PLANET EARTH

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Calgary Science Network: Making Connections

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WORKSHOP AND CURRICULUM OVERVIEW

The overview for the "Planet Earth" unit in Grade 7 indicates an emphasis on the Nature of Science and states:

"The scientific study of Earth is based on direct observation of landforms and materials that make up Earth's surface, and the sample evidence we have of Earth's interior. By studying this evidence, we discover patterns in the nature and distribution of the Earth's materials, and in the kinds of changes that take place. This knowledge can be used in developing models for geologic structures and processes—models that help both scientists and students enlarge their understanding of their observations, and guide further investigation and research".

Focusing Questions and Key Concepts

The **Focusing Questions** from the curriculum documentation are as follows:

- What do we know about the Earth we live on—about its surface and what lies below?
- What evidence do we have, and how do we use this evidence in developing an understanding of the Earth and its changes?

The **Key Concepts** of the Planet Earth unit are as follows:

- Strata
- Rocks and minerals
- Rock cycle: formation of igneous rock, metamorphism and sedimentary processes
- Mountain formation: folding and faulting
- Crustal movement/plate tectonics
- Chronological time scale
- Fossil formation
- Weathering and erosion
- Incremental change
- Development of models based on observation and evidence

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

1. Describe and demonstrate methods used in the scientific study of the Earth, and in observing and interpreting its component materials.

★ *investigate and interpret evidence that Earth's surface undergoes both gradual and sudden change (e.g., recognize earthquakes, volcanoes and landslides as examples of sudden and catastrophic change; recognize glacial erosion and river erosion as examples of incremental change)*

★ *interpret models that show a layered structure for Earth's interior; and describe, in general terms, evidence for such models*

★ *identify and explain the purpose of different tools and techniques used in the study of Earth (e.g., describe and explain the use of seismographs and coring drills, as well as tools and techniques for the close examination of rocks; describe methods used in oil and gas exploration)*

- ★ *explain the need for common terminology and conventions for describing rock and minerals, and apply suitable terms and conventions in describing sample materials (e.g., use common terms in describing the lustre, transparency, cleavage and fracture of rocks and minerals; apply the Moh's scale in describing mineral hardness)*

2. Identify evidence for the rock cycle and use the rock cycle concept to interpret and explain the characteristics of particular rocks.

- ★ *distinguish between rocks and minerals*
- ★ *describe characteristics of the three main classes of rocks—igneous, sedimentary and metamorphic—and describe evidence of their formation (e.g., describe evidence of igneous rock formation based on study of rocks found in and around volcanoes, describe the role of fossil evidence in interpreting sedimentary rock)*
- ★ *describe local rocks and sediments, and interpret ways they may have formed*
- ★ *investigate and interpret examples of weathering, erosion and sedimentation*

3. Investigate and interpret evidence of major changes in landforms and the rock layers that underlie them

investigate and interpret patterns in the structure and distribution of mountain formations (e.g., describe and interpret mountain formations of the North American Cordillera)
- ★ *interpret the structure and development of fold and fault mountains*
- ★ *describe evidence for crustal movement, and identify and interpret patterns in these movements (e.g., identify evidence of earthquakes and volcanic action along the Pacific Rim; identify evidence of the movement of the Pacific plate relative to the North American plate)*
- ★ *identify and interpret examples of gradual/incremental change, and predict the results of those changes over extended periods of time (e.g., identify evidence of erosion, and predict the effect of erosional change over a year, century and millennium; project the effect of a given rate of continental drift over a period of one million years)*

4. Describe, interpret and evaluate evidence from the fossil record

- ★ *describe the nature of different kinds of fossils, and identify hypotheses about their formation (e.g., identify the kinds of rocks where fossils are likely to be found; identify the portions of living things most likely to be preserved; identify possible means of preservation, including replacement of one material by another and formation of molds and casts)*
- ★ *explain and apply methods used to interpret fossils (e.g., identify techniques used for fossil reconstruction, based on knowledge of current living things and findings of related fossils; identify examples of petrified wood and bone)*
- ★ *describe patterns in the appearance of different life forms, as indicated by the fossil record (e.g., construct and interpret a geological time scale; and describe, in general terms, the evidence that has led to its development)*
- ★ *identify uncertainties in interpreting individual items of fossil evidence; and explain the role of accumulated evidence in developing accepted scientific ideas, theories and explanations*

A summary of key aspects of the curriculum with appropriate resources given out at the time of the workshop and one or two particularly appropriate web sites is provided below in tabular form for each of the four STS Outcomes. At the end of the handout, we have also included a more general resource section that will give you additional ideas about other possible books, material sources, field trips and guest speakers that could be used to enrich your teaching unit. We highly recommend that your school purchase a class set of rocks and minerals for teaching purposes if you do not already have one available. You will need these to show the students specific properties that they will need to look for when identifying unknown rock and mineral samples. These are available locally (see resource section).

PLANET EARTH WORKSHOP - GRADE 7 SCIENCE - STS OUTCOME SUMMARY - KEY ACTIVITIES AND RESOURCES - PART 1

STS OUTCOMES	ACTIVITIES	RESOURCES
Describe and demonstrate methods used in the scientific study of earth and in observing and interpreting its component materials.		
Interpret evidence for gradual/incremental changes in earth's surface: glacial erosion, river erosion, weathering (over years, centuries, Millennia). This topic is also dealt with in The Rock Cycle and The Geology of the City of Calgary sections.	Glacial Grinding Water Table Wind Erosion The Power of Roots	http://earthnet.bio.ns.ca/index.html GSC resource for earth science teaching - excellent activities http://www.seismo.unr.edu/ftp/pub/louie/class/100/interior.html Illustrated summary of seismic and its role in evidence
Describe the Earth's layered structure and identify evidence Tools for studying Earth's interior (core, seismic, oil/gas exploration tools)	Earth Egg Hidden Treasure Slinky P and S Waves	http://4dw.net/geolor/Geoteach_Earth_Science_Home_Page_geolor.htm Handy resource for downloading pictures of cross-sections, seismic tools; tectonics http://www.schoolscience.co.uk/content/4/chemistry/fossils/index.html Comprehensive explanation of oil and gas exploration, activities included. **Exploring Canada's Oil and Gas Industry** An excellent book available from the Canada Centre for Energy http://centreforenergy.com
Common terminology and tests for mineral identification	Mineral Tests for Hardness. Streak, Lustre, Cleavage, Shape, Effervescence Growing Crystals in the Classroom	http://www.minerals.net/index.html The Minerals and Gemstones Kingdom - beautifully illustrated Guide to identifying characteristics of minerals. Mineral samples in EdGEO kit Mineral testing kit GSC folded poster on Minerals GSC fold poster on Gemstones MAC Mineral posters

PLANET EARTH WORKSHOP - GRADE 7 SCIENCE - STS OUTCOME SUMMARY - KEY ACTIVITIES AND RESOURCES - PART 2

STS OUTCOMES	ACTIVITIES	RESOURCES
Identify evidence for the rock cycle, and use the rock cycle concept to interpret and explain characteristics of particular rocks		
		http://www.fi.edu/fellows/payton/rocks/create/ "Rock Hounds" - animations of how rocks are created in rock cycle, rock identification
Distinguish between rocks and minerals	Chocolate Chip Cookies	GSC folded posters on Rocks and Minerals
Origin of rocks - the Rock Cycle	Waxy Rock Cycle	http://www.bbc.co.uk/education/rocks/rockcycle.shtml BBC education site - very well done illustrations, links, earth science activities - excellent rock cycle resource
Common characteristics/ terminology used to identify rock types	Rock ID Making Sandstone Rock Hard Food	http://www.bwctc.northants.sch.uk/html/projects/science/ks34/rocks/list.html Interactive rock identification online project - excellent resource, on-line test.
Interpretation of local rocks and sediments	Dichotomous Key	http://www.geocities.com/RainForest/canopy/1080 "The Stupid Page of Rocks" - kind of an online "rocks for dummies" (See section on the Geology in the City of Calgary)

PLANET EARTH WORKSHOP - GRADE 7 SCIENCE - STS OUTCOME SUMMARY - KEY ACTIVITIES AND RESOURCES - PART 3

STS OUTCOMES	ACTIVITIES	RESOURCES
Investigate and interpret evidence of major changes in landforms and the rock layers that underlie them		
		This Dynamic Earth Please note that the background for this part is virtually all available in this USGS book, which is provided free with the workshop (courtesy of the National EdGEO Workshop Fund)
Structure and development of fold and fault mountains	Fault Models Rock Structure in 3D Sand folds and faults	http://interactive2.usgs.gov/learningweb/teachers/lesson_plans.htm U.S. geological survey site - source of excellent lesson plans, links, paper models
Interpret evidence for sudden changes in Earth's surface (volcanoes, landslides, earthquakes)	Earthquake Simulation Model	http://www.thetech.org/exhibits/online/quakes/ Excellent presentation covering all aspects of earthquakes (seismic waves, etc.) http://earthquake.usgs.gov/recenteqsww/ Map showing last 30 days of earthquake activity - very clear
Evidence of continental drift (volcanoes, earthquakes, ridges, continental masses	Convection Currents Cracker Tectonics	http://www.ucmp.berkeley.edu/geology/tectonics.html Info on plate tectonics, animations http://www.scotese.com/newpage13.htm Info on plate tectonics, animations

PLANET EARTH WORKSHOP - GRADE 7 SCIENCE - STS OUTCOME SUMMARY - KEY ACTIVITIES AND RESOURCES - PART 4

STS OUTCOMES	ACTIVITIES	RESOURCES
Describe, interpret and evaluate evidence from the fossil record		
Nature of fossils - rock type, locations, preservation (parts, molds, casts, replacement)	Making Fossils	http://www.ucmp.berkeley.edu/exhibit/exhibits.html Exceptional interactive site for exploring paleontology, earth history, includes a research lab that students can complete on line, assessment materials, handouts
Methods used to identify fossils and their role in interpretation of sedimentary rocks	Detective Work and Fossil Footprints Fossil Identification Game Paleogeography and Paleoecology Exercise	http://www.bsu.edu/eft/stone/resources.html Stories written in stone - online collection of planet earth activities http://www.tyrrellmuseum.com/ A site on dinosaurs and the local setting in Alberta
Geological time scale - appearance of life	Earth's Time Line Excavating your recycling Bin as a Fossil Record	http://www.webshots.com/ A site with lots of photographs, including more than 500 fossils GSC Colour Fossil Poster and Accompanying Booklet
Theories and explanations based on accumulated evidence		**The Land Before Us** (a book from the Royal Tyrrell Museum of Paleontology - Red Deer Press) Poster set of illustrations from above book

INTRODUCTION

GEOLOGY is the study of the Earth. It is much more than just learning about rocks and minerals, although that is an important part of it. Students can think of geology as a science that connects the past, present and future. Learning to "read" the rock and fossil records has allowed us to understand the dynamic nature of our planet, and to use this knowledge to begin exploring planets other than our own. This makes the study of Geology an exciting field for those interested in history, biology, physics, energy production, natural resource conservation, urban planning, space exploration - you name it. Virtually every scientific field can be related back to the study of Geology in one way or the other.

This handbook is structured to provide some background information and descriptions of activities for the entire unit. It generally follows the order in the curriculum unit, but we have made some adjustments so that the units can be taught in a more sensible order.

STS OUTCOME #1

Describe and demonstrate methods used in the scientific study of the Earth, and in observing and interpreting its component materials.

EARTH CHANGES

★ *investigate and interpret evidence that Earth's surface undergoes both gradual and sudden change (e.g., recognize earthquakes, volcanoes and landslides as examples of sudden and catastrophic change; recognize glacial erosion and river erosion as examples of incremental change)*

The idea that the Earth is continually changing as a result of both gradual and sudden changes will be an underlying theme of much of the workshop and will not be dealt with in depth here. Earthquakes and volcanoes will be dealt with under STS #3. Erosion will be dealt with under the Rock Cycle in STS #2 and also under the section on Geology in the Calgary area.

❖ Activity: Glacial Grinding

Materials:
- Plastic Cup
- Nails and gravel
- Water
- Plastic Wrap
- Smooth wood or shale

Procedure:
- Review glaciers with students
- Discuss evidence that glaciers have moved over land (scoured surfaces, terminal moraines, glacial till)
- Create miniature glaciers by half filling a paper cup with small nails or angular pebbles
- Cover with water and freeze
- When the glaciers are frozen, peel cup off and scrape glaciers slowly, in one direction, along wood or shale surface
- Students should observe the patterns formed and compare to pictures of actual scraping

❖ Activity: Wind Erosion

Materials:
- Several different kinds of rock
- White paper

Procedure:
- Take two pieces of rock and rub them together over a piece of paper for approximately two minutes. Do any particles fall?
- Explain to students that this is the same as wind erosion. Wind carries tiny particles of sand that blow against other rocks and act as an abrasive to break and wear down rock material
- Choose two other kinds of rocks and try the same experiment. Do some types of rock weather more easily than others? How could this explain various landforms?

❖ Activity: The Power of Roots

Materials:
- Shallow container (aluminum pie plate works well)

- Large spoon
- Plaster of Paris
- Paper towels
- Water
- Bean seeds

Procedure:

- Discuss how roots can actually break up rocks because of the force they exert as they grow (look at sidewalks and driveways)
- Mix Plaster of Paris (actually the mineral, "gypsum") according to package directions. Have students wear a mask if they are doing this
- Pour into aluminum pie pan
- Place bean seeds on wet plaster. Cover with damp paper towels. Leave seeds for one to two weeks, making sure that paper towels are kept moist
- Remove seeds and observe structure in plaster where roots once were. Do you think plants are strong enough to break rock?

EVIDENCE FOR THE LAYERED STRUCTURE OF THE EARTH

★ *interpret models that show a layered structure for Earth's interior; and describe, in general terms, evidence for such models*

The study of earthquakes and the structure of the Earth is called seismology. It is conducted by studying both natural and artificially produced seismic waves. Natural seismic waves are produced by earthquakes and provide the best evidence for the internal structure of the earth. Artificial seismic waves are produced by the firing of explosives or by using a vibrating machine that produces vibrations of a known frequency.

The devices for recording seismic waves are called seismographs and the seismic information they record is used to study the structure of the Earth. Studies range from looking at the whole Earth to looking only in the thin crustal skin of the Earth, the latter especially in the search for oil and gas.

Studies of the whole Earth have produced a picture of its structure from inside to outside. The information comes from measuring the vibrations set off by naturally occurring earthquakes. We are all familiar with the idea that different vibrations produce different sounds. For example tapping on a hollow wall produces a very different sound than that produced by tapping on a solid wall. These different sounds can be measured as vibrations or seismic waves.

Different Kinds of Waves

Movements within the Earth that cause earthquakes usually happen suddenly because the pressure has been building slowly and releases suddenly and catastrophically. The centre of the movement or the point of origin of an earthquake is referred to as the focus and the point on the surface directly above the focus is called the epicentre.

There are different types of waves produced: P-waves and S-waves move through the Earth; other waves (L-waves) travel at the Earth's surface.

Fast-moving compression waves (P-waves) travel at thousands of kilometres per hour and are the first to reach the Earth's surface and be recorded by seismographs. P-waves cause particles to move back and forth in the direction of the and therefore travel through all kinds of matter, including solids, liquids and gases.

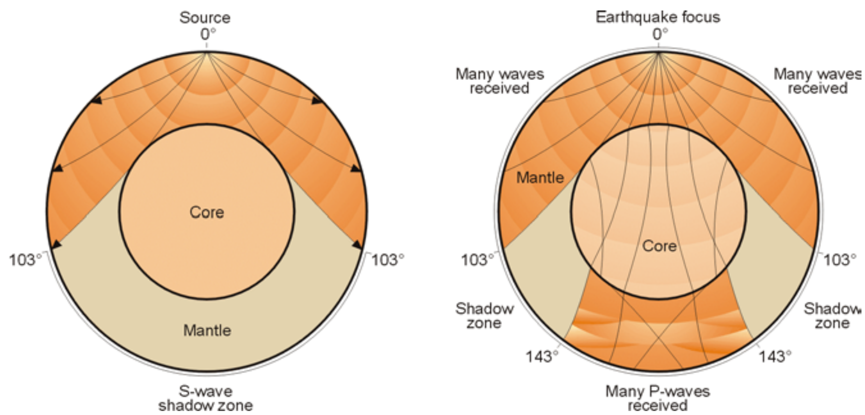
Slower moving shear waves (S-waves) arrive later at seismographs. S-waves cause particles to vibrate from side to side at right angles to the direction that the wave is traveling.

Because of this action, S-waves do not pass through liquids because molecules in liquid form slide past each other very easily and therefore do not transmit the wave.

The last waves to arrive at a seismograph are surface waves (Love waves and Rayleigh waves). These waves travel at the Earth's surface and cause most of the damage that results from earthquakes. Love waves have no vertical component and cause shearing action at the surface. Rayleigh waves produce both vertical and horizontal motions.

Waves and the Layered Structure of the Earth

It is the pattern of reception of P-waves and S-waves at seismographs around the world that has resulted in the knowledge of the layered structure of the Earth's interior. Since S-waves do not pass through liquids, it is possible to postulate that certain layers of the crust are liquid while others are solid.



In the first diagram you can see S-waves being deflected by the liquid core, creating a shadow zone in the southern hemisphere with an earthquake source at the north pole. In the second diagram you can see the P-waves passing through the core directly to the southern hemisphere. The combination of deflection of the S-waves and penetration of the P-waves creates a shadow zone between 103º and 143º. It was this observation that led to an understanding of the layered structure of the Earth.

❖ Activity: Earth as an Egg

Background:
The Earth is actually a ball of rock that weighs 6.6 sextillion (6.6 x 10^{21}) tons. When the Earth formed, the outer layer cooled more rapidly and a crust formed. Gravity caused the heavier elements to settle toward the middle where they remain. There are three main zones within our planet:

- Crust - consists of solid rock and a very thin layer (centimetres to metres) of soil. The crust is approximately 8 km thick under the ocean and 32 km thick where there are continents
- Mantle - this zone is 2896 km thick and consists of semi-solid rock. The temperature is around 871°C at the outer part where it meets the crust, but it gets progressively hotter downward. The mantle is in constant motion as a result of convection currents
- Core - this can be divided into an outer core and an inner core. The outer core is 2252 km thick and consists of melted iron and nickel at a temperature of 2200°C. The inner core is 1287 km to the centre of the Earth. It is a mixture of solid iron/nickel at a temperature of 5000 to 7000°C

Materials:

- Hard-boiled egg or apple
- Knife
- Overhead of cut-away Earth

Procedure:
- Explain to the students that the Earth is very much like an egg or an apple. The shell is thin and can be cracked easily. They can go ahead and do this, but tell them not to peel the shell off yet. Explain that the cracks are similar to plate boundaries, faults and mountain belts within the Earth's crust
- Have groups of students carefully cut an egg in half. With a marker, they can make a dot about the size of a pea in the centre of the yolk. This represents the solid inner core of the Earth. The rest of the yolk is the outer core. The white is the semi-solid mantle, and the shell is the crust. The relative proportion in size between shell, white and yolk is a fairly accurate representation of the Earth's layers

TOOLS FOR STUDYING EARTH'S INTERIOR

★ *identify and explain the purpose of different tools and techniques used in the study of Earth (e.g., describe and explain the use of seismographs and coring drills, as well as tools and techniques for the close examination of rocks; describe methods used in oil and gas exploration)*

There are many ways of studying the Earth's interior. We can do it remotely by using inferences from geophysical methods or we can do it directly by collecting rock samples from the Earth's interior.

Geophysical Methods

We have already noted how seismology has assisted us in understanding the overall structure of the Earth, but seismology is also used in much more focused ways to look at particular parts of the Earth's crust. A particular commercial application of seismology is used in the search for oil and gas. Such seismic surveys are routinely carried out by exploration companies. A series of receivers, called geophones, are set out along the ground surface and then a series of explosions or mechanical vibrations are used to produce waves that are reflected from the underlying rock layers.

The most common modern method of conducting a seismic survey on land uses special trucks to send vibrations of known frequency into the ground and collect the reflections. This method is more environmentally sound than detonating charges. In marine settings, "air guns" that use compressed air are a more environmentally sound approach than using explosives.

The data from seismic surveys are processed in powerful computers using software that enhances the preferred signals to get as clear an image as possible of the underlying strata. Data from a single line of geophones produces an image a thin vertical slice of the strata. These days, it is more common for a company to conduct 3-D seismic surveys; that is, collect data from a series of geophone lines and try to create a 3-dimensional image of the underlying strata. This is important, because layers significant to exploration commonly thin or thicken or change character, even over relatively short distances.

Excellent images of the sedimentary rocks in the topmost part of the crust are obtained using these methods and the underlying layers are usually clearly shown. Any faulting or folding that may have a strong bearing on the location of hydrocarbon deposits is also usually shown. However, geophysical methods only provide a remote view of the rock layers and are subject to interpretation by geologists and geophysicists. If the exploration team likes what it sees in the seismic survey, the next step is to locate a place to drill so that the information inferred from the seismic survey can be confirmed through actual samples.

Sample Collecting

The principal way to get samples of rock from the Earth's interior is through drilling. A drilling rig is set up at the desired location and a drilling bit, usually equipped with diamonds (the hardest mineral), is rotated in the ground and gradually penetrates through the layers of strata. In a normal drilling situation, small chips of the rocks that the drill passes through are returned to the surface for analysis. These are called cuttings and they are studied by geologists, geochemists and paleontologists to learn more about the physical characteristics of the rocks, their chemistry and their age. Critical physical characteristics are the porosity and permeability of the rocks. Porosity is the percentage of the volume of a rock that is occupied by spaces (pores) - obviously important for understanding whether the rock is likely to be able to hold fluids. Permeability is the capacity of the rock to actually transmit fluids.

If the geologist thinks that more detailed knowledge of the properties or relationships of the rock layers is required while drilling the hole, then more continuous rock sampling or coring is carried out. In ideal circumstances these are continuous records of the rock that the drill bit passes through, but there are lots of factors that conspire to render core collection less than complete.

Coring adds considerably to the cost of the well, so it is only undertaken for good reasons.

