GreatHearts®

Earth Science 8

April 14th-17th

Time Allotment:30 minutes per day

Student Name: ___________________________________

Teacher Name: ___________________________________

Earth Science 8: The Solar System
April 14-April 17

Packet Overview

Date	Objective(s)	Page Number
Monday, April 13	Break!	
Tuesday, April 14	1. Intro to Geology. Explain the defining characteristics of minerals and fundamental minerology.	2
Wednesday, April 15	1. Explain the process of mineral identification and classification.	5
Thursday, April 16	1.Explain the different processes of mineral formation.	11
Friday, March April 17	1. Differentiate between rocks and minerals and explain the rock cycle.	15

Additional Notes: Students are to designate a specific location in their home for their workspace to learn about the Earth.

This could be a table or desk anywhere in the home that could be labeled their school zone. By doing so, the students will have a stable work environment that they will keep all of their learning materials organized, they can visit, and take a rest from.

Academic Honesty

I certify that I completed this assignment independently in accordance with the GHNO Academy Honor Code.

Student signature:

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I certify that my student completed this assignment independently in accordance with the GHNO Academy Honor Code.

Parent signature:

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<u>Tuesday, April 14</u>

Unit: Geology

Geology is the study of the solid matter that makes up Earth. Anything that is solid, like rocks, minerals, mountains, and canyons is part of geology. Geologists study the way that these objects formed, their composition, how they interact with one another, how they erode, and how humans can use them. Geology has so many branches that most geologists become specialists in one area. For example, a **mineralogist** studies the composition and structure of minerals such as halite (rock salt), quartz, calcite, and magnetite (see below).

Minerology:

What are Minerals?

You use objects that are made from minerals every day, even if you do not realize it. You are actually eating a mineral when you eat food that contains **salt**. You are drinking from a container made from a mineral when you drink from a glass. Shiny metal silver, the white grains of salt, and clear glass may not seem to have much in common, but they are all made from **minerals** Silver is a mineral. Table salt is the mineral halite. Glass is produced from the mineral quartz. Scientists have identified more than 4,000 minerals in Earth's crust. Some minerals are found in very large amounts, but most minerals are found in small amounts. If minerals can be so different from each other, what makes a mineral a mineral?

A mineral is a crystalline solid formed through natural processes. A mineral can be an **element or a compound**, but it has a **specific chemical composition** and **physical properties** that are different from those of other minerals. Silver, tungsten, halite, and quartz are all examples of minerals. Each one has a different chemical composition, as well as different physical properties such as **crystalline structure**, **hardness**, **density**, **flammability**, and **color**.

Natural Processes

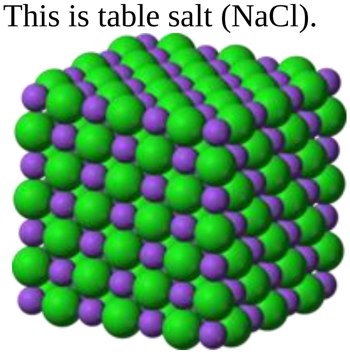
Minerals are made by natural processes. One common natural process that forms minerals is the **crystallization** of magma. Some natural processes shape Earth's features, while others include volcanic activity and the movement of tectonic plates (more on that in an upcoming unit). Rocks and minerals are formed in **sedimentary** layers of sand and mud and in the folding of those layers deep in the Earth, where they are exposed to high pressures and temperatures. A technician might make a gemstone in the laboratory, but this would have been created synthetically, **not by natural processes.**

Inorganic Substances

A mineral is an **inorganic substance**, which usually means it was not made by living organisms. Organic substances are all the carbon-based compounds made by living creatures, including proteins, carbohydrates, and oils. **This definition includes fossil fuels such as coal and oil**, which were originally made by living organisms millions of years ago. Everything else is considered inorganic. Therefore, oil and coal are **not minerals.** In a few exceptional cases, living organisms produce inorganic materials, such as the calcium carbonate shells of marine organisms.

Crystalline Solids

As you can see from this model, sodium ions (purple) bond with chloride ions (green) in a certain way to form halite crystals. This is table salt (NaCl).



Minerals **are crystalline solids**. Therefore, natural inorganic substances that are liquids are not minerals. For example, liquid water is inorganic, but it **is not a mineral** because it is a **liquid**. Even some solids may not be crystalline. A crystal is a solid in which the atoms are arranged in a regular, repeating pattern, like you see in the image of table salt above. Table salt contains the ions sodium and chloride. Notice how the atoms are arranged in an orderly way. Also, notice that the pattern continues in all three dimensions.

