Chapter 7 : Rocks and Minerals

https://www.worldatlas.com/articles/what-is-the-difference-between-a-rock-and-a-mineral.html

Guiding Question: Take a look at this group of rocks and minerals and think about this: Can you tell which ones are rocks and which are minerals? If you answered no – then let's read about rocks and minerals and learn the differences!

Learning Outcomes

At the end of this chapter, the students will be able to:

1. Label and explain the geologic processes demonstrated in the rock cycle
2. Explain the characteristics of the three types of rocks
3. Compare rocks and minerals
4. Describe the properties of minerals and how they are identified
5. Describe the processes of weathering, erosion and deposition

Essential Vocabulary

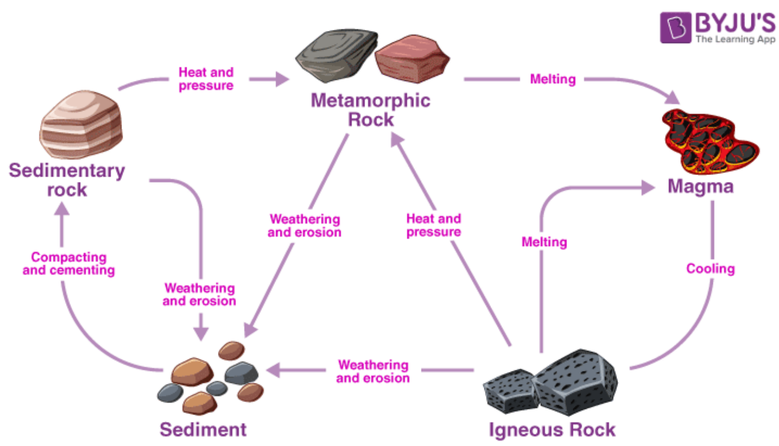
- Geosphere
- Metamorphic
- Igneous
- Sedimentary
- Crystal
- Inorganic
- Isotopes
- Weathering
- Erosion
- Deposition

Overview and Introduction to Rocks and Minerals

The Earth is a sphere composed of several different types of spheres. For example, the Earth has a geosphere, hydrosphere and atmosphere. In this chapter, we will be discussing the geosphere and what makes up that specific sphere. Rocks and minerals are a component of the geosphere and are often studied together. Rocks are naturally occurring and compose the geosphere. These materials are everywhere we look and sometimes we do not even recognize their importance.

The Rock Cycle

The rock cycle is a major way that recycles solid parts of the geosphere. Rocks are continually formed, changed and reformed. In other words, the rock cycle is a series of steps that result in and transform the three types of rocks in the Earth's crust. It is essential in understanding how the three basic rock groups are formed because each of the rock types are related to the other and how they are formed. Let's look at the rock cycle diagram and examine the relationship.

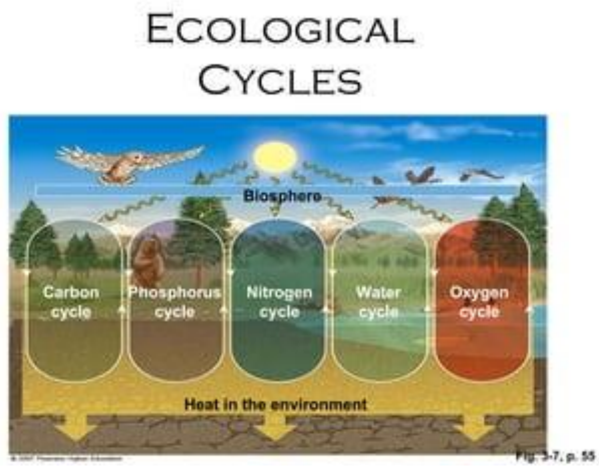


https://byjus.com/physics/rock-cycle/

This diagram illustrates the way rocks are altered and formed into new types of rock. For example, when rocks are pushed from upper levels to deeper levels of the Earth's surface, the amount of heat increase and the solid rock begins to melt and is then classified as magma. Magma is one step on the way to forming *igneous* rock. Igneous rock is a result of melting and cooling until the *magma* cools enough to make a solid rock. As you can see, the igneous rock can then be exposed to surface conditions that result in weathering and/or erosion. When rocks are weathered or eroded, the rock is broken down into smaller particles called sediment. The sediment can then be deposited and certain conditions allow the sediments to be compacted and cemented into a different type of rock called *sedimentary rock*. The sedimentary rock can then be heated and exposed to high degrees of pressure, resulting in the changes in rock and resulting in *metamorphic* rock. The diagram demonstrates that the cycle is not one simple path but can have several pathways. It is very important to recognize the multiple pathways exist and to understand the relationship between the rock types.

