18.3 The Rock Cycle

You have read that rocks and layers tell stories about Earth's history. A **rock** is a naturally formed solid made of one or more minerals. In this section, you will first learn about the minerals that make up a rock, and then about a special set of processes called the rock cycle.

VOCABULARY

rock - a naturally formed solid made of one or more minerals.

mineral - a solid, naturally occurring, crystalline object with a defined chemical composition.

Rocks are made of minerals

What is a mineral?

A **mineral** is a solid, naturally occurring, inorganic object with a defined chemical composition. Minerals have a crystal structure, which means they have an orderly arrangement of atoms. Minerals can be made of one or more elements. Graphite and diamonds, both made only of carbon, have different properties because they have different crystalline structures (Figure 18.14).

Minerals in Earth's crust

There are more than 4,000 minerals on Earth. Eight of these minerals make up about 98 percent of Earth's continental crust by weight. Feldspar and quartz are the two most abundant minerals. As silicate minerals, feldspar and quartz mostly contain silicon and oxygen, the two most abundant elements in Earth's crust (Figure 18.15).

How are minerals made?

Minerals are made by geologic processes. One process is the cooling of molten rock inside Earth. Granite, for example, is a rock that forms underground as molten rock cools. As cooling takes place, different minerals crystallize. You can see these individual mineral crystals in the photo of a piece of granite at the left. Another process that allows minerals to form or crystallize is when water containing dissolved minerals evaporates.

Minerals help tell the story

The crystalline structure and chemical composition of a mineral is determined by the conditions under which it forms. Additionally, existing minerals can change due to heat, pressure, or chemical reactions. When the minerals change, the rock that is made up of the minerals also changes.

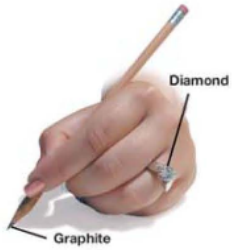


Figure 18.14: *Diamonds and graphite are minerals that are made of carbon.*

Approximate percentage by weight of elements in Earth's crust	
oxygen	46.6%
silicon	27.7%
other minerals	25.7%

Figure 18.15: *Oxygen and silicon are the two most abundant elements in Earth's crust.*

Common minerals and cleavage planes

Mica Mica is composed of silicon and oxygen along with iron, magnesium, and sodium. A piece of mica has layers, like a stack of pages in a book. Each single layer of mica is described as having one direction of cleavage or one set of cleavage planes. A cleavage plane is a surface along which a mineral cleanly splits. The placement of a cleavage plane occurs where there are weak bonds between the molecules in the mineral (Figure 18.16).

Feldspar and hornblende Feldspar is the most abundant mineral in Earth's crust. Feldspar is composed of silicon and oxygen along with sodium, calcium, and potassium. Feldspar has two cleavage planes at right angles to each other. Hornblende, also found in granite, is a dark mineral made of a mixture of elements including silicon, oxygen, and calcium along with iron, magnesium, or aluminum. Like feldspar, hornblende has two cleavage planes, but not at right angles.

Quartz Quartz is the second most abundant mineral in Earth's crust. Quartz crystals can appear to shine like glass. Unlike feldspar, quartz lacks cleavage planes (Figure 18.17). When quartz breaks, it does not split along planes. Quartz is made of silica and is used in making glass. Many gemstones are simply quartz with trace amounts of other elements or compounds mixed in. For example, onyx, agate, and amethyst are gemstones formed in this way.

VOCABULARY

cleavage plane - a surface along which a mineral cleanly splits.

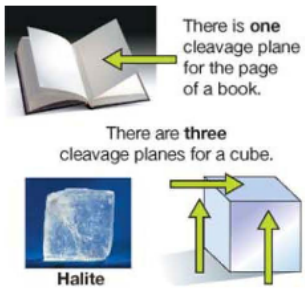


Figure 18.16: *Mica has one direction of cleavage and breaks into sheets. The mineral halite has three directions of cleavage and breaks into cubes.*