Chemical Composition

All minerals have a **specific chemical composition**. Minerals are either **pure elements** or **chemical compounds**. As you know, an element is a substance in which all of the atoms have the same number of protons. (Protons are the positive particles in the center of every atom, the nucleus.) You cannot change an element into another element by chemical means because the number of protons does not change. Silver, sodium, silicon, and oxygen are a few of the elements found in minerals. A few minerals are made of only one kind of element. The mineral silver is a pure element because it is made up of only silver atoms.

Most minerals, such as halite and quartz, are made up of chemical compounds. A chemical compound is a substance in which the atoms of two or more elements bond together. For example, the mineral quartz is made of the compound silicon dioxide, or SiO_2

Structure of Minerals

The **crystal structure** of a mineral affects the mineral's physical properties. Imagine you have three samples of halite. Each sample was found in a different country. They are all different sizes and shapes. They may have even been formed by different geologic processes. Will the samples all have the same crystal structure? Yes! **All halite has the same chemical composition and the same crystal structure, despite physical differences.** This is true of any type of mineral- a given type of mineral will have a specific **crystal structure.**

Crystals in Minerals

The shape of the crystals of a mineral is determined by the way the atoms are arranged. When crystals grow large, you can see how the arrangement of atoms influences the shape. Notice how the large table salt crystal above as a square shape. This shape is the result of the pattern of sodium and chlorine atoms in crystal. Now compare that drawing of table salt’s atoms to an actual table salt crystal, below.

These small crystals have similar shapes to the large crystal. You can see that the shapes of the crystals are made up of squares. If you sprinkle salt into your hand and look carefully at each grain of salt, **you will see that it is perfect little cube.**

A mineral has **both a characteristic chemical composition and a characteristic crystal structure.** There are different minerals have the same chemical composition, but different crystal structures. A classic example is diamonds and graphite. Diamonds are of course shiny, clear, very hard, and very valuable. Graphite is used as pencil lead and has a slippery feel. It is dark and soft. Diamond and graphite are both made of only carbon, but they are not the same mineral. **The crystal structure of diamond differs from the crystal structure of graphite**. The carbon atoms in graphite bond to form layers. The bonds between each layer are weak, so the sheets can slip past each other. The carbon atoms in diamonds bond together in all three directions to form a strong network. As a result, the properties of diamond differ from the properties of graphite.

Key Terms

chemical compound
A substance in which the atoms of two or more elements bond together.
crystal
A solid in which all the atoms are arranged in a regular, repeating pattern.
element
A substance in which all of the atoms have the same number of protons.
mineral
A naturally occurring, inorganic, crystalline solid with a characteristic chemical composition.
mineralogist
A scientist who studies minerals.

Review Questions

1. What is a crystal?

2. One mineral sample has a ratio of two iron atoms to three oxygen atoms. Another sample has a ratio of three iron atoms to four oxygen atoms. Explain whether the mineral samples are made of the same chemical compound.

<u>Wednesday, April 15</u>

How are Minerals Identified?

Imagine you were given a mineral sample similar to the one shown in the image below. How would you try to identify your mineral? If you were a mineralogist, you would use certain properties to identify the mineral. You can observe some properties by looking at the mineral. For example, you can see that the mineral below the color of gold and is shiny. But, you cannot see all mineral properties. You need to do simple tests to determine some properties, such as how hard the mineral is. You can use a mineral's properties to determine its identity because the properties are determined by the chemical composition and crystal structure, or the way that the atoms are arranged.

Color

Color is probably the easiest property to observe. Unfortunately, you can rarely identify a mineral only by its color. Sometimes different minerals are the same color. The mineral above is a gold color, so you might think that it is gold. The mineral is actually **pyrite**, or "fool's gold", which is made of iron and sulfide. It contains no gold atoms.

Often, the **same mineral** comes in **different colors**. The image below shows two samples of quartz—one is colorless (clear) and one is purple. The purple color of the quartz comes from a tiny amount of iron in the crystal. The iron in quartz is a chemical impurity because it is not normally found in quartz. Many minerals are colored by chemical impurities. Other factors, such as weathering, can also affect a mineral’s color. Weathering affects the surface of a mineral. **Because color alone is unreliable, geologists identify minerals by several traits.**

Streak

Streak is the color of the powder of a mineral. To do a streak test, you scrape the mineral across an unglazed porcelain plate. The plate is harder than many minerals, causing the minerals to leave a streak of powder on the plate. The color of the streak often differs from the color of the larger mineral sample, as the image below shows. If you did a streak test on the yellow-gold pyrite, you would see a blackish streak. This blackish streak tells you that the mineral is not gold because gold has a gold-colored streak. Streak is a more reliable property than the color of the mineral sample. **The color of a mineral may vary, but its streak does not vary.**

Here we see black and white hematite leaving a brown/red streak.

