

# Science Ch.9

Rocks and Minerals





Biography

## CAROL RAYMOND

### Research Scientist

Dr. Carol Raymond is a research scientist working for NASA at its Jet Propulsion Laboratory. In 2003, Dr. Raymond led a team of scientists and researchers to find out if earthquakes can be predicted from space.

By using images from two satellites, scientists can study fault areas on Earth. They can detect tectonic plate movements as small as one millimeter per year. Dr. Raymond led development of a 20-year plan to place a system of satellites in space. These satellites will monitor fault zones and try to give warnings about places where earthquakes might be ready to occur.

Dr. Raymond says that scientists eventually may be able to learn when stresses in the Earth's plates are at dangerous levels. She looks forward to a day when earthquake forecasters can give a monthly "hazard level" report, much like weather forecasters now predict approaching storms. This would give people and emergency services in the area time to prepare.

Dr. Raymond's research includes studying the movement of tectonic plates around the Earth and the history of ice sheets in Antarctica. She also studies the history of Mars and is currently the Project Scientist for the Dawn Discovery mission, which will study two large asteroids that were baby planets at the dawn of our solar system.



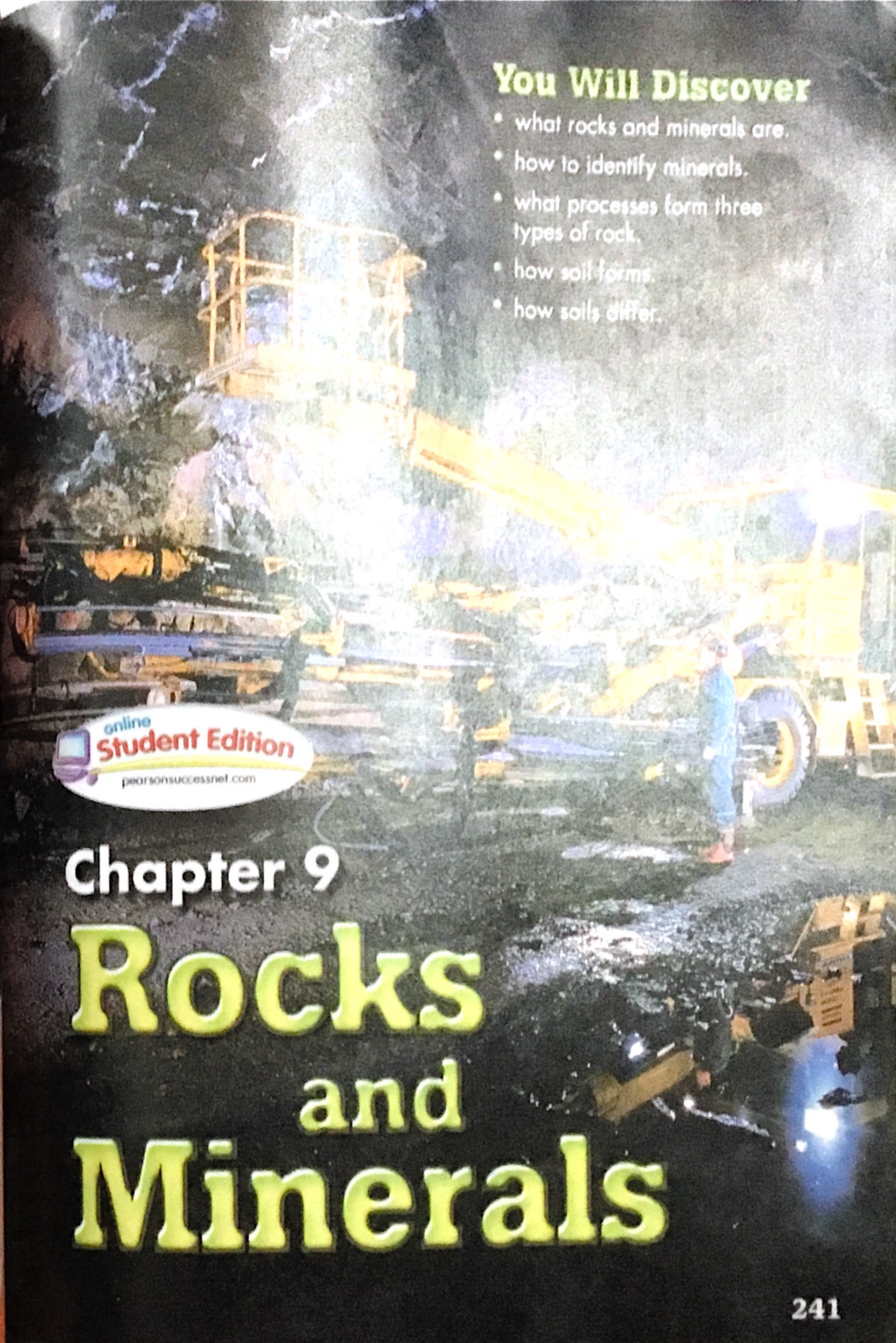
Satellite image of Iran/Zagros Mountains, Canyon Fault



Lab zone

### Take-Home Activity

Make a poster warning people about an earthquake that is predicted for the coming months. In your poster, include instructions for how people can prepare and what they should do to keep themselves safe.



### You Will Discover

- what rocks and minerals are.
- how to identify minerals.
- what processes form three types of rock.
- how soil forms.
- how soils differ.

