TOPIC 8

Fossils

Figure 5.74 Trilobites are one of the most famous groups of fossils. They date from a time before the dinosaurs, about 200 to 400 million years ago. Trilobites lived in warm ocean water and are now extinct.

What evidence do we have of ancient life more than 10 000 years old? Fossils provide clues about when life began, and when plants and animals first lived on land. We can study fossils to learn when certain organisms, such as the dinosaurs, flourished and disappeared.

Fossils tell us not only when and where organisms once lived, but also how they lived and behaved. Understanding the evidence can be challenging however. For example, when bones of the dinosaur *Oviraptor* were found with a clutch of eggs, it was thought that *Oviraptor* was an egg stealer. Recent finds in the Gobi desert in China reveal *Oviraptor* was more likely an attentive parent that protected its eggs and young.

Fossils are useful in determining the history and dates of the rock layers and may reveal information about the environment and climate. We know Antarctica's climate was once very different than it is today because fossils of leaves have been found there.

Types of Fossils

Usually the remains of dead plants and animals quickly decay and are destroyed. When the remains are protected from scavengers and micro-organisms, however, they can become fossilized.

If a carcass is in water and sinks to the bottom, the body can be buried by sediment. Soft parts, such as skin, muscle, or organs decay rapidly and are rarely found as fossils. The hard parts (bones, shells, or teeth) may be altered to become fossilized remains. When water penetrates the bones of a dead animal, the water dissolves the calcium carbonate in the bones. A deposit of another very hard mineral, silica (quartz) remains, turning the bones into a **petrified** (rock-like) substance.

When an organism is buried under many layers of sediment, pressure and heat may build up, leaving a thin film of carbon residue on rock surfaces. The residue forms an outline of the organism. The outline is called a **carbonaceous film**.

Pause & Reflect

Draw a sketch in your Science Log of how you think the dinosaur at the right would look when it hatched. Compare your sketch with those drawn by classmates. Are there some common characteristics? What might account for the differences in designs? How might scientists draw conclusions about how dinosaurs looked?

Figure 5.75 This is a reconstructed model of a dinosaur egg found at Devil's Coulee, Alberta.

Figure 5.76 Over 20 sets of fossilized dinosaur tracks have been found in Alberta. What information do you think a footprint provides about the animal that made it?

Figure 5.77 The Marrella is the most abundant of the Burgess Shale fossil animals. It may be a distant relative of crustaceans. What similarities to a crab or lobster can you see in the Marrella?

Figure 5.78 This fossilized patch of dinosaur skin was discovered near the Milk River Reservoir in southern Alberta in 1997. Although it shows the pattern of the skin, it does not preserve the colour. What colour and pattern do you imagine this skin would have been? Why?

Figure 5.79 This insect lived million of years ago. It was trapped in resin, which turned to amber. How is it similar to, and different from, common insects today?

Figure 5.80 Coiled ammonites are common fossils in Alberta. Hundreds of ammonites are sometimes found clustered together. Why do you think so many ammonites have been preserved as fossils?

DidYouKnow?

Southern Alberta is one of the best places in the world to study and observe fossils. Dinosaur Provincial Park is a UNESCO World Heritage Site. Over 36 species of dinosaurs have been discovered there.

In nearby British Columbia, the Burgess Shale is also a World Heritage Site. This site provides remarkable clues about the past. Many of its fossils preserve soft-body parts of marine animals.

Sometimes the actual organism or part of it may be preserved as a fossil. These are called **original remains**. Animals and plants have been found preserved in peat bogs, tar pits, and amber. Woolly mammoths have been found in the Yukon preserved in the ice.

Trace fossils are evidence of an animal activity. Worm holes, burrows, and footprints can be fossilized. They provide a fascinating glimpse of ancient life on Earth.

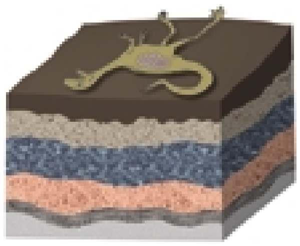
Figure 5.81 Fossilized ammonites are found worldwide. However, only those near Lethbridge display the beautiful gemstone ammolite. Millions of years of pressure and heat have turned these shells into rare and colourful mosaics.

DidYouKnow?

New types of dinosaurs are still being discovered. Recent finds include *Gigantosaurus*, found in Argentina, which was heavier than the *Tyrannosaurus Rex* and perhaps was one of the biggest carnivores that ever walked on Earth. *Seismosaurus* in New Mexico was a plant eater that was longer than a blue whale. Computer modelling shows that its tail could move faster than the speed of sound and produce loud, terrifying noises. The *Utahraptor* was twice as big as the *Velociraptor*, was smart and fast, and probably hunted in packs. A feathered dinosaur called *Sinosauropteryx* was found in China in 1996. And just 360 km from the South Pole, a crested-headed dinosaur called *Cryolophosaurus* was found. A new species call *Bambiraptor* is providing evidence for a link between birds and dinosaurs. *Bambiraptor* was found by a 14-year old boy in Glacier National Park, Montana.

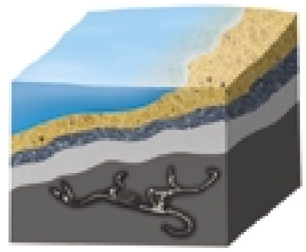
Fossil Mould and Cast Formation

Sometimes an organism falls into soft sediment, like mud. As more sediment falls, the original sediment gradually turns into rock. Water and air pass through pores in the rock, reaching the organism. Its hard parts dissolve, leaving a cavity in the rock called a **mould**. Other sediments or minerals may fill the hole, hardening into rock and producing a **cast** of the original object.

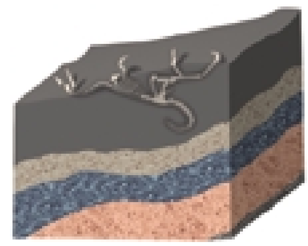


A An ancient animal dies. Its remains sink into the mud. The soft parts of the remains decay rapidly.

B The animal's hard parts are buried by sediment. Millions of years pass. The sediment slowly turns to rock.



C The skeleton gradually dissolves, leaving a mould in the rock. Other sediments fill the mould, forming a cast.



D The surface rock is eroded. The fossil is exposed.

Find Out **ACTIVITY**

Mystery Fossils

In this activity, you will make a mould of an object. Will your classmates be able to guess its identity?

Materials

small object (shell, ring, ornament, etc.)
plaster of Paris
sturdy spoon
2 Styrofoam™ plates
petroleum jelly
wax paper

Procedure

Day One

1. Place a thin layer of petroleum jelly on your object and the surface of a Styrofoam™ plate.
2. Mix water with the plaster of Paris to make 250 mL of the mixture.
3. Quickly spread the plaster of Paris on the greased plate.
4. Press your object in the plaster until it is almost buried.
5. Cover your specimen with wax paper to hide the object.

Day Two

6. Gently pry your object loose from the plaster.
7. Display your mould. Try to identify the moulds made by your classmates.

What Did You Find Out? Analyzing and Inter

1. Which objects make the best moulds? Why?
2. The filling in a mould is known as a cast of the object. Most fossils found on Earth are actually casts of living things. How could you make a cast of your object?
3. What uncertainties do scientists face when they investigate fossil evidence? Why do they need to investigate a variety of fossil evidence before making conclusions?

INQUIRY

INVESTIGATION 5-L

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Make a Lasting Impression

Certain conditions need to be present in order for fossils to form. In this investigation you will make and test a hypothesis about the type of materials that work best.

Question

What are the best conditions for making a fossil mould and cast?

Hypothesis

Read the procedure carefully. Then make a hypothesis about which mixture will make the best mould.

Apparatus

5 Styrofoam™ bowls
spoons
shells or plastic animals
graduated cylinder

Materials

plaster of Paris
sand
clay
pebbles
water

Procedure

1. Label four of the bowls A, B, C, and D.
2. In bowl A mix 250 mL of clay and 30 mL of water.
3. In bowl B mix 250 mL sand and 30 mL of water.
4. In bowl C mix equal parts pebbles and sand.
5. In bowl D make a mixture of equal parts of sand, clay, and pebbles. Add 30 mL of water and mix.
6. Choose the object you will use to make imprints.
7. Gently press the object into each of the four bowls. Remove the object after 30 s in each mixture. Clean the object between pressings.
8. **Observe** and **make notes** about the impressions left behind in each bowl. These impressions are called moulds.
9. Choose the best two moulds.
10. Mix approximately 100 mL of plaster of Paris with 10 mL of water in the fifth bowl. Continue adding water to the plaster until you get a thick but soupy mixture.
11. Gently spoon the plaster into your two best moulds. Fill the entire impression *but do not press so hard that you destroy the mould.*
12. Let the plaster dry overnight.
13. After the plaster is dry, remove your cast from the mould. **Observe** the details of the cast.