Figure 18.17: *Quartz is a mineral in granite. It lacks cleavage planes.*

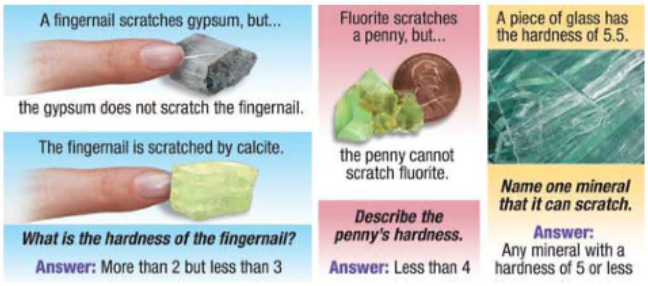
Mohs hardness scale

Identifying minerals

Mohs hardness scale was developed in 1812 by Friedrick Mohs (1773–1839), an Austrian mineral expert, as a method to identify minerals (Figure 18.18). This scale uses 10 minerals to represent variations in hardness. Here, the word *hardness* means resistance to being scratched. You can identify a mineral's place on the scale by whether it can scratch another mineral. For example, gypsum (hardness = 2) scratches talc (hardness = 1). The hardest mineral, diamond, can scratch all other minerals. Minerals of the same hardness (and without impurities) scratch each other.

Common items test hardness

You can use common items to test the hardness of a mineral. For example, your fingernail, a penny, a steel nail, or glass can be used. The following scenarios illustrate how to use Mohs hardness scale.



Streak plate test

Sets of minerals often come with a white, unglazed, ceramic streak plate or tile. You can identify certain minerals by scratching them on the streak plate. The color of the streak they leave behind can help you identify the mineral. For example, both pure gold and pyrite (also called Fool's Gold) are gold-colored minerals (Figure 18.19). Gold is rare and valuable. It leaves a golden-yellow streak. Pyrite is shiny, brassy, and a common mineral. It could be mistaken for gold, but it leaves a gray or black streak on a streak plate!

VOCABULARY

Mohs hardness scale - a scale used to identify minerals based on their hardness or resistance to being scratched.

Mineral	Hardness
talc	1
gypsum	2
calcite	3
fluorite	4
apatite	5
orthoclase (feldspar)	6
quartz	7
topaz	8
corundum	9
diamond	10

Figure 18.18: *Mohs hardness scale.*

Gold photo courtesy David John, USGS.

Figure 18.19: *Gold and pyrite.*

Rock groups

Three groups Now, that we have learned about minerals, let's learn about rocks. All rocks on or below Earth's surface belong to one of three groups, depending on how the rock formed.

Rock Group	Formation
Igneous	These rocks form when molten rock (lava or magma) cools and crystallizes.
Sedimentary	Particles of other rocks and minerals or once-living things are moved by water, wind, ice, or gravity and eventually settle in layers. The layers are compacted and cemented to form a new rock.
Metamorphic	These rocks form from other rocks that are changed by heat and pressure.

Rocks are made of old material Like the other planets, Earth was formed from the gas and dust that surrounded the Sun when it formed. Earth has gone through many changes since it formed 4.6 billion years ago. The rocks that are currently on our planet's surface are made of material that formed long ago. The oldest rocks found on Earth so far are approximately 4 billion years old. However, some rocks are "young." A young rock might be a million years old! The presence of young rocks on Earth suggests that old rocks have been recycled.

The original recycling plan Earth has been recycling material for billions of years and the rock cycle is the original recycling plan. The **rock cycle** (or geologic cycle) describes how rocks are formed and recycled by geologic processes. Igneous, sedimentary, and metamorphic rocks are all part of this cycle.

VOCABULARY

rock cycle - the formation and recycling of rocks by geologic processes.

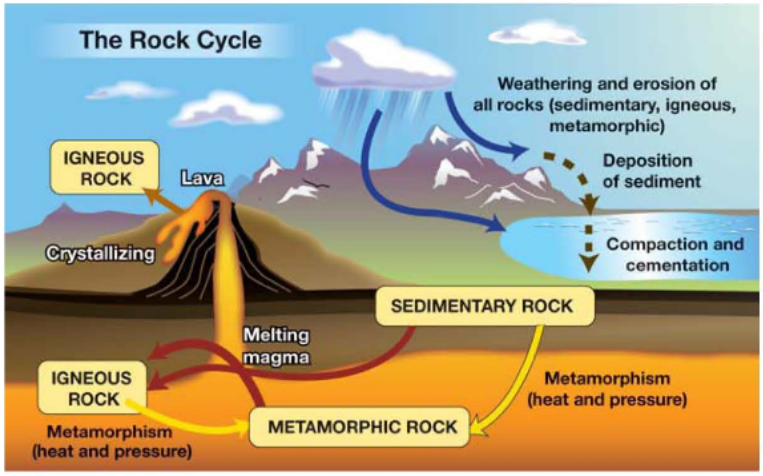
SOLVE IT!