Cores and cuttings from wells drilled for hydrocarbons are stored in government facilities in Canada, providing a comprehensive record of hundreds of thousands of wells that have been drilled in the past. These databases are often used to paln and execute new exploration programs. The storage and reference facilities for Alberta and the land north of 60 degrees latitude are both located in Calgary.

Many different tests can be performed on the rock samples brought to surface during drilling operations.

The rocks can be studied for physical properties such as porosity and permeability. The details of the rock's structure can be examined by making a thin section: a fragment of rock ground to less than a millimetre in thickness and then mounted between two glass slides. This can be examined using a microscope and an amazing amount of detail can be seen.

Sometimes, samples of rock are taken to be processed for microfossils such as the remains of plants (spores and seeds) or the remains of tiny animals such as foraminifera or conodonts.

In other cases it is important to know the total organic carbon (TOC) content of a rock. Rocks with high TOC are important as potential sources of hydrocarbons. In this case organic geochemistry tests are conducted on the rock sample.

❖ Activity: Slinky Waves

Materials:

- Slinky

Procedure:

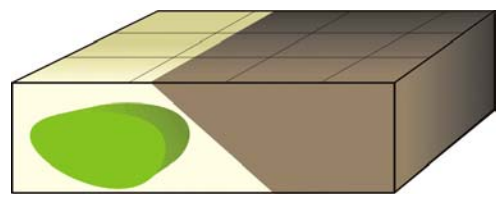
- Discuss how seismic waves move through the earth during an earthquake. These waves can cause mass destruction, even at great distances from the epicentre

- Have students simulate the two main types of waves generated. Students can work in pairs
- Sitting opposite of one another have each team member hold one end of the slinky.
- P-waves (compression or primary) arrive first. These waves travel quickly by pushing and pulling their way along. The students can gain a better sense of how these waves move by alternately pushing and pulling the ends of the slinky in a straight line
- The second waves are S-waves (shear or secondary). These waves travel more slowly from side to side in an undulating fashion. Students create this by moving the ends in opposite directions to either side. They will discover that there is a certain point where you get a uniform, S-pattern running along the length of the slinky
- Those who have experienced an earthquake relate that they can feel the distinct movements

❖ Activity: Hidden Treasure

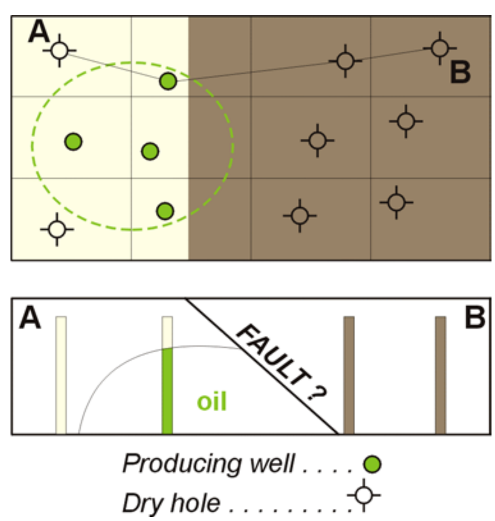
Materials:

- Marble Cake Mix
- Frosting
- Green food colouring
- Large cake pan
- 1-2 cm diameter plastic aquarium tubing cut into 10 cm lengths or large, clear plastic straws
- Unlined paper for cross-section
- Plates and forks (optional)



Procedure:

- Follow directions for mixing up marble cake. Take the white batter and place in half of the cake pan. Place the chocolate batter in the other half and overlap it onto the white batter so that you have a white "sandstone on one side, chocolate "shale" on the other side and overlapping colours in the middle
- Place several drops of green food colouring in an area a few centimetres across on top of the white batter. Stir it into this area so that you have a green "oil pool" sitting within the white "sandstone". This is the "treasure" you will be looking for later in the activity
- When cake is done, frost it. Mark off 12 sections as drilling areas
- Divide students into twelve groups. Give each a drill (tube or straw) and invite them up, one group at a time, to choose their drilling location and have them push the tube into the cake. Tell them they can only have one hole in a drilling area because of government regulations requiring space between drill holes
- Students examine the "core" they bring up to see if they encountered an oil zone (green dye). Students should save the core so that they can be used to make cross-sections later
- On the map, the students mark the location of their drill hole and label it as either dry (no oil) or as a well. Students will quickly discover that drilling near another oil well is no guarantee of success
- Students save their straw and place them in rows. These will be their core samples from which cross-sections can later be made.
- When all holes have been drilled, have students map out their oil field by looking at the dry hole versus oil well pattern
- Ask them to draw a cross-section of what the trap might look like underground by using the information from their cores
- Eat the oil field (optional)



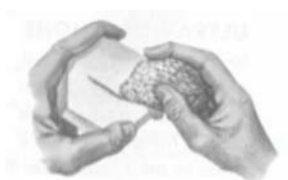
MINERAL IDENTIFICATION

★ *explain the need for common terminology and conventions for describing rock and minerals, and apply suitable terms and conventions in describing sample materials (e.g., use common terms in describing the lustre, transparency, cleavage and fracture of rocks and minerals; apply the Moh's scale in describing mineral hardness)*

Background:
Minerals are naturally occurring, non-living substances found in the earth. There are over 2000 different minerals but only a few are commonly found in the crust. Each mineral has a characteristic chemical composition that determines its overall appearance in much the same way as DNA determines how we look. There are a number of characteristic **properties** that can be used to identify any mineral specimen. We will look at each of these separately.

Mineral Property: Colour and Streak

Most minerals have a characteristic **colour** but this alone is not a good way to identify all mineral specimens. Some minerals such as quartz can occur in a rainbow of colours including clear, purple (amethyst), rose, or even black, depending on minute chemical impurities.


Streak Plate


Crushed Mineral

Streak is a much more accurate way of identifying minerals correctly. When a hand specimen of a mineral is scratched across a piece of unglazed tile, it will leave a "streak" of powdered mineral on the tile (most retail tile outlets will give these to teachers for free). Streak has a particular colour in different minerals. You can get a similar effect by taking a small piece of mineral and crushing it with a hammer. The powdered pieces will have the same colour as the streak on the tile. Some minerals have white streaks, which are difficult to distinguish from one another. However, certain minerals have very characteristic steak colours. For these minerals, streak is an important identification test. They include galena (grey-black), pyrite (green-black) and hematite (red-brown).

Mineral Property: Cleavage

This property describes the way a mineral breaks, and it can be very characteristic of certain specimens. The most common types of cleavage are flaky (as in mica), step-like (as in feldspar), cubic (as in pyrite and galena), and rhombic (as in calcite). These are shown below. Some minerals have no cleavage but they break in characteristic patterns (fracture). Quartz has conchoidal fracture that is exactly like thick window glass that has been chipped.

Readily available classroom materials can be used to demonstrate cleavage. For example, fridge magnets stuck together illustrate flaky cleavage such as that of mica. Stacking cubes put together are a perfect example of cubic cleavage such as occurs in halite or pyrite.

Diamond-shaped attribute blocks can be built up to show rhombic cleavage such as that of calcite.

Mineral Property: Lustre

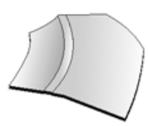
Lustre is a way a mineral appears to reflect light. There are two main categories: metallic and non-metallic. The lustre of non-metallic minerals can be further differentiated into glassy (quartz), greasy (graphite), pearly (feldspar), waxy (talc), or earthy (hematite). Common examples of minerals with metallic lustre are galena and pyrite. It is a good idea to have a sample set of lustres so that students can compare their specimens to it. An example is shown below.

Sources for lustre examples: Bead or craft shops are ideal places to find pearly or glassy lustres. Earthy lustre could be a piece of natural clay pottery. Waxy could be paraffin. Greasy could be a piece of plastic container or soap. Different metallic lustres could be coins, bolts, paper clips, etc.

LUSTRE CHART

METALLIC LUSTRE

NON-METALLIC LUSTRE

	Gem, costume jewellery	Glassy
	Soap	Greasy
	Pearl, costume jewellery	Pearly
	Candle	Waxy
	Clay pot piece	Earthy

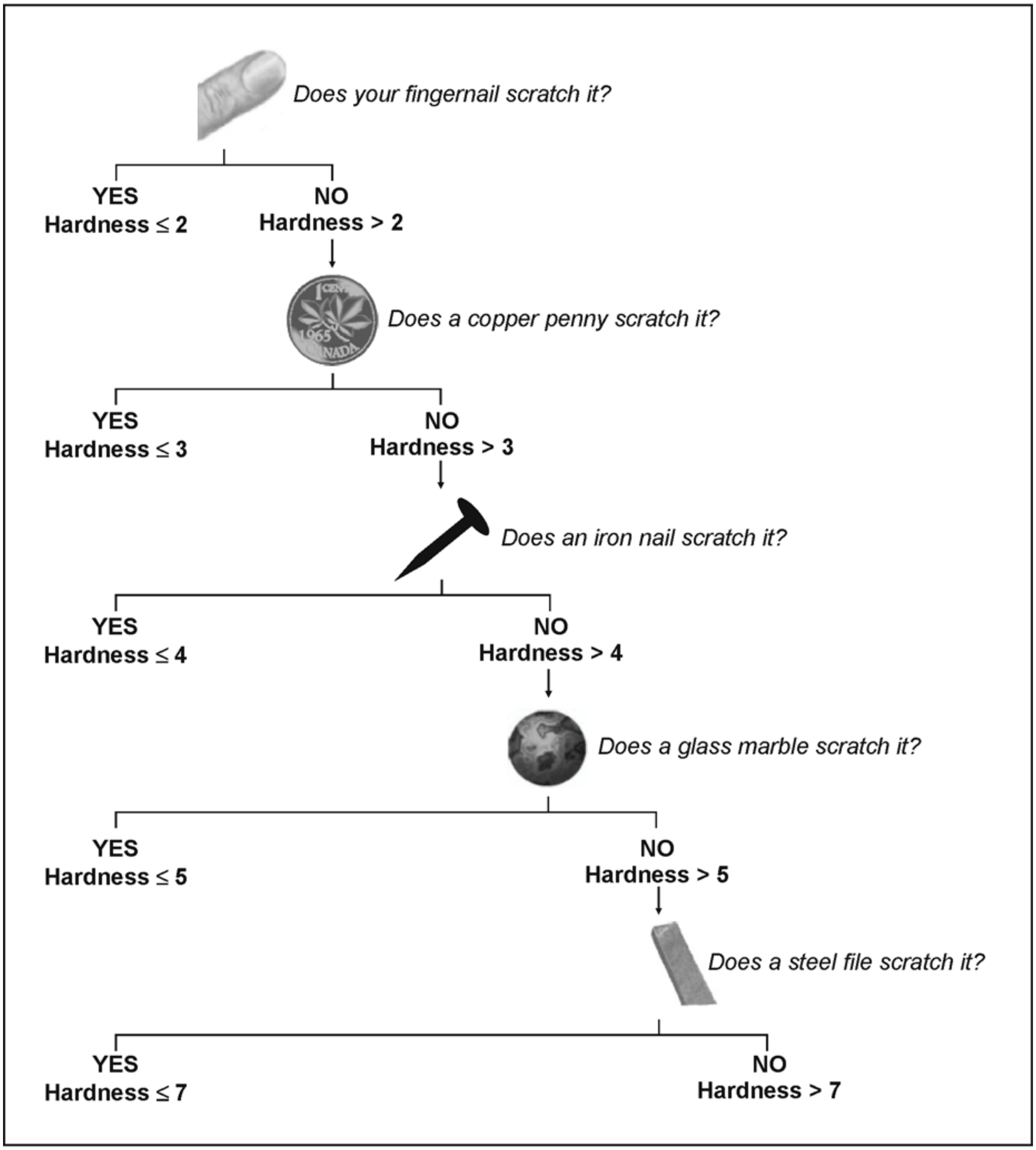
Mineral Property: Hardness

Minerals differ in hardness depending on their atomic structure. In the early 1800's, a German mineralogist named Friedrich Mohs developed a ten-point scale of hardness that is still being used by geologists today. This test is based on the premise that a mineral will scratch itself and any softer object. On the scale from 1 to 10, 1 is the softest and 10 is the hardest. Diamond has a hardness of 10 - it is the hardest known material at this time. The scale is listed below and includes hardness, an example of a mineral having that hardness, and a material that you can use to test the hardness. In order to determine the hardness of an unknown mineral, you would first try scratching it with your fingernail. If the mineral did not scratch, go to the next hardness up and try scratching it with a penny, etc. etc. The table on the next page is an example of how you might have the students work through the hardness test. They could then order then from softest to hardest.

HARDNESS CHART

HARDNESS	MINERAL	TEST MATERIAL
1	Talc	Soft pencil lead
2	Gypsum	Fingernail (2.5)
3	Calcite	Penny (3.5)
4	Fluorite	Iron nail (4.5)
5	Apatite	Glass (5.5)
6	Feldspar	Steel nail
7	Quartz	Steel file
8	Topaz	Sandpaper
9	Corundum	no common equivalent
10	Diamond	no common equivalent

HARDNESS TEST



≤ means less than or equal to
> means greater than

Note: You will not find many local minerals with a hardness greater than 7. These are more often gem quality minerals such as topaz, emeralds and diamonds. However, our most common mineral (quartz) has a hardness of 7.

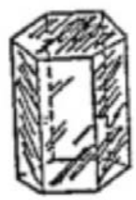
Mineral Property: Crystal Shape

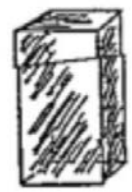
Many minerals have distinctive and beautiful crystal forms. These are visible as flat, clean surfaces on a mineral specimen. There are seven crystal systems but only four are commonly found. These are:

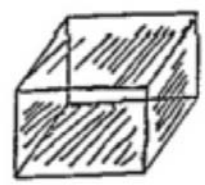
- Cubic (examples - galena, pyrite)
- Hexagonal (example - quartz)
- Tetragonal (example - zircon)
- Rhombic (example - calcite)

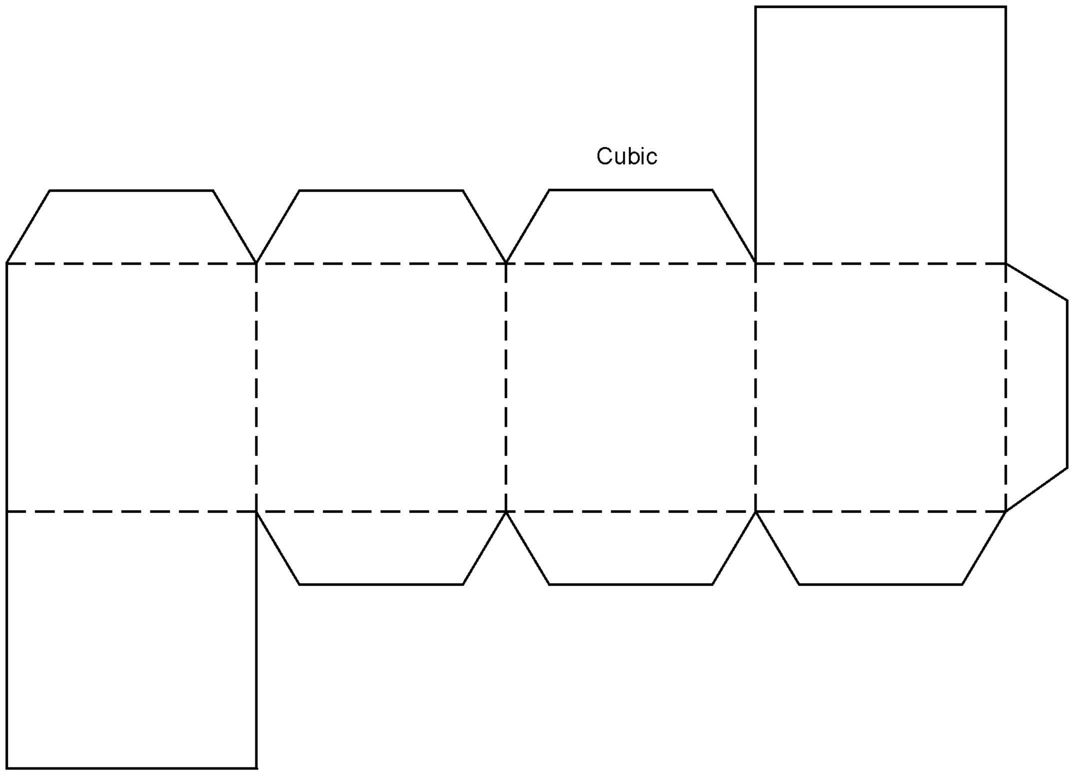
These crystal shapes are pictured below, and there are patterns for making three-dimensional models of each of these (plus others) on the following pages. Students should be able to describe the characteristics and differences of the common crystal systems, and to recognize the similarities between models and crystal shapes that they find. This is a good time to integrate the geometry strand from the math program.

