Earth Materials

UNIT 2

Student Reader

Front Cover:

The front cover shows a photograph of lava erupting out of a volcano. Volcanoes occur as a result of the movement of tectonic plates.

 ©2016 KnowAtom™

Unit 2: Earth Materials

Table of Contents

 ©2016 KnowAtom™

1 Earth's Minerals

The Hope Diamond

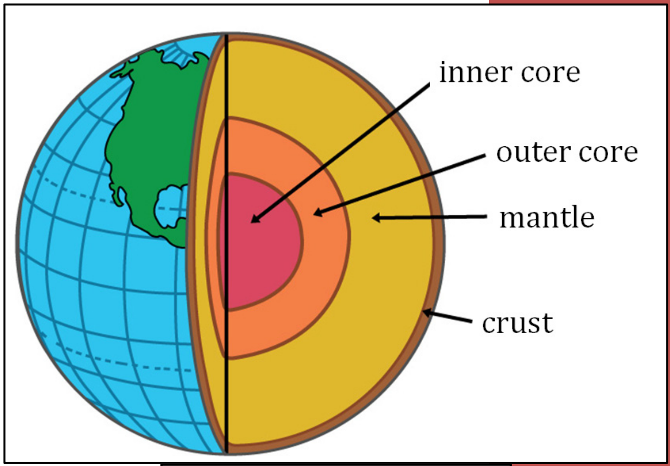
A museum in Washington, D.C., holds the world's largest deep blue diamond. This 45-carat blue diamond is the size of a walnut. It is called the Hope Diamond.

The Hope Diamond is on display at the Smithsonian Museum in Washington, D.C.

The Hope Diamond has long fascinated humans. More than 100 million people have visited the museum to see the diamond. It was first discovered in India in the 1600s, but its history goes back far beyond that. Scientists believe it is at least 1 billion years old and was formed so deep inside Earth that humans cannot travel there.

 ©2016 KnowAtom™

How Diamonds Form



Earth's layers

All diamonds are formed deep within Earth, at least 161 kilometers (100 miles) below the surface. They can only form under tremendous heat and pressure. This heat and pressure are a result of Earth's structure.

The center of Earth is a solid ball of metal iron and nickel. It is called the inner core. The core is 7,000 degrees Celsius, hotter than the surface of the sun. The outer core wraps around the inner core and is made of liquid iron and nickel.

The mantle is located around the outer core. The mantle is Earth's thickest layer. Imagine an apple. The core of the apple is like Earth's core, and the fleshy part that you eat is like the mantle. Earth's mantle is an ocean of semi-solid rock called magma. It is here where diamonds are formed.

Earth's "skin" is its crust. The solid crust is the coolest layer of the planet that forms the continents and holds the oceans.

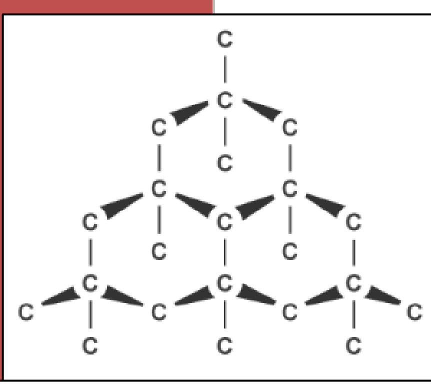
Diamonds Are Minerals

Diamonds are made mostly of a single element—carbon. The heat and pressure of Earth's interior caused the carbon atoms to join together in a way that result in the unique physical properties of diamonds.

Diamonds are minerals. Scientists have found more than 3,000 minerals, made up of different combinations of elements.

All **minerals** are naturally occurring, which means they are not made by humans. They would exist on Earth without people.

Minerals are also inorganic because they are not the product of something that is living or was once alive. (Leaves and shells are organic because they come from something that was once alive.)



a diamond's crystal structure of carbon atoms

They also have a definite chemical composition. This means that every mineral is made up of the same kind and number of atoms. For example, diamond can always be described by the chemical formula of C since it is made of carbon atoms. Lastly, minerals have an orderly crystal structure. This means their atoms are neatly organized to form a repeating pattern.

 ©2016 KnowAtom™

Identifying Minerals

One of the reasons that people are drawn to the Hope Diamond is its color. Blue diamonds are very rare. They are blue because they have traces of the element boron combined with the carbon atoms. Diamonds come in many different colors, including red, yellow, green, purple, and brown. Color is one property that scientists use to identify minerals.

In addition to color, there are many other property tests that scientists can do to identify a mineral. For example, scientists were fascinated to discover that the Hope Diamond gives off a fiery red glow after it has been exposed to ultraviolet (UV) light. This is called phosphorescence.

Scientists have learned that all natural blue diamonds glow red for about five minutes after being exposed to UV light. However, blue diamonds created by humans give off different colors. Because of this, phosphorescence helps scientists determine whether a blue diamond is real or fake.