Luster

Luster describes the way **light reflects off of the surface of the mineral**. You might describe diamonds as sparkly or pyrite as shiny, but mineralogists have special terms to describe the luster of a mineral. They first divide minerals into **metallic** and **non-metallic** luster. Minerals like pyrite that are opaque and shiny have a metallic luster. Minerals with a non-metallic luster do not look like metals. There are many types of non-metallic luster.

Density

Density describes **how much matter is in a certain amount of space**. Substances that have more matter packed into a given space have higher densities. The water in a drinking glass has the same density as the water in a bathtub or swimming pool. **All substances have characteristic densitie**s, which does not depend on how much of a substance you have.

Mass is a measure of the amount of matter in an object. The amount of space an object takes up is described by its volume. So, density of an object depends on its mass and its volume. You recall that density can be calculated using the following equation.

$$\text{Density} = \text{Mass}/\text{Volume}$$

Samples that are the same size, but have different densities, will have different masses. Gold has a density of about 19 g/cm3. Pyrite has a density of only about 5 g/cm3. Quartz is even less dense than pyrite and has a density of 2.7 g/cm3. If you picked up a piece of pyrite and a piece of quartz that were the same size, the pyrite would seem almost twice as heavy as the quartz. **A certain type of mineral will always have the same density, no matter how much of it you have.**

Hardness

Hardness is a mineral's ability to resist being scratched. Minerals that are not easily scratched are hard. You test the hardness of a mineral by scratching its surface with a mineral of a known hardness. Mineralogists use the **Mohs Scale**, below, as a reference for mineral hardness. The scale lists common minerals in order of their relative hardness. You can use the minerals in the scale to test the hardness of an unknown mineral.

As you can see, diamond is a 10 on Mohs Scale. Diamond is the hardest mineral**, which means that no other mineral can scratch a diamond**. Quartz is a 7, so it can be scratched by topaz, corundum, and diamond. Quartz will scratch minerals, such as fluorite, that have a lower number on the scale. Suppose you tested a piece of pure gold for hardness. Calcite would scratch the gold, but gypsum would not because gypsum is a 2 and calcite is a 3. That would mean gold is between the hardness of gypsum and calcite, or 2.5 on the scale. A hardness of 2.5 means that gold is a relatively soft mineral. It is only about as hard as your fingernail.

Mineral	Mohs Hardness	Image
Talc	1	
Gypsum	2	
Calcite	3	
Fluorite	4	
Apatite	5	
Feldspar	6	
Quartz	7	
Topaz	8	
Corundum	9	
Diamond	10	

Cleavage and Fracture

Minerals break apart in characteristic ways. Remember that all minerals are crystalline, which means that the atoms in a mineral are arranged in a repeating pattern. The pattern of atoms in a mineral determines how a mineral will break. When you break a mineral, you break chemical bonds. Because of the way the atoms are arranged, some bonds are weaker than other bonds. A mineral is more likely to break where the bonds between the atoms are weaker.

Cleavage is the tendency of a mineral to break along certain planes to make smooth surfaces. Minerals with different crystal structures will cleave in different ways, as the image below shows. Halite tends to form cubes with smooth surfaces, mica tends to form sheets, and fluorite can form octahedra.

***Halite** forms cubes when it cleaves.* ***Mica** breaks in sheets.* ***Flourite** forms octahedra, which have 8 sides*

Fracture describes how a mineral breaks when it is not broken along a cleavage plane. All minerals break but fracture describes a break when the resulting surface is not smooth and flat. You can learn about a mineral from the way it fractures. Jagged edges are usually formed when metals break. If a mineral splinters like wood it may be fibrous. Some minerals, such as quartz, form smooth curved surfaces when they fracture.

Other Identifying Characteristics

Minerals have some other properties that can be used to identify them. For example, a mineral's crystal structure can be used to help identify the mineral. Sometimes, a trained mineralogist can tell the crystal structure just by looking at the shape of the mineral. In other cases, the crystals in the mineral are too small to see and a mineralogist will use a special instrument that uses X rays to find out the crystal structure.