Analyze

1. What was the **manipulated variable**? What was the **responding variable**?
2. Which of the mixtures created the best moulds? Why? Which of the mixtures created the poorest moulds? Why?
3. What happened to each of the mixtures as they dried overnight?

Conclude and Apply

4. What would have happened if the object and the mixture had been added at the same time?

Word CONNECT

Many myths and folk tales have been created about fossils. For example, we now know that these fossil belemnites (A) are the shells of extinct squid-like animals. But ancient people thought they were darts flung to Earth during thunderstorms. They thought belemnites had medicinal powers and sometimes added them to burial mounds. Pictured below is horn coral (B), a common fossil of Alberta. Develop and write a myth about horn coral or another fossil choice. Consider what its shape might represent and how finding it might be significant to your story.


A Belemnites


B Horn Coral

Across Canada

Imagine having a job searching for and examining fossils! Paleontology is the study of the history of life on Earth as reflected in the fossil record. A paleontologist needs to know about many fields — physics, chemistry, biology, geology, and astronomy. Dr. Phil Currie has used all these subjects — and others — in his career as a paleontologist.

Currie's fascination with dinosaurs began with finding a plastic dinosaur in a box of cereal. He still has the plastic dinosaur, but in his years as a paleontologist, he has gotten to know the remains of many hundreds of real dinosaurs. Fieldwork has taken Currie to the Arctic, Argentina, and China, but his main focus is western North America. He is especially interested in dinosaur behaviour and migrations, and the origin of birds. As well as finding dinosaurs, Dr. Currie writes books and articles, gives lectures, and teaches students. He is Head of the Research Program and Curator of Dinosaurs and Birds at the Royal Tyrrell Museum near Drumheller. You can visit the museum's web site and read about the latest field research done by Dr. Currie and his team.

TOPIC 8 Review

1. What type of clues can fossils provide about Earth's history?
2. What conditions are necessary for fossils to form?
3. Name five types of fossils and describe how each is formed.
4. **Analyze** What parts of a living thing are most likely to be preserved as a fossil? Why?
5. **Thinking Critically** Identify each fossil type shown in the photographs on pages 418 and 419. Explain how you decided.

TOPIC 9 Geologic Time

Suppose that on a Tuesday, you want to find an article in the newspaper from last Saturday. You probably find Tuesday's paper on the top of the pile in the recycling bin. Underneath is Monday's paper, then Sunday's, and finally Saturday's at the bottom. You knew that you would probably find the older newspaper under the more recent ones. Geologists have used this principle to infer the relative ages of different layers of rock. It is called the **principle of superposition** (see Figure 5.82).

The principle of superposition states that in undisturbed layers of rock, the oldest layers are always on the bottom and the youngest layers are on the top. As you learned in Topic 2, sediments deposited at the bottom of bodies of water eventually form sedimentary rocks. Additional new layers of sediment continue to form over the previous layers. Unless something happens to move these layers, they stay in their original positions, like the newspapers in the pile. Another term for these sedimentary layers of rock is **strata.**

Geologists use a similar technique, called **relative dating,** to find the order in which events occurred. Scientists determine the relative age of rocks by examining their position in the strata. If a crack or a fault runs through a layer, it must have happened after the layer was in place, so the rock is older than the fault. Some fossils can be used to determine the age of the layer of rock in which they are found. If the creature that became fossilized was on Earth for only a short period of time and it was widespread, it can give accurate information about the age of the rock in which it is found. A fossil used to determine the relative age of the layer of rock is called an **index fossil**.

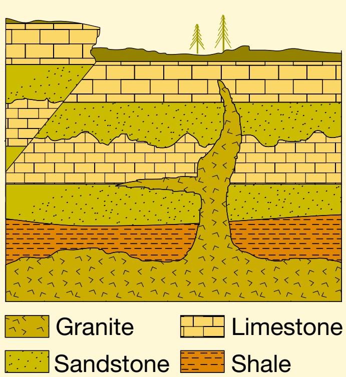
Figure 5.82 Geologists can use the principle of superposition to determine the relative ages of these layers of rock. The top layer is the youngest, and the bottom layer is the oldest.

Find Out ACTIVITY

Which Rock Is the Oldest?

Procedure

1. **(a)** Examine the illustration below. The legend will help you to interpret the layers.



   (b) Discuss the relative ages of the rock layers and events based on what you see.

2. **(a)** Make a sketch similar to the illustration.

   (b) Label the relative age of each rock layer on your sketch. The bottom layer is the oldest, so mark it with a 1. Mark the next oldest layer with a 2, and so on.

What Did You Find Out?

1. Where is the fault line in the rocks?
2. How do you know that this is an old fault line, which has not moved for some time?

Clues from Technology

You can easily use the dates printed on newspapers to put them in order. Unlike newspapers, rocks are not dated, so how can geologists establish their age?

The amounts of certain elements in a rock can tell geologists a great deal about the rock's age. Over billions of years, some elements can change into others. For example, over a period of 4.5 billion years, half of the uranium in a rock will turn into lead. The lead will then undergo no further change. This time period is called the **half-life** of uranium. The uranium is called the parent element. Once half of the parent element has changed, only half of the remaining element continues to change over a similar period of time. So, in another 4.5 billion years, half of the remaining uranium will change into lead. The process will continue until such a small amount of uranium remains, it may not be measurable, as shown in Figure 5.84.

By measuring the amounts of such elements in a rock, and by knowing the half life of the parent, a geologist can calculate the absolute age of the rock. This process is called **radiometric dating**.

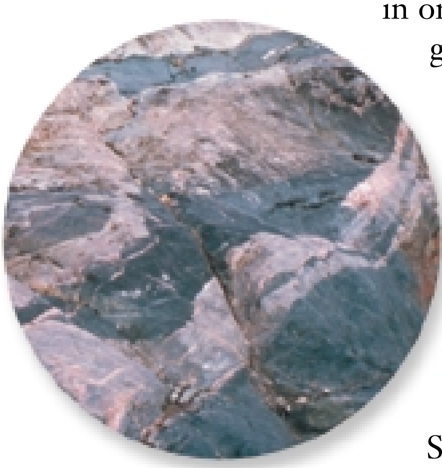


Figure 5.83 Scientists have determined that the oldest rocks on Earth's surface may be the Acasta Gneiss, found in the Northwest Territories. These rocks are 4.03 billion years old.

Math **CONNECT**

How old is a fossil that contains $\frac{1}{4}$ of its original carbon-14?

DidYouKnow?

It is very difficult for us to comprehend the vast expanse of 4.5 billion years. If we compare this period of time to a 24 h day, for example, humans have been here for only the last second, and the ancient civilizations in Egypt, Greece, and Rome took place in less than 1 s! (It has taken you much more than a second just to read the last three sentences.) Keep these ideas in mind as you read about geologic time scale.

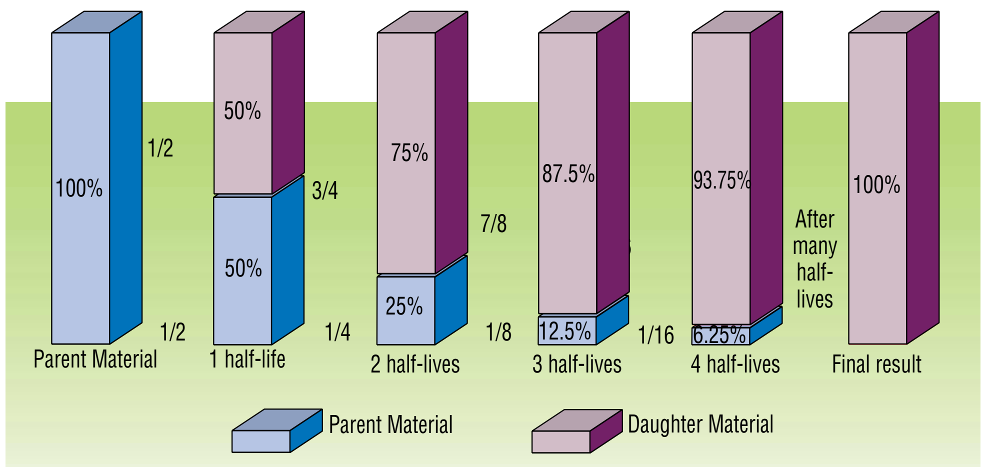


Figure 5.84 After each half-life, only one half of the parent material remains. Eventually almost all of the parent material will be gone.