Use the definition of a mineral to answer the following questions.

1. Is ice a mineral? Why or why not?
2. Is coal a mineral? Why or why not?

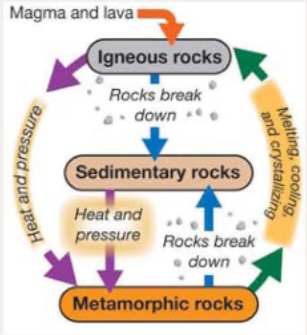
Rocks keep moving

The processes that keep rock material moving through the rock cycle include weathering, erosion, deposition, compaction and cementation, metamorphism, and melting and crystallizing. Weathering and erosion are ways in which rock is broken down and the pieces are moved from place to place. Compaction and cementation are processes which cause pieces of rock to become a sedimentary rock. You will learn more about the processes involved in forming sedimentary rocks in Chapter 23. When lava or magma cools, it forms crystals in a process called crystallization. Processes involving igneous rocks are explained in Chapter 20. Additionally, an important and fascinating geologic process—plate tectonics— plays an important role in the rock cycle. Rocks melt or metamorphose when subjected to heat and/or pressure. For example, the pressure between two pieces of Earth's crust that are coming together can create mountains of folded rock. If new mountains weren't always being built, the weathering and erosion of rocks over time would leave the continents smooth and flattened. You will learn about plate tectonics and metamorphic rocks in Chapter 19.



A Cycle with Many Pathways

The rock cycle does not always follow a simple path with igneous rocks forming first followed by sedimentary then metamorphic rocks. An igneous rock could become a metamorphic rock or a metamorphic rock could melt and crystallize to become igneous. All rocks will break down over time and might become part of a sedimentary rock. The important thing to remember is that the rock cycle allows material to keep changing form and moving from place to place on Earth.



Section 18.3 Review

1. Describe the difference between an element, a mineral, and a rock.
2. Is a diamond a rock or a mineral? Explain your answer.
3. List the two most abundant elements and the two most abundant minerals in Earth's crust.
4. Why are minerals an important part of the story of a rock?
5. The mineral halite naturally forms cubes. How many directions of cleavage does it have?


Halite
(sodium chloride)

6. What does the word *hardness* mean in reference to the Mohs hardness scale?
7. Use Mohs hardness scale (Figure 18.18) to answer the following questions.
   a. A mineral scratches talc and gypsum. This mineral does not scratch fluorite. What is the Mohs hardness of this mineral?
   b. A mineral scratches topaz and quartz, and is scratched by diamond. What is the Mohs hardness of this mineral?
   c. A steel nail scratches apatite but not quartz. What might be the hardness of a steel nail?
   d. Which mineral scratches all other minerals?
8. How does a streak plate test help identify a mineral?
9. Based on the reading, list one feature that you could use to identify each of the three groups of rocks.
10. What kind of rock is granite? Justify your answer.
11. Does the rock cycle have a beginning point and an ending point? Explain your answer.
12. True or false: Metamorphic rocks could be made from sedimentary and igneous rocks, but not from other metamorphic rocks?
13. A rock is 500,000 years old. Would you classify this rock as young or old? Explain your answer.

More Mineral Tests

You can identify a mineral using cleavage planes, a streak test, and the Mohs hardness scale. Following are some additional tests that geologists use to identify minerals.

Density: The density of the mineral is measured in g/cm^3. Some minerals are dense and heavy for their size. Others are less dense and light weight for their size.

Luster: Luster is how a mineral reflects light. Metallic minerals (like pyrite) are shiny. Nonmetallic minerals can appear dull or glassy (reflect light the way glass does).

Magnetism: Some minerals (like magnetite) are magnetic.

Acid test: Some minerals bubble and produce gas by reacting with dilute hydrochloric acid.


Pyrite has a metallic luster.