Some unusual and interesting properties can be used to identify certain minerals. Some of these properties are listed in the table below. Although these properties are rare, several minerals have them.

Table: Uncommon Mineral Properties

Property	Description	Example of Mineral
Fluorescence	Mineral glows under ultraviolet light	Fluorite
Magnetism	Mineral is attracted to a magnet	Magnetite
Radioactivity	Mineral gives off radiation that can be measured with Geiger counter	Uraninite
Reactivity	Bubbles form when mineral is exposed to a weak acid	Calcite
Smell	Some minerals have a distinctive smell	Sulfur (smells like rotten eggs)

Key Terms:

cleavage
The tendency of a mineral to break along certain planes to make smooth surfaces.
density
How much matter is in a certain amount of space; mass divided by volume.
fracture
The way a mineral breaks when it is not broken along a cleavage plane.
hardness
The ability to resist scratching.
luster
The way light reflects off of the surface of the mineral.
streak
The color of the powder of a mineral.

Review Questions

1. Which properties of a mineral describe the way it breaks apart?

2. A mineral looks dry and chalky. Why sort of luster does it have?

3. Why is streak more reliable than color when identifying a mineral?

Thursday, April 16

Mineral formation

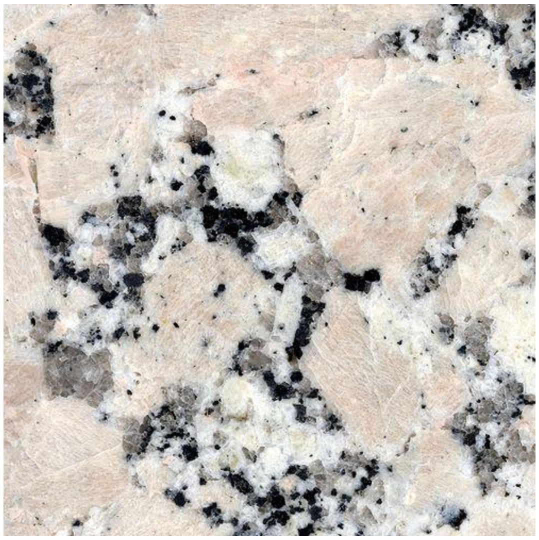
There are many types of minerals, and they do not all form in the same way. Some minerals form when salt water on Earth's surface evaporates. Others form from water mixtures that are seeping through rocks far below your feet. Still others form when mixtures of really hot molten rock cool.

Formation from Magma and Lava

There are places inside Earth where the heat is so great that rock will melt. Melted rock inside the Earth is also called molten rock, or **magma**. Magma is a molten mixture of substances that can be hotter than 1,000°C. Magma moves up through Earth's crust, but it does not always reach the surface. **When magma erupts onto Earth's surface, it is known as lava**. As lava flows from volcanoes it starts to cool, as the image below shows. **Minerals form when magma and lava cool.**

Rocks from Magma

Magma cools slowly as it rises towards Earth's surface. It can take thousands to millions of years to become solid when it is trapped inside Earth. As the magma cools, solid rocks form. **Rocks are mixtures of minerals**. Granite, shown below, is a common rock that forms when magma cools. Granite contains the minerals quartz and two different types of the mineral feldspar. The different colored speckles in the granite are the crystals of the different minerals. The mineral crystals are large enough to see because the magma cools slowly, which gives the crystals time to grow.

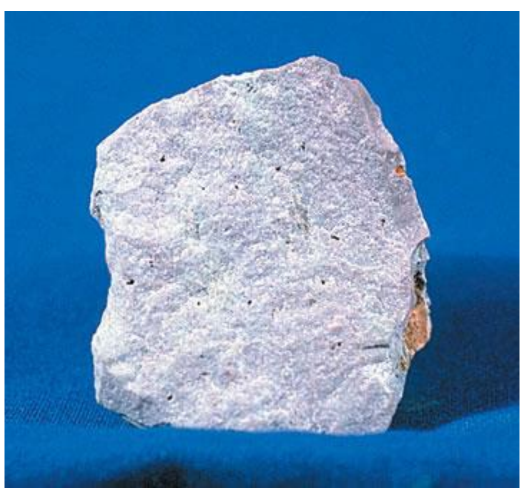


A close up image of granite.

The magma mixture changes over time as different minerals crystallize out of the magma. A very small amount of water is mixed in with the magma. The last part of the magma to solidify contains more water than the magma that first formed rocks. It also contains rare chemical elements. **When magma cools very slowly, very large crystals can grow**. These mineral deposits are good sources of mineral crystals.