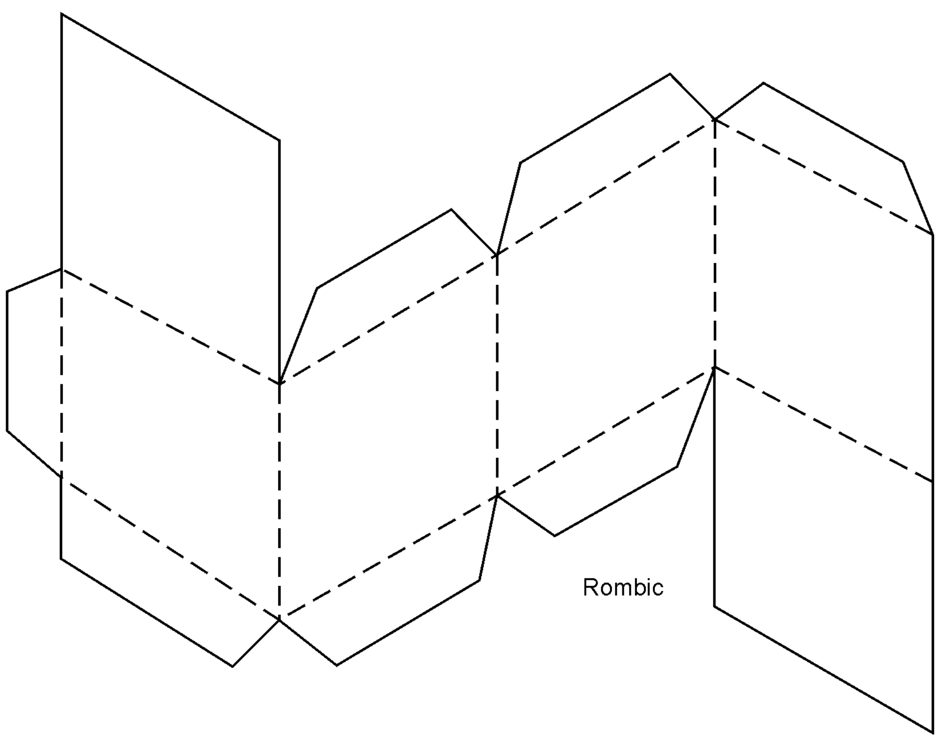

cubic


hexagonal

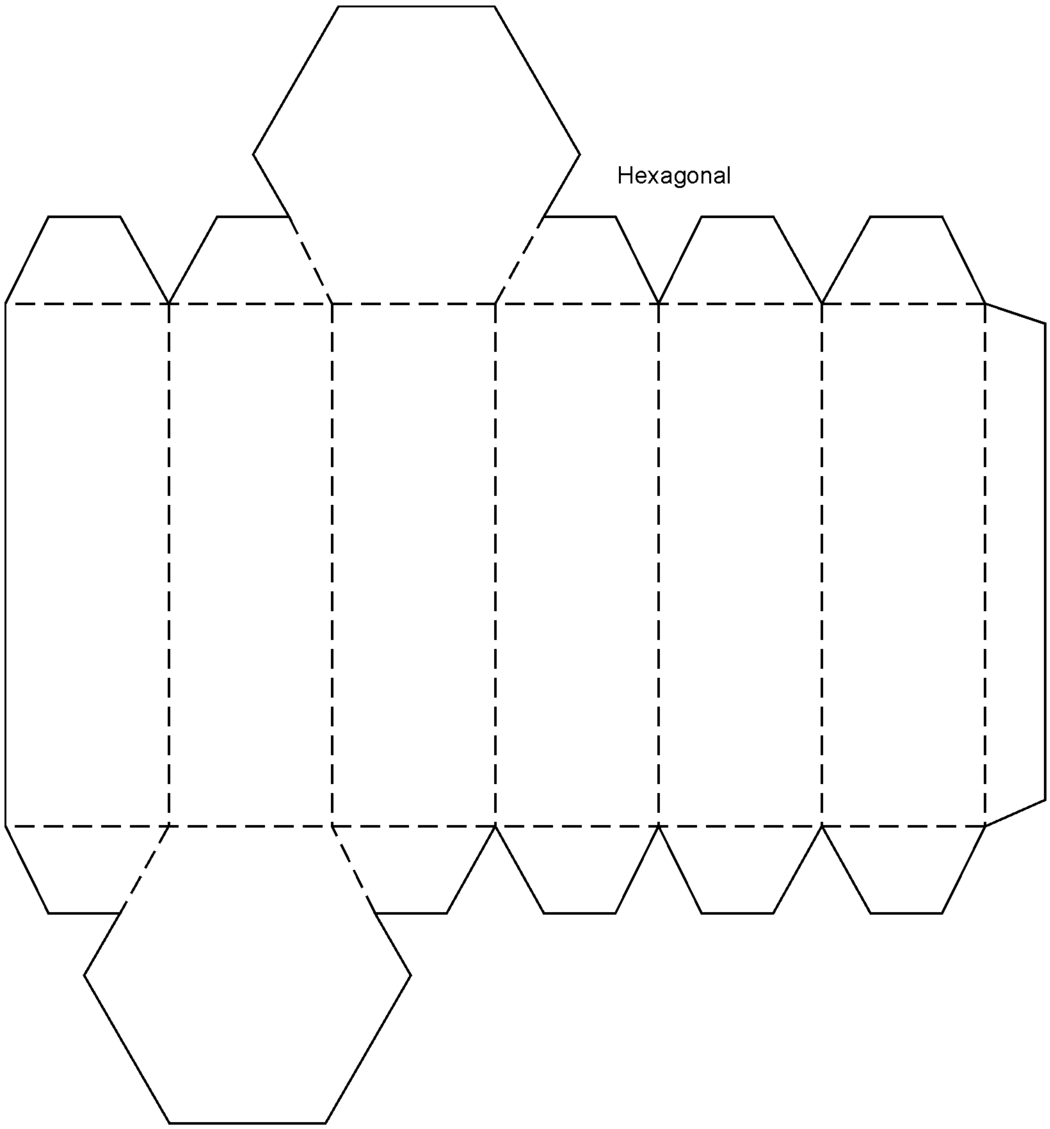

tetragonal


rhombic

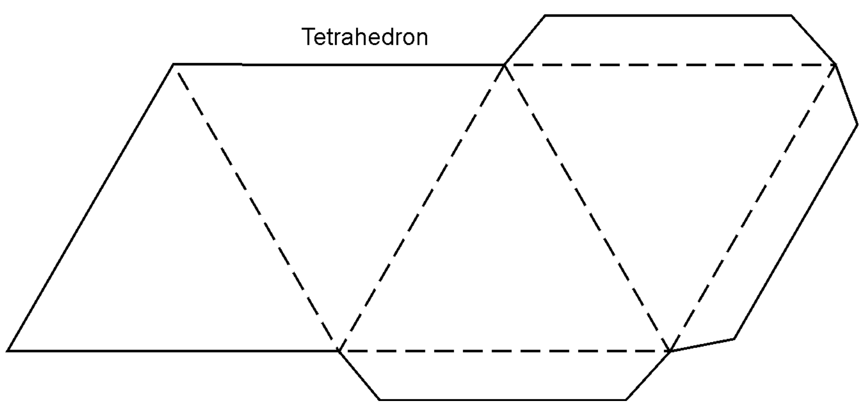

Cubic

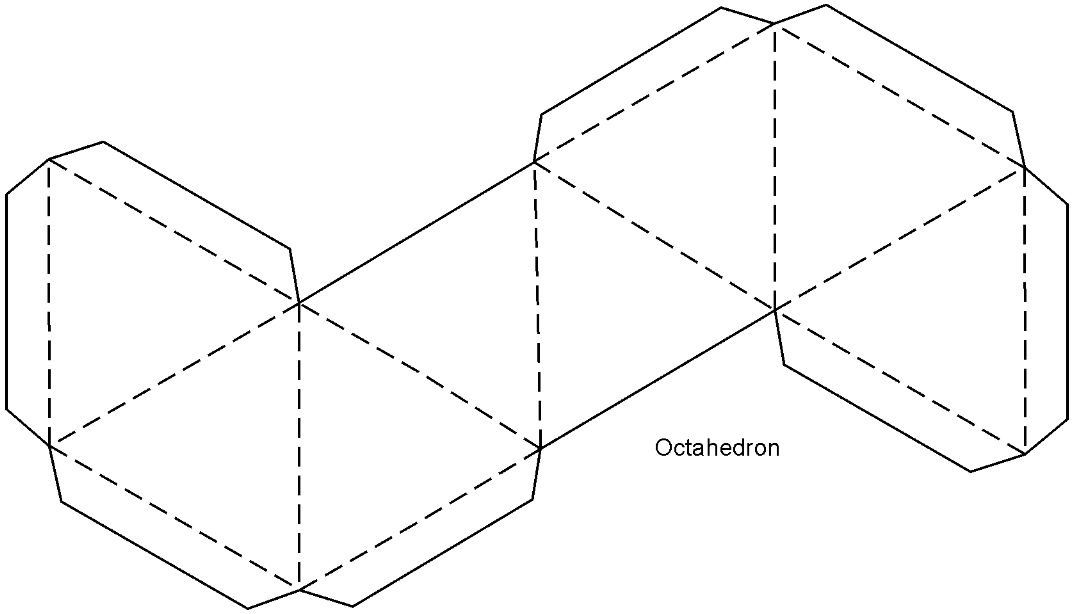

Rombic

Hexagonal

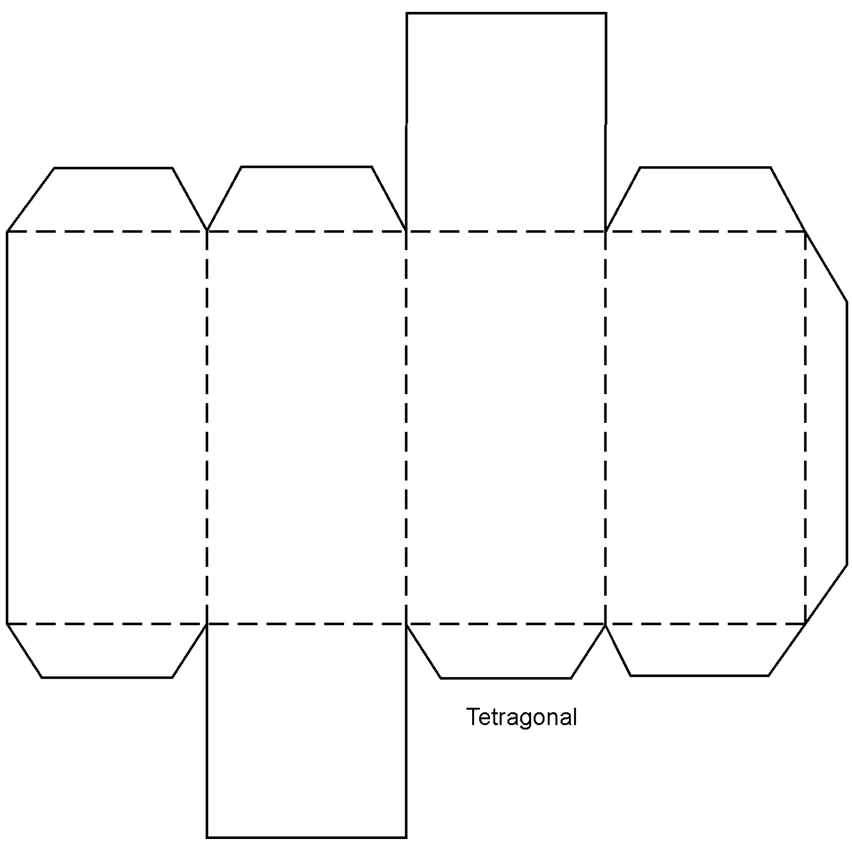


Tetrahedron





Octahedron



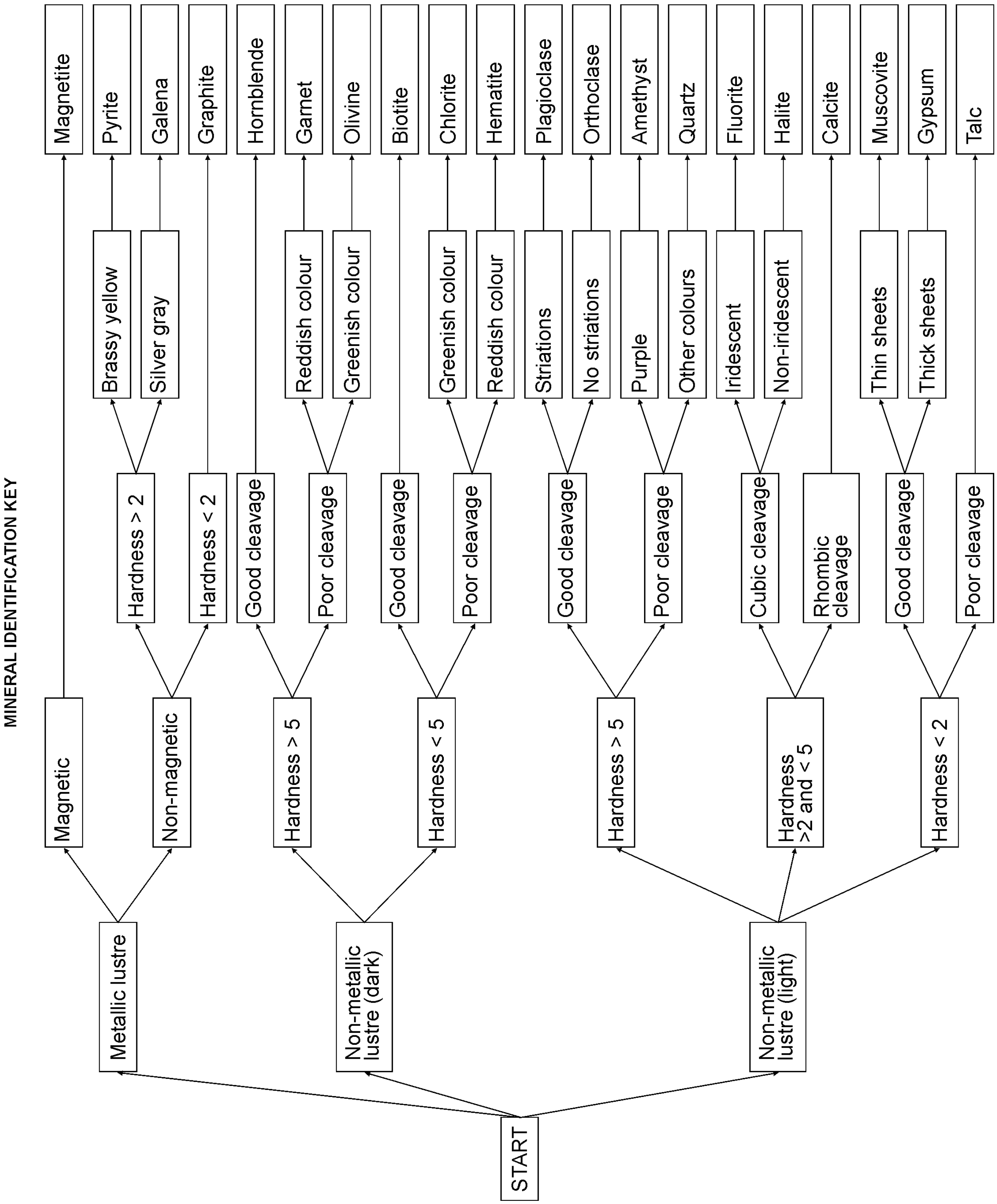
Tetragonal

Mineral Property: Effervescence (Fizzes in Acid)

Certain minerals will chemically react with an acid. This chemical reaction is called effervescence, and it is characterized by the creation of bubbles, or fizzing. If you have ever added baking soda and vinegar together, you will know what this reaction looks like. The mineral calcite is similar in appearance to quartz and several other common minerals, but it can be distinguished easily by performing the "acid test". That is because it is made up of calcium carbonate, which reacts with acid. Materials making up most other minerals do not react this way. In this test, you drop a very small amount of an acid onto the mineral or rock and watch for fizzing. The acid will react with the carbonate and cause gas bubbles to form. You may have to scratch the mineral or rock first and drop the acid onto the powder in order to see a reaction. This same test is done on a rock to determine if it is limestone since it also consists of calcium carbonate.

You can use an acid such as vinegar or dilute muriatic acid (available in hardware stores and used for etching concrete to prepare it for painting - dilute to 1 part acid: 10 parts water). You may find the vinegar is simply too weak to produce a reaction, which is why we suggest using dilute muriatic acid. It is much more impressive and allows the students to observe the reaction easily. However, THIS SHOULD ONLY BE DONE AS A DEMONSTRATION BY THE TEACHER. NO ACID, EVEN VINEGAR, SHOULD BE CONSIDERED COMPLETELY SAFE AROUND CHILDREN.

Mineral Identification Key



❖ Activity: Looking at Minerals

In this activity, students look at a variety of minerals and identify their characteristics based on hardness, colour, lustre, streak, crystal shape, and effervescence. You may want to set these up as a "centres" approach, or you may prefer to do each activity separately.

Materials:

- Mineral samples for groups of students. If you want the students to describe these minerals on a form, they should be numbered. A spot of "white-out" on the mineral allows you to write a number on it using permanent marker
- Property testing kits for each characteristic. These kits should have the materials and information sheets from the previous section (i.e. for lustre, have the lustre sample sheet, for hardness have the hardness sheet and suggested testing materials, etc.)
- Sheet for students that allows them to record their observations for each mineral
- Hand lenses
- If possible, it is very helpful to have a large mineral identification chart in the room. These are available at teacher supply stores or through catalogues
- Books on minerals that show coloured pictures. These are readily available at all libraries

Procedure:

- Allow students to explore properties of minerals until they are confident in recognizing distinctive characteristics. They can then record their observations for specific minerals. Some may want to use their information to actually identify the mineral if you have a book or poster available to aid them.

MINERAL IDENTIFICATION TABLE

Mineral	Lustre	Hardness	Cleavage/ Fracture	Crystal Habit	Colour	Streak	Other Distinguishing Characteristics
Graphite	metallic/ greasy	1.5	perfect, flaky	massive, scaly	black/ silver	black/ gray	very lightweight, marks paper
Halite	glassy	2	perfect, cubic	cubes or massive	usually colourless but may be variable	white	very lightweight, salty taste
Biotite	glassy/ pearly	2.5	perfect, platy	tabular	black/ brown	white	flexible cleavage plates
Muscovite	glassy/ pearly	2.5	perfect, platy	tabular	white/yellow/ gold	white	flexible cleavage plates
Calcite	glassy to dull	3	perfect, rhombic	variable, common rhombic	variable, colourless to dark gray	white	reacts with acid, may be iridescent
Galena	metallic	3	Perfect, cubic	cubic, massive or granular	gray, bluish tint common	gray	very heavy
Fluorite	glassy	4	cubic or octahedral	cubes, octahedra or massive	very variable- purple, yellow, blue	white	may be iridescent and/or fluorescent
Magnetite	dull metallic	5.5	no cleavage, conchoidal	massive or granular	Black	black	magnetic
Orthoclase (Feldspar)	glassy to dull	6	nearly cubic	blocky, nearly square	variable- shades of orange to white	white	
Pyrite	metallic	6.5	indistinct cubic	massive or cubic	brassy yellow	green-black	striations common
Quartz	glassy to waxy	7	no cleavage, conchoidal	hexagonal prisms topped by pyramid or massive	very variable- white to black	white	agate shows convoluted colours
Amethyst (Quartz)	glassy	7	no cleavage, conchoidal	hexagonal prisms topped by pyramid	massive, scaly	white	

MINERAL IDENTIFICATION WORKSHEET

Specimen #	Mineral ID	Lustre	Hardness	Cleavage/ Fracture	Crystal Habit	Colour	Streak	Other Distinguishing Characteristics

❖ Activity: Growing Crystals in the Classroom

There are numerous ways that crystals can be grown in a classroom. Some of these are very simple and some are more complex. Some are even edible! These are excellent tools for teaching students observation and recording skills as they watch the changes in their crystals.

Sugar, Alum and Epsom Salt Crystals

There are many different methods for growing these crystals but we recommend the following as being the easiest, and by far the most successful way found to date. The resultant crystals form quite quickly (within a day or two) and they are very large compared to some other methods. This allows the students to easily study and compare them using a hand lens.

Materials:

- Kettle for hot water
- Disposable plastic saucers (available at any grocery store)
- Sugar, Alum (available in spice section of grocery store) and Epsom Salt (available at pharmacies). You will probably need about 3-5 Tb. of each dry material
- Shatterproof, heat resistant container - approximately 1 litre capacity. Science room beakers are perfect for this if available
- 2 spoons - one for dry material, one for stirring

Procedure:

- Prepare saucers for students by putting their names on them with permanent marker. Write "alum", "salt" or "epsom salt" on saucer as well
- Boil water in kettle. When it comes to a boil, pour approximately 500 ml into your beaker
- Add one Tb. at a time of dry material (whichever one you want to use). After adding it to the hot water, stir until it is completely dissolved. Then add another Tb. Continue this process until you notice that a few, tiny grains remain on the bottom of the beaker and just won't dissolve. At that point, you have a saturated solution and you are ready to make crystals. If you notice that you are reaching saturation point (it takes quite a while for all of the material to dissolve but it eventually does) then add smaller amounts until you reach actual saturation. If you add too much dry material and you have quite a few grains left on the bottom of the beaker undissolved, then just add a bit more water. It is a lot like cooking - just add a bit here and there until you get it just right
- Pour enough of the saturated solution into the bottom of the saucer to cover it to a depth of approximately 3-5 mm. Set aside
- Check each day for crystal growth. You will see them change daily. Students can make measurements and record this progress. If you have different solutions (salt, alum, epsom salt) students will see a big difference in the shape of each crystal and they can draw these shapes as part of their observations

Crystal Rock Garden

This is similar to the previous activity where crystals are grown in saucers. The crystals are the same, but this one allows student to see how crystals grow naturally whereas the previous activity is better for allowing children to study larger, perfectly formed crystals.

Materials:

- For alum garden: 1 cup boiling water to ¼ cup alum
- For salt garden: ¾ cup boiling water to ½ cup salt
- For epsom salts: ½ cup water to 1 cup epsom salts
- Kettle for boiling water
- 2-litre pop bottles cut off so that about 15 cm remain at the bottom
- Collection of small rocks that will fit on bottom of pop bottle

- Optional: green florist's clay will hold rocks firmly to the bottom of bottle
- Optional: if you have a geode, this is a good example from nature of what the students are creating in the classroom

Procedure:
- Prepare rock garden by placing rocks in bottom of cut-off pop bottles
- Prepare crystal solution by boiling water and then adding dry material to it. Stir until as much of the powder has dissolved as possible
- Pour liquid solution over rocks in pop bottle
- Set aside and get ready to make observations. Within a few hours, crystals will start to form. After a few days, there will be a beautiful "garden" to look at. Geodes, and many other rock crystals are being formed in this way when water, saturated with minerals, seeps into spaces in rocks. When the liquid evaporates, the crystals are left behind

Bluing Garden
Materials:
- Dry sponge
- Aluminum pie plate
- Glass measuring cup
- Mixing bowl, metal spoon
- 60 ml table salt, 60 ml water
- 60 ml laundry bluing (Mrs. Stewart's - available in laundry section)
- 30 ml household ammonia
- Food colouring - the more colours, the better

Procedure:
- Place sponge in pie plate
- Pour salt water, bluing, and ammonia into bowl and stir
- Pour over sponge making sure to include any solid particles
- Sprinkle food colour randomly over sponge
- Set aside where it will not be disturbed for a few days. Observe crystals with hand lens. These beautifully coloured, very delicate crystals are fragile and will disintegrate if touched so it is best just to look!

Charcoal Garden
Materials:
- Several pieces of charcoal (briquettes or aquarium filter material)
- Aluminum pie plate
- 250 ml boiling water, 100 to 200 ml salt
- 60 ml vinegar
- Food colouring - variety of colours

Procedure:
- Scatter charcoal onto bottom of pie plate
- Fill measuring cup with 250 ml boiling water
- Stir salt into water until no more dissolves (saturated solution)
- Add 60 ml vinegar to salt solution
- Pour over charcoal. The top of the charcoal should be above the liquid level. Put several drops of food colouring over the charcoal
- Place the container where it will not be disturbed for a few weeks. Observe crystals with hand lens. These crystals are very fragile and will break if container is handled roughly

STS OUTCOME #2

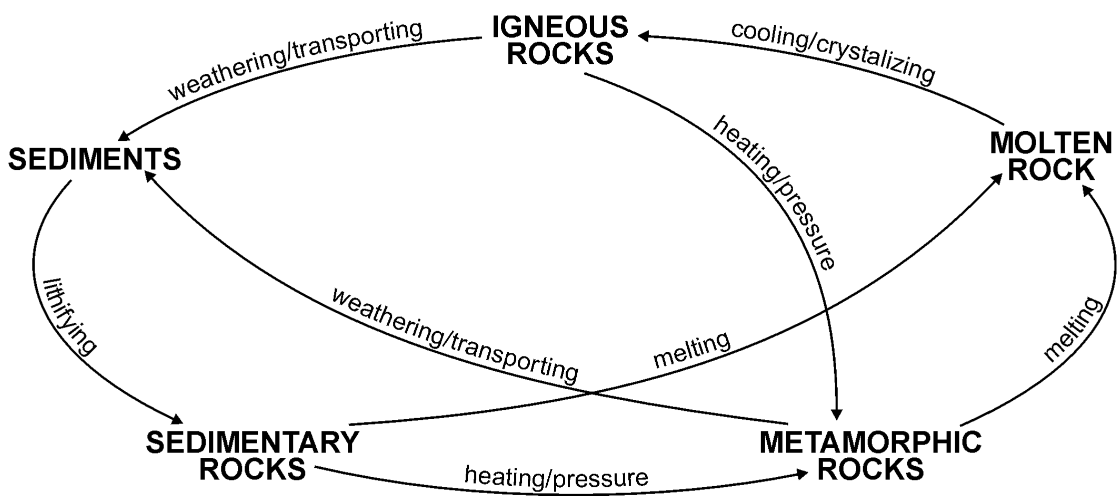
Identify evidence for the rock cycle and use the rock cycle concept to interpret and explain the characteristics of particular rocks.

R0CK IDENTIFICATION

- *distinguish between rocks and minerals*
- *describe characteristics of the three main classes of rocks—igneous, sedimentary and metamorphic—and describe evidence of their formation (e.g., describe evidence of igneous rock formation based on study of rocks found in and around volcanoes, describe the role of fossil evidence in interpreting sedimentary rock)*

Background:
When we think of what makes up our Earth, the first thing that comes to mind is rocks. When we hike in the mountains, walk along a riverbed, or sit on a beach, we constantly observe the rocks in our environment. Without realizing it, we automatically classify these rocks in our minds by observing particular features.

Rocks are made up of minerals but they are not minerals themselves. Rocks usually have more than one mineral within them. The way that mineral grains are arranged in rocks is a good clue to their identifications. Rocks can be grouped into three main types based on their origin. These are igneous, sedimentary, and metamorphic. The characteristics that we observe most easily in rocks, particularly the arrangement of mineral grains, help us classify them according to these categories.