Earth's Systems

The rock cycle is only one small part of Earth's systems. For example, there is the water cycle. Let's see how the water cycle is related to the rock cycle. Water is only one if the agents that can change features on the Earth's surface. It impacts certain features through a process called weathering. Weathering is a process that, when in contact with rocks either as rain or flowing water, tends to break down rocks to make smaller particles called sediment. We will read more about weathering, erosions and deposition later in the chapter. In addition to the rock and water cycles, there are other biogeochemical cycles that are tied into the rock cycle. For example, other cycles include the nitrogen cycle, phosphorus cycle, carbon cycle, oxygen cycle and sulfur cycle. Each plays a special role in the rock cycle. Let's review the processes associated with each of the cycles and the relationship to the rock cycle.



https://www.slideshare.net/mccracken/ecological-cycles

Cycle	Processes	Relationship to Rock Cycle
Water Cycle	Evaporation, condensation, precipitation and runoff	*Breaks down rocks and soils during the process*
Nitrogen Cycle	Bacteria convert atmospheric nitrogen into usable forms for plants; this is called nitrogen fixation	*Breaks down soil and sediments when plant roots grow*
Phosphorus Cycle	Crucial for DNA, RNA and ATP	*Cycles through rocks, soil, water and plants*
Carbon Cycle	As CO_2, used in photosynthesis	*Growing plants break down rocks and produce soil and sediments*
Oxygen Cycle	Closely linked to the carbon cycle and produced by photosynthesis	*Growing plants break down rocks and produce soil and sediments*
Sulfur Cycle	Bacteria convert sulfur compounds and involved in volcanic activity	*Cycles through rocks, soil, water and living organisms*

As you can see, each of these biogeochemical cycles impacts the formation of rock materials, resulting in sediments and other rock materials.

Igneous rocks

There are three main types of rock and igneous rock is one type. (*Igneous means fiery*) They are formed when magma or lava is cooled and becomes a solid. This can occur deep within the Earth where the heat allows solid rocks to melt into magma. This generally occurs near the Earth's plate boundaries; other times at specific hot spots in the Earth's crust. Magma is mostly produced with the plastic layer called the asthenosphere which is under the Earth's crust. Since the magma is less dense, the hot magma bubbles up to the Earth's surface and cools. On other occasions, the magma erupts from volcanoes and is called lava. The lava cools and solidifies and becomes igneous rock. Since this is all happening at the Earth's surface it is easy to understand why the Earth's surface is mostly composed of igneous rock. While only about 15% of Earth's land surface is igneous, most of the oceanic crust is igneous. Igneous rocks occur in many settings. For example, granitoids (granite and related rocks) are major components of the Earth's crust. These can make up younger mountain belts and Precambrian shields. Batholiths form the cores of many mountain ranges. This is a picture of Mt. Whitney which shows the Sierra Nevada Batholith (exposed rock).

https://opengeology.org/Mineralogy/6-igneous-rocks-and-silicate-minerals-v2/#631_Equilibrium_Between_Crystals_and_Melt

There are two main types of igneous rock: intrusive and extrusive. These form in different ways. When magma is trapped well below the Earth's surface and cools very slowly, this results in intrusive rocks. Since the magma has the time to cool, sometimes as long as thousands of years, the minerals crystals in the magma have the opportunity to row in size. As a result, intrusive rocks have a course grained texture. The majority of igneous rocks result from intrusive methods. Some common intrusive rocks are granite and gabbro.

https://1.bp.blogspot.com/-wyNlnjt8EEg/Wsjsx9vRjkI/AAAAAAAAPjg/XP5aWLaozdYGp_DVUhkJl4rRY3eq9KC3gCLcBGAs/s1600/gabbro%2Bvs%2Bgranite%2B2%2B%25281%2529.jpg

On the other hand, extrusive rocks result when magma escapes and cools above the Earth's surface. These generally are a result of erupting volcanoes. Since the magma reaches the surface, now called lava, it is exposed to the air and cools relatively quickly. Quick cooling results in less time for crystals to grow so these rocks are very fine grained. Basalt, the most common volcanic rock in the Earth's crust, is an example of an extrusive rock. Basalt is formed from rapid cooling of magnesium and iron rich lava. It is often used to make statues and cobblestones (from basalt columns).

Basalt

https://en.wikipedia.org/wiki/Basalt#/media/File:BasaltUSGOV.jpg

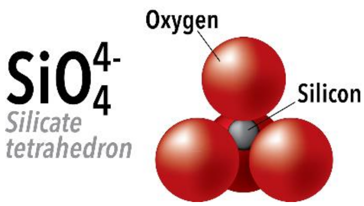
Basalt Columns

https://en.wikipedia.org/wiki/Basalt#/media/File:Causeway-code_poet-4.jpg

There are some extrusive rocks that cool so quickly they appear glasslike. An example is obsidian. In previous cultures, it had been used to make cutting tools, blades and arrowheads. In current times, obsidian is thought to protect your home from negative energies. It is glasslike from cooling quickly and naturally occurring but it is not a mineral.