Minerals from Lava

Lava is on the Earth's surface so **it cools quickly compared to magma in Earth**. As a result, rocks form quickly and mineral crystals are very small. Rhyolite is one type of rock that is formed when lava cools. It contains similar minerals to granite. However, as you can see in the image below the mineral crystals are much smaller than the crystals in the granite shown above. Sometimes, lava cools so fast that crystals cannot form at all, forming a black glass called **obsidian**. **Because obsidian is not crystalline, it is not a mineral**.



Rhyolite

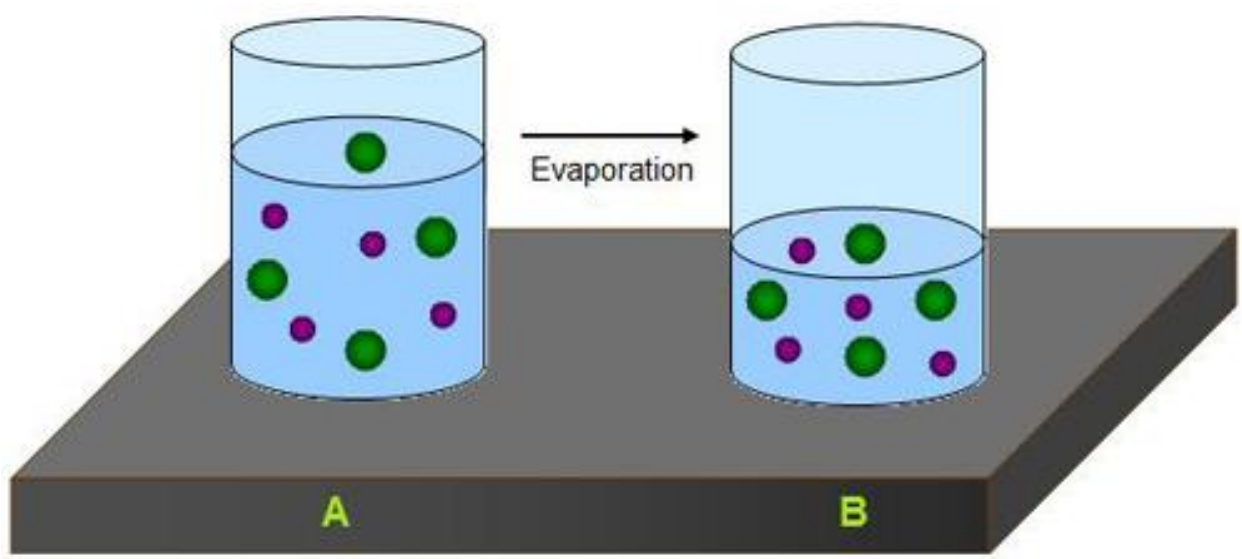
Formation from Solutions

Minerals also form when minerals are mixed in water. Most water on Earth, like the water in the oceans, contains minerals. The minerals are mixed evenly throughout the water to make a solution. **The mineral particles in water are so small that they will not come out when you filter the water**. But there are ways to get the minerals in water to form solid mineral deposits.

Minerals from Salt Water

Tap water and bottled water contain small amounts of dissolved minerals. For minerals to crystallize, the water needs to contain a large amount of dissolved minerals. Seawater and the water in some lakes, such as Mono Lake in California or Utah's Great Salt Lake, are salty enough for minerals to "precipitate out" as solids.

When water evaporates, it leaves behind a solid "**precipitate**" of minerals, which do not evaporate, as the figure below shows. After the water evaporates, the amount of mineral left is the same as was in the water before evaporation



When the water in glass A evaporates, the dissolved mineral particles are left behind.

Water can only hold a certain amount of dissolved minerals and salts. When the amount is too great to stay dissolved in the water, the particles come together to form mineral solids and sink to the bottom. Salt (halite) easily precipitates out of water, as does calcite, as the image below shows.

The limestone towers are made mostly of calcite deposited in the salty of Mono Lake, in California. These rocks formed under water when calcium-rich spring water at the bottom of the lake bubbled up into the lake, forming these calcite towers. If the lake level drops, the tufa towers appear in interesting formations.

Minerals from Hot Underground Water

Cooling magma is not the only source for underground mineral formations. When magma heats nearby underground water, the heated water moves through cracks below Earth's surface.