The Rock Cycle

The ROCK CYCLE refers to how rocks are constantly being recycled in much the same way as our garbage and waste. When rocks break down as a result of erosion, the tiny pieces are carried off and eventually buried again. If they are buried deeply enough, they will melt into magma and will eventually be reborn as igneous rock. The rock cycle is illustrated below, and is an essential part of understanding rock classification and identification.

Igneous Rocks
These rocks are formed when melted rock (magma) deep inside the Earth cools and hardens. The word "igneous" means "formed by fire". Some principal igneous rock types are:

- GRANITE - the most common igneous rock type. It forms deep within the Earth and is coarse-grained. Usually, it is multicoloured (white, pink, grey, black). Granite is the most common rock type on Earth, although most of it is buried and hidden from view
- BASALT - the most common volcanic rock. It forms when lava erupts from volcanoes and cools and hardens quickly. It is usually black and fine grained, and commonly exhibits flow patterns and evidence of gas bubbles
- OBSIDIAN - another volcanic rock that cools extremely quickly when it erupts directly into water. It is so fine-grained that it looks like black glass. That is because the crystals making up the rock did not have time to grow
- PUMICE - is a less common volcanic rock but is very interesting because it is the only rock that floats! It forms when escaping gases cause lava to foam up and harden, making it extremely porous and lightweight

Sedimentary Rocks
Sedimentary rocks are formed from eroded gravel, sand, mud and carbonaceous material that has been carried long distances by water or wind. It settles on the bottom of rivers, lakes and oceans. These loose sediments are deposited in thick piles that are slowly buried and harden as a result of pressure and chemical changes. They become sedimentary rock. There are five main types of sedimentary rocks:

- CONGLOMERATE - is formed when large, rounded pebbles (quartzite and feldspar) are carried by rivers, deposited, and cemented together by brownish sand or clay
- SANDSTONE - is formed when sand is carried by rivers or by wave-action. After it is deposited and buried, it becomes hard as the grains get cemented together. Commonly, you can see layers of different coloured grains in this rock. It feels much like sandpaper when you rub it
- SHALE - may be made from clay, mud, and/or silt carried by rivers and deposited. It is a soft, smooth rock that may appear layered
- LIMESTONE - is made of calcite from the skeletons and shells of millions of tiny sea creatures that rain down from above onto the sea floor. Usually, it is light coloured and it may contain fossils. Because it is primarily calcium carbonate, it will fizz in acid (vinegar, lemon juice or dilute muriatic acid)
- COAL - soft, black, and light rock made from ancient decomposed plant material. Our primary source of energy in Alberta

Metamorphic Rocks
Metamorphic rocks were originally some other rock type (sedimentary, igneous or other metamorphic). Metamorphic means "changed in form". When already existing rock is subjected to extreme temperature and pressure as a result of deep burial or mountain-building stresses, its original character changes drastically. Mineral grains tend to flatten and become aligned and new minerals may actually form due to chemical changes. Common types of metamorphic rocks are:

- QUARTZITE - is a very hard, light-coloured rock formed when sandstone is subjected to tremendous heat and pressure. It is one of the hardest rocks known, and is completely crystalline, showing no indication of the original sand grains
- SLATE - is a dark-coloured, very fine grained rock that was originally shale. It easily splits into very thin layers and may contain visible mica flakes. It is very hard and is often used for floor tiles

- GNEISS (pronounced "nice") or SCHIST - these are medium- to coarse-grained rocks that are variable in colour. They may form from shale, slate, sandstone or granite. Irregular or interlocked bands are often visible and mica is a major component
- MARBLE - is a soft, smooth, variably-coloured rock that forms from limestone that has been subjected to extreme heat and pressure. It may have intermixed colour bands. It will fizz in acid because its principal component is still calcium carbonate

When trying to determine rock types, you may find it helpful to have students follow an identification key like the one below (modified from "Science Is") or the table on page 37.

Rock Identification Key

1.a. You can see mineral grains — go to #2.

b. Grains are too fine to see — go to #4.

2.a. Grains look melted together or interlocked — go to #3.

b. Grains look glued together (not interlocked) — go to #5.

3.a. Grains are not lined up. They are randomly scattered — the rock is igneous (granite).

b. Grains are lined up and appear to be in rows — the rock is metamorphic (gneiss or schist).

4.a. Rock is glassy or bubbly — the rock is igneous (basalt or pumice).

b. Rock has hard, flat sheets that split off — the rock is metamorphic (slate).

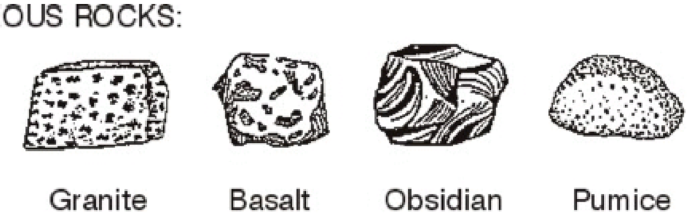
c. Rock is soft and may be layered — rock is sedimentary (shale).

d. Rock is black, soft, brittle, shiny in places — the rock is sedimentary (coal).

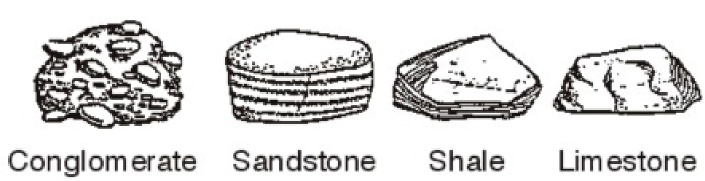
5.a. Grains feel gritty and are silt, sand, or pebbles sized — the rock is sedimentary (siltstone, sandstone or conglomerate).

b. Rock fizzes when acid is poured on and may contain fossils — the rock is

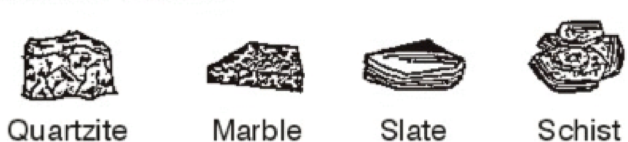
IGNEOUS ROCKS:



SEDIMENTARY ROCKS:



METAMORPHIC ROCKS:



sedimentary (limestone) or metamorphic (marble).

Rock Identification Activities

❖ Activity: Rock Identification Key and Flow Chart

In this activity, students will use different classification criteria to identify rocks as either igneous, metamorphic or sedimentary.

Materials:
- Rock Identification Key Overhead
- Rock Identification Flow Chart Overhead
- Laminated Identification Flow Charts for student use. These may be made by enlarging the flow chart from this handout onto 11 x 17 paper
- Student copies of Identification Keys
- Sets of rocks containing one of each type on flow chart, if possible

Procedure:
- Review the identification key and flow chart with the students
- Pass out rock sets to groups of students, along with a copy of the identification key and flow chart
- Guide students through the process of classification and identification for a few of the samples, and then let them work independently

❖ Activity: Fortunately/Unfortunately Rock Cycle Story

In this activity, the students make up a group story using a "fortunately, unfortunately" format. Most students who have had drama will be familiar with this process.

Material:
- Overhead copy of the Rock Cycle from handout

Procedure:
- You may want to begin the story yourself. For example, "The little quartz crystal was completely content as it slowly rode the convection currents in its molten magma home. Unfortunately..."
- Encourage students to refer to the overhead of the rock cycle. They should think of what rock type they might become next, what pathways are available to them, and what processes will get them from one point in the cycle to another. These should all be incorporated into their story. This is a good opportunity to assess the students' understanding of the rock cycle

❖ Activity: Cool Crystal Diet

If crystals want to stay "petite", all they have to do is grow in a cool environment. Students will see this in this experiment and be able to relate it to rocks that cooled quickly (e.g. some extrusive volcanic rocks) and those that cooled slowly (e.g. some intrusive igneous rocks).

Materials:
- Iodine (1 N solution works well)
- Eyedropper
- 2 or 3 glass slides and cover slips
- Candle/match

- Microscope
- Optional - refrigerator
- Variety of extrusive and intrusive igneous rocks

Procedure:

- Prepare three (if using refrigerator) slides by placing one drop of iodine on each and covering with a cover slip
- Place one slide aside in the room to crystallize
- Place one slide in the fridge to crystallize
- Hold one over a candle so that it gently warms are crystallizes within a few minutes
- Once crystallized, look at the slides under the microscope. Compare the crystal sizes under the same objective lens. Students should sketch the crystals using the same magnification
- Have students compare what they saw on the slide with the igneous rocks. What can they infer about the history of the rocks when compared to the slides?

Note: You may be able to observe crystals actually forming on the room temperature slide if you catch it at the right time.

What is happening?
In this activity, iodine represents magma. As magma cools, it crystallizes. Intrusive igneous rocks cool very slowly under the ground so crystals have a long time to grow. Therefore, these rocks are coarse grained (ex. granite). The slides that crystallized at room temperature and in the fridge would represent intrusive rocks. Extrusive rocks are ejected into cold air or water so they crystallize almost immediately, giving the crystals very little time to grow. Extrusive rocks are fine grained or glassy (ex. basalt or obsidian). The glass slide that was heated represents the rapid crystal formation of an extrusive rock.

❖ Activity: Waxy Rock Cycle

Materials:

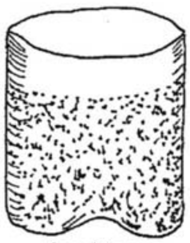
- Variety of used coloured wax crayons
- Crayon sharpener
- Aluminum pan or microwaveable container
- Aluminum foil
- Hammer and goggles
- Microwaveable container
- Microwave or candle and clothespin
- Samples of igneous basalt metamorphic gneiss and sedimentary sandstone

Procedure:

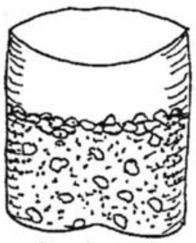
- Make crayon shavings. The different colours will represent sediments from the rock cycle. If using a candle, place shavings in an aluminum pan. If using microwave, use a microwave-proof dish
- Cover the pile of "sediment" with foil and an old book, for instance, and hammer the top to increase pressure. You will have now made sedimentary rock. Examine and record observations
- If using microwave, place microwave-safe dish in the microwave and put on medium High for 2-4 minutes. If using candle, hold aluminum pan with a clothespin and heat over flame for several minutes. <u>Wear goggles</u>
- Remove from heat, place foil over top of sedimentary rock and apply pressure. Observe the metamorphic rock resulting from increased heat and pressure. Record observations
- Return to heat using same procedure as #4. Heat until you have molten lava. As it cooks, the rock will be igneous. Record observations
- Give students real rock samples and see if they can identify rock types based on their observations

❖ Activity: Making Sandstone and Conglomerate

In this activity, students actually have a chance to make sandstone and conglomerate in much the same way that it is made in nature.



Sandstone



Conglomerate

Materials:

- ½ cup (118 ml) water
- Clear plastic pop bottle (cut off 10 cm from bottom)
- 2 ½ Tb. Epsom Salt
- Stirring spoon
- ½ cup (100 g) dry sand if making sandstone
- 2 Tb. sand and 2 Tb. gravel if making conglomerate

Procedure:

- Pour water into bottom of cut-off pop bottle
- Stir in Epsom Salt and stir until dissolved
- Add sand (sandstone) or sand and gravel (conglomerate) and stir so that the dry materials are completely moistened
- Let sit for several hours, periodically pouring off excess liquid from the top
- When no more excess liquid comes out, set aside for at least a week until completely dry
- Remove from bottle bottom. You now have a cemented piece of sandstone or conglomerate

Rock Hard Food Analogies

Geological processes that form rocks are remarkably similar to many of the things that we do in the kitchen every day! The following foods are an excellent way of teaching students how some of the classification criteria that we use in rock identification are formed in nature, including grain size, sediment layering, mineral alteration, and cementation.

Chocolate Chip Cookies - These are an excellent (and yummy) way for students to think about the difference between rocks and minerals. Minerals are made up of one kind of material only. Rocks are made up of several different kinds of minerals. The chocolate chips in the cookie represent this very well. Also, the ingredients that went into the cookie batter are like smaller mineral grains of different types (flour, salt, sugar). After the ingredients are mixed and buried, they heat up and harden into their new form. The individual minerals may not all be seen, but they are all there and give the cookie its distinctive characteristics.

Sedimentary Sandwich - Sedimentary rocks are formed when layer after layer of sediment is laid down, eventually hardening into rock. These layers are often different materials since this happens over thousands of years, and things tend to change in that amount of time. Bread at the bottom and top could be sandstone, peanut butter could be clay, jam with chunks of fruit could be conglomerate. It is very common to find these "sandwich-style" layers in natural sedimentary rock.

Rice Crispy Squares - are a good example of cemented sandstone. The rice cereal grains are gathered and cemented together by the marshmallow. This is very much like sand grains being cemented together by mineral-rich water over time.

Puffed Rice Cakes - If the rice grains are subjected to extreme heat and pressure conditions, they lose their original character altogether. The result is an amorphous mass where original grains are "smeared" out and merge with neighbouring grains so that you can no longer distinguish one from another. This is analogous to sandstone being metamorphosed into quartzite.

Candy Granites and Basalts - Sugar candy in various forms is an excellent way to show students the difference between granite (coarse-grained intrusive igneous rock) and basalt (fine-grained extrusive igneous rock). Granite is coarser grained because the crystals had a longer time to grow as the rock cooled slowly underground. This is why you can see the individual grains interlocked. Rock Crystal Candy is made this way and the crystals can easily be seen. Basalt cools very rapidly as it is ejected from a volcano directly into cool air or water. The crystals do not have time to grow and are invisible, giving the rock a smooth texture. If there are no air bubbles, it will look like glass (obsidian). This is how toffee or Candy Glass (made without the butter) would look. If air bubbles or gasses were trapped during the quick cooling, the rock will have lots of little holes. This is how Spun Sugar Candy is made. It is very porous and much lighter in weight than other sugar candies.

❖ Activity: Rock Hunting Field Trip

Equipment list:
Before going on a rock collecting expedition, you should prepare by making sure you have the equipment that you will need.

- A rock hammer (square on one end and pick-shaped on the other)
- Safety goggles
- Gloves
- Strong knapsack
- Hand lens
- Masking tape
- Marker
- Plastic bags
- Old cloth
- Newspaper
- Good shoes

Field trip rules:
When you go with your students, be sure to stress safety at all times. Goggles should be worn when using the rock hammer. Loose hillsides and rock faces should not be climbed. Never go alone! Treat other people's property with respect!

When choosing specimens, encourage students to look for freshly broken pieces of rock since weathered surfaces tend to hide the rock's actual appearance. Remind them to take only the best specimens they find and limit the number that they will be allowed to bring back. As students collect their specimens, have them wrap a small amount of newspaper around each one and label by placing masking tape around the rock. Students can write their name and sample number on the tape. If the students are expected to carry their own specimens, they will be more likely to choose appropriate sizes.

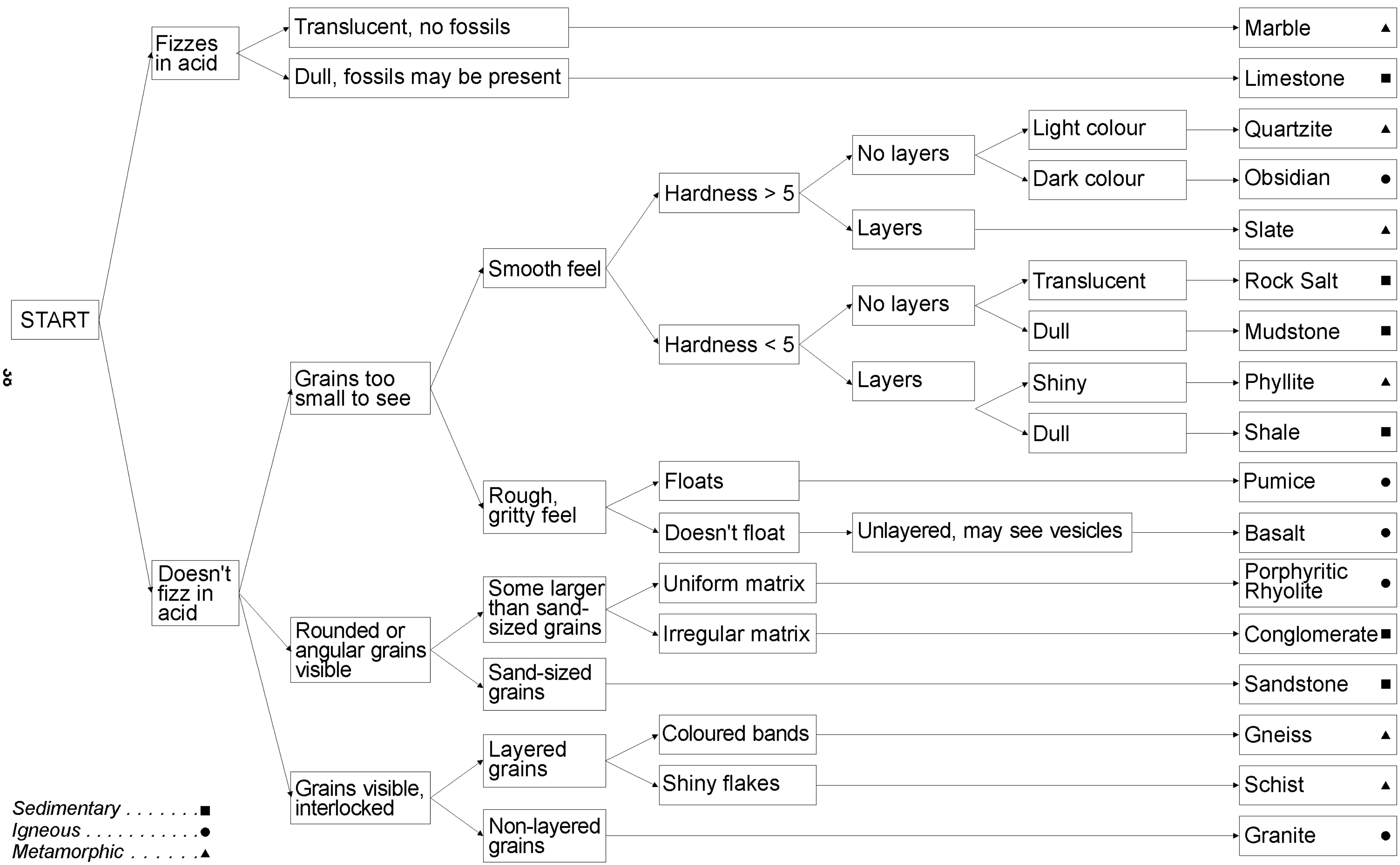
Breaking bigger rocks into smaller pieces:
Often times, students will want to take a sample that is too large to carry. It is possible to break larger rocks into manageable pieces using the following method. This also provides better surfaces on which to observe rock properties for identification purposes:

- Put safety goggles on
- Place rock in plastic bag and squeeze air out
- Place in another plastic bag and cover with cloth
- Place on concrete or another large rock and hit with hammer until broken

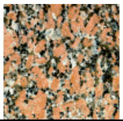
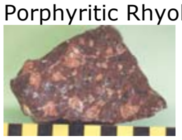
Preparing rocks for display:
Before setting up rock and mineral samples in the classroom, have students paint a small, white patch on the specimen's bottom side. They may use tempera paint, latex paint or

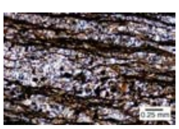
white-out. On the white dot, a sample number should be written with a marking pen. The student may also want to put their initials on the dot so that they get their rock back. For each numbered sample, you can make an index card that will go along with the specimen when it is displayed. This card can include information such as specimen number, date collected, name of rock or mineral if known, where found, and name of collector. When this has been done, rocks and minerals are ready to be sorted, classified and identified using the property tests and flow charts described previously.

IDENTIFICATION OF ROCK TYPES TABLE



ROCK SPECIMEN INFORMATION SHEET

ROCK NAME		DESCRIIPTION	ORIGIN
IGNEOUS	 Granite	Granite is a combination of light and dark coloured minerals. Light minerals include quartz grains, white or pink feldspar and silvery muscovite. Dark minerals include biotite and hornblende. Granite is a coarse grained rock with interlocking crystals randomly arranged.	An intrusive igneous rock that forms deep in the Earth's crust from cooling magma. The magma is usually silica (quartz) rich and the slow cooling produces large crystals that are visible without a microscope.
	Basalt 	Dark gray to black, made up of microscopic crystals, very hard, may contain evidence of gas bubbles (vesicular basalt).	Volcanic in origin, formed from magma that erupts from a volcano or a fissure as lava. Because it cools quickly, there was not enough time for grains to become large enough to see.
	Porphyritic Rhyolite 	Usually light coloured (gray, tan, reddish, greenish) with very large crystals scattered throughout a fine-grained matrix. It may show some evidence of gas bubbles or flow lines.	This started out as an intrusive rock as seen by the large crystals (phenocrysts). However, before more crystals could form the magma was suddenly ejected out of a volcano or fissure so the matrix is microcrystalline and the rock is considered extrusive.
	Obsidian 	Glassy and usually black, although there make be white crystals that look like snowflakes (snowflake obsidian) or red swirls. Glass-like conchoidal fracture which looks like a ridged semicircle.	An extrusive volcanic rock that forms from lava that erupts into cold water. It hardens so quickly that crystals have no time to form, thus the glassy texture.
	Pumice 	Very light gray to medium gray with lots of gas bubbles giving it a sponge-like appearance. Volcanic glass that is so lightweight it will float in water.	An extrusive igneous rock that comes from magma containing a great deal of trapped gas. This gas causes an explosive eruption, which results in a volcanic glass filled with air spaces when the magma suddenly cools.
SEDIMENTARY	Conglomerate 	Looks like a mixture of sand and different sizes of rounded pebbles. If the pebbles are angular, it is called Breccia.	Sand and pebbles collect on river banks or shorelines. As more sediment piles on top, the underlying layers compact and are cemented by material (usually quartz or calcite) dissolved in water that seeps through them.
	Sandstone 	Can be nearly white to red or brown. Composed of grains that are mainly the same size but size may vary slightly in layers. Can be fine, medium or coarse grained. This is usually determined by the "feel" of the rock.	Resistant quartz sand grains are produced by weathering of other rocks such as granites. Deposited in a basin such as an ocean or a river. Sediments are buried and compacted under the weight, and then cemented.