https://en.wikipedia.org/wiki/Obsidian

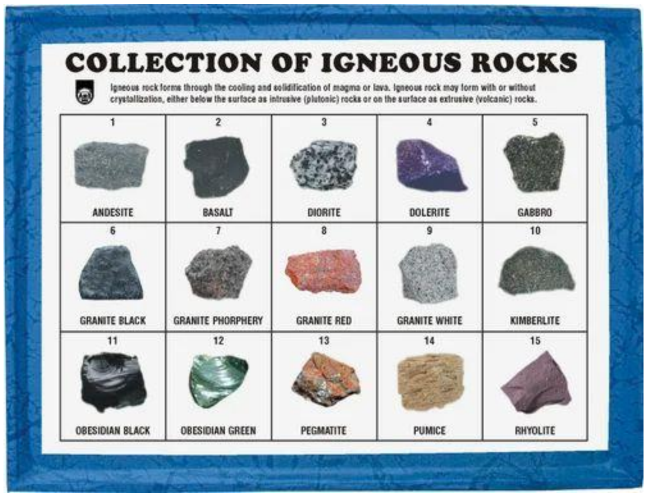
Most igneous rocks are composed of silicon and oxygen. This means they are composed of silicate minerals. Some igneous rocks contain other minerals such as sodium and carbon. About 95% of the Earth's crust and upper mantle are silicates. The makeup of the silicates includes one silicon atom and four oxygen atoms.



https://openpress.usask.ca/app/uploads/sites/29/2018/04/silicate-1.png

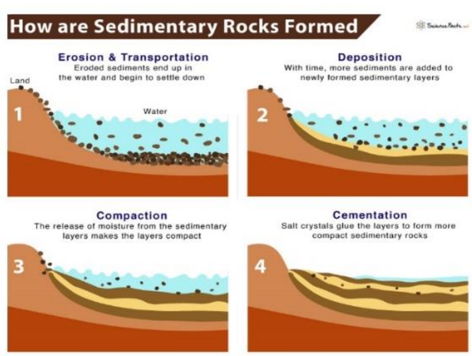
Igneous rocks are names according to their composition. For example, granitic rocks are high in silica content Light silicates have more potassium, sodium or calcium. A common example is granite. Basaltic rocks contain dark silicate minerals and an example is feldspar. Dark silicates are iron rich.

Here are some other examples of igneous rocks:



https://m.indiamart.com/proddetail/collection-of-15-igneous-rocks-4313625233.html

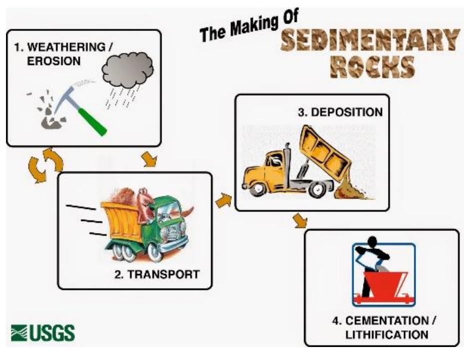
Sedimentary rocks comprise the second type of rock. If you recall the rock cycle, you will remember that sedimentary rocks are formed through several steps. For example, igneous rock might be weathered into smaller pieces called sediments. Other types of erosion, like wind and water, might displace those sediments and allow the pieces to drop in nearby areas. As the sediments build up, they become compacted. The layers of sediments build up and apply pressure to the underlying layers, compacting them. During this process, there may be times that dead organisms may be trapped between those layers, forming fossils. As the layers become compacted, various agents, such as water, might deposit minerals into the openings between the sediments, causing cementation. The process continues until you have solid layers called sedimentary rock. You can probably tell from reading about the process, that most sedimentary rock is formed near the surface of the Earth. Since that is the case, you can infer that the actions that form sedimentary rock are those that act on the Earth's surface, especially erosion or weathering. It can take between thousands to millions of years for sedimentary rocks to form.



https://www.sciencefacts.net/sedimentary-rocks.html

As you can see from the illustration, while sedimentary rock is gene break rally found near bodies of water, it can also be found in deserts and caves. As you review the illustration, let's go into more detail about how sedimentary rock is formed. The seven steps include: weathering, erosion, transportation, deposition, precipitation, lithification, and cementation.

Weathering can be mechanical or chemical. Mechanical weathering occurs when large rocks break into smaller rocks particles. The result is often sand and mud. On the other hand, chemical weathering occurs when agents, such as acid rain, cause chemical reactions that wear away rocks into smaller, and different, sediments. The sediments are worn away into smaller particles through erosion. Then they are moved by agents such as wind, water, and gravity in a process called transportation. Finally, as the sediment motion is slowed down, the sediments begin to be deposited and can build up as the beginnings of sedimentary rock. These deposits are exposed t agents such as rain, or precipitation, and the chemicals in the rain result in mineral deposits in the sediments. As the sediments become compacted, the space between the particles decreases and sediments begin to form sedimentary rock. Moisture between the particles is released in a process called lithification. After that, the compacted sediments are cemented to form sedimentary rock. The process takes time and the length depends on the location and other environmental factors.