Hot water can hold more dissolved particles than cold water. The hot, salty solution reacts with the rocks around it and picks up more dissolved particles. As it flows through open spaces in rocks, it deposits solid minerals. The mineral deposits that form when a mineral fills cracks in rocks are called *veins*. When the minerals are deposited in open spaces, large crystals can form. These special rocks are called ***geodes***. The image below shows a geode that was formed when amethyst crystals grew in an open space in a rock.

Key terms:

lava
Molten rock that has reached the Earth's surface.

magma
Molten rock deep inside the Earth.

rocks
Mixtures of minerals.

Review Questions

1. How does magma differ from lava?

2. What are two differences between granite and rhyolite?

3. What happens to the mineral particles in salt water when the water evaporates?

Friday, April 17

Rocks are a symbol for everything solid and steady and unchanging- if someone is reliable they are ‘rock solid’ or ‘rock steady.’ If you compare something to a rock you mean you can rely on it to never change, but always stay the same.

The truth is, however, that rocks do change. All rocks on Earth change as a result of natural processes that take place continuously. These changes usually happen very slowly. They may even happen below Earth's surface so that we do not notice the changes. **The physical and chemical properties of rocks are constantly changing in a natural, never-ending cycle called the rock cycle.** The rock cycle describes how each of the main types of rocks is formed, and explains how rocks change within the cycle.

A rock is a naturally-formed, nonliving Earth material. Rocks are made of collections of **mineral** grains that are held together in a firm, solid mass.

This rock contains several different minerals, as shown by the different colors and textures found in the rock.

The individual mineral grains that make up a rock may be so tiny that you can only see them with a microscope, or they may be as big as your fingernail. Each rock has a unique set of minerals that make it up, and rocks are usually identified by the minerals observed in them. **Because different minerals form under different environmental conditions, the minerals in a rock contain clues about the conditions, like temperature, that were present when the rock formed.**

Rocks can also be described by their texture, which is a description of the size, shape, and arrangement of mineral grains. Rocks may be small pebbles less than a centimeter, or they may be massive boulders that are meters wide. Smaller rocks form when larger rocks are broken apart and worn down.

Three Main Categories of Rocks

Rocks are classified according to how they were formed. The three main kinds of rocks are:

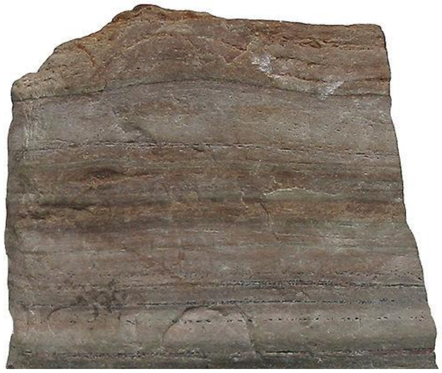
1. ***Igneous Rocks*** - form when **magma** (**molten** rock inside the Earth) or **lava** (molten rock that has erupted onto the surface of Earth) cools either at or below Earth's surface.

*This flowing lava is an example of molten mineral material. It will harden into an **igneous rock**.*

2. ***Sedimentary Rocks*** - form by the compaction of **sediments**, like gravel, sand, silt or clay. Sediments may include fragments of other rocks that have been worn down into small pieces, materials made by a living organism or **organic** materials, or chemical **precipitates**, which are the solid materials left behind after a liquid evaporates. For example, if a glass of salt water is left in the sun, the water will eventually evaporate, but salt crystals will remain behind as precipitates in the bottom of the glass.