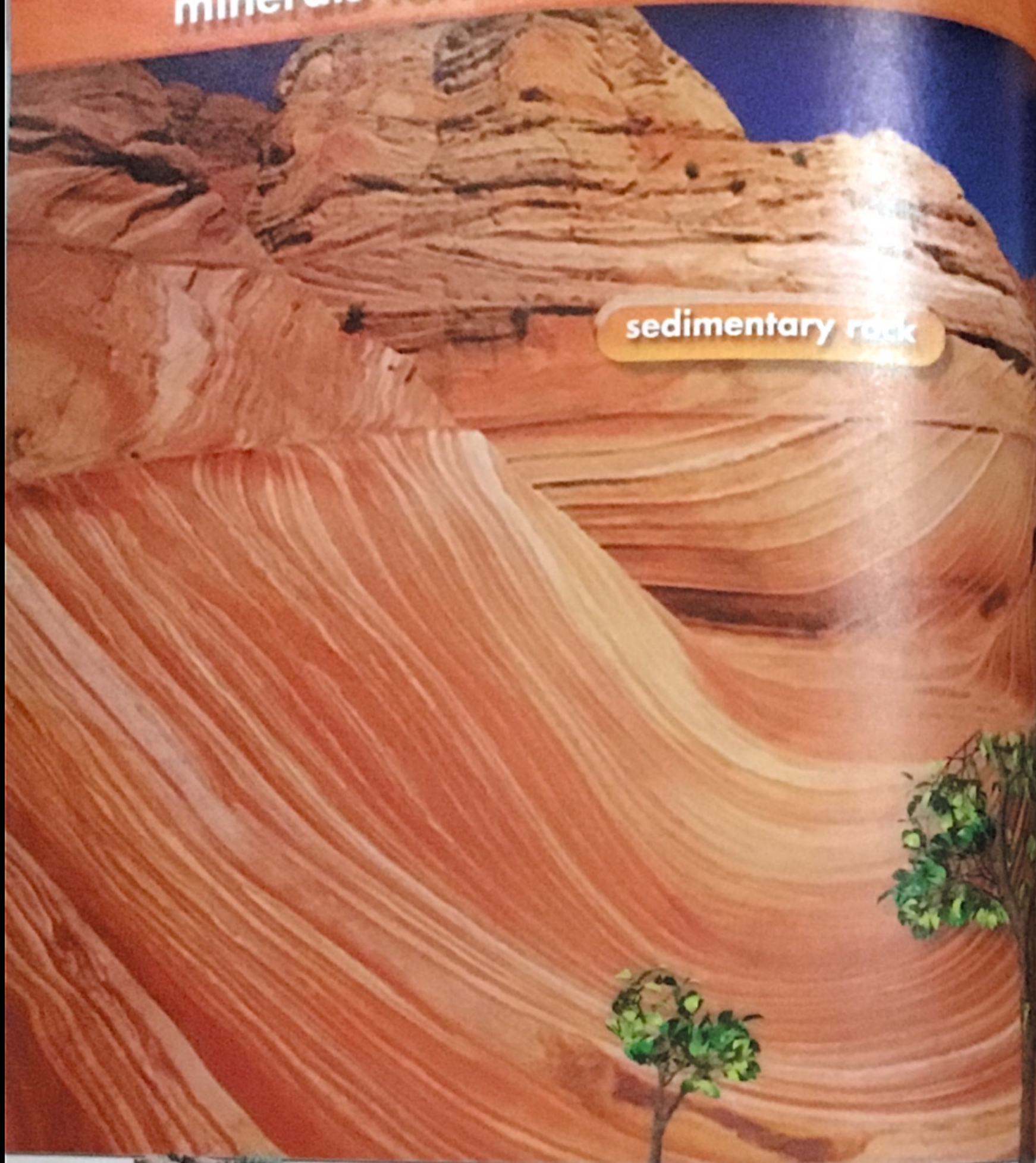
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## Chapter 9

# Rocks and Minerals



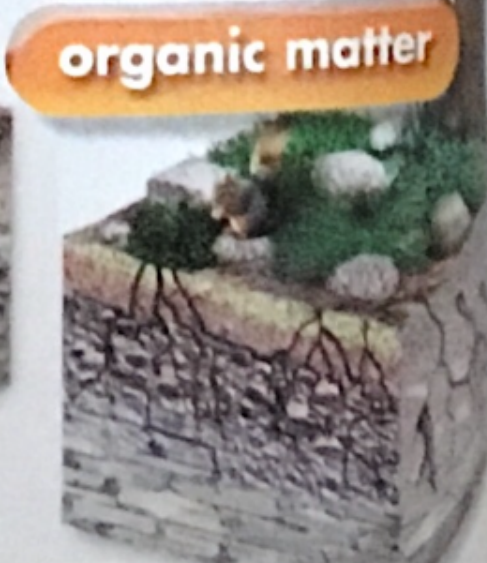
# How do rocks and minerals form soils?