Scientists also use **radiocarbon dating**, a type of radiometric dating, to find out when recent events in Earth's history occurred. Radiocarbon dating uses carbon-14, a rare form of carbon, as its parent material. This method is used to find the age of fossils, bones, and wood that are up to 50 000 years old. After 50 000 years, the amount of carbon-14 left in the sample is too small to measure. All living things take carbon-14 out of the environment to build cells and tissues. When they die, the carbon-14 changes into nitrogen gas in a half-life of 5730 years. The amount of carbon-14 left in the tissue allows scientists to determine the age of the remains.

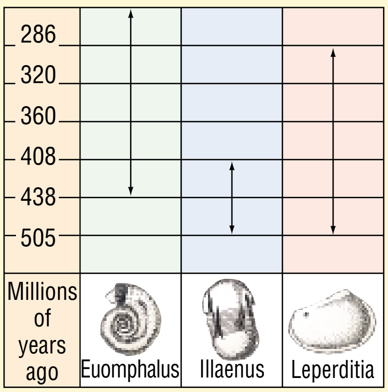
Find Out **ACTIVITY**

Tell-Tale Layers

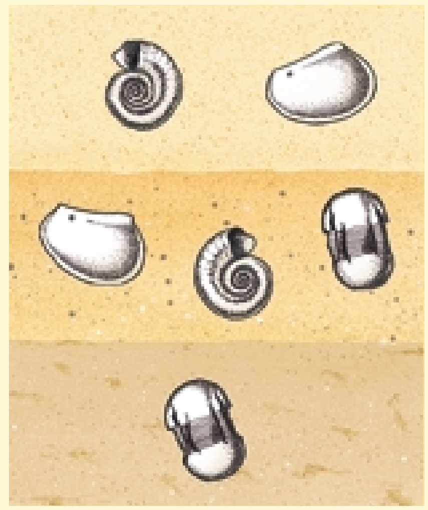
What can fossils tell us about Earth's age?

Procedure

1. Examine the cross-section at the right. It shows three layers of sedimentary rock with the fossils found in each layer.
2. The chart below identifies each fossil. The vertical arrows indicate the time span in which the animal lived.



3. Study the cross-section and the chart carefully. Identify the time range in which each layer might have been formed.
4. Make an inference from the fossil evidence about when the middle layer of rock might have been formed.



Geologic Time Scale

The geologic time scale is a division of Earth's history into smaller units based on the appearances of different life forms. It starts 4.5 billion years ago when Earth was formed. The largest divisions in the scale are called **eons**. Eons are divided into **eras** and eras are divided into **periods.** Examine the time scale on page 426 to locate eras and periods.

For the first 4 billion years, there is little fossil evidence. This vast expanse of time is called the **Precambrian**. Scientists think the earliest supercontinent, **Rodinia**, formed during this time, about 1.1 billion years ago. Rodinia split apart 750 million years ago, forming the ocean basins. There is evidence that simple forms of life, such as bacteria, algae, fungi, and worms, lived on Earth during the Precambrian. Because the bodies of these creatures were soft, they left little fossil evidence. The three eras that are rich in fossil evidence began 570 million years ago: the **Paleozoic Era** (ancient life), the **Mesozoic Era** (middle life), and the **Cenozoic Era** (recent life).

Pangaea, the second supercontinent to form, came together during the Paleozoic Era about 350 million years ago, and broke up about 180 million years ago during the Mesozoic Era. The dinosaurs dominated Earth in the Jurassic Period, which was 200 million years ago during the Mesozoic Era. The fossil evidence indicates that Pangaea first split into a northern portion called **Laurasia** and a southern portion called **Gondwanaland** (see Figure 5.86).

Figure 5.85 Is this how the supercontinent Rodinia looked about 750 million years ago?

Figure 5.86 Present day North America was once part of Laurasia. The split into Laurasia and Gondwanaland was the first break-up of Pangaea.

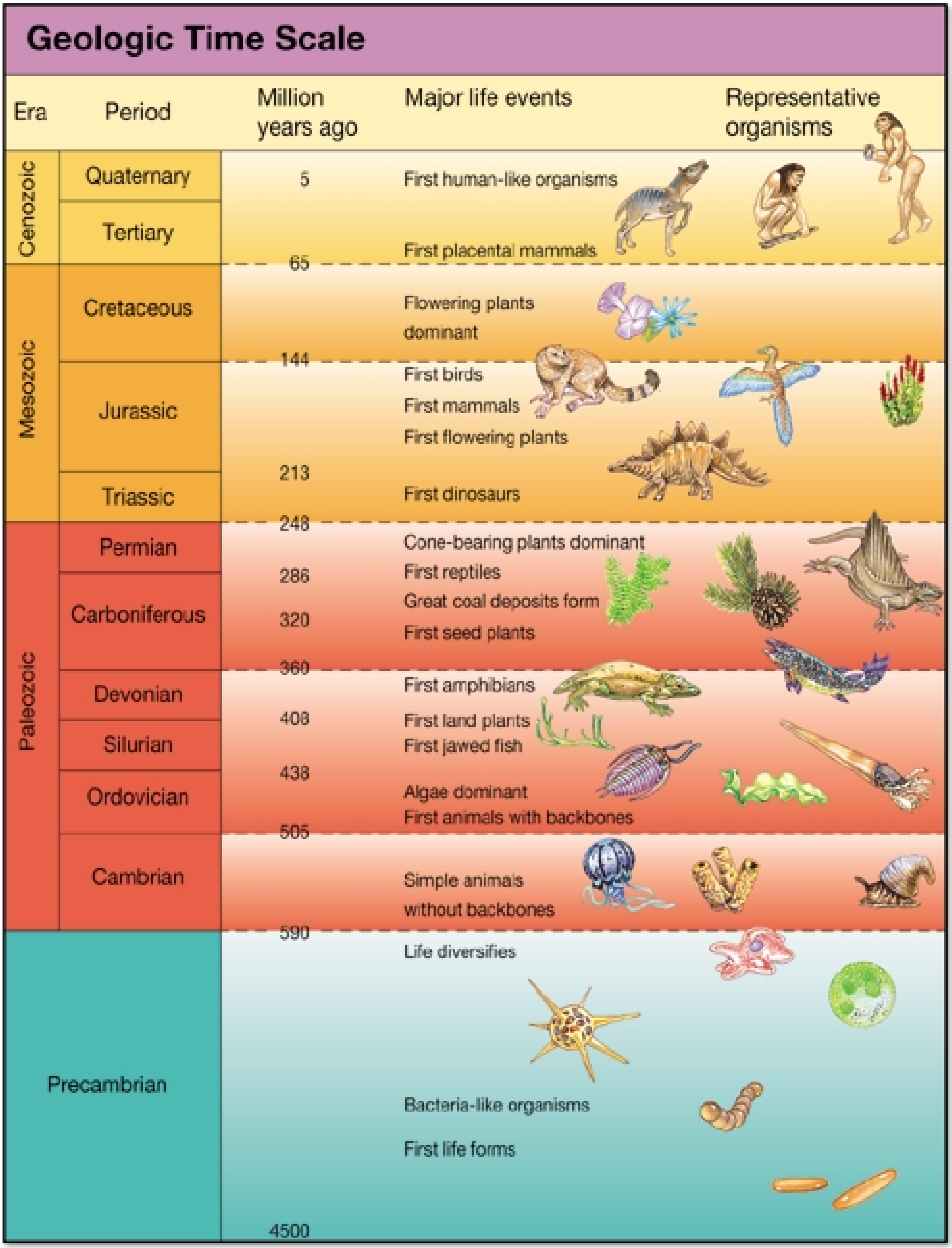


Figure 5.87 This geologic time scale provides even greater detail about geological events than you have just studied. It divides eras into periods. The scale shows the approximate dates that scientists now have for the first appearance of each general group of organisms on Earth.

Find Out **ACTIVITY**

Call That Old?

You are a geologist. You must organize the information you have about the history of Earth's crust and construct an informative time line.

Materials

scissors, adding machine tape, metre stick or ruler, pencil, set of coloured pencils

Procedure

Initiating and Planning

1. Look back over Topics 1 to 9. Note when various events in Earth's history occurred and when various ideas about Earth's history were suggested. Decide which events you want to include on your time line. If you have time, you might want to research other events you could also include.
2. Decide how long a piece of adding machine tape you need for your time line. Use a scale of 1 m of tape = 1 billion years. If you have ideas about other materials you might use to construct a time line, have them approved by your teacher. For example, you might do this activity using the computer.
3. Decide how you will indicate events on your time line.
4. Complete your time line.