Other diamonds do not phosphoresce. Instead, they fluoresce, which means they give off light only as long as UV light is shined on them.

One of diamond's most well-known properties is it hardness. Hardness is a measure of a mineral's resistance to scratches. Mineralogists use a 1-10 hardness scale called the Mohs scale. Talc is a 1, which means it is very soft. Diamond, in contrast, is a 10, making it the hardest naturally occurring mineral. It is so hard that only another diamond can scratch it. Its hardness is caused by the way that the carbon atoms join together.

This is a blade that has diamonds in the metal.

The hardness of diamonds makes them useful for different applications. For example, they are used in cutting tools for military materials such as airplane parts and armor.

Most diamonds are also excellent electrical insulators. This means that they do not conduct electricity. Conductivity is tested by placing the mineral in a circuit and seeing if it conducts electricity. However, blue diamonds such as the Hope Diamond are semiconductors. Depending on what other molecules are around, semiconductors can sometimes conduct electricity. Blue diamonds can sometimes conduct electricity because boron is a semiconductor.

Diamonds are also excellent thermal conductors. This means they conduct heat. This explains why diamonds feel cold to the touch.

 ©2016 KnowAtom™

Scientists rarely rely on just one property test when they are identifying a mineral. Many minerals share some of the same physical properties, including color and hardness. However, when many of a mineral's properties are examined, it often results in a unique set of properties that can be used to correctly identify the mineral.

This diamond has a high luster because its surface reflects light.

For example, in addition to hardness and conductivity, scientists look at a mineral's luster. Luster is the way light reflects off of the surface of a mineral, and how bright, dull, or greasy the mineral appears.

Luster falls into two categories: metallic and nonmetallic. Cut diamonds often have a metallic luster. This gives them a brilliant, freshly polished look. In contrast, uncut diamonds can have a greasy or dull luster.

Pure diamonds are also the most transparent known material. Transparent substances allow light to pass through. Pure diamonds are rare, however. Some non-pure diamonds are translucent, which means they allow some light through and absorb some light. Opaque diamonds absorb all light.

Name: ____Date: _____________________

Mineral Properties Investigation

Can minerals be identified based on their physical properties? Use the materials at each test station to carry out the procedure below to investigate the question.

Test Stations

- #1 Streak Station
- #2 Hardness Station
- #3 Magnetism Station
- #4 Conductivity Station
- #5 Fluorescence Station
- #6 Color Station
- #7 Luster Station
- #8 Transparency Station

Procedure

1. Collect 1 of the 14 numbered minerals. Circulate through the test stations and use the directions listed on the template at each station to record the physical properties of the mineral in Table 1: Mineral Properties. When completed, return the mineral to the pick-up station for another team to use.
2. Repeat Step 1 for the remaining minerals in the set.
3. Use the Mineral Identification Tables A, B, and C, along with the mineral properties you recorded in Table 1, to identify the name of each mineral. Once you've identified the mineral, record its name in the last column of Table 1: Mineral Properties.

 ©2016 KnowAtom™

Table 1: Mineral Properties									
Mineral #	Luster	Streak	Hardness	Magnetism	Conductivity	Florescence	Color	Transparency	Mineral
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

 ©2016 KnowAtom™

Mineral Identification Tables

Table A: Metallic Minerals			
Luster	**Hardness**	**Other Physical Properties**	**Mineral Name**
Metallic	Harder than Glass	light to dark gold color; tarnishes brown to green; gray-black streak; hardness = 6–6.5	pyrite
		dark-gray to black color, with copper flecks; black-dark grey streak; hardness = 6; magnetic	magnetite
	Softer than Glass	copper to dark brown in color; tarnishes to green-black; gray-black streak; hardness = 2.5-3; conducts electricity	copper
		dark grey color; dark grey/black streak; hardness = 1-2; conducts electricity	graphite
		silvery grey or black color; white to brown streak; hardness = 3.5-4; slight odor of sulfur	sphalerite

Table B: Nonmetallic (Dark) Minerals			
Luster	**Hardness**	**Other Physical Properties**	**Mineral Name**
Nonmetallic (dark)	Softer than Glass	green, blue, brown and/or gray; greenish-brown streak; hardness = 3.5-4.0	malachite
		black, dark green, or dark brown; white to gray streak, flakes off in thin sheets; fragile; hardness = 2.5-3	biotite (mica)
		dull red color; reddish-brown streak; earthy appearance; hardness = 1.5-5.5	hematite