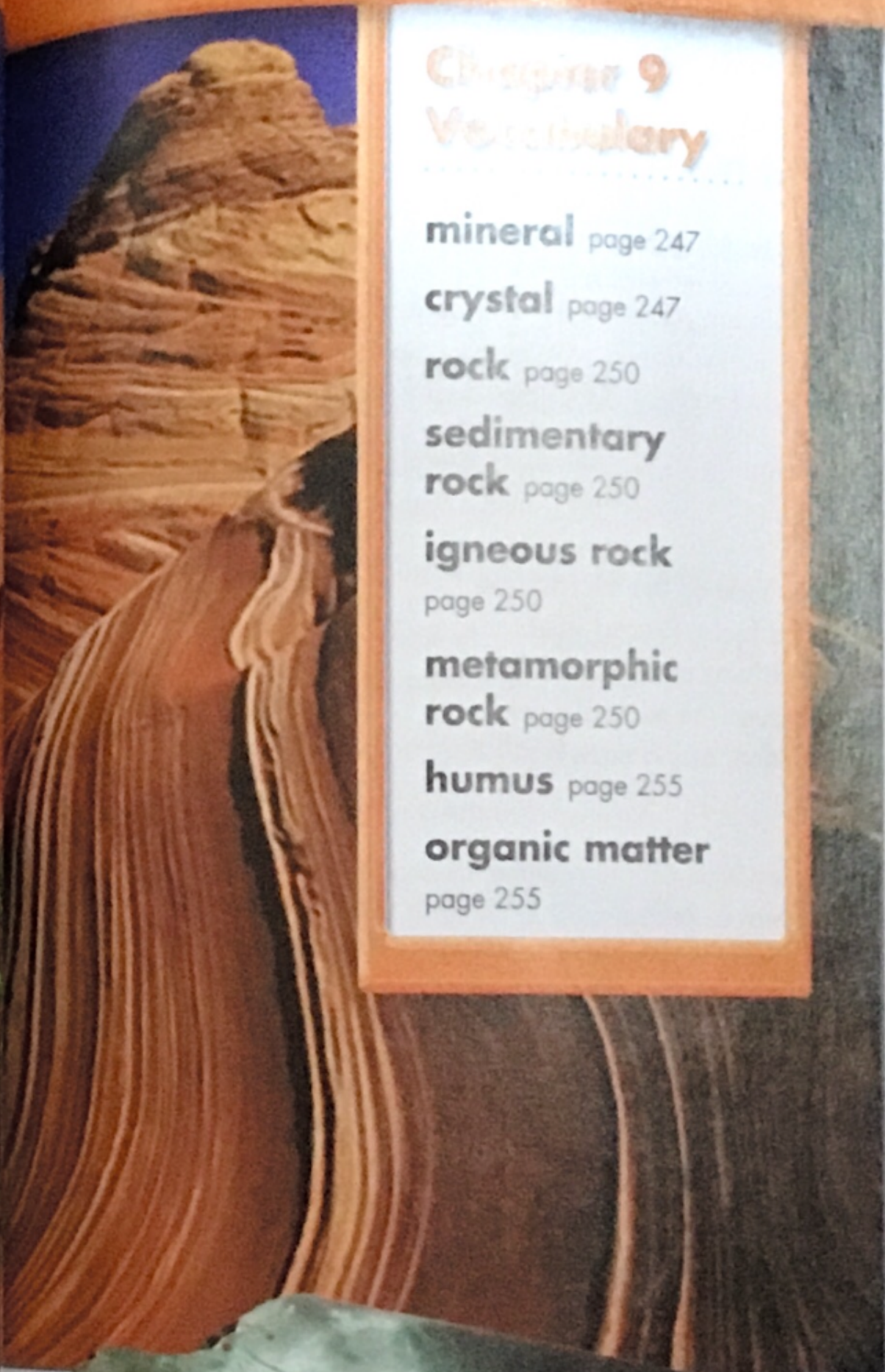
sedimentary rock



humus



organic matter



crystal

mineral

## Chapter 9 Vocabulary

- mineral page 247
- crystal page 247
- rock page 250
- sedimentary rock page 250
- igneous rock page 250
- metamorphic rock page 250
- humus page 255
- organic matter page 255



igneous rock



metamorphic rock



## You Are There!

Gold! Dust and noise fill the cool Nevada air as gold mining trucks move tons of dirt. Searching for the precious metal is part of another day's work. Gold is too heavy to use for tools and too soft to be used for cutting. Yet no other mineral is as highly prized as gold. Its beauty has sparked wars, lured explorers to the New World, and made it a symbol of wealth. Exactly what is gold?



## Lesson 1

# What are rocks and minerals?

*Each kind of mineral has its own unique chemical structure. Differences among minerals result from the way the particles of each mineral are arranged. Deep within Earth, newly formed rocks are exposed to heat and pressure. At Earth's surface, rocks are gradually broken down.*

## Minerals

Gold is only one of the many different minerals found on Earth. A **mineral** is a natural, nonliving solid with a definite chemical structure. To be a mineral, a substance must fit all parts of this definition. For example, coal is not a mineral because it is made from plants that lived long ago.

How many minerals can you name? You probably know more minerals than you think. For example, have you ever looked closely at grains of sand? If so, you were probably looking at a mineral called quartz. Earth's crust contains more than 4,000 kinds of minerals, yet only about two dozen are common. Other minerals you might be familiar with are diamond, quartz, emerald, copper, and ruby. Gemstones, such as emeralds and rubies, are minerals that are valued for their beauty and rarity.

Notice in the pictures that minerals have a geometric shape. The geometric shape is due to the way their particles are arranged. Minerals are made up of **crystals**. The particles of crystals are arranged in a particular, repeating pattern. This pattern is reflected in the shape of the crystal.

Crystals form when minerals are made in nature. Under perfect conditions, some crystals are large. But most crystals are so small that they cannot be seen without a microscope.

1. **Checkpoint** Brass is made from zinc and copper, which are combined at high temperatures in furnaces. Is brass a mineral? Explain your answer.
2. **Math in Science** About what percentage of minerals are common?

Pyrite

Beryl

Selenite





## Identifying Minerals

When you visit a zoo, you can identify many animals. You use characteristics such as size, color, and shape. Minerals also can be identified according to their characteristics, or properties. Scientists use hardness and other properties to identify minerals.

Talc, used in talcum powder, is a mineral. Talc is less hard than other minerals. Scientists use the Mohs hardness scale to tell the hardness of minerals. A mineral's hardness refers to how difficult it is to scratch its surface. A mineral can be scratched only by a harder mineral. The softest measure on the hardness scale is 1. The hardest is 10. Talc has a hardness of 1. Diamond is the hardest natural substance known. Its hardness is 10.

## Mohs Hardness Scale



## Other Properties of Minerals

A mineral may have different colors, depending on the kinds of materials in its crystals. For example, pure corundum is colorless. But when its crystals contain small amounts of chromium, it forms ruby, a red gemstone. A mineral's true color can be seen in its streak. The streak is the mark it makes when rubbed against an unglazed ceramic tile.

Just as a fingerprint can identify a crime suspect, the shape of its crystals can help identify a mineral. For example, fluorite crystals are shaped like cubes.

These four mineral samples may look different, but reddish-brown streaks show that all are the same.



Magnetite

Minerals also show particular patterns when they are broken. Many minerals tend to split, or cleave, along flat planes. This splitting is called cleavage. Other minerals do not split. Instead, they fracture, or break, into uneven pieces.

Luster is the appearance of a mineral in reflected light. A mineral may appear metallic or nonmetallic, greasy, glassy, or even waxy. Compare the luster of the quartz with that of corundum.

Some minerals have unusual properties. For example, fluorescent minerals show colors when viewed under ultraviolet (UV) light. A few minerals, such as magnetite, are magnetic.

Several minerals are valuable because they are beautiful or have unique characteristics. Many of these minerals are also rare, which adds to their value. These minerals are often important natural resources. Since natural supplies are limited, scientists often seek ways to reuse minerals or replace them with less expensive materials. For example, aluminum and tin are two minerals that can be recycled. Scientists can make synthetic, or artificial, forms of gemstones such as diamonds, rubies, and emeralds.

1. **✓ Checkpoint** In the hardness scale, which minerals can be scratched by fluorite?
2. A streak plate is an unglazed ceramic tile. How can a streak plate help you identify a mineral?
3. **Social Studies in Science** Minerals are important natural resources. Find out where minerals are mined in the United States. Draw a map that shows these locations. Identify rare minerals.



## Rocks

Most minerals are not found in pure form. Instead they are mixed together in rocks. A **rock** is a solid, natural material made up of one or more minerals. When studying rocks, scientists look at the rock's color and texture. Scientists can use a rock's characteristics to determine where and how it formed.