What Did You Find Out?

1. Where on the time line do most events occur? Why might they occur here?
2. Compare your time line with your classmates' time lines. Did your classmates include any events that you feel you should have included in your time line?
3. If you were to do it again, how might you improve your time line?

Extension

4. Choose a period of time on your time line, and research it. Try to find out about other major events that you could add to your time line.

Career CONNECT

Digging out the Facts

Take a look at the following occupations:

mineralogist	oil rig operator	paleontologist	geologist	paleobotanist
museum curator	miner	archaeologist	surveyor	geochronologist

With your group, produce a booklet or multimedia presentation about one of the occupations. Make sure that you describe what it has to do with the study of Earth's crust. You can use photographs and illustrations from magazines or from the Internet. If possible, interview someone working in the occupation and include your interview as an article.

TOPIC 9 Review

1. What is the principle of superposition? How does it help geologists to determine the ages of rocks?
2. Compare radiometric dating with relative dating. What do they indicate?
3. What does "half-life" mean? Give one example.
4. How old is Earth? Describe Pangaea, Laurasia, and Gondwanaland. When did they exist, and what evidence do we have about them?

TOPIC 10 Fossil Fuels

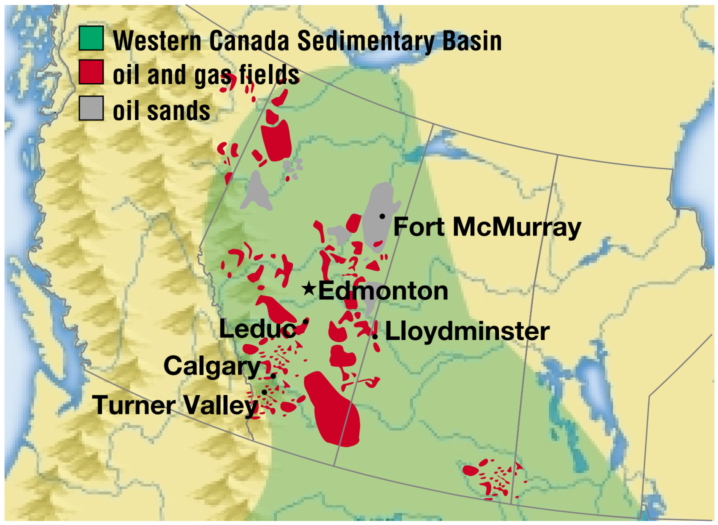


Figure 5.89 The most productive oil and gas area in Canada is the Western Canada Sedimentary basin, which includes most of Alberta. However, reserves of fossil fuels are limited. Their use as a fuel is a major source of pollution. Alternative sources of energy, such as solar and wind energy, are being developed.

Figure 5.88 Each of these giant trucks carries more than 300 t of oil sand. To support the weight they need tires that are 3 m wide! These trucks operate 24 h a day, 365 days of the year, at the oil sands mining projects near Fort McMurray.

Did you know that the energy that fuels your car might have come from ancient plants and animals? The source of most of the fuels used today is petroleum. How did it form? Where is it found?

Petroleum is a naturally occurring mixture of hydrocarbons, such as bitumen, coal, oil, and gas. Petroleum is most often found in sedimentary rock basins. These basins were formed from the sediments of tiny plants and animals deposited in the mud and silt. The basins were under heat and pressure for millions of years. It is thought that during that time, the soft parts of the plants and animals were transformed into solid, liquid, or gas hydrocarbons called **fossil fuels**. Coal is usually formed from plants that grew on the land. Oil is usually formed from water-based plants and animals. Natural gas can be formed from either land-based or water-based plants and animals.

Another theory about fossil fuels suggests that hydrocarbons may have been trapped inside Earth during the planet's formation. Since then, oil and natural gas have been slowly rising to the surface.

Oil and natural gas can move long distances through the strata and sometimes escape at the surface. Sometimes the lighter compounds are removed by the air or water, leaving heavier types of oil behind.

Finding and Mining Fossil Fuels

How do earth scientists know where to find oil and gas? They study surface rocks and samples from deep within the ground to identify traps where oil and gas have accumulated within rock formations. Pictured in Figure 5.91 are just three ways that oil and natural gas can be trapped.

Bitumen is a heavy, almost solid form of petroleum. Some bitumen deposits are found near the surface and can be mined. The sands are scooped up by electrically powered shovels and loaded into trucks. Hot water is used to separate the bitumen from the sand at the processing plant. In other places, the bitumen is too deep for mining to be economical. The underground oil sands reservoir is heated with steam and the melted bitumen is pumped to the surface.

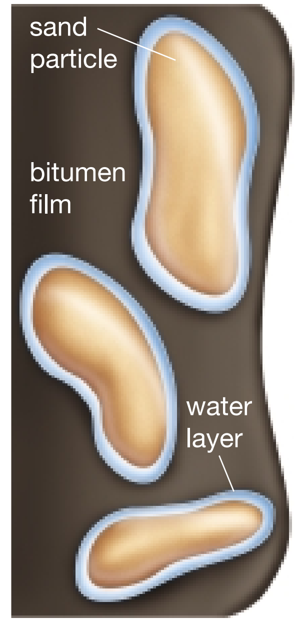
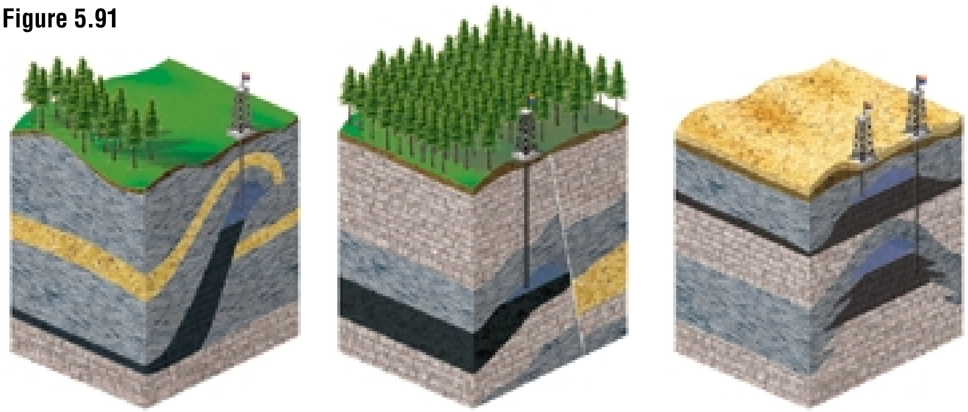


Figure 5.90 Each particle of oil sand is coated with a layer of water and a film of bitumen.

Figure 5.91



A **Thrust Fault** The original limestone layer was first folded then thrust-faulted. An example is the Turner Valley oil and gas field in south-western Alberta.

B **Normal Fault** The Dunvegan gas field in north-western Alberta is an example of a normal fault trap.

C **Reef** An ancient coral reef has been folded to form several traps, such as at the Leduc oil and gas field.

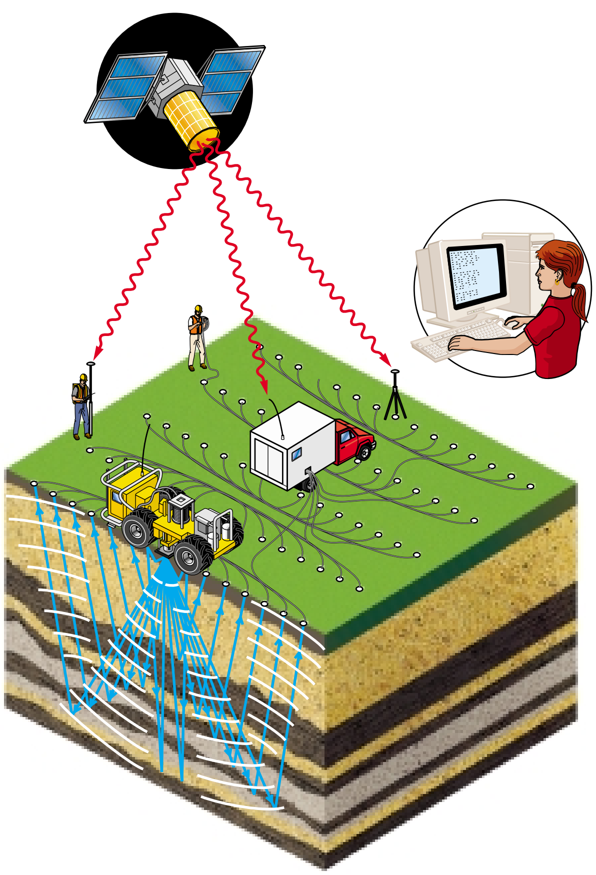


Figure 5.92 Seismic crews use modern technology to help locate oil and gas. A satellite-based global positioning system identifies the location. Large vibroseis trucks send energy waves into Earth's crust to create seismic waves. The waves are analyzed using computer software.