	Mudstone 	Colour may be tan, green, brown, gray, red or black, depending on the source of clay or mud. Massive and structureless with no layers. It crumbles easily. Smells like wet mud when moistened. A weaker rock than shale.	Mud and clay particles accumulate in a basin such as a deep lake or ocean. If they are not buried deeply enough, they will become a very weak rock that crumbles into powder when weathered.
	Shale 	Colour may be tan, green, brown, gray, red or black. Particles are too small to be seen by the unaided eye but you can usually see evidence of layers. Shale is weak and breaks along layers. When moistened, shale usually smells like wet mud.	When clay sediments settle in deep, quite water, they accumulate and can become deeply buried. If these layers are buried deeply enough, they will be compressed and converted into a soft rock called shale.
	Fossiliferous Limestone 	White, gray or tan, may be fine or medium grained but not crystalline, fossils are commonly visible, fizzes in dilute hydrochloric acid.	Formed in ocean water as a result of coral reefs being buried by mud or by lime mud being deposited on the sea floor, the product of calcareous organisms dying and raining down.
	Rock Salt 	Transparent to translucent, colourless to white, massive or cubic crystals, very soft (can be scratched by fingernail). Made up of the mineral halite.	Sometimes stretches of seawater become land-locked because of tectonic or climatic changes. As the water of an enclosed sea area evaporates, the result is a salt lake with a saline content higher than that of the ocean. Further evaporation leaves a large expanse of crystallized salt, which is buried by other sediment to become rock.
METAMORPHIC	Marble 	Usually white but may be streaked with other colours, fine to coarse grained crystals, fairly soft, fizzes in dilute HCl.	Formed from limestone that has been subjected to extreme temperature and pressure.
	Phyllite 	Commonly silver or greenish. Shiny appearance depending on which direction it is seen from. This characteristic sheen often identifies phyllite. Corrugated appearance to layers. Very fine grained.	The parent rock for phyllite is slate. As slate becomes more deeply buried underground and pressure and temperature continue to rise, chlorite and mica crystals recrystallize into larger crystals, which reflect light more easily than slate. Transitional between slate and schist.
	Schist 	Layered rock with abundant shiny mica crystals (small, flaky crystals). Layers are usually thin with interlayered mica and quartz. Layers may be somewhat wavy. May be medium or coarse grains. Usually split easily along layers of mica.	Schists are usually formed from shales (parent rock). Often sea floor shales that are exposed to tremendous pressure and temperature during tectonic activity such as subduction.

ROCK IDENTIFICATION WORKSHEET

Sample #	Rock ID	Reactoin to acid (yes/no)	Grains visible (yes/no)	Grains separate or interlocked	Layers (yes/no)	Grain size (mm)	Hardness (soft/hard)	Feel (smooth/ rough)	Lustre (dull/shiny/ translucent)	Colour	Other (fossils/bubbles)

GEOLOGY IN THE CITY OF CALGARY

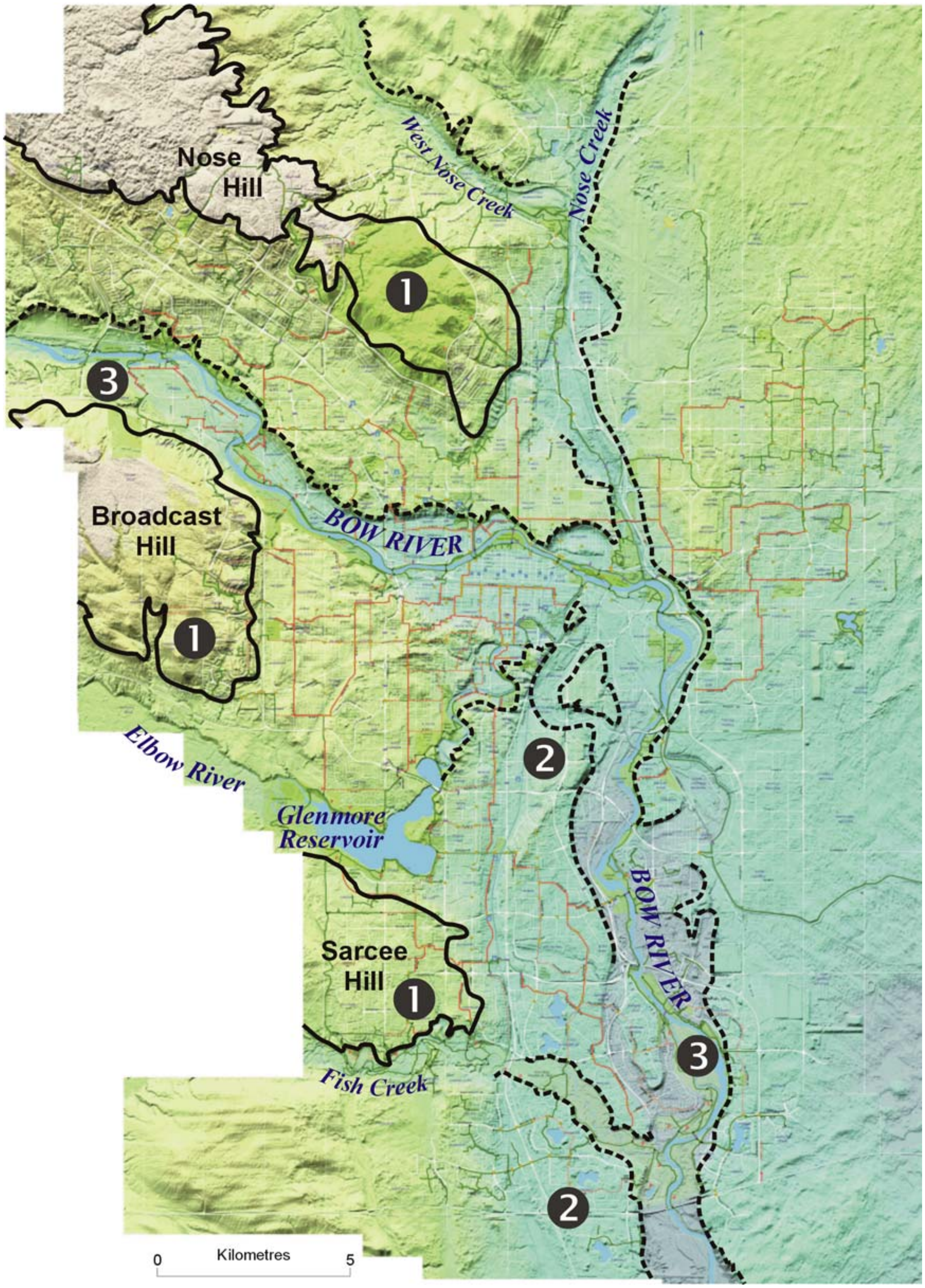
★ *describe local rocks and sediments, and interpret ways they may have formed*
★ *investigate and interpret examples of weathering, erosion and sedimentation*

General

The City of Calgary was founded at the confluence of the Bow and Elbow rivers near the west edge of the Canadian plains. These plains slope gently northeastward, away from the Rocky Mountains. The undulating topography in the city has a relief of about 175 m. It is mainly the product of erosion by the rivers in Quaternary times (the last 1.6 million years) and generally reflects the underlying bedrock surface.

The are three main levels in the topography of Calgary:

1. The highest level consists of the mostly flat-topped uplands that have a bedrock core and comprise erosional remnants of old river plains. The bedrock is Paskapoo Sandstone of Paleocene age (early Tertiary), about 58-65 million years old. The upland areas are Nose Hill, Broadcast Hill and Sarcee Hill that rise to elevations of 1270 m, about 175 m above the Bow and Elbow river beds.
2. The middle level is an undulating plain that fills the space around and between the hills. The surface at this level is generally glacial till but may also contain river deposits related to streams. In northwest Calgary, this area is covered by hummocky moraine deposited by glaciers.
3. The lowest level consists of the river flood plains, which are in places up to 2 km wide and cut down about 35 m below the middle level. Downtown Calgary is situated on this level.



The map above shows the geography of the City of Calgary with the key topographic levels identified. The solid lines represent escarpments bordering bedrock-cored uplands (level 1, above). The dashed lines indicate distinct rims separating the intermediate topographic level from modern flood plain. Where the dashed lines are missing, the intermediate level slopes gradually down to river level. From Osborn and Rajewicz (1998).

Bedrock Geology

Outcrops of bedrock are rare in the Calgary area. Where it occurs, it generally consists of fine- to medium-grained sandstone and shale of early Tertiary (Paleocene) age. It represents the deposits of meandering rivers that were eroding the Rocky Mountains as they were being created during the period of mountain building known as the Laramide Orogeny. These rivers spread enormous amounts of sediment eastwards from the mountains during the Tertiary. The whole unit is about 600 m thick beneath Calgary and is generally referred to as the Paskapoo Sandstone, although it has also been divided on a finer scale into the lower Paskapoo Formation (with volcanic rock fragments) and an upper Porcupine Hills Formation (with sedimentary rock fragments).

Outcrops occur in several places, notably the Edworthy ravine at Edworthy Park, the Spruce Cliff area downstream along the Bow River, the southwest slope of Nose Hill and the north shore of Glenmore Reservoir. Other less impressive outcrops occur along the Bow River at various places, such as Silver Springs. Locally, plant fossils and fossil clam shells are common within the sandstone. However, most of the bedrock is covered by unconsolidated sediments related to the latter stages of glaciation and associated river and lake deposits of Quaternary age.

The sandstone has been quarried over the years as building stone, in particular, following the devastating fire of 7 November 1886 that destroyed the wooden buildings in downtown Calgary. The old part of our city hall built in 1911 at 800 Macleod Trail East is a fine example of the use of local sandstone.

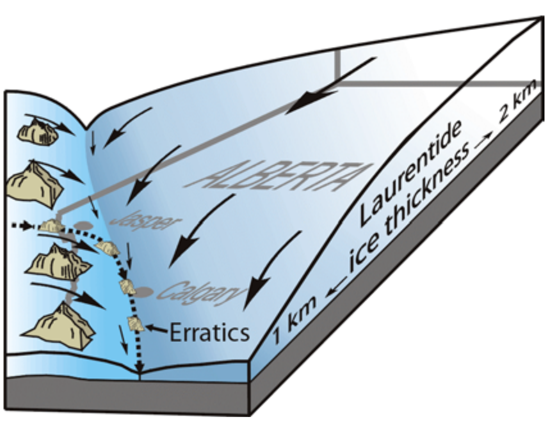
If a hole were drilled beneath Calgary it would pass through more than 4000 m of sedimentary rocks before striking the crystalline, metamorphic and igneous rocks of the Precambrian.

Deposits of the Glacial Era

The unconsolidated sediments overlying the bedrock in the Calgary area vary greatly in thickness. They average about 10-15 m on the uplands and 0-80 m thick at the intermediate and lower levels. In general three, distinct layers are recognized:

Early to preglacial sediments
The lowest level is represented by bodies of gravel that lack any pebbles of crystalline rocks. These are generally thought to predate the main glaciation (because of the lack of pebbles from the shield) and may be of early Pleistocene age (about 1.6 milion years old).

Glacial tills and river sediments
The next level is a complex body of tills (unsorted sediment deposited directly beneath glaciers) and deposits laid down by rivers. The story is complicated because the glaciers that deposited these sediments came from different directions. The largest ice sheet (Laurentide Ice) was moving material from the centre of the continent towards the margins. Smaller glaciers in the mountains (the remnants of which we can still see today - for a little while longer, anyway) extended out from the mountains and moved material from there. A third body of ice, the Athabasca Valley ice, has been suggested to have been moving from north to south through the region as well.



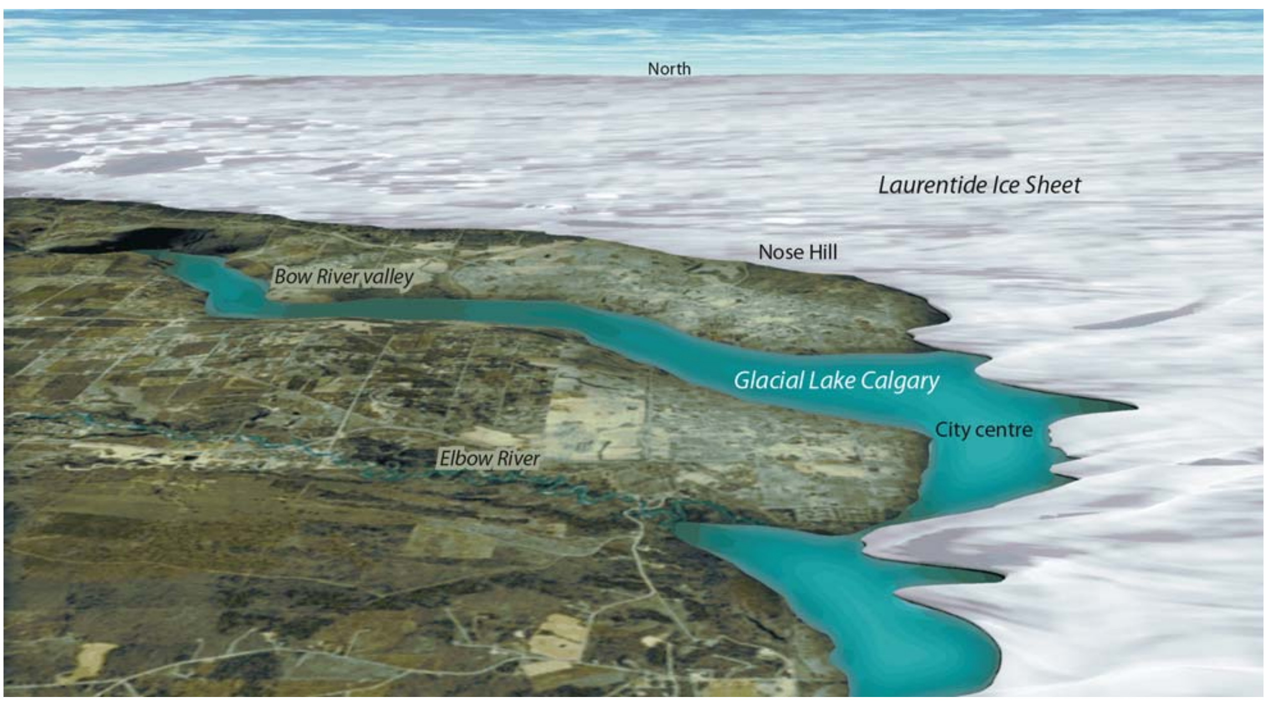
This diagram shows the ice sheets thought to be responsible for glacial and fluvial deposits in the Calgary area.

The three operating sanitary landfills in Calgary are based in these glacial deposits. The east Calgary and Shepard landfills are contained in finer grained sediments, but the Spy Hill operation has many coarse deposits within it. As a result, liquid disposal is not permitted at the Spy Hill facility.

Glacial Lake Calgary Deposits
Finally, in central and northwest Calgary, there are lake deposits associated with an ice-dammed lake called Glacial Lake Calgary. This lake extended up the Bow Valley past the town of Cochrane and its highest level is reckoned to have been 1220 m. The lake is thought to have existed until about 11,000 years ago.

The lake sediments are mainly silts but also include clay and fine sand. Locally there are pebbles, large blocks and/or lenses of gravel that were presumably rafted into the lake by surface ice. The overall texture of the sediments can change over relatively short distances.

Some of these silts cause significant problems for construction in Calgary and may also cause slope failures following heavy rainfalls. Many central and northwest structures are built on these sediments. However, large buildings like the Foothills Hospital and the University of Calgary facilities are founded on piles that transfer the load of the building to the lower tills.



This image shows a hypothetical configuration of glacial lakes in the Calgary area. This is the concept of "Glacial Lake Calgary".

In an excellent paper on the urban geology of Calgary, Osborn and Rajewicz (1998) explain the following incident at the time of construction of Banker's Hall downtown:

"One of the more serious problems caused by the silts to date occurred during the 1987 excavation for the foundation and basement parkade of Bankers Hall, a high-rise office building in downtown Calgary. Many borehole logs for downtown construction projects show bodies of silt, most likely lacustrine, between post-glacial alluvium and underlying till; such bodies, cohesionless and saturated, were encountered several metres below grade during the excavation. Running of silts through lagging boards of the shoring walls caused loss of ground underneath adjacent 9th Avenue, which is the major downtown artery. Silt fans formed in the excavation, a crack appeared in the street, a crane toppled and the shoring wall tilted a small amount. Work was halted while the excavation, and indeed the substructure of the building, was redesigned. Litigation followed the eventual late completion of the building."

The ability of these silts to flow when saturated also causes slope failures in Calgary. Most of these slope failures occur along the bluffs and headlands of the former lake and most move slowly. One can look upon most of these movements as a result of the quest for slope stability following the downcutting by the river, however, some have a decidedly human cause. It is thought that watering of lawns in areas adjacent to river bluffs is the main cause of slope failure, because it elevates the level of the natural water table.

There are several areas with slope stability problems, including the Spruce cliff area (with the very obvious scar of the Wildwood slide), slopes above the Elbow River in the Parkhill area, the slopes separating Crescent Heights from Sunnyside, and perhaps the most prominent at Home Road on the edge of Varsity Estates.

Deposits of the Post Glacial Era

Volcanic deposits
One interesting deposit that caps much of the glacial sequence is the so-called Mazama tephra. This is the result of a massive volcanic explosion in southern Oregon that occurred about 6850 years ago and laid down a huge area of ash and volcanic debris over northwestern North America.

Formation of our present landscape
Following the glaciation and the release of Glacial Lake Calgary, the local rivers began cutting through the lake sediments and other deposits to form the landscape we know today.

Further reading:

Jackson, L.E. and Wilson, M.C. (Editors) 1987. Geology of the Calgary Area. Canadian Society of Petroleum Geologists.

Osborn, G. and Rajewicz, R. 1998. Urban geology of Calgary. *In* Urban Geology of Canadian Cities, P.F. Karrow and O.L. White (editors), Geological Association of Canada Special Paper42, p. 93-115.

Wilson, M.C. 1983. Once upon a river: Archeology and geology of the Bow River at Calgary, Alberta, Canada. Archeological Survey of Canada, National Museum of Man, Mercury Series, Paper 114, 464 p.

STS OUTCOME #3

MAJOR CHANGES IN THE EARTH

Investigate and interpret evidence of major changes in landforms and the rock layers that underlie them.

For this outcome we use the book entitled "This Dynamic Earth" that is produced by the United States Geological Survey. We suggest reading this book and using the web site associated with it for the basic information. We have, however, supplied some good activities below.

Investigate and interpret patterns in the structure and distribution of mountain formations (e.g., describe and interpret mountain formations of the North American Cordillera)

- ★ *interpret the structure and development of fold and fault mountains*
- ★ *describe evidence for crustal movement, and identify and interpret patterns in these movements*

❖ Activity: Fault Models

Materials:

- Fault Model Sheets from Internet USGS Learning Web
  http://wrgis.wr.usgs.gov/docs/parks/deform/7modelsa.html
- Scissors
- Glue
- Coloured pencils
- Triangular make-up sponges

Procedure:

- Follow directions given on the website for models
- Using the models, students can demonstrate normal, reverse (thrust) and strike-slip faults.
- Students should make sketches of their fault models
- You may wish to print off the questions that go along with the fault models. They are useful for focusing students on key points
- Students can also use make-up sponges to demonstrate movement in reverse and normal faulting and folding

❖ Activity: Rock Structures in 3-D

Materials:

- Play dough or modeling clay in variety of colours
- Cheese cutter
- Paper, pencil

Procedure:

- Make a model of three folded layers of rock using different colours of clay
- Cut across the top of the fold to show the effects of erosion. You may do this at a slant or horizontally
- Lay a fourth colour of modeling clay on the "Eroded" surface
- Simulate another phase of erosion by slicing a slanted layer off the top
- Place a piece of paper over the exposed surface and sketch the pattern
- Have students try and visualize the structure of the underlying rock layers by observing the surface pattern. This is where geologists begin their search for oil and gas

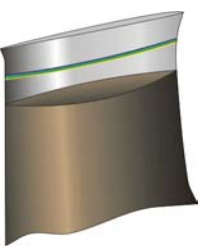
❖ Activity: Sand Folds and Faults

Materials:
- Transparent plastic box (e.g. Ferrero-Rocher chocolate box)
- Thick cardboard to tightly fit box as a vertical partition
- Dry sand
- Flour

Procedure:
- Stand the cardboard up in one end of the plastic container
- Pour in a layer of sand approximately one cm thick. Sprinkle a thin layer of flour on top of the sand. Continue to alternate layers of sand and flour until box is about half full
- Grip the piece of cardboard and move it slowly and gently toward the opposite end of the box
- Stop when it is about halfway there
- Look at how the layers have moved. Some have bent (folds) while others have slid up or down (faults)

❖ Activity: Rock Hard?

In this activity, students will gain a better sense of how a rock, which is hard and rigid, can be shaped into the incredibly contorted fold patterns that can be seen in the mountains and sometimes in individual rock specimens.



Materials: (Enough for one baggie of ooze)
- Pictures of fold structures
- Small, snack-size zip-lock bags
- Measuring cup
- Spoon
- 125 ml (½ cup) powdered cornstarch
- 60 ml (¼ cup) water
- Food colouring (optional)

Procedure:
- Show students some pictures of highly contorted folds and ask them to think of ways they could have formed. Remind them of the characteristics of rocks (hard, brittle, rigid...). Have them "visualize" some of their suggestions and predict what patterns they might expect
- Make ooze:
  - Place cornstarch into the zip lock bag and add water
  - Zip bag up
  - Mix cornstarch and water by squeezing the mixture through the outside of the bag (unless you want to let them mix it "hands on" which is really messy but also really fun)
  - When all of powder is wet, the mixture should flow when gently pressed but harden when hit sharply
- Experiment with the ooze. Strike it, squeeze it, place object on topic of it, observe what happens
- Ask students what they have to do to get their ooze to flow (folds) rather than break (faults). They will discover that gentle, prolonged pressure is required. If more force is used over a short period of time, the ooze will simply break
- Ask students to relate what they have observed to tectonic forces slowly pushing against rocks over millions of years

What is happening?
The mixture of cornstarch and water does not behave like a normal fluid. It is therefore called a non-Newtonian fluid. Specifically, it is an isotropic fluid. When a force is applied over

a short period, it responds by hardening since the particles get into each other's way as they attempt to flow. However, when less force is applied over a longer period of time, the particles are able to easily slide past each other and flow. The viscosity of the fluid actually changes in response to a shearing force. Over the great expanse of geologic time, the layers of solid rock that were originally relatively flat can "flow" with the help of heat and pressure. This property of rock is called plasticity and it is evidenced wherever you see fold structures. If forces are applied over shorted periods of time such as in the case of earthquakes, the rock breaks and faults are created.