Rocks may not look very active, but they are always changing. As time passes, rocks break down, and the minerals in them are recycled. This pattern of change is called the rock cycle. The events of the rock cycle take place over millions of years. Study the diagram of the rock cycle to see how the three types of rock—metamorphic, igneous, and sedimentary—are formed.

**Sedimentary rock** is made from pieces of rocks and minerals. It forms in layers, with the oldest rock at the bottom. Because the layers are formed in sequence, sedimentary rock is like a "history book" with past events captured in each layer. Sometimes, the evidence of past events includes fossils, the remains of once-living animals or plants. Fossils are found only in sedimentary rock. An example of sedimentary rock is limestone. Limestone is made from the shells of tiny sea animals or from dissolved minerals that settle out of seawater.

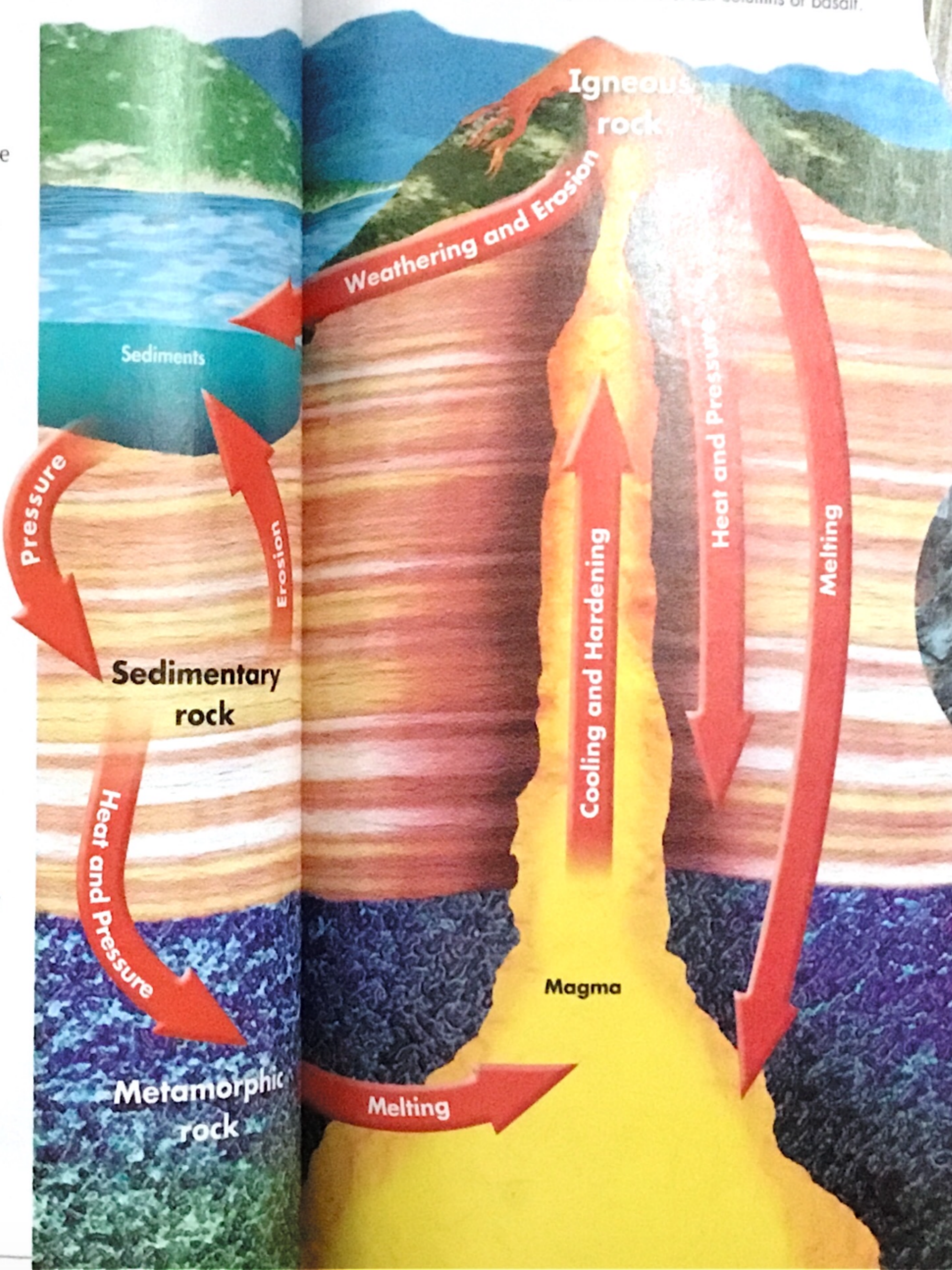
**Igneous rock** forms when magma—the molten rock inside the Earth—cools and hardens. Some igneous rocks harden below Earth's surface and only appear after the rocks above them have worn away. Other igneous rocks form when lava cools at the Earth's surface. When lava cools quickly, fine-grained rock forms. Slowly cooling magma forms coarse-grained rock.

**Metamorphic rock** forms when heat, pressure, or chemical reactions change one type of rock into another type of rock. Metamorphic rock is made from sedimentary rock or igneous rock. For example, marble is a metamorphic rock that is formed from limestone, which is a sedimentary rock.



**Sedimentary rock**  
The Vermilion Cliffs are multicolor sandstone formations in northern Arizona and southern Utah.

## Rock Cycle



### Igneous rock

Basalt is a fine-grained rock made from magma that cooled quickly when it reached the Earth's surface. The Devil's Postpile National Monument in California is named for its 18-meter-tall columns of basalt.



### Metamorphic rock

Gneiss is formed from both igneous and sedimentary rock.



1. **✓ Checkpoint**  
According to the picture, what causes igneous rock to change to magma?
2. **🔍 Compare and Contrast** How are igneous rock, sedimentary rock, and metamorphic rock similar? How are they different?





## The Grand Canyon

A desert was here long ago, and then a sandy beach. Deposits of sand and mud made the sandstones that are here today.

A layer of shale formed from silt deposited by a river.

A layer of sandstone formed when the area was a desert or a beach with deposits of mud and sand.

Layers of limestone and shale were formed when shallow seas covered the land more than 540 million years ago. Limestone layers contain fossils of marine organisms. The deepest limestone layers have the oldest fossils.