Cool Tools

Drilling is called "making hole." A revolving steel bit grinds a hole through the rock layers. Industrial diamonds or tungsten carbide can be used on the drill bit to reduce wear and help penetrate harder rock formations.

INQUIRY

INVESTIGATION 5-M

SKILLCHECK
- Initiating and Planning
- ✸ Performing and Recording
- ✸ Analyzing and Interpreting
- Communication and Teamwork

Where Shall We Drill?

Drilling for oil and gas can be very expensive. Just because your neighbours have a working well on their property does not mean that your land will provide an oil- or gas-producing well. In this activity you are going to make a three-dimensional model of the farm you just inherited from your grandfather in the foothills of Alberta. You are curious as to whether there could be a deposit of oil and gas under the land. However, you have only enough money to drill one hole and you do not want to make a mistake. Therefore you have hired a geologist to research the area and make a block diagram for you. Now all you have to do is interpret the diagram and tell your crew where to drill.

Although advanced technology is used to find likely places for gas and oil, there is no guarantee. Drilling is always a gamble. Sometimes nothing is found, and sometimes there is greater-than-expected success.

Question

Where will you drill for oil?

Prediction

Make a prediction about which areas are likely to contain oil.

Materials

coloured pencils, glue, scissors

block diagram (provided by your teacher)

Procedure

1. Colour the block diagram on the sheet provided by the teacher. Be sure to follow the legend on the sheet and make the colours dark.
2. Cut, fold, and glue the diagram according to the instructions on the sheet.
3. You have just created a geologic map and four cross-sections.
4. Study the block diagram carefully.

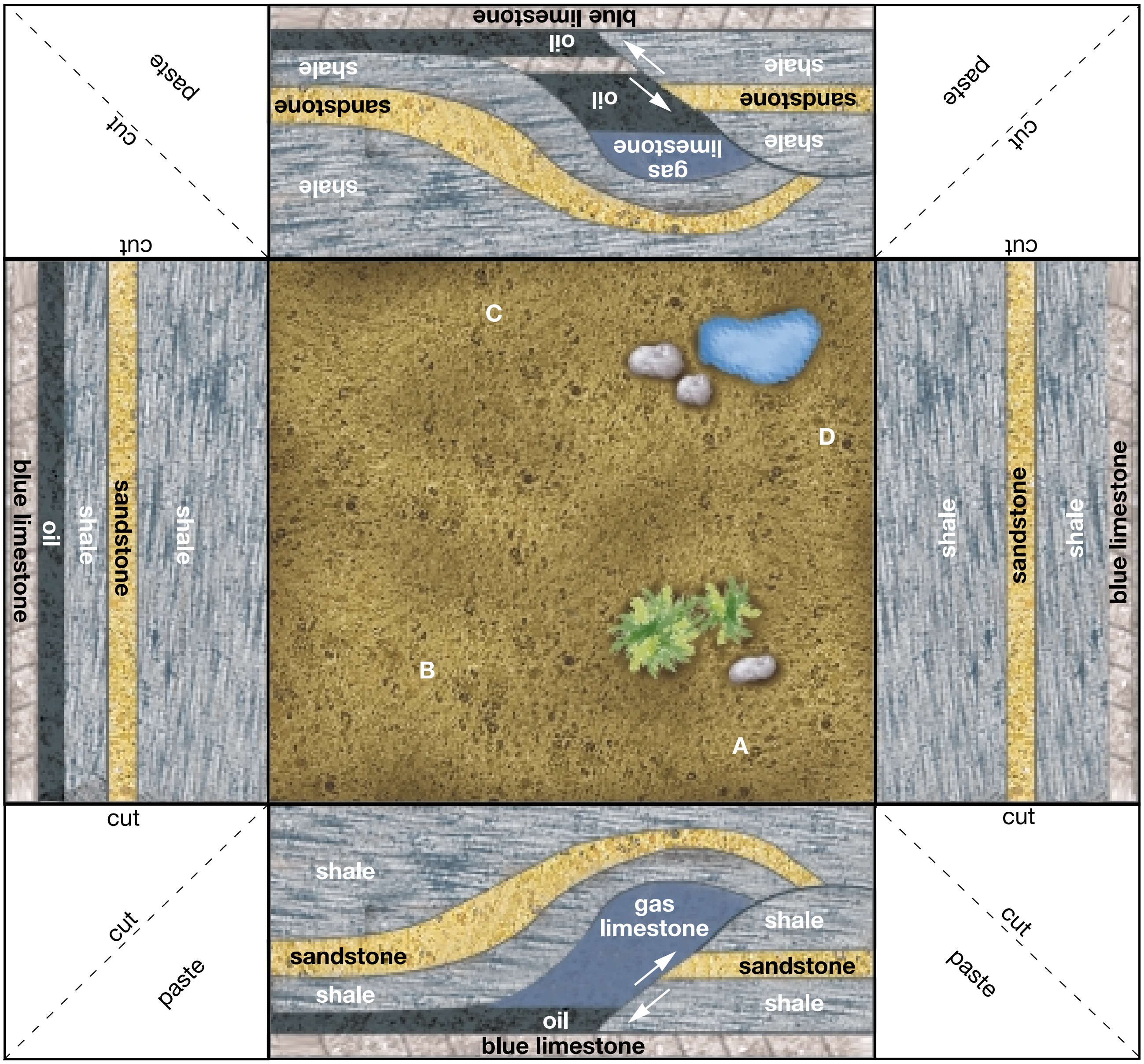
Analyze

1. At which location (A, B, or C) would you drill for oil? Why?
2. Are there any other locations where you would expect to find oil?
3. What is the name of the oldest rock in the area? How do you know?
4. What type of fault occurred. Why is the glacial till not faulted?

Conclude and Apply

5. Write a brief history of the area starting with the formation of the oldest bed.
6. Make another block diagram from the cross-section A, B, or C shown on page 431.

Do not cut or write on this page.



www.school.mcgrawhill.ca/resources/

Where is petroleum found on Earth? Why is it sometimes found under the ocean? Learn more about this energy resource by going to the web site above. Go to **Science Resources**, then to **SCIENCEFOCUS 7** to find out where to go next. Prepare a brief report of your findings.

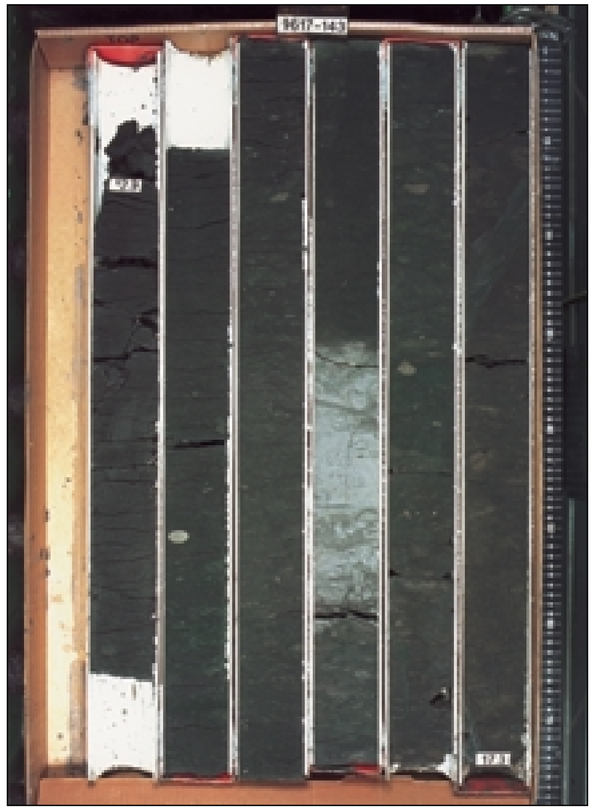


Figure 5.93 Sometimes core samples are drilled at potential well sites. The cores are stored in government laboratories, and information about them is added to a data base. What type of data do you think core samples provide about rock? Which type of data base would you use?

Career CONNECT

"Oil" in a Day's Work

Petroleum companies hire people like Jennifer Dunn to help them find the best places to dig for oil and natural gas. Jennifer is a petroleum geologist. She uses what she knows about Earth's crust to figure out where these petroleum products may be, far below the surface.