https://www.geologyin.com/2014/11/sedimentary-rocks-and-processes.html

Sedimentary rock is classified into groups based on how they are formed. The three basic categories are clastic, biogenic and chemical. Clastic sedimentary rocks are usually classified according to grain size. For example, the grains can be classified as clay-sized, silt-sized, sand-sized or gravel-sized. The sizes range from microscopic (clay-sized) to very large boulders (Gravel-sized). Sandstone is a common rock produced by sand-sized particles. You have probably seen some gravel-sized sedimentary rock because most of us are familiar with a common one called conglomerate. Look at these examples:

sandstone

https://www.sandatlas.org/sandstone/

conglomerate

https://mineralseducationcoalition.org/minerals-database/conglomerate/

Sandstone is made of sand and has small grains. Conglomerate is course-grained and generally found in riverbeds where there are lots of pebbles and sand. We sometimes think it looks like concrete and many of us use it to decorate gardens.

Another type of sedimentary rock is called biogenic. Biogenic sedimentary rocks are carbonate based rocks. Another term would be biochemical sedimentary rocks. Most of these rocks are formed from the remains of marine organisms such as mollusks and corals. They are produced when organisms use materials dissolved in water and the result is different kinds of rocks, including limestone or coal.

Limestone
https://stock.adobe.com/search?k=limestone&asset_id=297343860

Coal
https://zh.mindat.org/min-11368.html

Think about coal and the uses mankind has for it. Coal has served as a heating source for many countries. In addition, many sedimentary rocks (shale) contain petroleum and natural gases. Finally, sedimentary rocks are sources of iron and aluminum.

The final type of sedimentary rock is chemical sedimentary rock. These rocks are formed when a solution becomes supersaturated and precipitates out of the solution. A common example of this type of rock is halite or rock salt and gypsum.

Halite rock salt
https://geologyscience.com/minerals/halite/

Gypsum
https://geology.com/minerals/gypsum.shtml#google_vignette

Halite is called a sedimentary mineral because it is precipitated from salt water and occurs when the ocean water is evaporated. There are salt flats in deserts where the water has evaporated and left rock salt deposits. Gypsum is also considered a type of rock mineral.

An unusual feature of sedimentary rocks is the possible presence of fossils in these types of rock. Since sedimentary rock is formed in layers, or strata, there are occasions when previously living organisms are found between the layers. Fossils can be traces or remains of organisms. They cam be from prehistoric life or from more recent living organisms. Scientists can use fossils to date layers of rocks as well as describe possible environments. Prehistoric fossils include trilobites and dinosaurs. Fossils of nautilus show how little some organisms evolve. Examine these fossils and see if you can explain why fossils are found in sedimentary rock but not in igneous or metamorphic rocks.

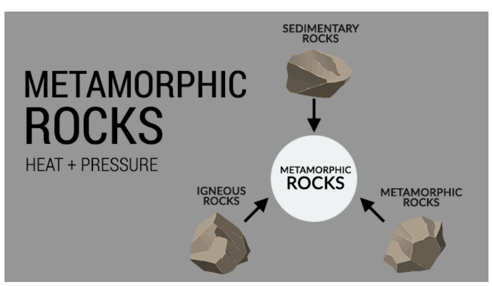
Trilobite
https://smithsonianassociates.org/ticketing/tickets/earliest-animals

Nautilus
https://www.discovermagazine.com/planet-earth/take-a-tour-of-these-incredible-living-fossils

You will study more about fossils in another chapter. Here are some examples of sedimentary rock:

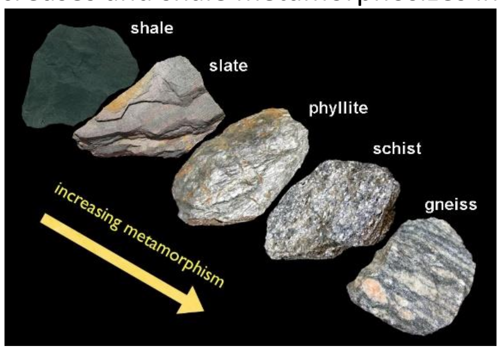
https://www.sciencefacts.net/sedimentary-rocks.html

Remember when you studied how caterpillars change into butterflies? It was called metamorphosis and indicated one thing changed into another. That is what happens with metamorphic rock.   The final rock type we will study is metamorphic rock. Metamorphosis occurs when one object changes into another object – like metamorphic rock. Examine the rock cycle illustration above and see how each type of rock can change into the other type of rocks. Let's see how metamorphic rock is formed in this process. One thing that makes metamorphic rock different from igneous and sedimentary is that metamorphic rock forms from other types of rocks. In other words, one type of rock changes into another type of rock as a result of certain specific conditions. Igneous or sedimentary rock must be exposed to changing environmental conditions, such as high heat and high pressure. Those are the two main causes that produce metamorphic rock. You probably recall that pressure and heat build up the deeper you go into the Earth's crust, so metamorphic rocks are often formed deep in the crust. They can also be formed wherever rock is hot but stays in a solid state, allowing it to recrystallize into a new form. Metamorphic rock can also form along the tectonic plates on the Earth's crust. The plates often collide with great force and result in areas of high pressure. The result are changes to the texture or composition of the rock that has undergone metamorphosis.