 ©2016 KnowAtom™

Table C: Nonmetallic (Light) Minerals			
Luster	**Hardness**	**Other Physical Properties**	**Mineral Name**
Nonmetallic (light)	Harder than Glass	white, gray or pink color; white streak; may faintly fluoresce in UV light; translucent; hardness = 7	quartz
	Softer than Glass	colorless to yellow, blue, green, or purple; transparent to translucent; white streak; fluoresces in UV light; hardness = 4	fluorite
		white or colorless; white streak; transparent or translucent; may faintly fluoresce in UV light; hardness = 3	calcite
		colorless or white; white streak; transparent or translucent; hardness = 2.5	halite
		can appear white, gray, or gray brown; white or pale green streak; pearly luster; hardness = 1	talc
		bright yellow to yellow brown color; white or yellow streak; strong odor; feels greasy; hardness = 1.5-2.5	sulfur

Section 1 Review

Reading Comprehension Questions:

1. What is the main idea of Section 1?

2. What key details does the text provide to support the main idea of the text?

3. On page 5, the text includes a diagram of Earth's internal structure. What is the relationship between diamonds and Earth's internal structure?

4. How does the text use evidence to support the claim that a mineral's properties are a result of its atomic structure?

5. Identify a quote from the text that answers the question: "Why do scientists use multiple properties to identify a mineral?"

 ©2016 KnowAtom™

Erupting Volcanoes

People cannot travel to Earth's interior. The deepest any machine has drilled into the planet is 12 kilometers (7 miles). We can only see diamonds that have been carried from the mantle to Earth's surface by volcanic eruptions.

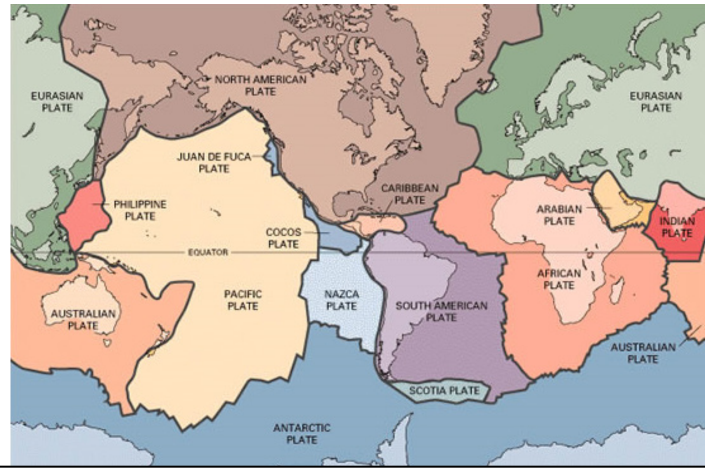
a volcano erupting

Volcanoes are structures formed around a hole in Earth's crust that releases magma. Magma that reaches the surface during an eruption is called lava. Lava is liquid rock that turns into solid rock as it cools. The magma carries diamonds with it.

Scientists believe that the kinds of volcanoes that brought diamonds to the surface don't occur anymore. Scientists think this is because Earth used to be much hotter. This resulted in volcanic eruptions that were very explosive. The erupting magma carried the diamonds, which had already formed, from the mantle to Earth's surface very quickly—traveling 48-64 kilometers (30-40 miles) per hour.

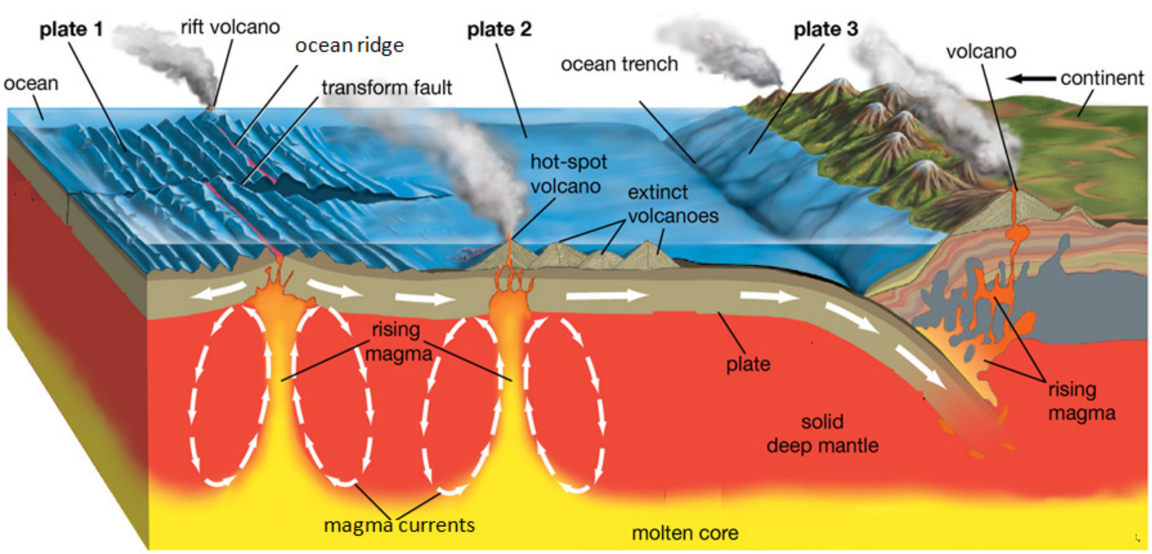
Moving Plates

Volcanoes happen because Earth's crust is broken into drifting slabs of solid rock called **tectonic plates**. The plates cause Earth's surface to look like a jigsaw puzzle.