To decide if a spot may yield oil or natural gas, Jennifer needs to find out what kinds of rock are deep underground. She visits the area and examines the rocks on the surface. Then she and her co-workers use a special drill to bring up a "core sample," a thin cylinder of rock, from far under the ground. By studying the core sample, she can see the types of rock it contains and how they were formed. After additional tests, she makes maps explaining what the whole area is like and decides if there is a good chance of finding oil or natural gas there.

What kind of education do you think Jennifer needed for this job? Find out about the geology courses or programs offered by a university, college, or technical school near you. Try to find out what careers these courses or programs could lead to by talking to someone at that school or to a guidance counsellor in your own school.

TOPIC 10 Review

1. What is petroleum?
2. How are coal, oil, and natural gas formed?
3. How do geologists decide where to drill for oil and gas?
4. What are some common products that come from fossil fuels?

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

petrified
carbonaceous film
mould
cast
original remains
trace fossil
principle of superposition
strata
relative dating
index fossil
half-life
radiometric dating
radiocarbon dating
eons
eras
periods
Precambrian
Rodinia
Paleozoic Era
Mesozoic Era
Cenozoic Era
Pangaea
Laurasia
Gondwanaland
petroleum
fossil fuels
bitumen

Reviewing Key Terms

1. Fill in the blanks with key terms, then find the terms in the word search. Words can be written backwards, forwards, or diagonally. Do not write in this book.

(a) On the geologic time scale, Cenozoic is an _____ and Cambrian is a _____. (9)

(b) ______ fuels include oil, natural gas, and coal. (10)

(c) The earliest supercontinent was called _____. (9)

(d) An _____ fossil can be used to determine the relative age of strata. (9)

(e) A _____ is a cavity in rock left when hard parts of an organism dissolve. A _____ is produced when sediments fill in the cavity. (8)

M	K	H	Q	E	N	I	M	E	R	S	C
U	V	E	N	G	Z	Q	C	O	T	B	A
O	R	I	G	I	N	A	L	R	U	S	S
A	N	M	G	P	R	G	A	U	R	L	T
E	U	W	E	T	L	T	A	H	O	V	D
M	H	S	G	S	A	N	S	E	D	G	U
G	L	R	Y	V	O	J	W	E	I	N	V
D	O	I	R	E	P	Z	I	G	N	I	G
V	V	K	S	B	I	H	O	R	I	T	N
G	N	D	V	S	M	V	N	I	A	A	E
I	N	D	E	X	O	H	F	H	C	D	K
E	Y	E	Q	Y	I	F	X	A	E	R	D

(f) A woolly mammoth found preserved in the ice is an example of _____ remains. (8)

(g) Layers of rock are also called _____. (10)

(h) A dinosaur footprint is an example of a _____ fossil. (8)

(i) Relative, radiometric, and radiocarbon _____ provide information about the age of the strata. (10)

Understanding Key Concepts

2. Make a series of labelled diagrams showing the formation of a mould and cast fossil. (8)

3. Explain why we do not have fossil evidence of all the species that once lived. (8)

4. How do we know how old Earth's crust is? (9)

5. Explain two ways that fossil fuels may have formed. (10)

Ask an Expert

Is it possible to study rock that is many kilometres below Earth's surface? Charlotte Keen would answer with a resounding "Yes!" Charlotte is a senior research scientist with the Bedford Institute of Oceanography and the Geological Survey of Canada. For 28 years, she has been studying the rock under the ocean floor. In 1995, she won the J. Tuzo Wilson Medal for her outstanding contributions to geophysics in Canada.

Q What exactly is a geophysicist?

A A geophysicist is a scientist who uses knowledge of physics — the interactions of matter and energy — to study parts of Earth that are beneath its surface.

Q What part of Earth do you study?

A I look at the continental margin off the east coast of Canada that runs from Baffin Bay right down to south of Nova Scotia. This is the area where the North American continent, of which Canada is part, once separated from neighbouring continental plates. Continental margins can tell us a lot about how Earth is changing, and the rock underneath them holds great potential for natural resources: oil, gas, and valuable minerals. I study the rock that lies up to 40 or 50 km below that margin.

Q How can you study rock so far below Earth's surface?

A I look at the way vibrations from sound waves travel through that rock. My colleagues and I plan experiments for the area we want to study. We assemble a team of nearly 100 people, gather the necessary equipment, and then head out to sea. We lower very sensitive recording devices onto the ocean floor of the area we will study. After that, the ship travels away from the devices firing an air gun, which makes a very loud sound. The sound waves go down through the water and into the rock. Some waves bounce up off layers of rock, others go deeper before they bounce back. When each sound wave reaches the device, it is recorded.

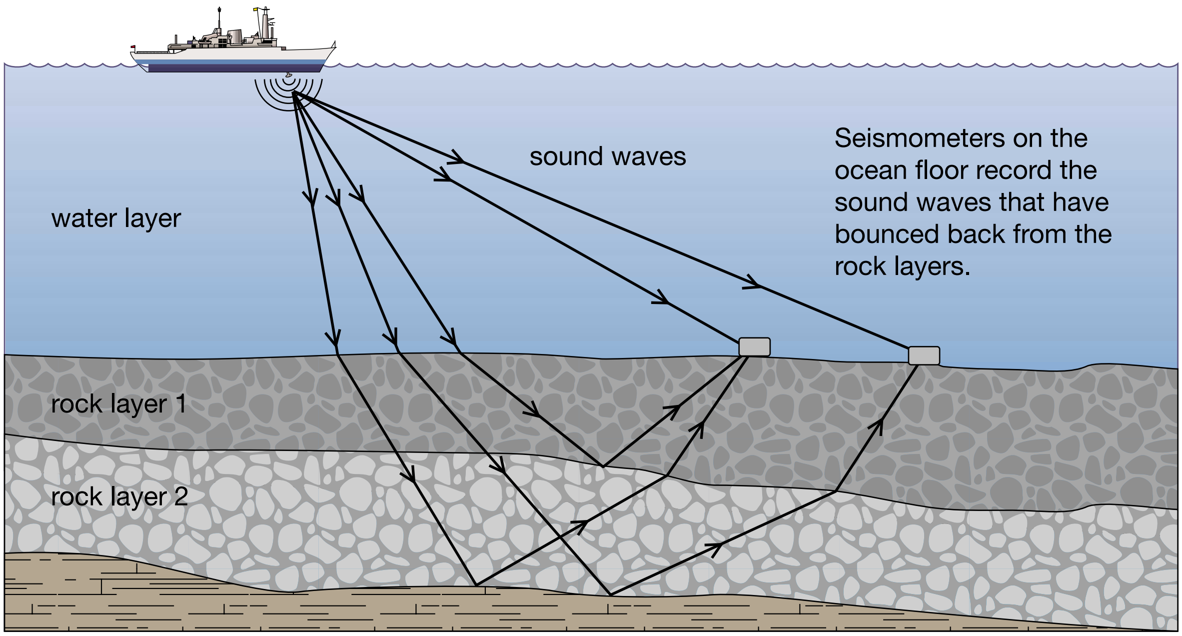
Q How the sound is recorded tells you something about the rock?

A Yes. Sound waves travel through different types of materials at different speeds. The amount of time it takes for each sound wave to be recorded helps me figure out what kind of rock the sound wave may have passed through. We keep firing the air gun from many different distances, keeping track of exactly where we were and the time at which it was fired. Usually, we are at sea for two to four weeks to record everything that we need. Once we're back on land, I analyze the data from the recording devices to figure out what type of rock exists in each place and how thick the layers of rock are.

Q Why did you decide to study the rock under the ocean, rather than somewhere else?

A When I graduated from physics at Dalhousie University in Halifax, research in oceanography was expanding in Canada. It was an exciting time. I think my love of the sea had a lot to do with my decision too. I was born in Halifax and my whole family enjoyed sailing.

An air gun is fired from the ship, making a loud sound.



Q **What can the rock under the ocean tell you that other rocks cannot?**

A Rock under the ocean provides information about ocean floor spreading. This is something we have been investigating since technology developed during World War II became available to us.

Q **Does the fact that the sea floor is spreading mean that Earth is getting bigger?**

A No, it doesn't. As new crust is produced in one area, it disappears in another. There are deep trenches in certain parts of Earth's oceans. At these trenches, a plate will slip past another one, down into the mantle, where it melts and turns back into magma. This is a continuing process.

Q **Why is the study of rock under the ocean "special"?**

A The technology is fairly recent, and the latest theories about what is occurring on and beneath Earth's crust are still quite new. The theory of sea floor spreading was only developed in the 1960s. It is exciting to be able to explore areas where new observations can be made. Who knows what the ocean floor still has to tell us about Earth's crust?