❖ Activity: Earthquake Simulation Model

Materials:

- 2 bricks
- Pieces of string
- "Bungee" cord
- Tray of water
- Paper
- Pen
- Blu Tak

Procedure:

- Put two bricks, one on top of the other, on a table
- Put the tray of water on top of the bricks
- Tie the string around the top brick
- Draw a bar across the paper and cut in half so that the bar is divided in the middle
- With Blu Tak, attach one half of the paper on the bottom brick and the other half on the top brick so that the bar appears continuous
- Hook the end of the bungee cord onto the string and gently, but persistently pull the bungee cord until the top brick suddenly slides
- At the moment the brick slides, observe the waves that travel through the water. The shock waves travel down the bungee cord in the same way seismic waves travel through the earth after an earthquake
- The displaced bar represents a fault that has suddenly moved

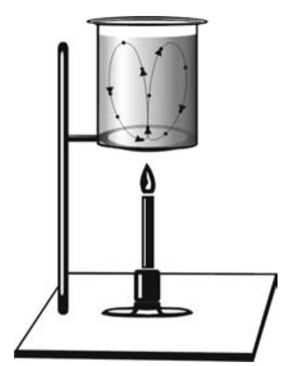
★ *identify and interpret examples of gradual/incremental change, and predict the results of those changes over extended periods of time (e.g., identify evidence of erosion, and predict the effect of erosional change over a year, century and millennium; project the effect of a given rate of continental drift over a period of one million years)*

❖ Activity: Seasoned Convection

The mechanism by which plate boundaries diverge can be shown to students through a demonstration of convection currents.

Materials:

- 300 ml oil
- 15 ml (1 Tb) dried spice such as basil or oregano
- 1 L heat-proof beaker
- Ring stand with ring holder
- Candle/matches
- Safety goggles



Procedure:

- Pour the oil into the beaker
- Sprinkle the seasoning on top of the oil
- Place candle on base of ring stand

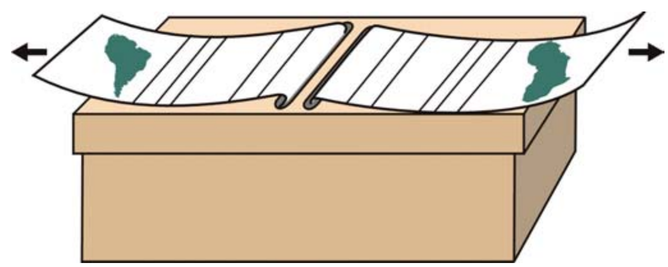
- Place beaker on ring holder
- Position ring so that it is just above flame level of candle
- Light the candle and wait for several minutes while the oil heats up
- As it heats ask students to observe the movement of spices in the oil. They will rise above the flame and fall away from the center of the heat source. They can observe this from two angles to get a better effect (from the side and from above)
- REMEMBER to have students wear safety goggles when observing oil. We have never known it to splatter but it could happen

What is happening?
In the activity, the oil represents the molten, viscous mantle and the spices are used to show how convection currents are set up in this material. The oil over the candle becomes more warm and less dense so it rises. This causes the spices on the surface to move away from the heat source. Away from the direct heat, the oil is cooler and more dense so it sinks and the spices are carried with it. They act of convection moves these spices toward the warm zone and the cycle of moving up, out and down starts over again. Convection currents in the magma carry the lithospheric plates away from divergent rift.

❖ Activity: Rolling Out the Red Sea Carpet

Divergent tectonic plate boundaries can be more difficult for students to visualize but this activity allows them to create an oceanic spreading zone on their own.

Materials:
- Globe or world map, preferably with plate boundaries
- Shoe box (men's)
- Scissors or Exacto knife
- Two partial rolls of paper towels
- Markers



Procedure:
- Have students draw a picture of land on the first sheets of both paper towel rolls
- Subsequent sheets should have a series of lines (parallel to roll) drawn so that each roll is an exact duplicate. These lines represent the magnetic "stripes" that have been mapped and help determine ocean crust age and rate of movement
- Prepare the shoe box by cutting two parallel strips into the lid (long enough to pull paper towels through)
- After marking paper towels (6 or 7 on each roll), roll them back up and place them into shoe box
- Extend the end sheets (land) out of the box so that the edges meet. Ask students what that edge would be called (rift zone, fault...)
- Slowly start pulling the paper towels outward. The land divides into two "plates" and then move apart. As they continue to move, ocean floor is created. The magnetic strips will be symmetrical on either side of the rift zone

What is happening?
The two paper towel rolls represent two tectonic plates at a divergent plate boundary. At a rift boundary, magma from the mantle wells up into the lithosphere at the "crack" between plates. Convection currents within the magma carry the floating plates away from the rift zone and as the magma hardens, it forms new oceanic crust. The magnetic stripes actually represent periodic shifts in the magnetic poles over geologic time and when mapped, they provided one of the best pieces of evidence for plate tectonic theory.

❖ Activity: Plate Pages

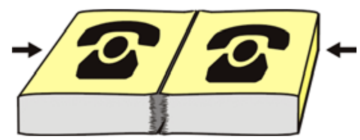
Converging plate boundaries and their complex structures can be modeled using two phone books.

Materials:

- 2 phone books

Procedure:

- Place the two phone books together (spines facing outward)
- Push the books together to simulate tectonic plates crashing into one another
- Observe the different structures that are created, including folds, up-thrown faults, intersplintering rock layers.



What is happening?
The pages of the phone book represent the layers of rock making up the lithosphere. Where two plates converge (such as in the Himalayas) these layers are come crashing into one another in a slow but relentless push from either side. This results in very high mountains with incredible deformation.

STS OUTCOME #4

Describe, interpret and evaluate evidence from the fossil record.

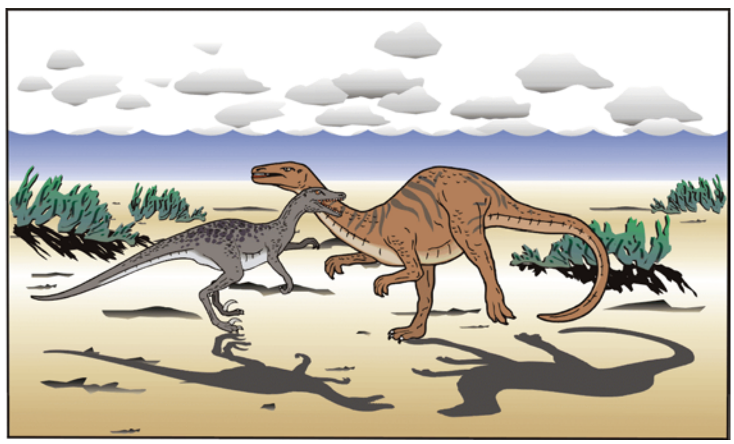
HOW FOSSILS FORM

★ *describe the nature of different kinds of fossils, and identify hypotheses about their formation (e.g., identify the kinds of rocks where fossils are likely to be found; identify the portions of living things most likely to be preserved; identify possible means of preservation, including replacement of one material by another and formation of molds and casts)*

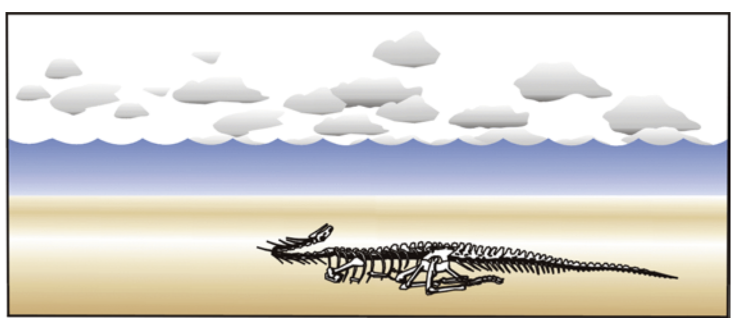
When an animal or plant dies, it eventually disappears. On the surface of the Earth it may be eaten up by scavenging birds and animals like crows, vultures or coyotes. It may be eaten up by smaller creatures like beetles, maggots and bacteria. What is left will rot away and normally disappears without trace. It takes special circumstances to preserve animals or plants so that they are preserved as fossils. It takes extra special circumstances to preserve a fossil well.

Here is a typical case:

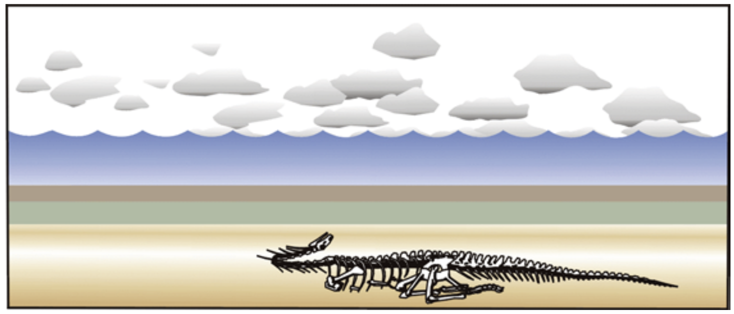
A dinosaur is killed by another alongside a lake. Its body is washed into the water and the remains come to rest on the lake bottom.



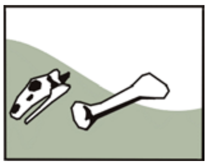
The soft parts of the dinosaur decompose, but the hard parts, like bones and teeth, remain on the lake bottom.



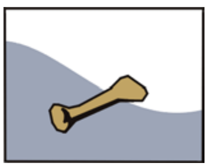
Lake sediments gradually accumulate on the lake bottom. Layers of mud and silt begin to exclude oxygen and decomposition slows down. As time passes and more sediment accumulates, the bones and teeth are trapped inside as fossils.



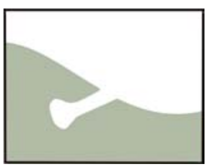
At this stage four different things can happen to the bones and teeth to turn them into fossils:



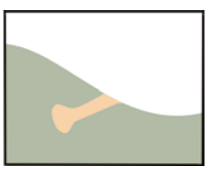
Original remains. The bones and teeth remain unchanged. This is an extremely rare case and requires special conditions.



Petrified fossils. In some cases, the original material of the teeth and bones are replaced by another mineral, typically silica. This preserves the original structure beautifully, but the original materials have been replaced by another mineral.

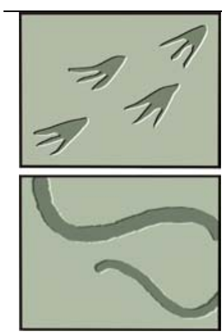


Mould fossils. The bones and teeth rot away slowly and leave holes in the rock that are the same shape as the original material. These holes are called moulds.



Cast fossils. Once a mould forms, it is common for the mould to be filled in by sediment or other materials. In this case these secondary materials make a fossil that is the same shape as the original remains, but made up of different material. This is a cast.

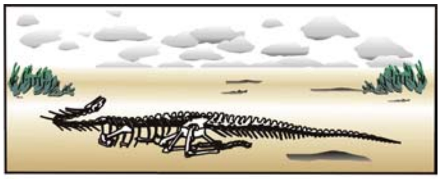
Other kinds of fossils reflect the activities of organisms and are called **trace fossils.**

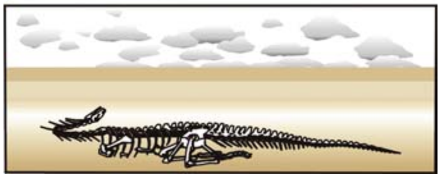


For example when an animal, such as a dinosaur leaves a footprint in mud by the lake, these may get dried out by the sun and filled with sediments and be preserved. Similarly when a worm or snail burrows through the sediment in search of food, such traces may also be preserved.

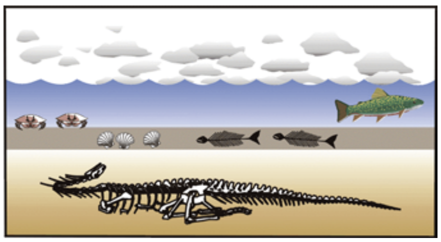
HOW GEOLOGISTS READ THE LAYERS OF SEDIMENTARY ROCK

The following images portray the geological history of one area over a period of time.

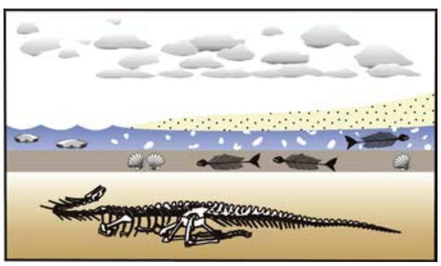




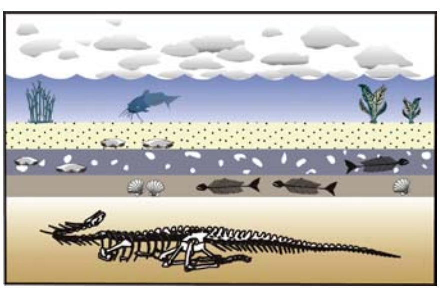
An animal dies in the desert and leaves its remains in the sand. The sandstone that forms contains fossils of the bones and teeth of this desert animal.



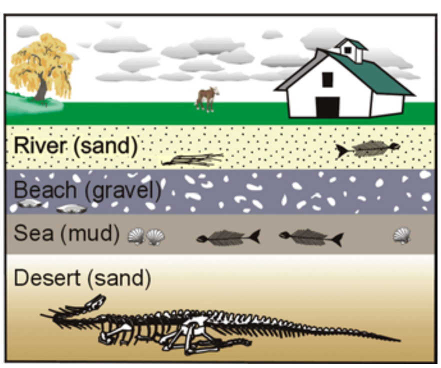
As time passes, the sea may have spread over the area, allowing muds to accumulate on the seabed. Sea animals, such as fish that swim above the seabed and clams that live on or in the seabed, die and their hard parts gradually accumulate. Their remains will be present in the mud.



Over many years, the sea may withdraw from the area, and a beach may be formed. The beach may be made up of pebbles, forming a gravel layer. Different creatures that lived along the shoreline, such as crabs, would be preserved as fossils.



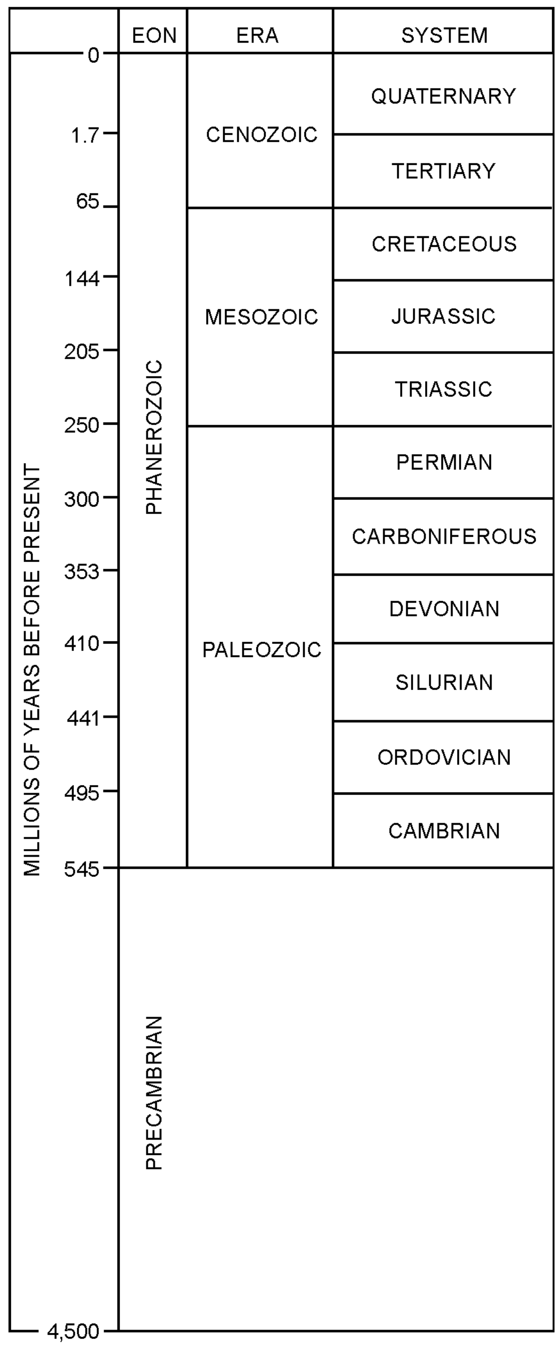
Finally, once the sea receded far from the area, rivers might have formed cutting into the gravels, and a new variety of fresh water organisms and plants would be found as fossils in this sand layer.



The materials that accumulate during each of the stages in the geological history of the area - the desert sand, the marine mud, the gravel and the freshwater sand – form a series of layers, known as beds. These beds, originally soft sediments, gradually turn to rock as they are compacted by overlying sediments and cemented by minerals deposited from the water seeping between the grains of sediment. Each bed contains a distinct suite of fossils that can help in the interpretations of the age and environment of deposition of the sediments.

It takes thousands to millions of years for sedimentary rocks to form. Paleontologists (people who study fossils) have recognized that different layers contain unique fossils and, based on this observation, have devised a geological time scale. The time scale is divided into two eons: Precambrian (4500-545 million years ago) and Phanerozoic (545 million years ago to the present). Fossils are scarce in much of the Precambrian because of the great antiquity of the rocks. The Phanerozoic is divided into three eras: the Paleozoic, the Mesozoic and the Cenozoic in ascending order. These eras are, in turn, divided into periods. The base of each period is defined by the appearance of a particular fossil and each period is characterized by a particular suite of fossils.

GEOLOGICAL TIME SCALE



FIVE PRINCIPAL APPLICATIONS OF FOSSILS

★ *explain and apply methods used to interpret fossils*

Telling time . . . . . Biostratigraphy

Paleontological study of fossil assemblages makes possible the dating and comparison of fossiliferous rocks throughout the world. Organisms that are abundant, evolve quickly, have a wide distribution and are relatively tolerant of a wide range of environments make the best time indicators. Species that have these characteristics are likely to be used for definition of short intervals of time called zones and they are referred to as index or guide fossils. Many paleontologists, particularly those employed by oil companies and government agencies, are involved in this branch of paleontology which is called *biostratigraphy.*

Understanding ancient environments . . . . . Paleoecology

The appearance and disappearance of different fossils through time tells a story of changing environmental conditions. One of the main objectives in studying sedimentary rocks is the reconstruction of the environment in which the sediments that formed the rocks were deposited. Accurate reconstruction of environments can lead to the discovery of natural resources such as coal, many metals, salt, oil and gas. A study of the environmental requirements of organisms that become fossils provides the most accurate information on the ancient environment in which they lived. Studies of this type are referred to as *paleoecology.*

Understanding the history of life on Earth

Without the study of fossils we would know nothing about the history of life on Earth and the connections of various groups of organisms in the chain of biological evolution. Even though the fossil record is imperfect because organisms have different potential for preservation as fossils (only some are preserved), it is the only record of life on Earth. Detailed studies of fossils are primary components of research on evolution and biodiversity.

Understanding continental movements . . . . . Paleobiogeography

Unusual patterns in the distribution of fossils were one of the first reasons that scientists began to suspect that the continents had not always been in the same positions they are today. Now that it is well established that continents have moved over the surface of the Earth, the present-day distribution of fossils is used as one line of evidence to reconstruct the position of continents and oceans in the geological past. Just as the distribution of animals and plants on the Earth today is affected by various environmental conditions, so were the organisms on the ancient Earth. The use of fossils for this purpose is termed *paleobiogeography.*

Understanding the relationships of life to planet Earth . . . . . Paleobiogeochemistry

Knowledge of the history of life provides important information for the understanding of processes that have taken place, and still are taking place on the Earth's surface. The existence of life on Earth has affected the chemistry of the oceans and atmosphere over the past 3 500 million years. The fact that organisms began to secrete shells and skeletons of substances (mainly calcium carbonate, silica and organic compounds) has had, and still has, a significant effect on the distribution of important elements on Earth, especially calcium, carbon, silicon, and oxygen. The appearance of land plants and their continued existence has a profound effect on the composition of the atmosphere. For all these reasons it is important to study the impact of the history of life on the *paleobiogeochemistry* of the Earth.

❖ Activity: An Exercise in Understanding Geological Time

Earth's Time Line
Background:
Geologists have been able to estimate the age of the Earth by studying the rocks and minerals and by dating radioactive isotopes contained within them. The current theory is that the earth is approximately 4.6 billion years old, but that is subject to change as new dating methods are being discovered. The oldest mineral actually dated is a piece of zircon that is 4.3 billion years old. Since its birth, our Earth has been in constant turmoil and motion. Continents have split and moved, and the crust continues to shift today. There have been several mass extinctions, islands have been born and buried, and climates have changed drastically. In this activity, your students will make a timeline from the earth's birth to present day that they can actually walk along in order to get a better idea of how old our planet really is.