tectonic plates (shown here in different colors) beneath the continents

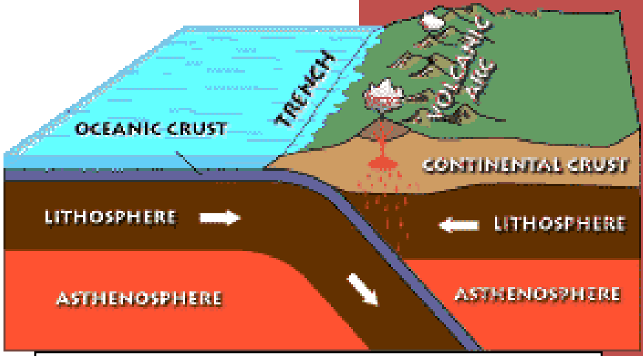
Heat from Earth's core causes the semi-solid rock of Earth's mantle to rise and fall like ocean tides. As magma moves beneath the crust, it pushes the tectonic plates toward or away from each other. The places where Earth's tectonic plates meet are called fault lines.



©2016 KnowAtom™

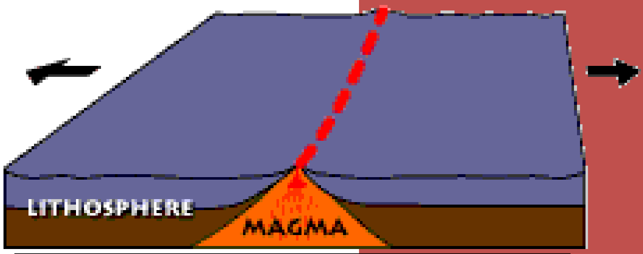
Plate Boundaries

The different movements of the tectonic plates change the surface of Earth. When two plates move toward one another perpendicular to the fault line, they form a convergent boundary. When two tectonic plates collide at a convergent boundary, the force is very powerful. It can cause the land to be uplifted, forming mountain ranges and volcanoes, as well as earthquakes.



convergent plate boundary

Sometimes two plates move apart from one another perpendicular to the fault line. These plates form a divergent boundary. This movement can create ocean trenches, valleys, earthquakes, and places where magma wells up onto Earth's surface.



divergent plate boundary

Transform boundaries are formed when two plates slide past each other in parallel, grinding along their sides as they go. This motion can cause earthquakes.

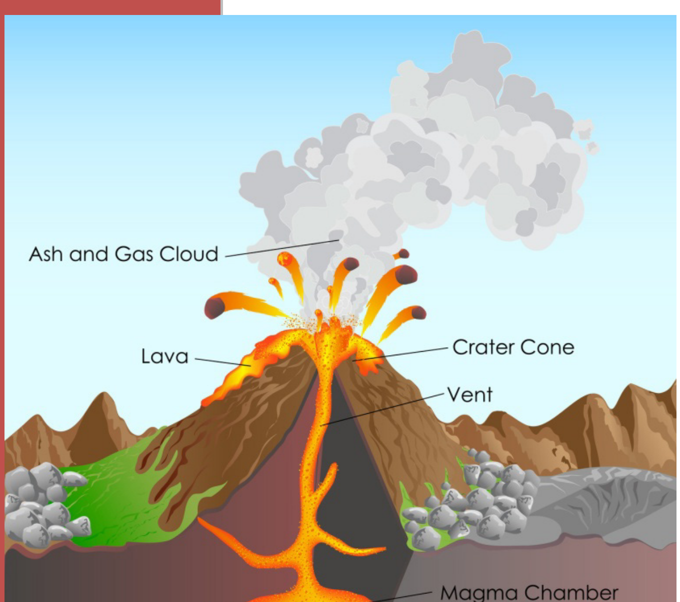
transform plate boundary

Active Volcanoes

Volcanoes form because of Earth's tectonic plates.

Sometimes, the movement of the tectonic plates causes holes, called vents, to open up in Earth's crust. The vents allow magma from the mantle to seep through. This is how volcanoes form.