EXPLORING Further

The Speed of Sound

Geophysicists like Charlotte Keen study how vibrations travel through different materials. Try this experiment to compare how sound vibrations travel through wood, glass, and metal.

Hold a ticking watch by its band and place the back of the watch against a large glass window. Put one ear on the window 1 m away from the watch and cover your other ear with your hand. Can you hear the ticking? Now, try the same thing with the watch 1 m from your ear on:

- a metal vacuum cleaner hose or water pipe
- a wooden table or board.

How did the sounds compare? Which materials transferred the ticking sound best?

DESIGN YOUR OWN

INVESTIGATION

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

A Creative Crust

Think About it

Unit 5 has shown how Earth's crust is always moving and changing. Some changes are incremental and may take many millions of years. Other changes are sudden and occur in minutes or hours. In whatever way they occur, the changes in Earth's crust result in events such as the following:

- Minerals form when magma cools.
- Rocks form in various ways and are classified as igneous, sedimentary, or metamorphic.
- Weathering causes rock to erode and sediment to form.
- Mountain formation is caused by convection currents under Earth's tectonic plates.
- Earthquakes occur when pressure at fault lines becomes too great.
- Volcanoes erupt when magma pushes upward, usually due to plate movement.
- Fossils indicate when various strata in Earth's crust formed.
- Fossil fuels are created over millions of years.

Your task is to think of a question to investigate about one of the processes that have shaped Earth's crust. Formulate your question based on information you have learned in this unit. For example, you could ask how the pressure at a fault line might vary before an earthquake occurs. You might ask how weathering by pure water or acidic water affects a substance such as chalk. Develop an experiment that will help you to answer your question.

Skill FOCUS

For tips on how to set up a controlled experiment, turn to Skill Focus 6.

For tips on using technology tools to present your results, turn to Skill Focus 9.

Materials

Brainstorm a list of the materials that will be most appropriate in answering your question. You may also need electronic resources, art materials, or construction materials.

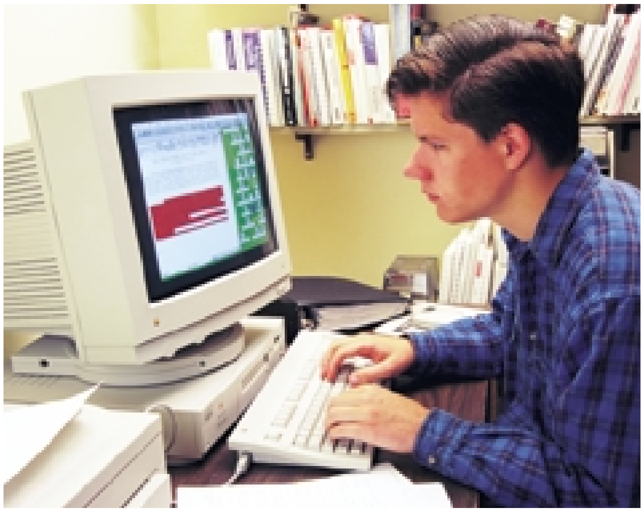
Safety Precautions

- Do not mix chemicals without your teacher's knowledge and approval.
- List additional safety precautions as you design your experiment.

Initiate and Plan

1. With your group, decide on an experimental question to investigate. You might need to do some further research in order to decide on the question.

2. Formulate a hypothesis or a prediction that will answer your question. Base your hypothesis on previous knowledge and on inferences that you can make as a result of that knowledge.



3 Design an experiment to test your hypothesis or prediction. Use words and diagrams to explain your design. Think about the order in which you could carry out the steps in your procedure. Decide on the feature you will change (the manipulated variable) and the feature you will observe changing (the responding variable). Decide what your control will be. You might find it helpful to refer to the Experimental Design Checklist.

Perform and Record

(Test Your Hypothesis)

4 Set up and perform your experiment. If necessary, carry out second and third trials. Make any modification to your experiment, if necessary.

5 Gather and record data and observations as you conduct your experiment. Decide how to record and present your data in a clear format (table, graph, diagram, etc.).

Analyze and Interpret

(Draw Conclusions)

6 Draw conclusions based on the results of your experiment. Discuss your conclusions with your group.

7 Did your findings support your hypothesis? Explain.

8 Write up your findings in a laboratory report. Be sure to include the following:

- Introduction
- Hypothesis or Prediction
- Procedure (step by step), including a diagram
- Data/Observations in the form of words combined with graphs, tables, etc.
- Conclusions

Experimental Design Checklist

1. Have you clearly stated the purpose of your experiment, the question you want to answer?
2. Have you written your best guess (hypothesis) about what you expect the answer will be?
3. Have you written a step-by-step procedure?
4. Have you obtained all the information you need from a variety of sources?
5. Did you make a complete list of all the materials you need?
6. Have you identified all of the variables in your experiment?
7. Identify all sources of error that you can think of in your design.
8. Did you repeat your experiment several times? How many?

UNIT 5

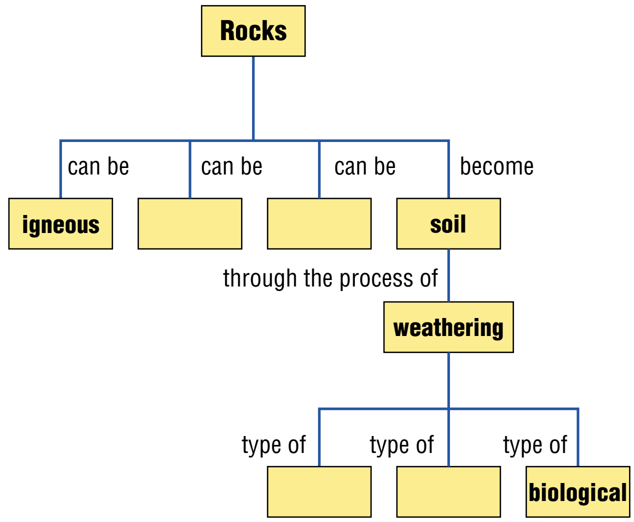
Review

Unit at a Glance

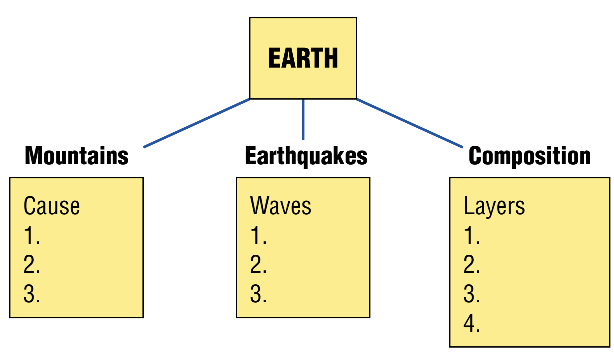
- Minerals are made from one or more elements. Minerals can be identified by properties, such as hardness, lustre, colour, streak, cleavage, and fracture.
- The three main rock families are igneous, sedimentary, and metamorphic. The rock cycle is the process through which rocks continue to change.
- Earth's surface is constantly being worn down and carried away through the forces of erosion. Some types of erosion, such as glaciers, bring slow, incremental change. Other types of erosion, such as flash floods, bring sudden change.
- Mechanical, chemical, and biological weathering wear away Earth's crust. Sedimentation builds up Earth's crust.
- The theory of plate tectonics describes the movement of the crust on Earth's mantle. Biological, geological, and meteorological evidence show that the continents have drifted over time.
- Earthquakes are caused by sudden movements in Earth's crust where tectonic plates meet.
- A volcano is an opening in Earth's crust that releases lava, steam, and ash when it erupts.
- Most mountains are formed by tectonic plates converging or diverging.
- Evidence suggests that Earth is about 4.5 billion years old.
- Fossils are evidence of ancient life. Fossils provide clues about the history and past climates of Earth, and about the plants and animals that lived long ago. Fossil fuels may have been created from the soft parts of ancient plants and animals.

Understanding Key Concepts

1. In your notebook, copy and complete the concept map below:



2. What hardness does a mineral have if it cannot be scratched by glass, but it can scratch an iron nail?
3. Use cardboard to make three-dimensional models of each major crystal shape.
4. Here are four answers to four different questions:
   Alfred Wegener
   J. Tuzo Wilson
   plate tectonics
   convection currents
   Write a question for each answer.
5. In your notebook, copy and complete the following concept map about Earth's crust.