https://earthhow.com/metamorphic-rocks/

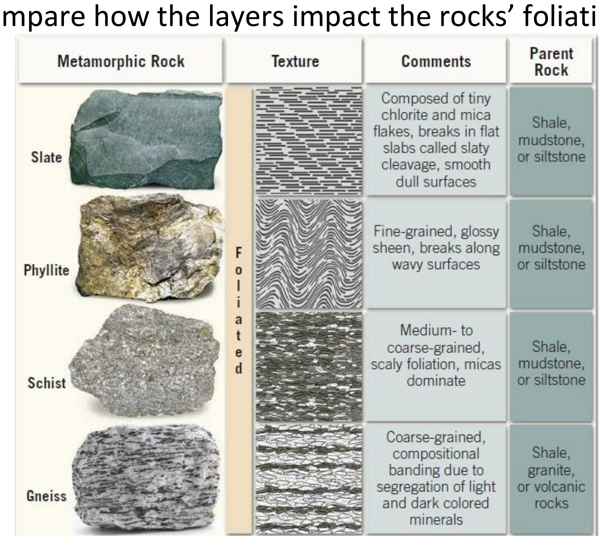
When rocks undergo these changes, the result is often a change in the chemical components. For example, certain conditions increase metamorphism and the initial rock becomes another type of metamorphic rock. The initial rock is called the parent rock (protolith) and it exists before any changes occur. Parent rock can be any type of rock, including another metamorphic rock. As the pressure and heat increases, changes in the parent rock begin to occur. White the parent rock does not completely melt (or it would become magma and then igneous rock), the changes do impact the textures and minerals in the parent rock. Generally, the chemical composition stays relatively stable during the changes. Look what happens as pressure and temperature increases and shale metamorphosizes into gneiss.



https://pressbooks.cuny.edu/gorokhovich/chapter/rocks-and-rock-cycle-ii-characteristics-of-metamorphic-rocks/

Let's look at some other examples of how one type of rock becomes metamorphic. Granite is an igneous rock that is exposed to heat and pressure and changes into gneiss. Shale can become slate and limestone becomes marble.

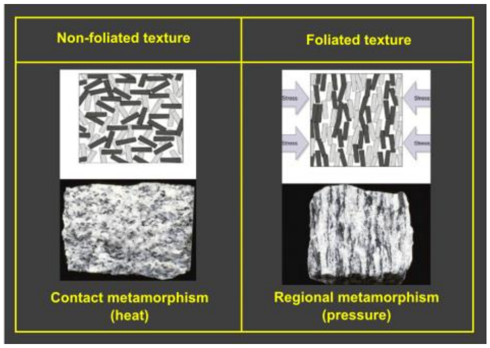
Metamorphic rock is mostly classified by texture and composition. They tend to have course crystalline textures. This type of rock can also show distinctive layering called foliation. Foliated rock is composed of repeated layering while developing into metamorphic rock. The layers can be thick or thin and it is a result of different amounts of pressure at different angles during formation. Foliated rocks can be split into thin plates. Foliation results in bands that show the colors of the minerals that formed the rock because the mineral grains are aligned. When you observe a foliated rock, you might see different layers or colors or textures. Examine the following chart to compare how the layers impact the rocks' foliation.



https://mimaed.com/foliated-metamorphic-rocks/

The opposite of foliated is non-foliated rock. In non-foliated rocks, the mineral grains are non-aligned.

https://www.slideserve.com/osric/heat-and-pressure-change-rocks



https://socratic.org/questions/what-are-the-characteristics-of-foliated-and-non-foliated-metamorphic-rocks

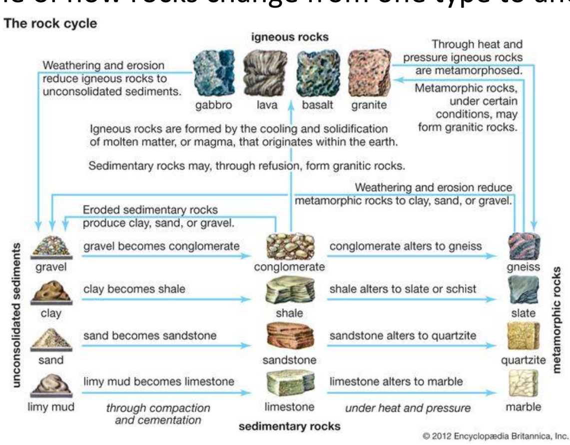
Non-foliated rocks do not have a sheet-like structure. There may be several reasons why metamorphic rocks form as non-foliated. First, the parent rock may be composed of one type of mineral. If that is the case, there are no distinct minerals to line up and becomes foliated. Another reason may be that the parent rock is not subjected to high pressures and the minerals remain unaligned. At other times, the parent rock may be exposed to hot igneous rock that changes the mineral structure without adding pressure. Examples of non-foliated metamorphic rock include marble and quartzite.