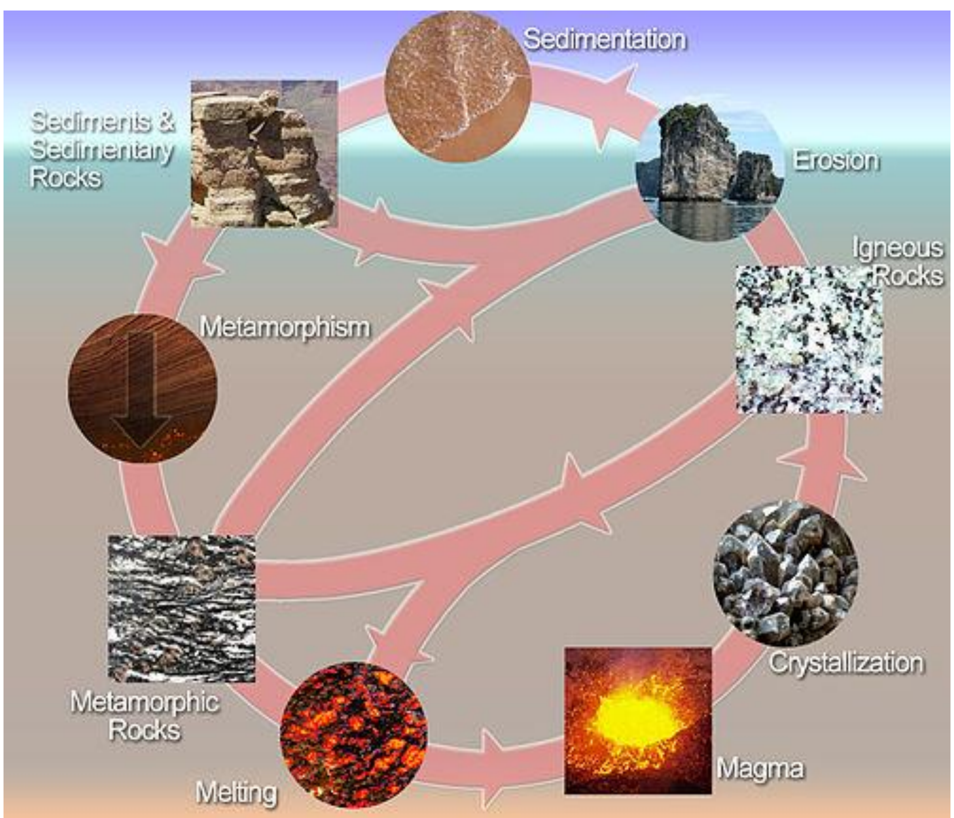
*This sandstone is an example of a **sedimentary rock**. It formed when many small pieces of sand were cemented together to form a rock.*

3. ***Metamorphic Rocks*** - form when an existing rock (of any type) is changed by heat or pressure within the Earth, so that the minerals undergo some kind of change, or metamorphosis.



*This quartzite is an example of **a metamorphic rock**. It formed when sandstone was **changed by heat and pressure** within the Earth.*

Rocks can be changed from one type to another, in a process known as **the rock cycle.** The image below shows the rock cycle, and how the three main rock types are related to each other. The arrows within the circle show how one type of rock may change to rock of another type. For example, igneous rock may break down into small pieces of sediment and become sedimentary rock, or it may be buried within the Earth and become metamorphic rock, or it may change back to molten material and re-cool into a new igneous rock. There is **not** a single set path that any rock must take through the rock cycle. An igneous rock could become a metamorphic rock or become a sedimentary rock, and a sedimentary rock could become a metamorphic rock or an igneous rock, etc.



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The Rock Cycle

Any type of rock can undergo changes and become any new type of rock. Several processes are involved in the rock cycle that make this possible. The key processes of the rock cycle are crystallization, erosion and sedimentation, and metamorphism. Let's take a closer look at each of these:

Crystallization. Crystallization occurs when **molten material hardens into a rock**. An existing rock may be buried deep within the earth, melt into magma and then crystallize into an igneous rock. The rock may then be brought to Earth's surface by natural movements of the Earth. Crystallization can occur either underground when magma cools, or on the earth's surface when lava hardens.

Erosion and Sedimentation. Pieces of rock at Earth's surface are constantly worn down into smaller and smaller pieces. The impacts of running water, gravity, ice, plants, and animals all act to wear down rocks over time. The small fragments of rock produced are called sediments. Running water and wind transport these sediments from one place to another. They are eventually **deposited**, or dropped somewhere. This process is called erosion and sedimentation. The accumulated sediment may become compacted and cemented together into a sedimentary rock. This whole process of eroding rocks, transporting and depositing them, and then forming a sedimentary rock can take hundreds or thousands of years.

Metamorphism. Sometimes an existing rock is exposed to extreme heat and pressure deep within the Earth. Metamorphism happens if the rock does not completely melt but still changes as a result of the extreme heat and pressure. A metamorphic rock may have a new mineral composition and/or texture.