Volcanoes can be active, dormant, or extinct. It depends on how close the crack in Earth's surface is to an available pool of magma in the mantle, called the magma chamber. An active volcano erupts at least once every 10,000 years. A dormant volcano hasn't erupted in the past 10,000 years, but is expected to again. An extinct volcano is expected to never erupt again. A volcano can become dormant or extinct if the movement of tectonic plates carries it away from its source of magma.



anatomy of a volcano

 ©2016 KnowAtom™

Landforms Patterns

The majority of landforms on Earth's surface have formed because of the movement of the tectonic plates. Because of this, mountains, valleys, and volcanoes are common at fault lines.

Earthquakes are also common at fault lines. If two plates get stuck together, they build up energy until they can break apart. Earthquakes are the vibrations felt when tectonic plates gather enough energy to move past one another.

Earthquakes occur all over the world at all three kinds of plate boundaries: convergent, divergent, and transform. Volcanoes are most common along divergent and convergent boundaries.

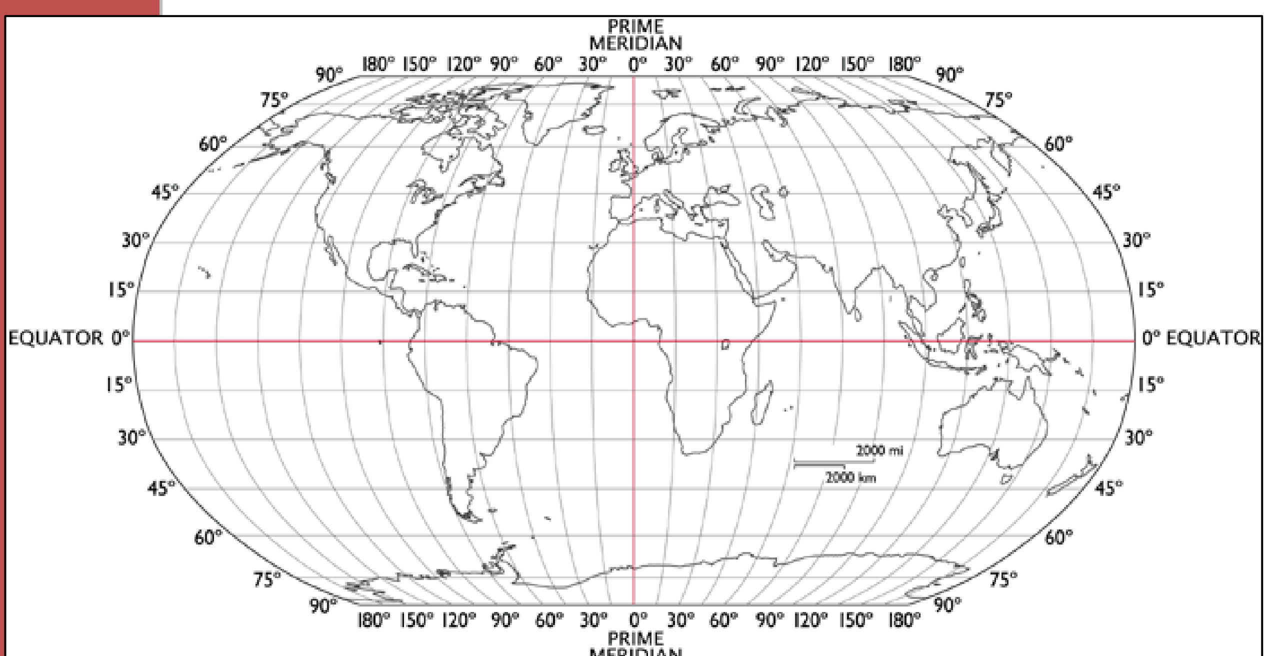
One of the most well-known plate boundaries encircles the Pacific Ocean. It is often called the Ring of Fire because so many earthquakes and volcanic activity occurs here. The Ring of Fire has more than 450 active volcanoes.

Mapping Patterns

Geologists use maps to make sense of the data they collect about Earth's surface. Every location has a set of two coordinates that meet at a specific point on Earth: latitude and longitude.

Horizontal latitude lines mark how far a point is north or south of the equator. Vertical longitude lines mark how far a point is east or west of the prime meridian.

Latitude and longitude lines help scientists identify specific locations on Earth. For example, they can use the latitude and longitude points of specific volcanoes to see whether any patterns emerge in the locations.



 ©2016 KnowAtom™

Name: ______________________________ Date: ________________

Earth's Surface Features Investigation

How do Earth's features (earthquakes and volcanoes) relate to the location of Earth's tectonic plates? Use the materials and procedure to investigate the question.

Procedure

1. Use a colored pencil and the latitude and longitude coordinates in Table 1 to plot the location of each earthquake on the blank world map template.
2. Repeat Step 1, this time with a different colored pencil to plot the location of each volcano.
3. Create a legend/key for the earthquakes and volcanoes on the map.