Developing Skills

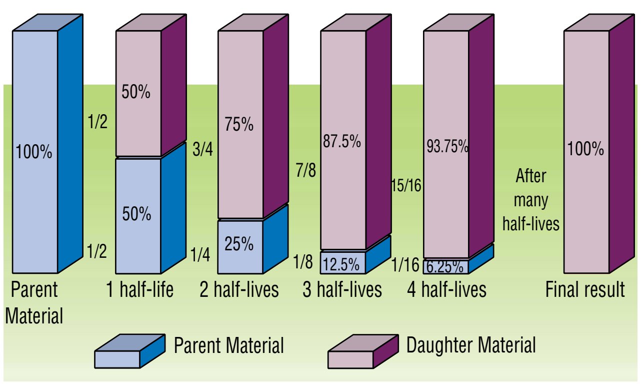
6. Examine the rocks in your neighbourhood. Are they mostly from one rock family, or are all three families represented? What might be the reasons for finding more of one type than another?

7. Investigate the effects of erosion and sedimentation in your geographic area. Find examples of all three types of weathering. Describe the effects of glaciation.

8. Describe how convection currents have changed the surface of Earth.

9. What information might a geologist discover by examining strata? How does the principle of superposition help a geologist understand rock layers?

10. Carbon-14 has a half-life of 5730 years. In a fossil which had 40 g of parent material, 5 g of the carbon-14 is left. About how old is the fossil? Explain how you got your answer.



11. Give two examples of gradual change. Explain their causes. Give two examples of sudden change. Explain their causes.

Problem Solving/Applying

12. Could you find a fossil in an igneous rock? Why or why not?

13. If all you had to use was a piece of paper, a steel knife, and a glass bottle, how could you tell the difference between calcite and quartz? What other test would help you identify calcite?

14. Use the rock cycle to explain why pieces of granite and slate can be found in the same piece of conglomerate.

15. Suppose you were given two rocks to classify. Rock A was formed deep underground and was found at the surface. Rock B was found in an underground mine but was formed at the surface. Write a paragraph about each rock. Identify the family to which each belongs. Speculate how each might have been formed and moved to its new location.

16. Draw a sketch of a meandering river. Imagine you are planning to build three hotels in the river valley. Where would you place them? Mark their locations on your sketch, then show where you think the river will be in 50 years and in 100 years.

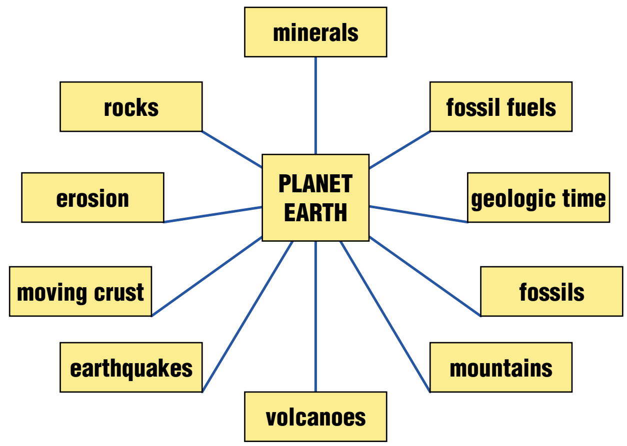
17. Read the newspaper excerpt below, and answer these questions:
   (a) What inaccuracy does this article contain?
   (b) Aside from its greater strength, why do you think the Kobe earthquake killed thousands of people, while the earthquake described in this article killed only about 60 people?

> About 60 people were killed, many as they slept, during an earthquake in central Bolivia yesterday. A 5.9 magnitude quake struck, followed by a second one, 13 min later, with a magnitude of 6.8. The epicentre was 89 km below Earth's surface. Repeated aftershocks—up to 150 in the first 12 h alone—sent panicked residents fleeing any buildings left standing. About 30 000 people, mostly farmers, live in the area hit by the quakes. Eighty percent of houses in the community where the earthquake struck were destroyed, the hospital roof caved in, and a landslide blocked access to the town. Reports indicate that the town was almost wiped out. People gathered in main plazas after the jolts, fearing the aftershocks would bring down more buildings. Streets were cleared of rubble by tractors so that workers could assist the injured and homeless.
>
> Adapted from *Winnipeg Free Press*, May 23, 1998

18. You have just discovered a fossil common to your province in the ground at a construction site. How will you find out how old the fossil is? What does the age tell you about the ground where it was found? What can you infer about the ancient climate and environment of the province?

19. Suppose you were studying fossils from a specific location and era. You notice that all the creatures had shells. Could you conclude that there were no worms living at that time and place? Explain your answer.

20. Copy this chart in your notebook. For each topic choose one question that you would like to investigate. Write each question next to its topic.



Critical Thinking

21. Why do you think some igneous rocks have holes or air spaces? Do you think such rocks are likely to be intrusive or extrusive? Explain why.

22. How can water be a factor in both mechanical and chemical weathering?

23. Laser beams are used to measure plate movement. How would they need to be set up and monitored?

24. What is the relationship between the locations of earthquakes, volcanoes, and mountain ranges? Which parts of the world have all three?

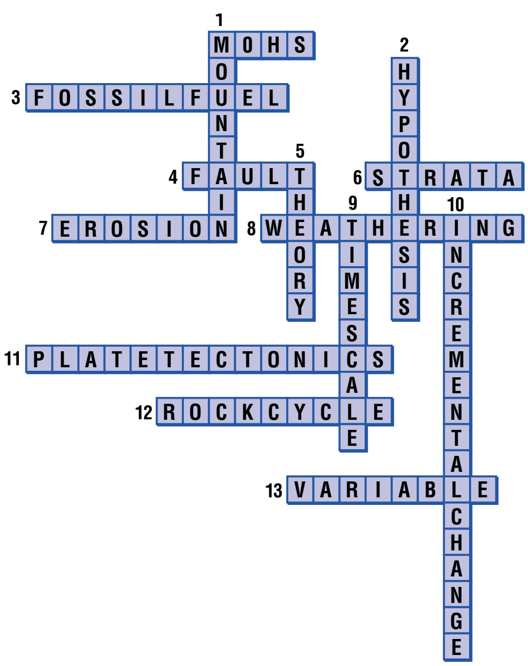
25. Research in newspapers, magazines, or on the Internet to find an article about an earthquake or volcano. Write a summary of the article to share with the class. Identify three questions that the article did not answer.

26. Imagine that you are designing a display showing dinosaurs in their environment. Why would you not include any models of humans in the display? How would you explain this to the museum staff?

27. Many trilobite fossils are found in Alberta. What does this tell you about Alberta's past?

28. What are three questions that scientists have not yet been able to answer about Earth's past? Why is each question difficult to answer? Predict the answer for each question. Support your predictions with evidence.

29. Reverse crossword puzzle. This is a completed crossword puzzle about Earth's crust. Your challenge is to write the clues. Remember to classify your clues as "Across" and "Down" and to number each.



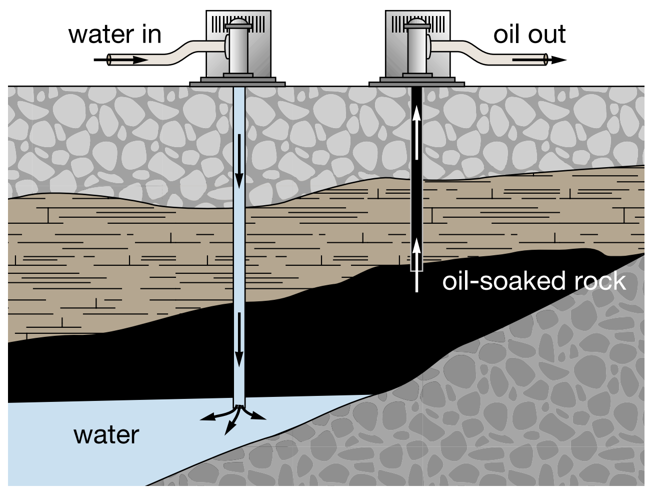
30. Like water wells, oil wells use pumps to bring the underground liquid up to the surface. Pumping petroleum is not as easy as pumping water because the oil is a very thick liquid. It is found in small, sponge-like pores of underground rock. The diagram below shows how petroleum is brought up to the surface.

Examine the diagram and answer the following questions

(a) How many pumps are lifting oil up to the surface?

(b) Which pump is lifting oil up to the surface?

(c) What is the other pump doing? Explain how it helps to separate the oil from the rock.



Pause& Reflect

Look back to the Focussing Questions at the beginning of Planet Earth on page 352. Record your answers to the three questions in your Science Log. How does the new information you've learned in this unit connect with your previous understanding? What new questions do you now have about Earth's Crust? How could you find the answers?