Summary of Rocks

There are many types of rock but all are a result of the rock cycle. Each is an important part of the cycle and each depends on each other. Important ideas to remember about the rock cycle include the following:

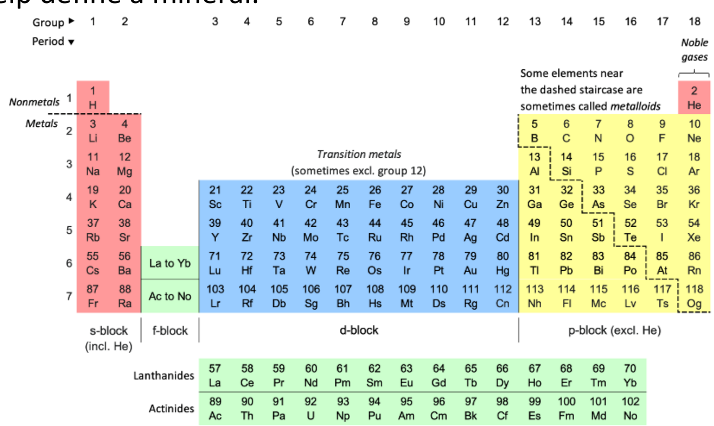
- Sedimentary rock is layered and can contain fossils as a result of the layers being compacted and cemented around dead organic remains,
- Igneous rock is a result of heating sedimentary and/or metamorphic rock and develops as molten magma cools,
- Metamorphic rock occurs when the mineral content of the rock is changed while the rock remains solid,
- The rock cycle is dynamic and ongoing, and
- Rocks can contain minerals (but minerals do not contain rocks).

This following is an example of how rocks change from one type to another:



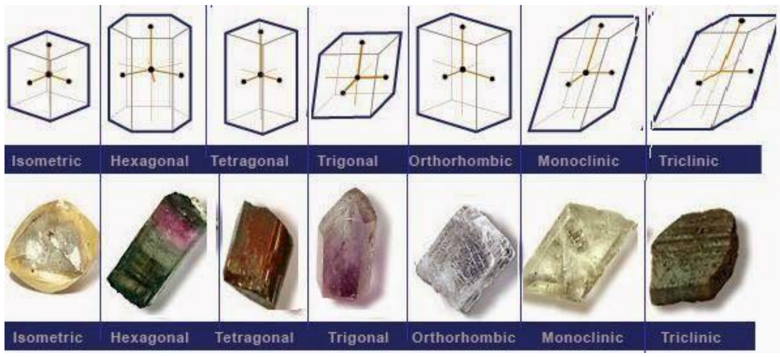
Now that you have reviewed the rock cycle and learned about the types of rocks, let's see how rock are related to minerals. In order to really understand minerals, we need to start with the concept of matter.

The heart of matter starts with the periodic table. The periodic table is an organized arrangement of chemical elements that allows us to study them and understand how they behave. Elements are the simplest form of matter. They are the basic building block of minerals. The smallest part of matter is called an atom, composed of three main parts: protons, neutrons and electrons. The atom is defined as the smallest part of matter that retains the specific characteristics of the given element. In other words, an atom of carbon has all the characteristics of carbon, while an atom of hydrogen has the characteristics of hydrogen. The number of protons in the nucleus of the atom is how we identify elements and defines the characteristics. Another term for the number of protons is the atomic number of the element. Combining two or more atoms of the same element makes a molecule; chemically combining two or more elements makes a compound. Chemical compounds have definite chemical compositions – that is one of the definitions of a mineral. You will learn more about elements, atoms, compounds, isotopes, and the period table in another chapter but let's think about the other criteria that help define a mineral.

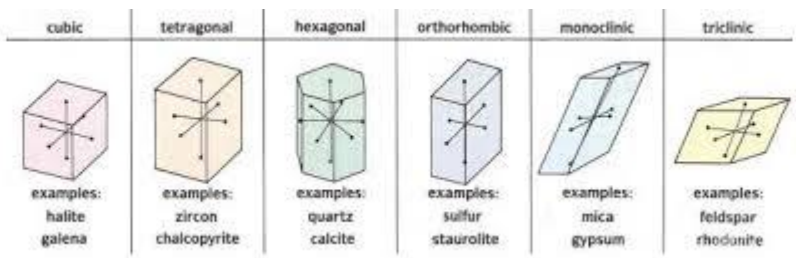


https://en.wikipedia.org/wiki/Periodic_table#/media/File:Colour_18-col_PT_with_labels.png