Table 1: Coordinate Data			
Earthquakes		Volcanoes	
° Latitude	° Longitude	° Latitude	° Longitude
40N	120W	60N	150W
5S	110E	35S	70W
4S	77W	45N	120W
23N	88E	15N	61W
14S	121E	20N	105W
28N	34E	0	75W
45S	168E	40N	122W
52N	175E	40N	30E
45N	10E	30N	60E
13N	85W	55N	160E
23N	125E	3S	37E
35N	30E	40N	145E
35N	140E	10S	120E
46N	12E	41N	14E
28N	75E	5S	105E
61N	150W	15N	35E
35N	110W	30S	70W

 ©2016 KnowAtom™

Analyze the maps

1. Describe any patterns you noticed in the locations of earthquakes and volcanoes relative to the continents on your world map template.

____

____

____

____

2. Place the Tectonic Plates Map transparency sheet over your world map template so the edges of the two maps line up. Describe any patterns you notice in the location of earthquakes and volcanoes relative to the tectonic plates.

____

____

____

____

3. Describe any relationships you notice between the direction of plate movement and the locations of earthquakes and volcanoes on the overlapping blank world map template and tectonic plates transparency map.

____

____

____

____

____

 ©2016 KnowAtom™

Section 2 Review

Reading Comprehension Questions:

1. What are two main ideas of Section 2, and how are these ideas supported by key details?

2. How does the text describe the Ring of Fire? What can you infer from this description about how often Earth's surface experiences changes in that region?

3. What is the cause-and-effect relationship between volcanoes and the presence of diamonds on Earth's surface?

4. How does the text explain why there are patterns in the locations of various landforms and events such as volcanoes and earthquakes?

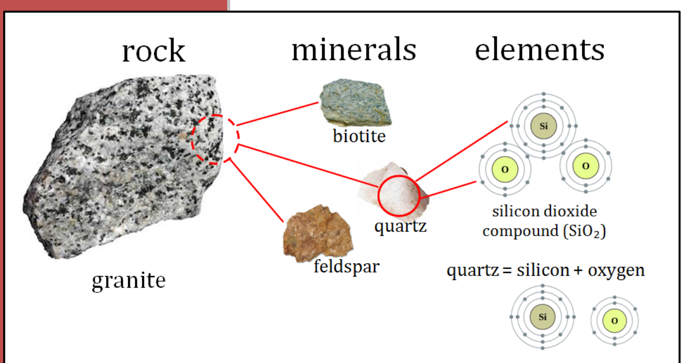
 ©2016 KnowAtom™

3 Earth's Rocks

Diamonds in the Rock

Diamonds are one of the world's major natural resources. Around $13 billion worth of diamonds are produced every year.

Because of this, there are people around the world who search for diamonds. People who search for diamonds often look for specific kinds of rock that hold diamonds within them. This is because minerals that are pressed together form rocks.



All **rocks** are made up of mixtures of minerals. When minerals are pressed together by the heat and pressure of Earth's interior, they can combine to form different kinds of rock. Rocks make up Earth's surface and other terrestrial objects.

Scientists classify rocks based on how they are formed. There are three categories of rock: igneous, metamorphic, and sedimentary. Each category of rock has different properties that scientists can use to identify it.

Igneous Rock

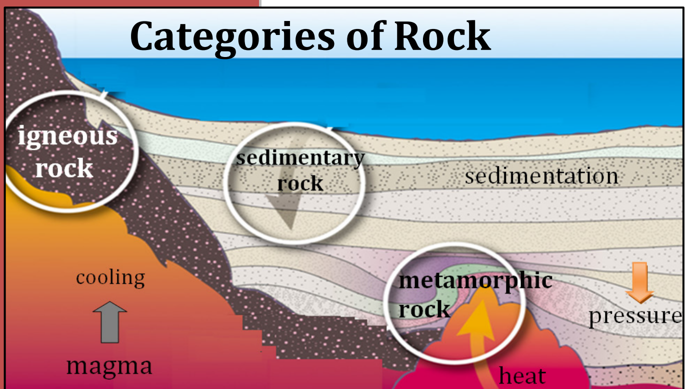
Many diamonds are found in a kind of rock called kimberlite. Kimberlite rocks are generally only found in very old parts of Earth's crust. Kimberlite is a kind of igneous rock. **Igneous rocks** are often found around volcanoes because they form when hot semi-solid or liquid rock (either magma or lava) from Earth's mantle cools into solid form. The magma either cools slowly below Earth's surface or is released as lava in volcanoes.

When magma spews from a volcano, it cools quickly when it is exposed to the cooler temperature of Earth's oceans or atmosphere. The cooled lava hardens into igneous rock. Rocks formed this way are fine-grained or glassy.

Igneous rocks form when lava cools and hardens.

However, not all magma erupts out of a volcano. Some magma is pushed slowly toward Earth's surface over many years. This magma will cool more slowly than magma erupting from a volcano. Igneous rocks formed this way are coarser.

