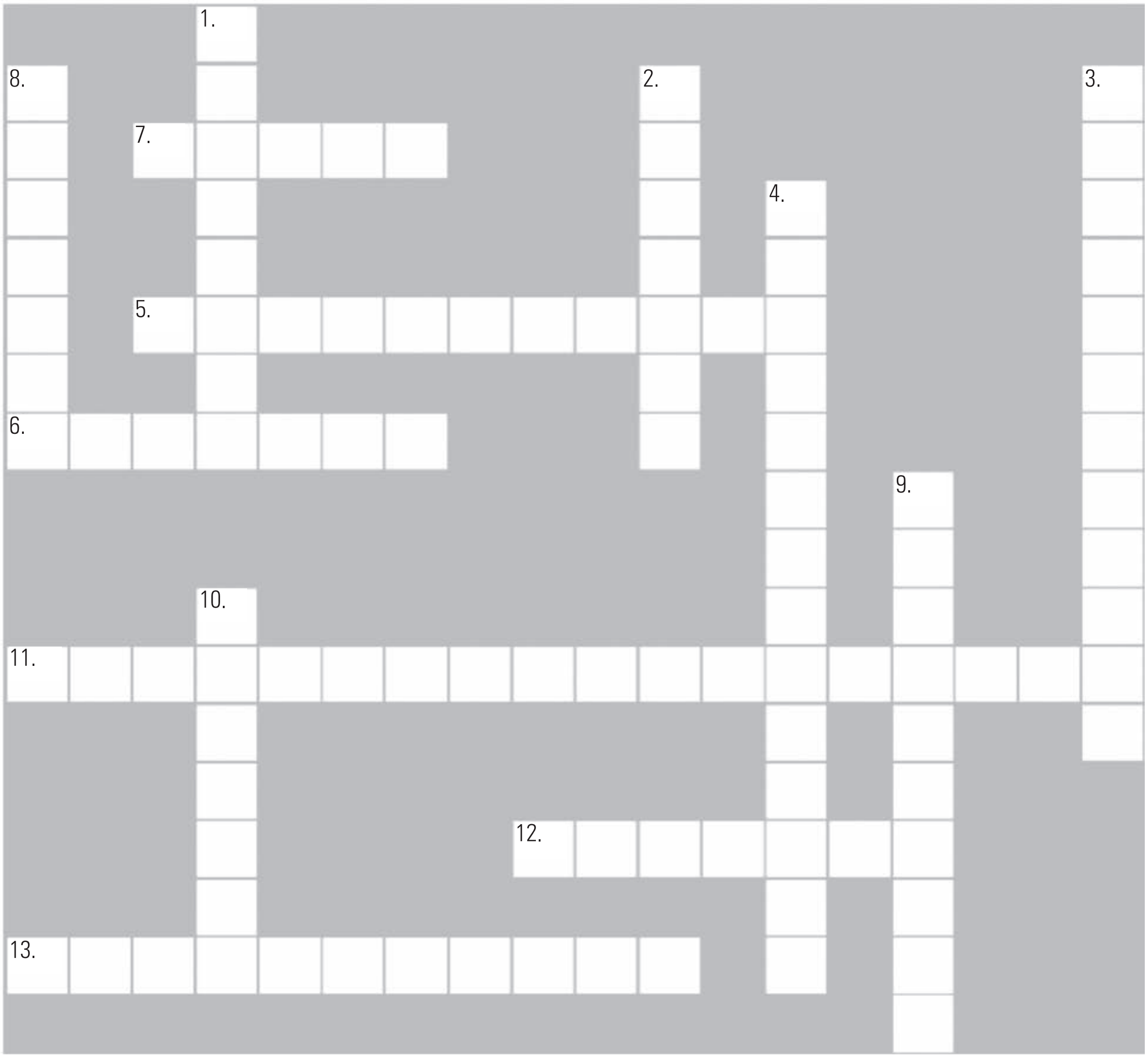
6 CONCEPT OVERVIEW CHART

Concept	Examples	Characteristics

What is it like?	What is it unlike?	Can you illustrate it?

Definition

6 ACTIVITY C – CROSSWORD PUZZLE



ACROSS

5. A type of erosion that can blow you away
6. The physical breakdown of rock.
7. Organic material that is needed in soil formation.
11. A part of a glacier where the amount of snow added is more than the amount of snow melted.
12. An enormous block of ice found on every continent except the one down under.
13. A way that a glacier moves – it also describes how toothpaste moves in it's tube.

DOWN

1. Spoon shaped domed hills of glacial sediment.
2. A force that is involved in the creation of glaciers and also keeps your feet on the ground.
3. A way a glacier moves – the bottom line.
4. Part of a glacier where melting takes place.
8. Ridge-like till deposits created by glaciers.
9. This process breaks rock down into small pieces.
10. Glacial landform that is bowl-shaped – add water and they becomes lakes