Materials:
- 50 metres of adding machine paper (may need two rolls)
- Metre stick
- Marking pen

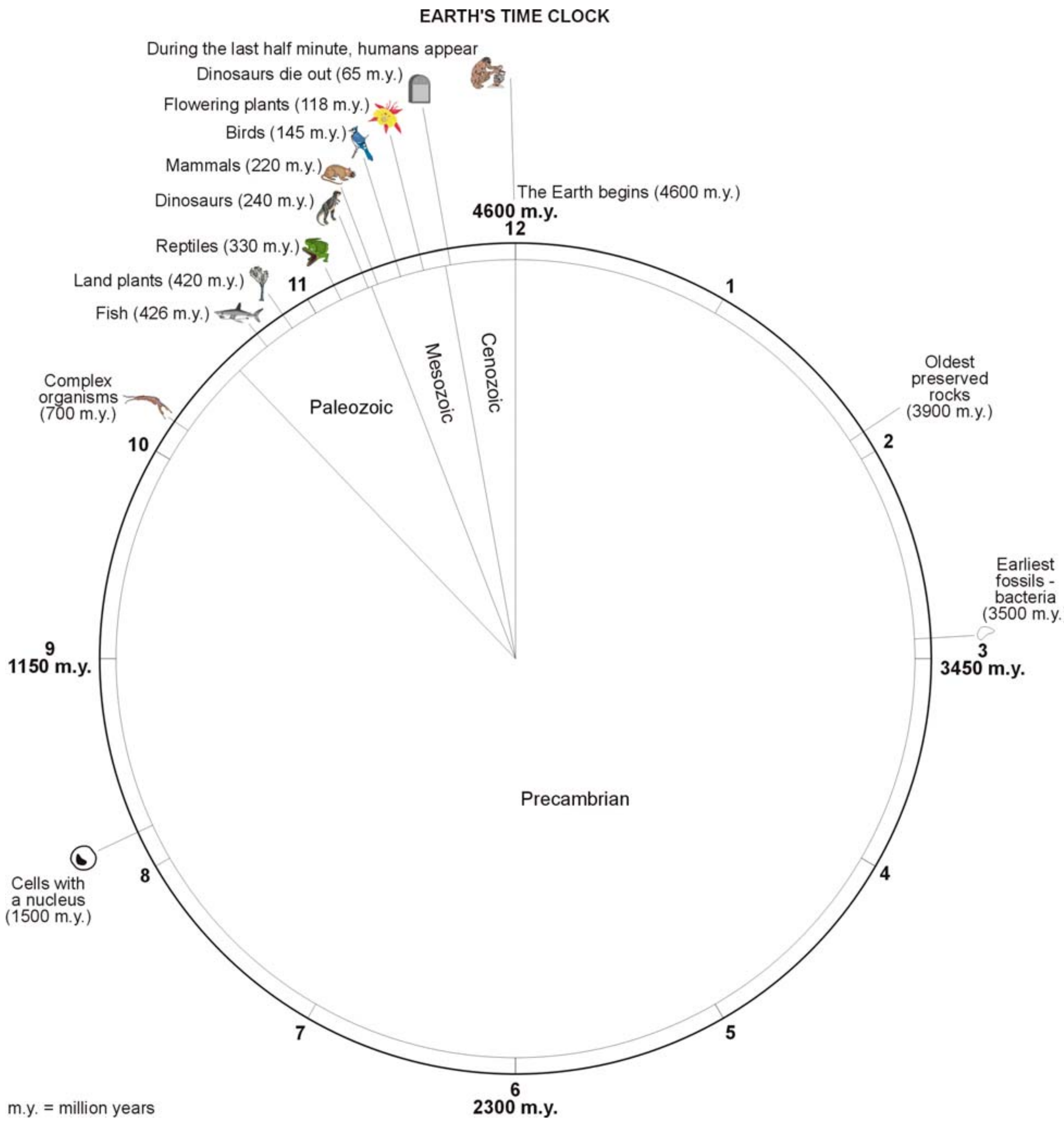
Procedure:
The 50 metres of paper (46 metres exactly) will represent the 4.6 billion (4600 million) years that the earth has been around. This is a scale of one cm equals one million years. Major events in the earth's history are marked onto the roll of paper. The following table gives you the names and dates of the geologic eras, as well as major events and life forms. It also tells you how many centimetres you should have between events on your time-line. Children can make pictures of the events on the paper. This time-line includes only major events, but you may want to have the children do some research to add on other dates such as when certain dinosaurs or other fossilized creatures appeared. HINT: You will need a LOT of wall space to display your time line (hallway).

EARTH'S TIME LINE

Era	Event	Millions of years ago	Centimetres added on
Cenozoic	Present Day 	0	Start
	Homo Sapiens appear	1	+1
	 Ice Age	2	+1
	First Primate	3	+1
	Mass extinction (dinosaurs, many marine species), possible meteorite?	65	+62
Mesozoic	 Dinosaurs decline 	70	+5
	Rocky Mountains form, first flowers	136	+66
	Pangea splits apart, continents begin to separate	190	+54
	 Flying reptiles, birds, small mammals appear	200	+10
	First dinosaurs appear 	210	+10
	Mass extinction (75% of species wiped out)	225	+15
Paleozoic	 First reptiles, trees, insects appear	350	+125
	First land plants, first amphibians	395	+45
	First fish 	400	+5
	Horseshoe crabs, sharks appear	500	+100
	 Trilobites, first shell-bearing organisms appear	545	+45
Precambrian	Major mountain building	1000	+455
	 Oldest forms of life appear (algae, bacteria)	3400	+2400
	Formation of Earth from gaseous cloud	4600	+1200

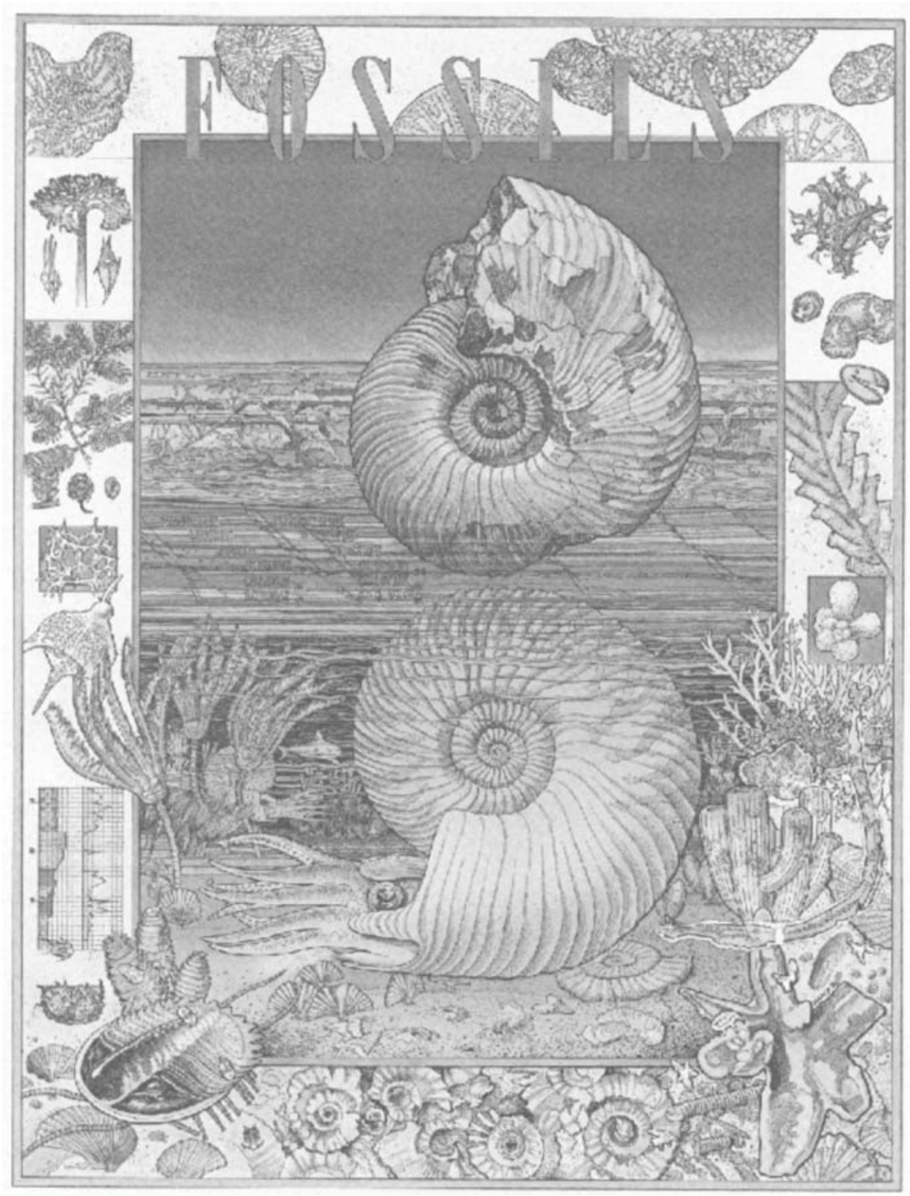
❖ Activity: Earth History Clock

The immensity of time in our Earth's history can also be visualized by looking at a clock face and breaking the 4.6 billion years down into a 12-hour period. You will be given a colour version of this chart with which to make the clock.



The Geological Survey of Canada's Fossil Poster

As part of the workshop you will receive a fossil poster together with an explanatory book with a cover like this:



We will use fossil specimens and this poster to explore the diversity of life on Earth through geological time. The poster illustrates fossils of plants and animals that have inhabited the Earth over the course of its history. The Earth formed more than 4 500 million years ago, but the first life, probably bacteria, did not appear until about 3 500 million years ago. Since that time life has evolved on Earth through a process that has given rise to a great variety of plants and animals. Most of these organisms are now extinct and known only from the fossil record. The study of animals and plants that have lived in the past is called *paleontology* and scientists who study fossils are known as *paleontologists.* In order to become a professional paleontologist, a person must study geology and biology, but anyone can have fun collecting and identifying fossils in their own area. Fossils occur in sedimentary rocks which are present in most regions of Canada. To find out what rocks are present in your area consult a geological map or report dealing with your region. Collectors should take care to learn any rules and regulations that apply, to respect the property rights of landowners, and to take safety precautions. Good specimens should be shown to professional paleontologists because they may represent a species new to science or provide other valuable scientific information.

This poster was created by Calgary artist Dennis Budgen in consultation with Godfrey Nowlan and Terry Poulton of the Geological Survey of Canada who wrote the text for the booklet.

Posters of Illustrations in "The Land Before Us"

The artist who created the GSC Poster, Dennis Budgen, was also commissioned to do illustrations for the Royal Tyrrell Museum's book on the geological history of Alberta entitled "The Land Before Us". This series of illustrations is available as a set of seven posters: one is the cover of the book and the others illustrate the development of life on Earth as seen from an Alberta perspective. There are posters illustrating the Precambrian, Early Paleozoic, Late Paleozoic, Early Mesozoic, Late Mesozoic and Cenozoic. These posters are a terrific teaching tool, especially when combined with the information in the book for which they were developed. We will go briefly through these posters in the workshop and we highly recommend using the book and posters in your class. The book is available in bookstores and the posters are available from the artist, Dennis Budgen (see resource list at end of this booklet).

We will use the posters from these two sources to illustrate the five main applications of fossils in earth science.

❖ Activity: Detective Work and Fossil Footprints

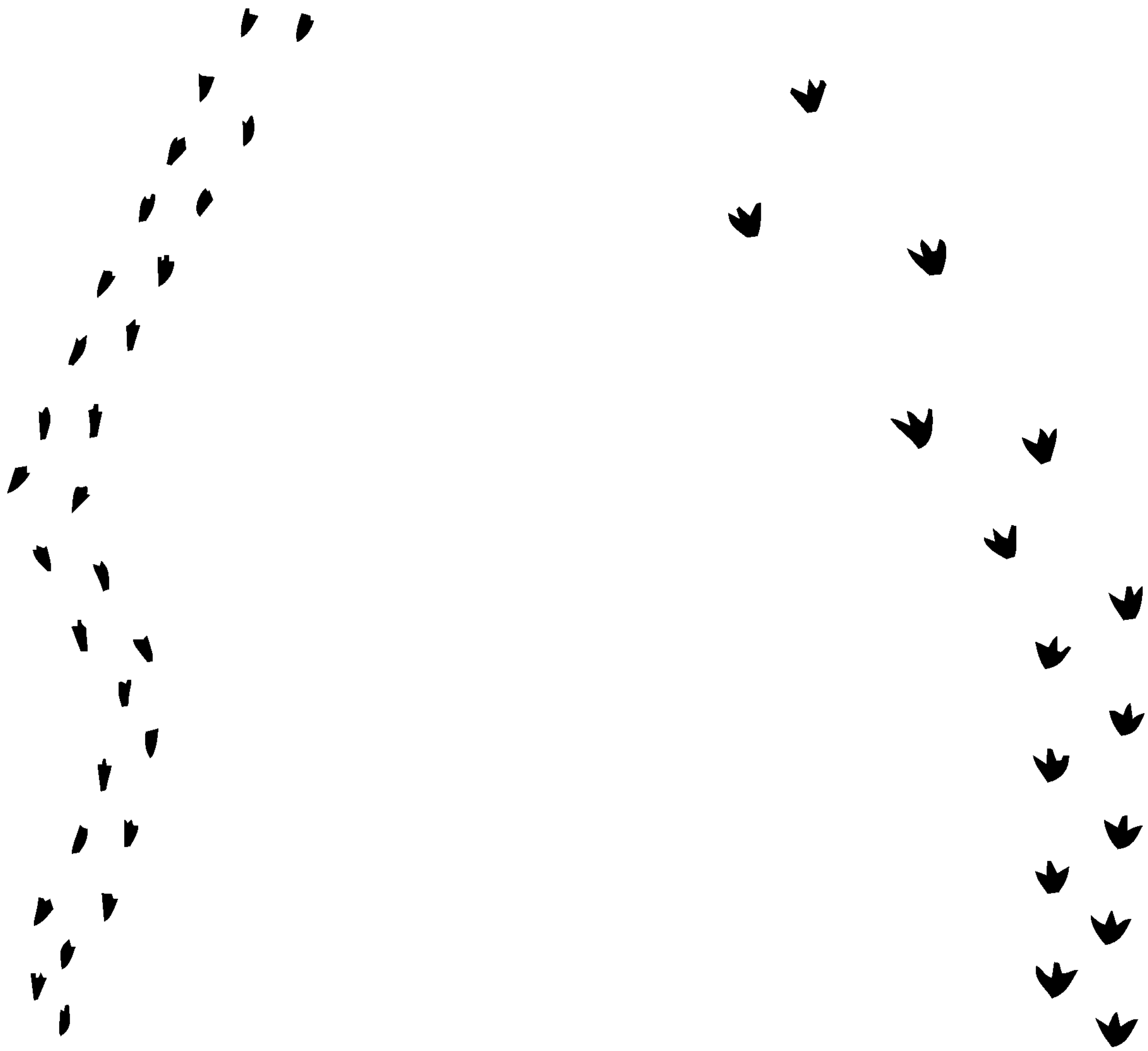
Paleontologists, the geologists who study fossils are detectives in the sense that they use clues in the incomplete rock and fossil record to interpret ancient life and events. In this detective work, geological clues can be interpreted in more than one way. Commonly, more than one plausible story may explain the evidence.

When the students have finished this exercise, they should be able to interpret footprints as a record of a past event and propose defensible hypotheses for the event that produced the footprints.

Footprints are called trace fossils: there are lots of other kinds, including burrows or feeding tracks left in sediment by burrowing animals. Interpreting trace fossils often requires lots of ingenuity and imagination.

Procedure

- Fossil footprints were found by a paleontologist in the partially covered surface of a rock outcrop (Footprints 1). Examine the drawing of the footprints. Please note the footprints in the rock are much larger than shown in the drawing. Write down your observations and interpretation of what could have occurred to make these footprints
- The geologist removed some plants and dirt from the rock outcrop and found many more footprints. These are shown in Footprints 2. Write down your new observations and interpretations. What kinds of animals could have made these tracks? Did they walk on two legs or four? What event caused the footprint pattern? Were the footprints made at the same time? There are lots of questions you can ask



Footprints 1

Fossils are neat, but what use are they?

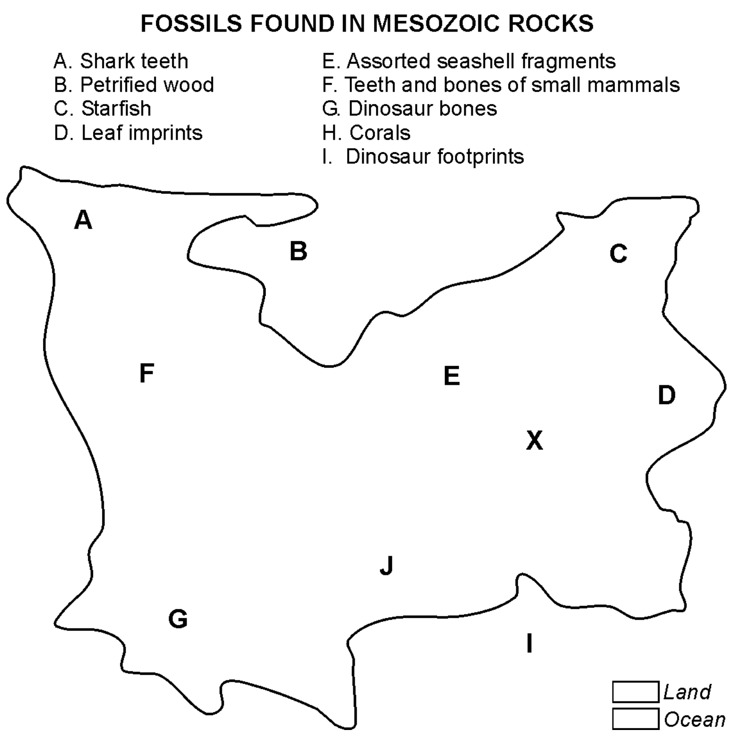
❖ Activity: Paleogeography and Paleoecology Exercise

Materials:

- Handout of map (see next page)
- Crayons or coloured pencils

Procedure:

- Pass out the maps. Explain that this is a map of an imaginary continent. Locations A through I are places where fossils have been found in rocks of Mesozoic age (the "Age of Dinosaurs", roughly 70 million-250 million years ago). The object of the activity is to make a map of what the continent looked like during Mesozoic time, i.e. where the land and ocean areas were at that time
- Have students select colours for land and water and make a key for the map
- The table at the bottom of the handout shows which fossils were found at each location. (The locations and fossil types are arbitrary and can be adjusted to suit your needs or preferences.) Have students colour each locality as either land or ocean. With elementary students it would work better to provide this information orally rather than to give them the written table. (For example, "At location A we found shark teeth. Was this land or ocean? O.K. colour that area with your colour for ocean.")



- Ask the students to colour all the areas around and between the localities as either land or ocean (interpolate between data points). Emphasize that the outline of the modern continent may have no relationship to the Mesozoic boundary
- Ask students whether location X was land or ocean in the Mesozoic, according to their maps
- Have students use the same data to make a different possible map (interpretation). For extra credit or homework, have them see how many possible interpretations they can make from the same data

Students will learn how evidence from fossils can be used in paleogeographic interpretation and they will gain experience in developing multiple hypotheses.

It is preferable, however, to preface this exercise with some discussion/activities on fossils, including what they are, how they form, and what they tell us.

In the end, no two maps should be identical. The class should be fairly well split on the interpretation of location X. This provides an opportunity for discussion of questions such as: Who is right? Is there a right answer? (yes) Do we know what the right answer is? (no) How could we find out what interpretation is correct? (get samples from location X). Students can explore ways to get more information from the data already in hand.

This activity is a simplified version of the process used in activities such as oil and gas exploration. In oil exploration, a geologist maps a variety of data, interpolates between the data points, and develops an interpretation which is usually in the form of a map. This interpretation is then tested by drilling an exploratory well (at a cost of anywhere from several hundred thousand to tens of millions of dollars). The vast majority of such wells do not produce any oil. The data from failed wells is incorporated into a revised interpretation and the process starts over.

❖ Activity: Making Fossils

The simplest method is to press a shell or other object into plasticine or another modeling compound to make an impression. It forms a mould; the impression can be filled with plaster to make a cast. This is a clean and simple way of understanding how some fossils are preserved. We will make fossils in the workshop period.

Make an insect in amber
Advantages of this are that the "fossil" is visible through the "amber" and the result is also durable. Disadvantages of this are the complications with odours produced in the curing of the compounds. This procedure might be better carried out outside the classroom in order to avoid contact with unpleasant odours. *Check the materials you are using carefully for any health hazard*

Materials:
- Hobby kit of embedding resin (contains resin, hardener, and jewelry molds)
- Dead insect

Procedure:
- Mix some resin with a few drops of hardener
- Half fill a mold with the resin and let it set
- Put the dead insect on top of the hardened resin and pour in another layer of resin and hardener
- Once it has set the block of resin will come out of the mold with the insect preserved inside it – just like a fossil insect preserved in amber

Make a cast
A mold type fossil is created when Bigfoot walks across the muddy flats. The sun bakes the mud into hard clay. The clay is filled in with a softer material such as sand. Over many years the footprint is subject to pressure from overlying sediment and the clay gets even harder. Erosion may eventually wash away the softer material and the footprint is exposed, only to be discovered by an amazed paleontologist.

Sometimes a footprint is filled with a material that will harden even more than the impression in the mud. Erosion wears away the mold leaving behind a three-dimensional cast of a Bigfoot. This leaves the paleontologist even more impressed.