Categories of Rock



Sedimentary rock forms from layers of sand, soil, clay, gravel, and other sediment that built up in one location over time. Sediment is a collection of particles and pieces of living and nonliving things. It collects in layers over time. Over thousands of years, the pressure of more and more top layers of sediment compresses the bottom layers of sediment into solid rock. The oldest sediment forms the bottom-most layers of the rock. Newer layers replace older layers at the top.

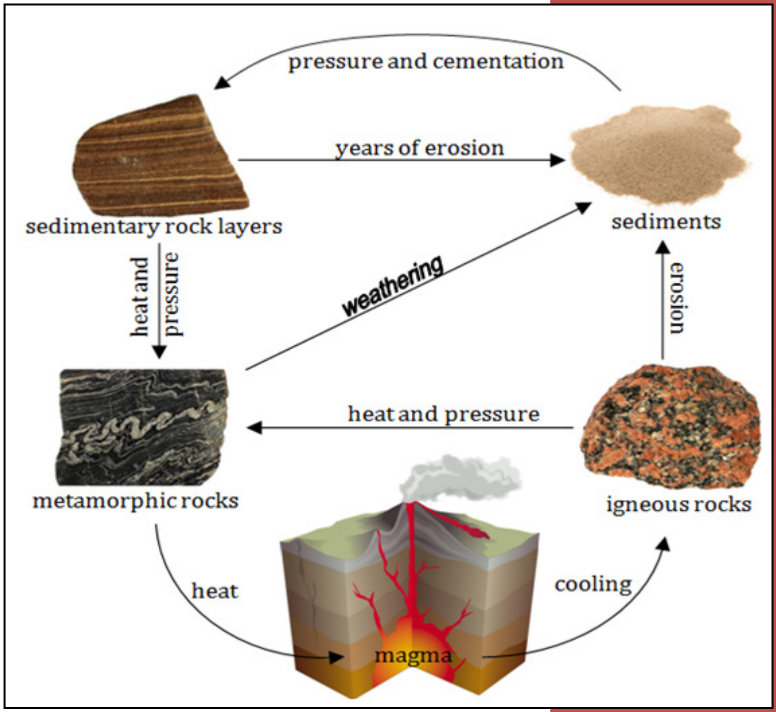
Metamorphic rock is a category of rock formed in chemical reactions where one type of rock is changed by pressure or heat into a new type of rock with different properties. The movement of the tectonic plates can cause rocks to get pushed down deep into the crust. There, the heat and pressure of all the weight on top of it cause chemical reactions in the rock to change it into a new rock with different properties. In a chemical reaction, the molecules of a substance are rearranged into a new substance with new properties. The word "metamorphose" means "to change or to transform." It can take millions of years for a metamorphic rock to form.

 ©2016 KnowAtom™

The Rock Cycle

Rocks do not remain the same forever. The matter that makes them up is cycled and transformed into different categories over time.

For example, rocks on Earth's surface break down into sediment. That sediment can collect in layers. Over time, heat and pressure can compress the layers of sediment into new sedimentary rock.

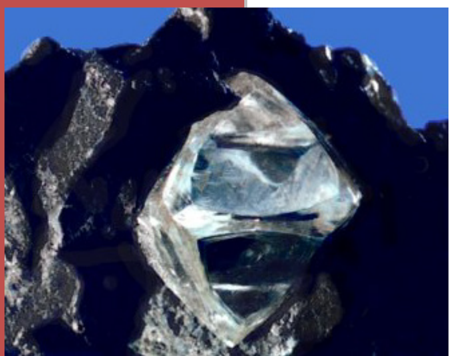


processes of the rock cycle

Or the sediment can get pushed deep into Earth's crust by the movement of tectonic plates. There, it can undergo chemical reactions that change its properties, turning it into metamorphic rock. Eventually, any rock pushed deep into Earth's interior will melt into magma.

If magma reaches the surface, it will cool and harden into rock again. The processes that form, break down, and re-form rock from one category to another are called the **rock cycle**.

Weathering Rock



Weathering can expose the diamond in kimberlite rock.

All rocks on Earth's surface are broken down over time through a natural process called weathering. **Weathering** is the breakdown of rock into small pieces from exposure to wind, water, changes in temperature, and/or biological forces. For example, when kimberlite rocks reach the surface, they are immediately weathered. Sometimes weathering wears down the rock so much that the diamond becomes exposed. There are two kinds of weathering: mechanical and chemical.