Minerals are often considered the building blocks of rocks. They have very specific characteristics , including thy have a definite chemical composition. According to the International Mineralogical Association, the other four generally accepted criteria for identifying a mineral are (1) they are naturally occurring, (2) they are inorganic, (3) they are solid, (4) they have a crystalline and orderly internal structure, and (5) they have a definite chemical composition. Let's review each of the criteria. First, the mineral must be naturally occurring. That means minerals are a result of Earth's geologic processes. Manmade minerals are not considered to be "real minerals" since they are not naturally occurring. While real diamonds are considered a mineral, lab created diamonds are not considered minerals. Second, minerals are inorganic. That means they have never been living. While we know carbon is an important component in organic materials, we also know that the element is inorganic and defined as a mineral. There are some scientists that believe the shells of some marine animals can be considered minerals because they are secreted by the organisms and are inorganic compounds. That is just something to think about. Third, at room temperature, the mineral must be a solid. This means, as the mineral naturally occurs it must be a solid. The only exception is mercury which is a liquid at room temperature, but still classified as a mineral. Since the mineral is a solid in its natural state, it has the properties of a solid, making the atoms have an orderly atomic arrangement. Most minerals have a crystalline structure, even if in different crystal arrangements. Examine the different crystal formations: PICK ONE

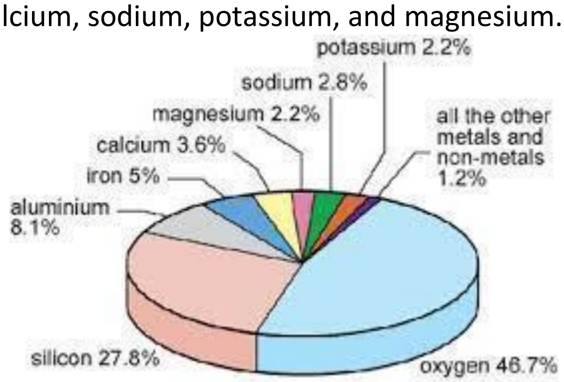


https://www.geologyin.com/2014/11/crystal-structure-and-crystal-system.html



https://www.geologyin.com/2014/11/crystal-structure-and-crystal-system.html

Finally, minerals have a well-defined chemical composition. That means most minerals are compounds, with a few exceptions such as gold and silver (which occur in nature). And these chemical compositions can range from $Mg_3Si_4O_{10}(OH)_2$[talc] to C [diamond], complex compounds to simple elements. It is interesting to note that, while there are more than 4000 minerals, there are eight main elements that make up most of the Earth's crust and most of the minerals we find on Earth. The most abundant elements found in the Earth's crust are oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium.



https://brainly.com/question/22506456

All these different minerals can be identified through specific physical and chemical properties. Properties help identify minerals. Some of the most common properties used to identify the minerals include luster, color, streak, hardness, cleavage, fracture and specific gravity. Let's take a look at each of these properties. First is luster. Luster is the ability of the mineral to reflect light and how the interior refracts light. It is considered a physical property. We often think about luster as shininess, but, in reality minerals can have many different kinds of luster. Minerals can have metallic or non-metallic luster. Examine the samples below to see the different kinds of luster a mineral can have and can be used to identify the different minerals.

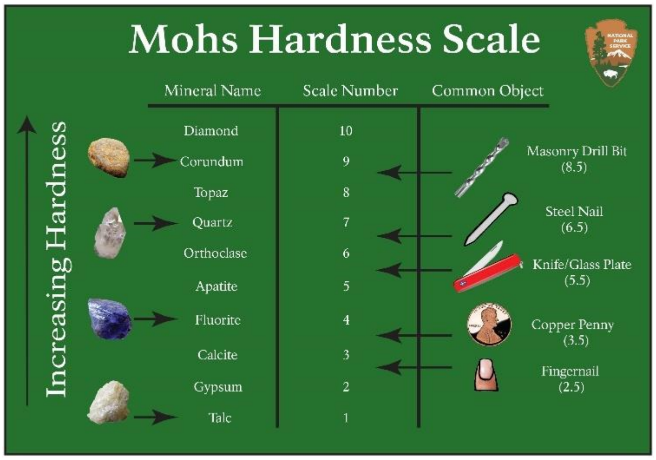
https://farmcity.it/the-difference-between-metallic-and-non-metallic-minerals-mm-PwvD02S3

Another property is color. While easily observable, color in not as reliable as some of the other properties. In fact, some impurities can change the color of a mineral. For example, corundum can be blue (sapphire) or red (ruby), depending on the impurities in the mineral. However, both are still corundum. Look at the variety of colors below for one specific mineral and see why color is not a reliable property to identify minerals.

Streak is a more reliable property to use to identify minerals. Streak is the color of the mineral's powder. It is obtained by rubbing the mineral across a streak plate and looking at the streak that is left on the plate. Even if the color of the mineral changes, the color of the streak does not. Some minerals, such as quartz, do not have streak. To use streak, minerals must be softer than the streak plate. Streak is still a good way to identify minerals. Look at the sample streaks below:

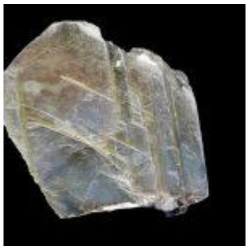
https://www.geologyin.com/2014/03/the-streak-of-minerals.html