Note that **the rock cycle really has no beginning and no end**: Therefore, it's a never-ending cycle. The concept of the rock cycle was first developed by James Hutton, an eighteenth century scientist often called the "father of geology." Hutton spoke of the cyclic nature of rock formation and other geologic processes and said that they have "no [sign] of a beginning, and no prospect of an end". The processes involved in the rock cycle take place over hundreds or even thousands of years, and so in our lifetime, rocks appear to be fairly "rock solid" and unchanging. However, a study of the rock cycle shows us that change is always taking place.

deposited
: Put down or dropped by water or wind onto the ground.

mineral
: Naturally-occurring solid that has a definite crystal structure.

molten
: Something that is melted.

organic
: Having to do with living things.

precipitates

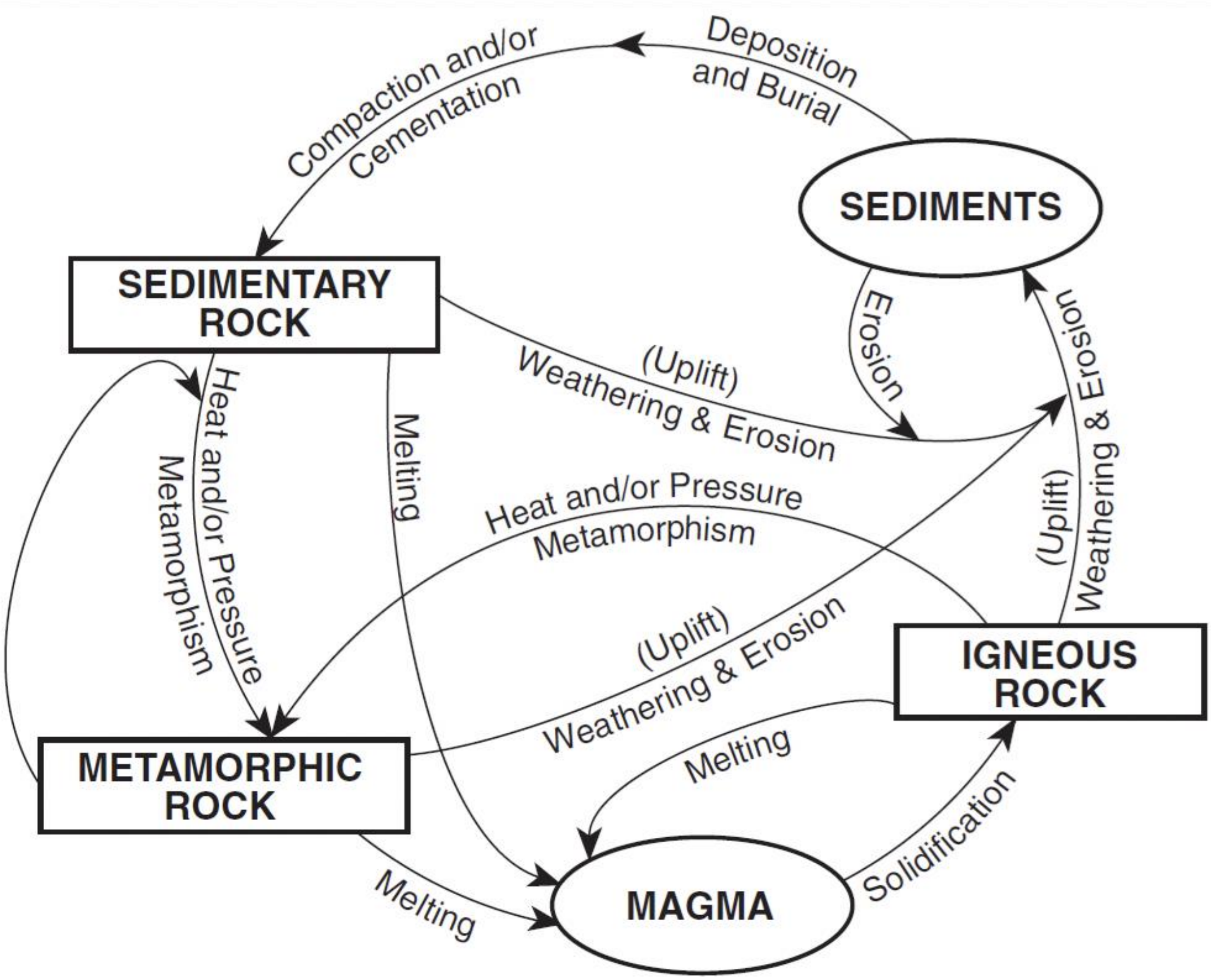
Solid substance that separates out of a liquid; a solid substance that was once dissolved in a liquid and gets left behind when the liquid evaporates.

sediments

Small particles of soil or rock deposited by wind or water.

Rock Cycle Assessment:

Use the diagram below to answer the writing prompt on the following page:



You are now a sedimentary rock. Congratulations. In 4-6 sentences, write below how you might travel through the rock cycle. You must at one point become an igneous rock, you must at one point become a metamorphic rock, and you must end your journey as you began- as a sedimentary rock. Be sure to explain the transition between each type of rock.