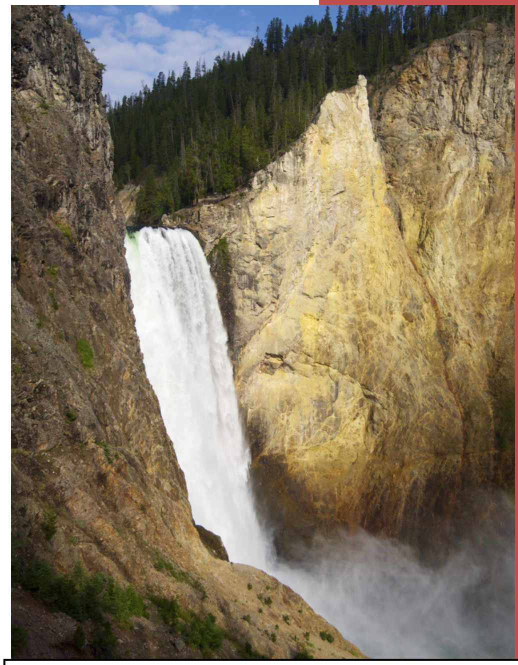
Mechanical weathering takes place when rocks are broken down by physical force without any change in their chemical structure. Mechanical weathering is a physical change because it does not affect the chemical structure of a substance. Whenever rocks and sediment grind against each other, they mechanically weather surfaces. This kind of weathering is called **abrasion**.

Chemical weathering occurs when chemical reactions change the composition of rocks, rearranging the atoms or molecules into new substances with different properties. Chemical weathering generally occurs gradually over time.

 ©2016 KnowAtom™

Eroding Rock

Wind, water, or gravity then transports the sediment to new locations in a process called **erosion**. Kimberlite rocks containing diamonds have been found in areas away from volcanoes, eroded by wind, water or gravity.



Water weathers and erodes rock as it travels over it.

Weathering and erosion usually work together. For example, wind and water carry pieces of sediment that grind against rock and wear it away. Water can also seep into cracks between rocky particles and expand, making cracks larger. Over time, the rock wears down from the inside and crumbles into sediment.

Weathering and erosion are both processes that can occur rapidly or over many years. For example, it can take many years for some rocks to be broken down into smaller pieces of sediment and to then be transported through erosion to a new place. However, erosion can also occur rapidly, such as through landslides caused by flooding.

Earth's Systems

As water moves over rock, two of Earth's systems interact together. A **system** is a set of connected, interacting parts that form a more complex whole. Each system is made up of parts that influence one another. At the same time, the systems interact with each other.

Earth's systems

For example, all of the water found on Earth makes up an Earth system called the hydrosphere. Earth's landforms, including rocks and soil, are part of a system called the geosphere. As water moves over Earth's surface, it shapes the geosphere as it weathers and erodes the rocks and soil it passes over. When wind weathers and erodes rock, another system is at work. The atmosphere is the Earth system made up of a mixture of gases, dust, water vapor, and other molecules above Earth's crust. Earth's gravity holds the atmosphere in place.

Another Earth system is called the biosphere. This system includes all living things on Earth. Living things depend on all of the other systems for survival. At the same time, living things impact their surroundings as they breathe air, drink water, and live on Earth's surface.

 ©2016 KnowAtom™

Section 3 Review

<u>Reading Comprehension Questions</u>:

1. What is the main idea of Section 3? What details are used to support this idea?

2. How might the matter that makes up an igneous rock end up as part of a sedimentary rock?

3. Compare and contrast chemical and mechanical weathering. Use what you know about physical and chemical changes in your answer.

4. How can interactions among Earth's systems be used to describe how rocks are weathered and eroded?

 ©2016 KnowAtom™

Science Words to Know

abrasion – a type of mechanical weathering that occurs when rocks and sediment grind against each other

chemical weathering – a kind of weathering that occurs when chemical reactions change the composition of rocks, rearranging the atoms or molecules into new substances with different properties

erosion – the transport of sediment by wind, water, or gravity

igneous rock – a category of rock formed when hot liquid rock (either lava or magma) cools into a solid

mechanical weathering – a kind of weathering that occurs when rocks are broken down by physical force without any change in their chemical structure

metamorphic rock – a category of rock formed in chemical reactions where one type of rock is changed by pressure or heat into a new type of rock with different properties

mineral – a naturally occurring, inorganic solid with a crystal structure

rocks – mixed mineral matter that makes up the surface of Earth and other terrestrial objects

rock cycle – the processes that form, break down, and re-form rock from one category to another

sedimentary rock – a category of rock formed from layers of sand, soil, clay, gravel, and other sediment that built up in one location over time

system – a set of connected, interacting parts that form a more complex whole

tectonic plates – drifting slabs of solid rock, called plates, that make up Earth's surface

volcano – a structure formed around a hole in Earth's crust that releases magma

weathering – the breakdown of rock into smaller pieces from exposure to wind, water, changes in temperature, and/or biological forces; there are two kinds: mechanical and chemical

 ©2016 KnowAtom™

Focus on what matters.

©2016 KnowAtom™