At the bottom of the canyon, granites and schists were deposited more than 2 billion years ago.

## Clues to the Past

Did you know that every rock tells a story? Rocks have clues that tell us about past events. For example, a rock with tiny seashells reveals that the area where the rock formed was once an ancient sea. Large rocks may be evidence of a glacier, which left the rocks behind millions of years ago. By looking closely at rocks, scientists can learn a great deal about Earth's history.

Like detectives, scientists collect evidence, study it, and draw conclusions. A lot of evidence can be found in sedimentary rock. Because sedimentary rock forms in layers, scientists know that the oldest layers are at the bottom. Based on this fact, scientists can learn the relative age of each layer and the materials found in it. This method is called relative dating. Relative dating lets scientists place past events in sequential order. But it cannot reveal how long ago each event occurred.

Few places show Earth's story as dramatically as the Grand Canyon of Arizona. The canyon was formed five million years ago when the Colorado River cut through many layers of sedimentary rocks. Today visitors to the Grand Canyon can see more years of Earth's history than anywhere else on Earth. As you can see in the diagram, many layers of rock are exposed. Each layer has evidence of events that took place long ago.

## Fossils

Fossils can form when an organism is buried in soft mud. Most fossils form from hard parts, such as bones, shells, or wood, that do not rot away. When fossils form underwater, minerals dissolved in the water may replace the animal's shell or skeleton and then harden. Burrows and footprints can also be fossilized.

Many fossils were made by species that are now extinct. Scientists have learned when many of these organisms lived. Finding these fossils in a rock can help scientists determine the rock's age. For example, trilobites were hard-shelled, ocean-dwelling animals. They were common about 500 million years ago. When scientists find a trilobite fossil, they know that the surrounding rock formed during this period.


## Space Rocks

Some rocks are formed in outer space. When large rocks survive their trip through space and strike the Earth, they make a giant hole called a crater. Barringer Meteor Crater, a bowl-shaped pit found in the Arizona desert, is about 1.6 kilometers wide and about 180 meters deep. The crater formed when a meteorite hit the Earth 20,000 to 50,000 years ago.



A Petoskey stone is a fossil of marine animals known as corals. Petoskey stones are commonly found in Michigan's Lower Peninsula, which was covered with a shallow sea 350 million years ago.

### ✓ Lesson Checkpoint

1. Why do minerals have geometric shapes?
2. How can rocks help scientists learn about Earth's past?
3.  **Compare and Contrast** How are gold, a mineral, and limestone, a sedimentary rock, alike and different? Use a graphic organizer to write your answer.

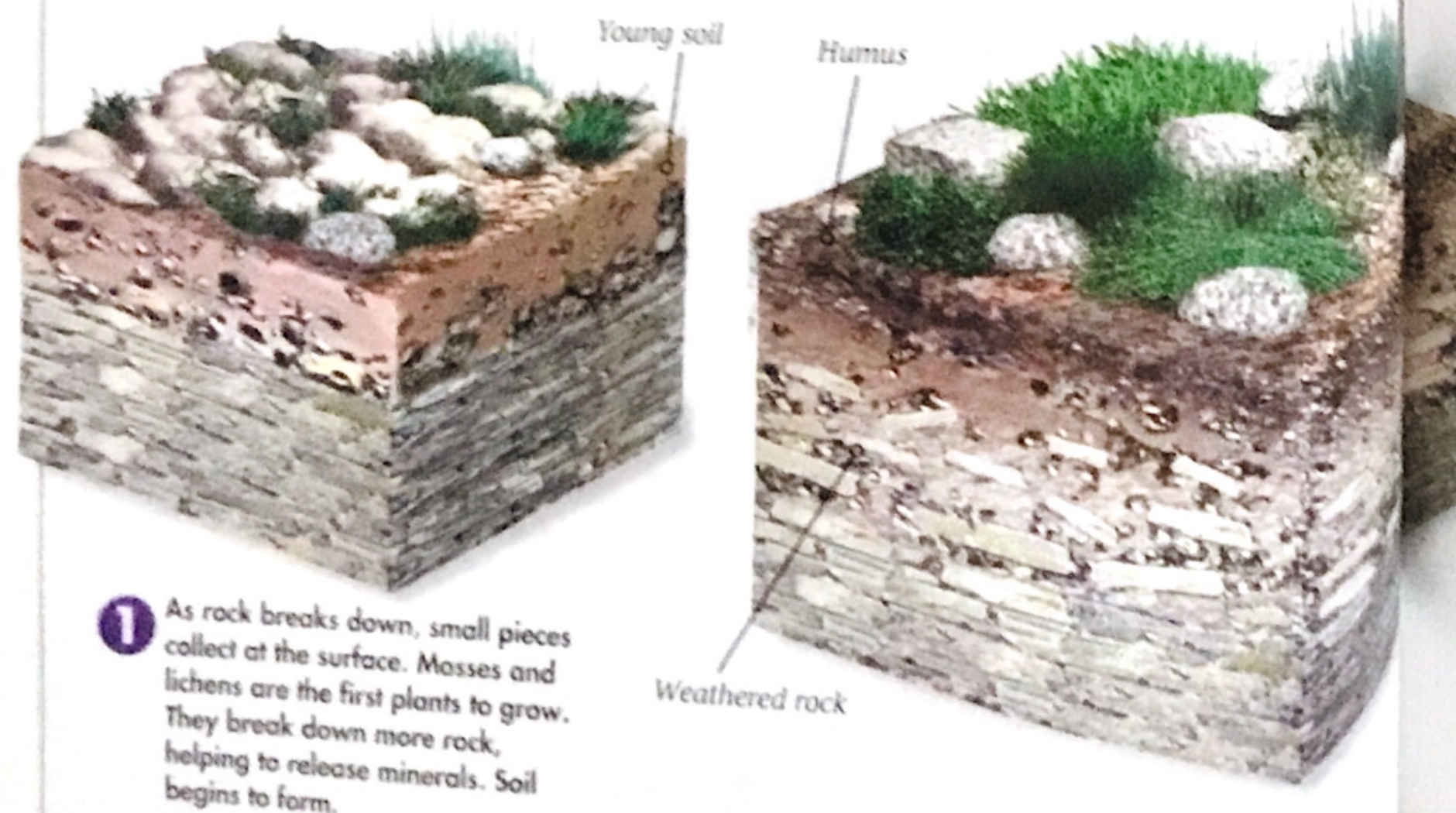


# Why is soil important to living things?

Soil is made of weathered rock, air, water, and the remains of living organisms. Almost all land-dwelling organisms depend on soil for life. Plants obtain water and minerals from soil, and animals need plants for food. Insects and many other small animals live in soil. So do fungi and bacteria that are too small to see.