Materials:
- Plasticine
- Margarine container (or similar)
- Small objects (plastic dinosaurs, animals, washers, bolts, etc). Avoid long thin objects
- Plaster of Paris
- Sand or soil

- Water
- Paper towels
- Liquid plastic (optional)

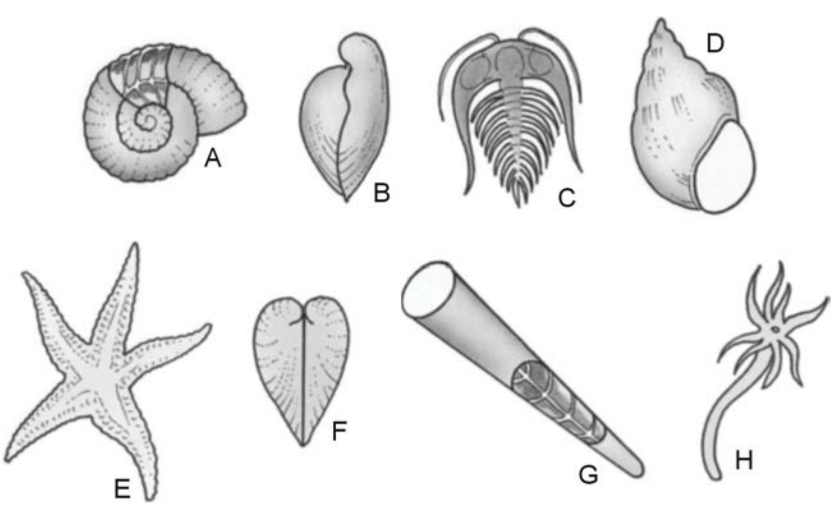
Procedure:
- Put about 2 cm of plasticine into the bottom of a margarine container. Build up around the edge slightly higher than the middle. Smooth the edges with the container
- Press small objects into the plasticine, and remove them, leaving only the impression
- Do not write words in the clay as this distracts from the fossil image
- In a separate container add 1 cup of Plaster of Paris and ¼ cup of sand or garden soil
- Add water to the dry ingredients stirring in about ¾ cup of water or until the mixture resembles a milkshake. Do not drink. Adding water to dry ingredients works better for some reason, so try not to over water
- Pour this mixture over the plasticine, but do not fill the margarine container to the top. Gently tap the container on the desk for a couple of minutes to allow any bubbles in the mixture to rise to the top
- Let sit for about four hours or overnight is even better. As the plaster hardens it first goes through an exothermic reaction giving off heat. With further hardening time the plaster goes through an endothermic reaction and the container gets quite cold
- Invert the container over a paper towel and press gently on the bottom of the margarine container. The fossil should separate from the plasticine
- This gives you a clear mold fossil. The plasticine mold could be used again if you wish
- Give the student a small ball of plasticine if they need to remove any bits in crevasses. By pressing their ball into the stuck pieces they usually come out.
- Sometimes we coat our fossils with a thick coat of liquid plastic. It seals the plaster as well as yellows over time giving them an older appearance

  *Plaster of Paris is really not very expensive and the concept of how some fossils are formed will remain with the student

Make a petrified fossil

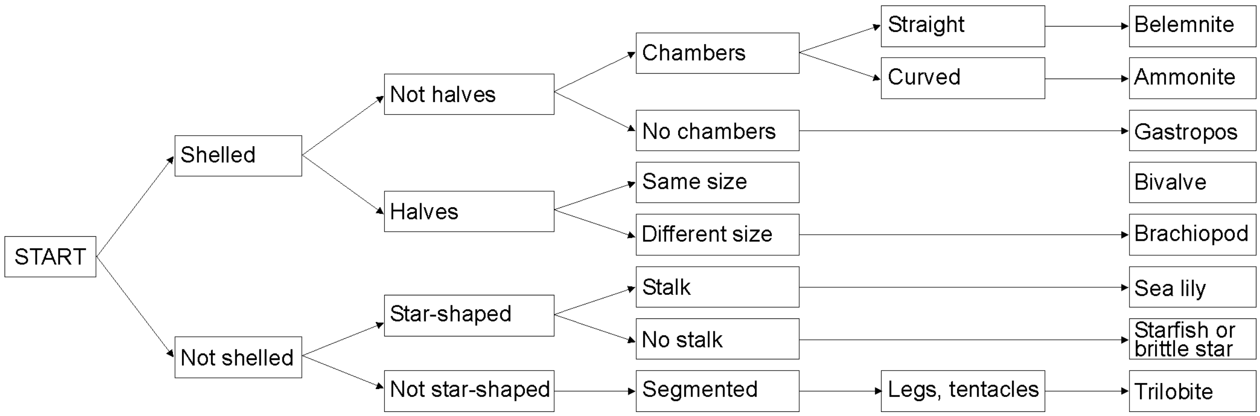
To make a petrified fossil, place a tablespoon of plaster of Paris on a paper towel. Collect the edges around the plaster and secure with an elastic band. Cut off most of the paper towel not holding the plaster. Place the ball into a beaker and cover with dry sand. Add water to the beaker to soak the sand and let sit overnight. Remove the hardened ball from the sand and let it dry for another day. Using tongs burn off the paper towel using an alcohol lamp. The burnt paper adds the appearance of the fossil. It will look somewhat like a plant bulb.

Fossil Identification Game



Use this chart to identify these eight mystery fossils. Check the fossil poster and booklet for additional information on the fossils once they are identified. Alternatively, you can use an internet site to download fossil images and have your students identify them. Go to http://www.webshots.com/explore and search for “fossils”. There are lots of images to choose from.

FOSSIL IDENTIFICATION CHART



❖ Activity: Excavating Your Recycling Bin as a Fossil Record

(Adapted from an original idea by Mark A. Williams, Kennedy Middle School, Albuquerque, NM)

Overview
We are going to simulate how scientists study the past. Scientists use layers of rock with fossils to understand the past. (These layers of rock are called 'STRATA')

Materials:
- Trash can
- Work sheet
- Your recycling bin and two views of it for labeling

Objectives:
- Relationship of rock layers (oldest deposited on bottom)
- Describe objects in trash as events occurring through time
- Fossil record is in 3-D (actually 4-D because of the time involved)
- Collection of accurate data is critical

Procedure:
- Students divided into groups
- Each group will be allowed to excavate X cm of paper from the recycling bin
- Each group assigned a different layer of paper. Try to learn as much as they can about their layer
- Record data on the outlines given. There is a top view and side view of the recycling bin. Facts that may be useful: subject, dates, teachers names, position of paper, type of paper, photocopy

Example of where to record data

Mr. Smith's Quiz	1 cm
Xerox Math etc.	2 cm
Vocabulary sheet	2 cm etc.

Students write data collected here as a side view. However, another view from the top of the bin can also be labelled.

Tying it All Together:
Students can see that papers in bin are similar to the fossil record in that deposition of papers in the recycling bin are events through time like the changing fossil record. Fossil record is in 4-D. Accurate data is necessary before destroying sequence.

❖ Activity: Stressed critters

Materials:
- Modeling clay or play dough
- Fossil or shell

Procedure:
- Make a "fossil" impression by pressing a shell or fossil into modeling clay
- Using the same fossil or shell, create another impression in exactly the same manner
- Squeeze the second impression so that the imprint shape is deformed
- Ask students to infer the direction of force or pressure acting on the rock to create this deformation pattern
- Explain to students that fossils in metamorphic rock can provide clues about the geologic history of an area, but fossils are usually destroyed during metamorphic conditions because of extreme pressure and temperature

FOSSILS IN THE CALGARY AREA

Places to find fossils
Some fossils can be found in the Tertiary bedrock around Calgary. Fossil clamshells and plant material are relatively common in the Paskapoo Formation. An excellent example of abundant clamshells can be seen in a block placed for ornamental purposes at the northeast end of the footbridge across the Bow River at Edworthy Park. Many large blocks of sandstone used for ornamental landscaping in the Shawnessy subdivision of southwest Calgary have good plant fossils. Check your neighbourhood, especially if you are located near any of the main river valleys or other areas of bedrock outcrop.

The best place to see lots of fossils is to go to the Royal Tyrrell Museum of Palaeontology in Drumheller. This is one of the best paleontological museums in the world. The Tyrrell also maintains an interpretive centre at Dinosaur Provincial Park and runs trips through the badlands that show the fantastic abundance of fossils in the area.

The river valleys in Calgary also contain lots of different kinds of rocks moved by glaciers and the rivers themselves. It is common to find blocks of limestone with fossils in them. Many other blocks are composed of unfossiliferous quartzite.

Finding fossils
Each fossil is a unique object — the remains or traces of an ancient animal or plant. The location of a fossil is as important as the fossil itself. Fossils, together with associated geological and biological evidence, help paleontologists determine what, where, when and how ancient animals and plants lived and died. Location also leads paleontologists to where other fossils are likely to be found. When improperly handled, a fossil loses much of its scientific value. Please ensure that if you find what you think may be a significant fossil, contact the Royal Tyrrell Museum of Palaeontology in Drumheller (823-7707) or the Geological Survey of Canada office in Calgary (292-7000). When properly collected and recorded, the knowledge of Alberta's rich fossils can be shared.

Alberta's Historical Resources Act and fossil collection and ownership
Alberta's Historical Resources Act, which governs fossil collecting defines two ways of collecting fossils:

- Surface collecting - gathering isolated fossils, which are clearly on the surface of the ground. Surface collecting is permitted on private land with the landowner's permission.

You may keep surface finds as a custodian but ownership resides with the province of Alberta, making it illegal to sell or take such fossils out of the province without an approved Disposition Certificate.
- Excavating - digging, prying or somehow extracting a fossil buried or embedded in the ground or rock face. Fossils should never be removed from their original stratigraphic position without being properly mapped and dated by a paleontologist.

Excavating fossils requires a permit. Applications on standard forms are processed through Resource Planning at the Royal Tyrrell Museum of Palaeontology. Procedures outlined in the Province of Alberta's Historical Resources Act must also be followed before any part of the collection can be retained. All applications are reviewed by the Alberta Palaeontological Advisory Committee to the Minister of Culture and Multiculturalism.

It is illegal to remove fossils from provincial and federal parks in Alberta.

Paleontological resources are protected by the Historical Resources Act. All fossils collected in Alberta since July 5, 1978, and all fossils still in or on the ground, are owned by the province. The province may transfer ownership of fossils identified by a Control List established in 1987 to private parties. This list allows for responsible trade of certain fossils that are abundant within the province and thus have limited research and display value.

Although the law is stringent, please encourage your students to look for fossils in the area. Many of the most significant fossil discoveries have been made by young people. For example, the dinosaur egg sites in the badlands were found by a high school student. Another, more local example, is that of an eight year old who found what he thought was a fish tail near his house in Shawnessy. He brought the specimen to the Geological Survey of Canada where it was identified as the leaf of a palm tree. It was the first one recorded from the area and had great significance, because the presence of palm fronds means an absence of frost. It changed the general environmental interpretation for the early Tertiary rocks in the area to a warmer regime than was previously believed.

So, encourage responsible examination and collecting.

THE IMPORTANCE OF ROCKS AND MINERALS IN OUR LIVES

Historically, man has used rocks and minerals for just about every conceivable purpose. One million years ago, during the Stone Age, early man used rocks and minerals for tools, weapons, and building material. Since that time, we have found more and more uses for these natural resources.

Every product that we use comes from plants, animals, minerals, or a combination of the three. By far the most common product source is mineral. Even products that are not made from minerals directly are made from metal machines (metal is made from minerals). It is estimated that each person will use an average of 16 000 to 18 000 kg of rock and mineral products each year! In a lifetime, the average person will use 350 kg of lead, 380 Kg of zinc, 680 kg of copper, 1 450 kg of aluminum, 41 000 kg of iron and steel, 250 000 kg of coal, and over 500 000 kg of stone, gravel, cement and clay. The computer industry alone uses almost every type of mineral mined today for either hardware or software, and we are finding more uses for mineral products every day.

The table on the next page contains many of the more common rock and mineral uses. This list is by no means complete and you and your students should be able to easily add onto it.

ROCK AND MINERAL RESOURCE LIST	
Rock or Mineral Name	Value to People
Quartz	Glass, sand, gems, radio transistors, silicon chips, quartz crystals for computers and watches, lenses for glasses, binoculars and telescopes
Gypsum	Chalk, plaster, gyp rock, filler in candy, paint filler
Talc	Talcum powder, crayons, paint
Mica	Spark plugs, insulation
Halite	Table salt, soap, fertilizer
Fluorite	Fluoride for toothpaste
Galena	Lead
Hematite	Iron and steel
Aluminum	Several metal products
Silver	Coins, jewellery, film, silverware
Gold	Coins, jewellery, electrical components
Sylvite	Potassium for fertilizer
Sodalite	Fertilizer, semi-precious stone
Diamond	Gemstone, industrial drills, needles for record players (antiques)
Graphite	Pencils, lubricant
Sulphur	Fertilizer, industrial uses
Bauxite	Abrasive cleaners, metal, bricks, alum
Turquoise	Semi-precious stone
Corundum	Gemstones (sapphires, rubies), sandpaper
Clay	Bricks, pottery, ceramics, tile
Granite	Building stone, monuments
Marble	Building stone, monuments
Slate	Floors, roofing, blackboards
Limestone	Cement, building stone
Dolomite	Building stone, epsom salt
Oil	Fuel, plastic
Coal	Fuel

❖ Activity: Animal, Vegetable, Mineral Jeopardy

This is a game you can play with your students that will reinforce not only what rocks and minerals are, but also how they are used by our society. Divide the class into two teams and have each team make a number of cards with products from animals, plants, or minerals. For example:

ANIMAL	PLANT	MINERAL
Belt	Desk	Rubber duckie
Milk	Paper	Window
Steak	Jeans	Computer chip
Fur coat	Peanuts	Nail
Wool sweater	Rubber band	Milk jug
Glue	Juice	Brick
and so on . . .	and so on . . .	and so on . . .

Students take turns reading cards for the opposing team who must tell whether their product is an animal, vegetable or mineral. You can have one student list these under three columns on a piece of chart paper as you play the game.

ADDITIONAL RESOURCE SUGGESTIONS

Books For Teacher Use

A Traveller's Guide to Geological Wonders in Alberta (Ron Mussieux and Marilyn Nelson, 1998) The Provincial Museum of Alberta, 1998, 245 p.

Earth Through the Ages (Philip B. Carona)

Explorations in Science (Level 3) *Rock Solid*

Explorations in Science (Level 3) *Rock Talk*

FOSS Earth Material Module (Gr. 3-4)

Geology Crafts for Kids (Alan Anderson and Gwen Diehn, 1996)

Hands-On Minds-On Science - Geology (Teacher Created Material 1994)

Innovations in Science (Level 3) *Let's Go Rocking*

In Search of Ancient Alberta (Barbara Huck and Doug Whiteway) Heartland Publications, 1998, 287 p.

Let's Do Science (Science Alberta Foundation)

Overhead and Underfoot (AIMS Teacher Resource)

Planet Earth (Milliken, 1984)

Rocks and Minerals (Carson-Dellosa Publishing 1994)

Rocks and Minerals (National Science Resource Centre)

Rocks, Minerals and Fossils (Carson-Dellosa 1994)

Rocks, Sand and Soil (Windows on Beginning Science)

Science Is... (Susan Bosak)

Shake, Rattle and Roll (Spencer Christian, 1997)

Simple Earth Science Experiments with Everyday Materials (Louis Loeschnig)

Books For Teacher and Student Use

Caves (Scholastic)

Dancing Elephants and Floating Continents (John Wilson) Key Porter Books, 2003, 47 p.

Dr. Art's Guide to Planet Earth (Art Sussman) Chelsea Green Publishing, 2000, 122 p.

Fossils - A Guide to Prehistoric life (Rhodes, F.H.T., Zim, H.S. and Shaffer, P.R. Golden Press, New York 1962)

Gemstones - Planet Earth Series, Time Life Books

Geology (Rhodes, F.H.T., Golden Press, New York, 1991)

How the Earth Works - Reader's Digest (1992)

The Land Before Us: The Making of Ancient Alberta (Royal Tyrrell Museum, Red Deer College Press, 1994)

The Last Billion Years: A Geological History of the Maritime Provinces of Canada (Atlantic Geoscience Society) Nimbus Publishing 2001, 212 p.

Make It Work - Earth (Scholastic)

The Quicksand Book (Tomie de Paola)

Rocks and Minerals - A guide to familiar minerals, gems, ores and rocks (Zim, H.S. and Shaffer, P.R., Golden Press, New York, 1957)

Rocks and Minerals (Illa Podendorf)

Rocks and Minerals - Eyewitness Books (Dr. R.F. Symes)

Rocks and Soil (Scholastic)

Stone Wall Secrets (Book plus teacher's guide) 1998 publication, Kristine and Robert Thorson, Tilsbury House Publishers, Maine

Our Petroleum Challenge: Exploring Canada's Oil and Gas Industry (Petroleum Communication Foundation, 1999, Sixth Edition, 100 p.) Excellent summary of all aspects of the industry. The seventh edition will be available from Centre for Energy 1-877-606-4636; http://centreforenergy.com/

Posters and Music

Climate Change posters for Canada – free for teachers; contact the Geological Survey of Canada (see below) http://adaptation.nrcan.gc.ca/posters/

Geoscape posters for Canada - free for teachers; contact the Geological Survey of Canada (see below)

Colour Poster Prints from "The Land Before Us". The beautiful prints depicting various geological times in Alberta's history are available at a very reasonable price from the local artist himself - Dennis Budgen. He can be contacted at 282-0031.

Rocks and Water - Geology concepts set to music in this fun tape by Chris Rawlings. Available through Cooking Fat Music, 67 Wrenson Road, Toronto, Ontario M4L 2G5; mailto:wrenfolk@interlog.com

See Geological Survey of Canada publications (below)

Publications From Geological Survey of Canada

Contact the Geological Survey of Canada Bookstore to find out what they have available. Many of the publications are free, particularly folded posters on minerals, rocks, fossils, meteorites and gemstones. The phone number for the Calgary office is 292-7030.

Kits and Crates

Minerals, Metals and Meteorites - a "Museokit" available from Glenbow Museum in Calgary. Loan period two weeks. There is a fee involved. Call 268-4110.

Science Alberta Foundation Science Crates including:

- Bedrock Basics
- Junior Paleontologist
- Quakes and Quartz

Cost is $25 per crate for a 3-week rental period. Contact Science Alberta Foundation at (403) 220-0077, ext. 222; or e-mail crates@sciencealberta.org

School Boards will often have rock and mineral kits available for teachers. Contact your local board if you are not sure.

Top quality rock and mineral specimens at a very reasonable price are available locally (Calgary) through Dwarven Mountain Rock and Minerals Ltd., Mike Clark, Box 63, Site 3, RR1, T1P 1J6, Strathmore, Alberta, phone 934-4965.

Rock and Mineral Sets are also available from several supply catalogues including Wards Scientific, Northwest Scientific, and Boreal Scientific.

Guest Speakers

Possible resource people are geologists, archaeologists, jewellers, local rock-hound clubs, etc.

There are five Science Hotlines in Alberta and these are an excellent source for both information and guest speakers on any scientific topic. They provide a free service that links teachers to volunteers who can answer questions, give presentations, lead field trips, judge science fairs, etc. Their contact information:

- Calgary Science Hotline, Calgary Science Network - Contact Julia Millen at 263-6226; http://www.calgarysciencenetwork.ca/; mailto:scihot@telus.net
- Edmonton Science Hotline - Contact Michael Caley at 448-0055
- Medicine Hat Science Hotline - Contact Lisa Reich at 527-5365
- Red Deer Science Hotline - Contact Jill Craig at 309-2211
- Peace Country Science Hotline - Contact Susanne Kuechle at 539-9847

Field Trip Suggestions

- Glenbow Museum Calgary-The Earth's Crust (2 hour school program Grade 7; phone 268-4110)
- Royal Tyrrell Museum of Palaeontology in Drumheller
- Nose Hill in Calgary - natural area where students can observe glacial till, erratics, erosion features, etc
- Creek or river beds
- Road cuts
- Excavation sites
- Lapidary shops

Teacher Workshops

Making Connections (Calgary Science Network) puts on excellent science workshops for teachers throughout the year. Contact Elspeth Snow at 230-1431 for more information. Information http://www.calgarysciencenetwork.ca/. VERY reasonably priced!

Internet Connections

- SchoolNet - Contains lots of links to teaching resources. http://www.schoolnet.ca/home/e/
- Atlas of Canada http://atlas.gc.ca/
- Canadian Landscapes http://sts.gsc.nrcan.gc.ca/clf/landscapes.asp
- Canada Centre for Remote Sensing http://www.ccrs.nrcan.gc.ca/ccrs/
- Climate Change Posters http://adaptation.nrcan.gc.ca/posters/
- Geoconnections http://www.geoconnections.org/
- Geological Survey of Canada - Educational Materials for earthquakes, landslides, images of Canada's landscape with geological explanations and much, much more. http://www.nrcan.gc.ca/gsc/education_e.html
- GeoScience K-12 Resources - This web site was designed for Alberta teachers and consists of lists of relevant, educational web resources that have been categorized by grade level. http://www.cuug.ab.ca:8001/~johnstos/geosci.html
- EarthNet - An online searchable database of teaching resources related to earth sciences. http://earthnet.bio.ns.ca/
- Calgary Science Network - Calgary Science Hotline and Making Connections - This site has links to relevant science sites on the net for geology and other science topics. http://www.calgarysciencenetwork.ca/
- Natural Resources Canada - Interactive site on the use of minerals. http://www.nrcan.gc.ca/mms/stude-etudi/sat_e.htm
- Ecole des Mines in Paris - This site has photographs of minerals. http://cri.ensmp.fr/gm/photos.html
- Geology Link – A good information site for all levels, from Houghton Mifflin. http://geologylink.com/
- EdGEO Workshops in Earth Sciences - The web HQ of the organization that funded the rock and mineral kits provided with this workshop. http://www.edgeo.org/
- Ground Work: Exploring for Minerals in Canada - An interactive site on mineral exploration put together by Science North and the Canadian Institute of Mining; click groundwork. http://sciencenorth.on.ca/learn/coolscience/index.html
- Royal Tyrrell Museum of Palaeontology - An excellent site for information on fossils. http://www.tyrrellmuseum.com/

- Miller Museum of Geology, Queen's University - An excellent site on the early history of the Earth. http://geol.queensu.ca/museum/museum.html

- Calgary Science Centre - Local information on science happenings. http://www.calgaryscience.ca/

- An Internet Rock Shop - Information on minerals of all kinds. http://mineral.galleries.com/

- Volcano World - A comprehensive site on volcanoes. http://volcano.und.nodak.edu/vw.html

- Geoscape Canada - Posters explaining the geology of Canadian cities. http://geoscape.nrcan.gc.ca/

- This Dynamic Earth – the web version of the book you received at the workshop http://pubs.usgs.gov/publications/text/dynamic Geology animations http://wrgis.wr.usgs.gov/docs/parks/animate/mpegs.html