## Forming Soil

The rock cycle isn't the only process that rocks are part of. They also are part of the process that forms soil. New soil begins when exposed rock begins to break down. This process, called weathering, can be due to physical factors, such as frost, drought, or changes in temperature. Rainwater and the substances dissolved in it also can break down rock. As weathering occurs, rock is broken down into smaller and smaller pieces. Air and water fill the spaces between the pieces of rock. The tiny particles of rock, along with the air and water, are the nonliving, or inorganic, part of soil.



- 1** As rock breaks down, small pieces collect at the surface. Mosses and lichens are the first plants to grow. They break down more rock, helping to release minerals. Soil begins to form.

- 2** As weathering continues, more soil forms. Larger plants appear. Dead plants and animals create humus, which provides nutrients for plants.

As time passes, bacteria, fungi, and plants begin to grow among the particles. When these organisms die, they rot, or decay. **Organic matter** is any substance that is made of living things or the remains of living things. The dark-colored, organic matter formed from decayed plant and animal remains is called **humus**. Humus, the organic part of soil, is rich in nutrients needed by plants.

Soils form in three layers, which can be seen in a soil profile. A soil profile is a vertical cross section of the soil and the rock underneath it. It reveals what is inside the soil. Each layer of soil has a different structure and color. The first layer is the topsoil, a mixture of small rock pieces, humus, and other organic matter. Most of the living things in soil are found in topsoil. Loose organic matter, such as dead leaves and twigs, often covers the topsoil.

Rainwater sinking into the topsoil carries minerals down to the second layer, the subsoil. Subsoil has less organic matter than topsoil, so it is lighter in color. Minerals carried away from the topsoil build up in the subsoil. The third and lowest layer is made up of the parent rock material. There is very little organic matter in this layer.

- ✓ Checkpoint** Why are mosses and lichens sometimes called "pioneer plants"?
- 🔄 Compare and Contrast** How are topsoil and subsoil alike and different?

- 3** A mature soil is home to many kinds of living things. This soil is rich in organic matter and contains many plant roots.





## Kinds of Soils

Most of us think of soil as dark brown and crumbly, but there are many kinds of soils. Clay soils are fine grained and hold water extremely well. When rainfall is plentiful, clay soils can become waterlogged. Silt soils have medium-sized grains. Sandy soils are large grained and hold water poorly. Most soils are a mixture of clay, silt, and sand. Loam is a type of soil that contains silt and sand in roughly equal amounts.

## Factors That Affect Soil

The climate of an area may be the most important factor that determines the type of soil that forms. The weathering that breaks down rock to form soil takes place more quickly in climates with a lot of rainfall and warm temperatures.

In tropical climates, the plentiful rainfall washes minerals out of the topsoil into the subsoil. The result is that tropical topsoil is very thin and not very fertile. In contrast, desert areas receive very little rain, so weathering is slow. The little rain that does fall evaporates quickly. Minerals that were dissolved in the water collect on the soil surface.

The type of soil that forms also depends on the kind of rock from which it forms. The kinds of minerals in the rock affect the characteristics of the soil. For example, reddish soils come from rock with iron-rich minerals. The minerals also can affect the weathering process.

Earthworms help soil formation by mixing the soil and breaking down organic matter.



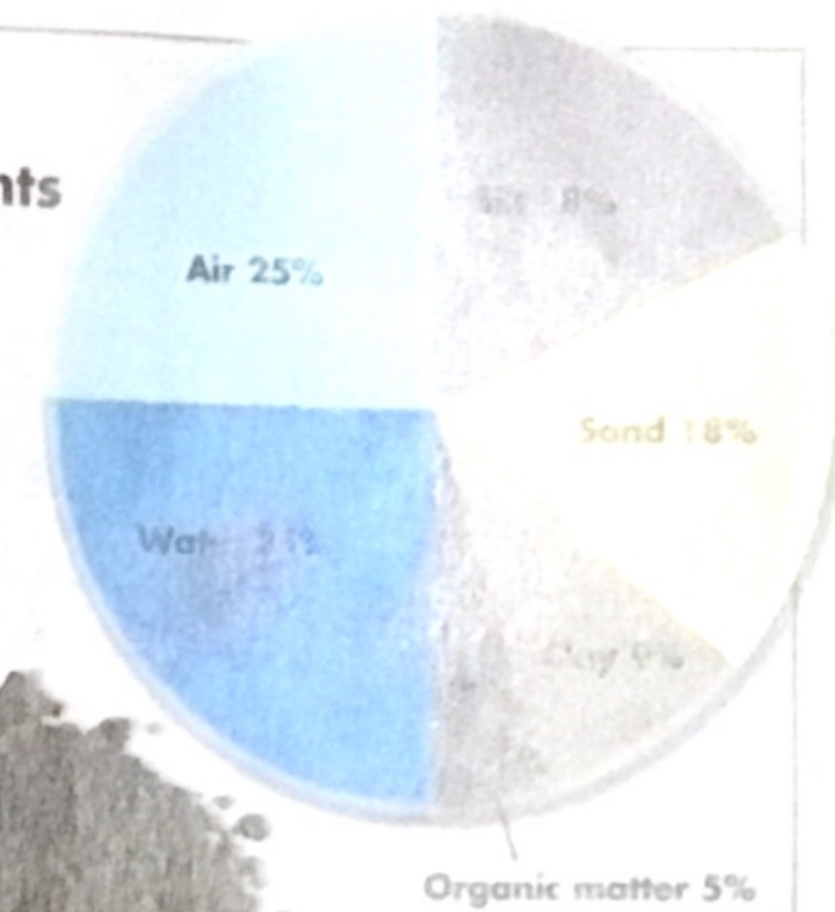
Light-colored sandy soils have little organic matter. They are large grained and drain quickly.



Peat is partly decayed plant material that has been buried and compressed in a swamp. When dried, peat can be burned as fuel.

## Components of Loam

Loam is an ideal soil for plants. It holds water, drains well, and often contains organic matter.



Humus is dark colored. It is formed from decayed plant and animal remains.

Soil color also is affected by the amount of organic matter in it. Soils with more organic matter are darker in color. Forest soils from the eastern United States have a lot of humus and are dark brown. The many leaves that fall from the forest trees every autumn help form the humus. The decaying leaves and plentiful rainfall form a thick, fertile soil. Tropical soils, which have little humus, are lighter in color.

Another factor that affects soil formation is the shape of the land. Mountains usually have thin layers of topsoil because much of the soil is eroded from their slopes. Land that is flat usually has a thick layer of topsoil.

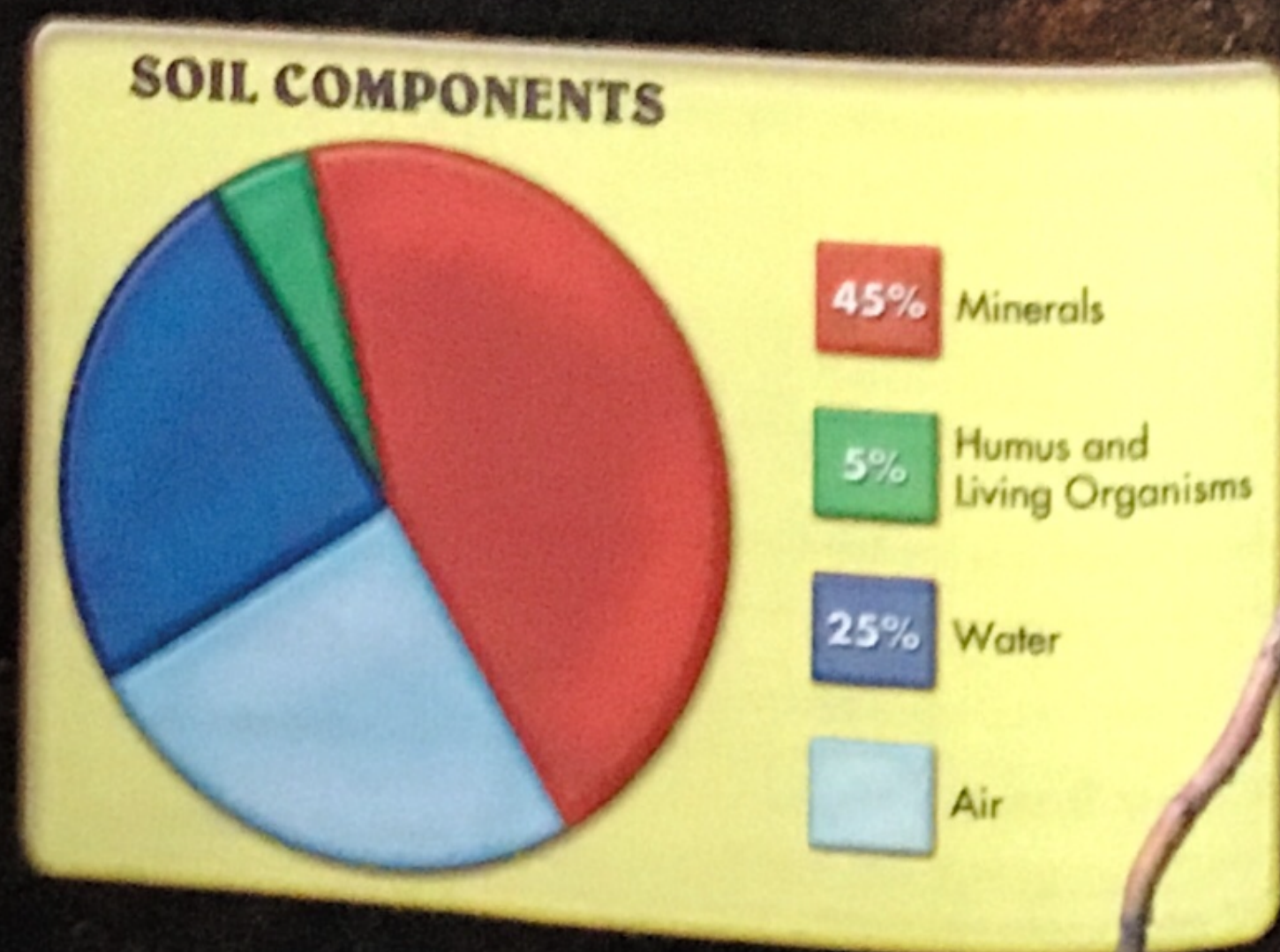
## ✓ Lesson Checkpoint

1. How are humus and organic matter related?
2. **Compare and Contrast** How do clay soils differ from sandy soils?
3. **Writing in Science Persuasive** Write an advertisement for an ideal soil for growing plants.



# FRACTIONAL PARTS of SOIL

Soil, which we often refer to as dirt, is one of our most important resources. Plants, which provide food, oxygen, and many other things for us, require soil for nutrients. Without soil, life on Earth would be impossible, yet soil is made up of common materials. The circle graph on this page represents the components of a typical sample of soil. Humus is the part of the soil that comes from decayed plant and animal remains.



Use the circle graph to answer these questions.

1. It may surprise you that air is a major component of soil. What percent of the soil sample shown in the graph is air? What percent is not air?
2. What fraction of this soil is made up of air and water together? of minerals and water?
3. A square raised garden measures 2 m on each side and is 15 cm deep. About what volume of minerals would be in the soil needed to fill the raised bed if the soil matches the sample used in the circle graph? What volume of humus and living organisms would be in it?
4. It is estimated that more than 22 trillion, 727 billion kg of soil is lost per year, worldwide, due to erosion. Write this number in standard form and in scientific notation.
5. Minerals in the soil are sometimes classified by size. Silt particles are between  $4 \times 10^{-3}$  mm and  $6 \times 10^{-2}$  mm in diameter. Would a clay particle that is 0.003 mm in diameter be larger or smaller than a silt particle? Explain.

Lab  
zone

## Take-Home Activity

Find a potted plant or an empty pot. Estimate the volume of soil the pot would hold. Remember to include units. Potting soil is sometimes sold in cubic yards. Find out how many pots of this size you could fill with 1 cubic yard of potting soil.



# Chapter 9 Review and Test Prep

## Use Vocabulary

<b>crystal</b> (p. 247)	<b>mineral</b> (p. 247)
<b>humus</b> (p. 255)	<b>organic matter</b> (p. 255)
<b>igneous rock</b> (p. 250)	<b>rock</b> (p. 250)
<b>metamorphic rock</b> (p. 250)	<b>sedimentary rock</b> (p. 250)

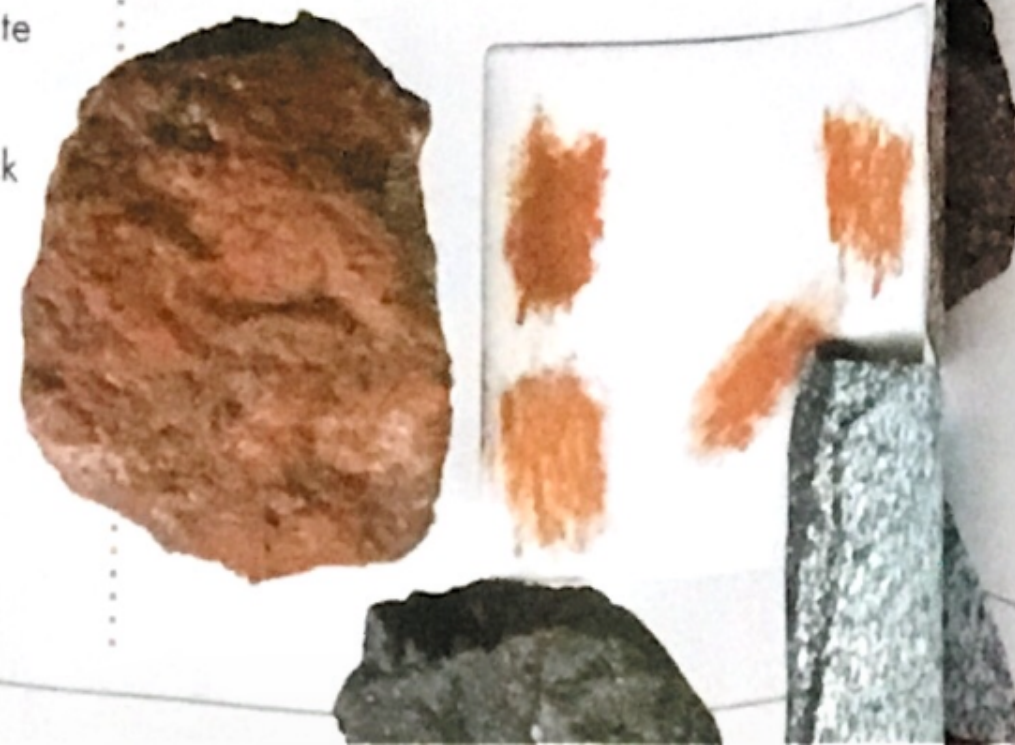
Write the term from the list above that best matches each phrase.

- Any substance that is made of living things or the remains of living things
- A nonliving, naturally occurring solid with a definite chemical structure
- Rock that is made from pieces of rocks and minerals
- Formed from one or more minerals combined
- Rock that forms from molten rock that has cooled and hardened
- The dark-colored matter formed from decayed plant and animal remains
- A naturally formed solid with a definite internal pattern
- Rock that forms when one type of rock changes into another type of rock

## Explain Concepts

- Describe four characteristics that can be used to identify minerals.
- Describe the three layers found in a soil.
- Use the information in the table to identify the mineral shown in the picture below.

	Hematite	Feldspar	Topaz
<b>Hardness</b>	6.5	6.0–6.5	8
<b>Cleavage</b>	none	breaks along two surfaces	breaks along all sides
<b>Fracture</b>	curved	uneven	brittle, uneven
<b>Streak</b>	brownish-red	white	white
<b>Appearance</b>	dull brown, brownish red, red, grey, or black	many colors	gold-yellow, green, or cream



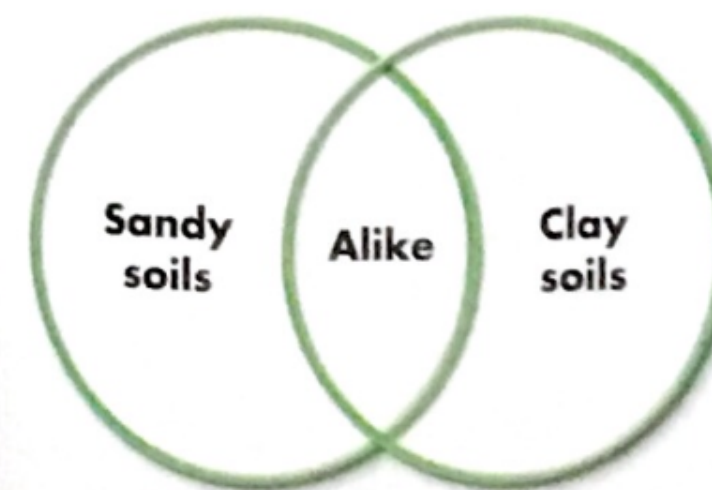
- Industrial diamonds are found in drills, rock-cutting saws, and metal-cutting tools. Explain why diamonds are used to make these items.

## Process Skills

- Predict** Mosses and lichens begin growing on bare ground in pieces of weathered rock. Predict what will happen next and explain why.
- Model** Sedimentary rock forms in layers. Make a model to show why this is so.

## Compare and Contrast

- Make a graphic organizer like the one shown below. Fill in the correct information to show how sandy soils and clay soils are alike and different.



## Test Prep

Choose the letter that best completes the statement or answers the question.

- Marble is formed from limestone that is heated under pressure deep within the Earth. What kind of rock is marble?
  - Ⓐ metamorphic
  - Ⓑ sedimentary
  - Ⓒ volcanic
  - Ⓓ igneous
- Which soil layer is least similar to the underlying rock?
  - Ⓐ subsoil
  - Ⓑ topsoil
  - Ⓒ humus
  - Ⓓ parent rock
- In the Grand Canyon, the oldest fossils are found
  - Ⓐ on the surface of the ground.
  - Ⓑ in the uppermost layer of rock.
  - Ⓒ in the middle layers of rock.
  - Ⓓ in the lowest layers of rock.
- Explain why the answer you chose for Question 16 is best. For each of the answers you did not choose, give a reason why it is not the best choice.
- Writing in Science** **Descriptive** Suppose that you have been given a sample of an unknown mineral. Write a paragraph describing the steps you would take to identify the mineral.