Some minerals are easily scratched with a fingernail or knife while others can scratch glass. This property where the mineral resists scratching is called hardness. The hardness of a mineral can be determined using some common objects, such as a fingernail, an iron nail, copper pennies, or a plain knife. Hardness can be observed when one of these objects scratches the mineral. Measuring hardness of a mineral is a relatively reliable way to identify minerals. It is measured using Mohs Scale of Hardness. Mohs test demonstrates the level of hardness. Mohs Hardness Scale can be used to test relative hardness when two minerals are compared to each other. The hardness ranges from soft (1) to hard (10). Most hardness kits contain samples of each hardness level. For example, talc (1) is commonly used as a reference mineral for a soft mineral while corundum(9) is used as to reference a hard mineral. (it should be noted that diamond is hardness of 10 but it is less common to locate for everyday testing.) If a specific mineral can scratch another mineral the scratched mineral is softer. While any mineral can scratch a mineral softer than itself, it cannot scratch one that is harder. You can also test hardness with common objects, such as fingernails (hardness between 2 and 2.5) or glass (hardness between 4 and 7) or even knife blades (hardness between 5 and 6.5).



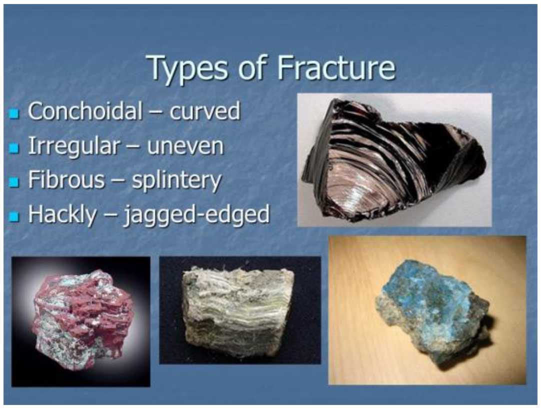
https://www.nps.gov/articles/mohs-hardness-scale.htm

Cleavage is described as the tendency of a mineral to split along smooth planes. The break usually happens along a plane that has weak bonding forces. Many times, the cleavage is aligned to the crystalline formation of the mineral. For example, the cleavage tends to occur in a parallel direction to the crystal formation. When cleavage occurs perfectly, the faces produced are smooth and the break occurs easily. A perfect example is mica, a mineral used in electronics, plastic, and paint industries, which splits into very distinct layers easily:



https://mineralseducationcoalition.org/minerals-database/mica/

On the other hand, fracture is when the mineral breaks along an irregular surface. As a result, there are different kinds of fracture but none produce smooth planes. You can see from the examples below that there are several types of fracture in minerals. The facture that resembles a shell is curved and occurs in minerals such as quartz and flint. The irregular fracture is rough and the most common type of fracture. Splintery fracture produces surfaces that appear like partially separated splinters or fibers, like jadeite. Most metals produce a hackly fracture which has sharp edges and jagged points. Look at these examples:
https://slideplayer.com/slide/9115787/#google_vignette



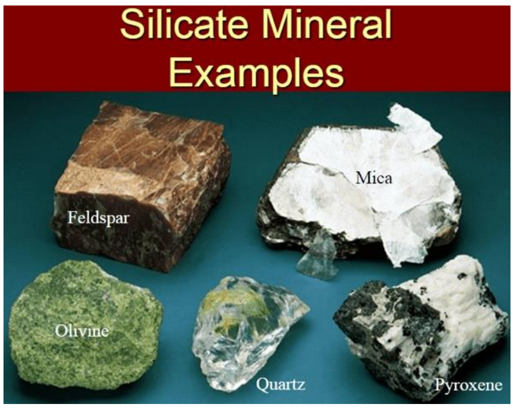
Specific gravity and density are somewhat related. Specific gravity is the ratio of the density of a substance to that of a standard substance, in this case, water. Each mineral has a characteristic specific gravity, just like elements have a specific density. It is one of the most reliable properties of minerals when helping to identify a mineral. The main purpose of specific gravity is to show whether or not something will sink or float.

There are also special properties that help identify minerals but are not used as commonly as the common ones. These include properties like magnetism, taste, odor, reactivity with acid, fluorescence, tenacity, transparency, radioactivity, effervescence, double refraction, and crystalline structure. Let's look at the table and see the summary of the properties and how they are used to identify minerals.

Property	Description	Types
Luster	Ability for the mineral to reflect light	Shiny, dull, oily, glassy, pearly, metallic, nonmetallic, resinous, waxy, vitreous
Color	Observable color of the sample	Not as reliable as some tests as the color is impacted by impurities present in the sample
Streak	Color of the mineral's powder when mineral is rubbed on an unglazed porcelain plate (streak plate)	Use color of powder which may not be the same color as the mineral; more reliable than just using color of mineral
Hardness	Resistance of a mineral to abrasion or scratching	Use Mohs Scale to test mineral hardness of soft minerals to hard minerals
Cleavage	Tendency of the mineral to break along the planes of weak bonding	Breaks (cleaves) along parallel flat surfaces called cleavage planes
Fracture	Mineral breaks in more or less random patterns with no smooth planar surfaces	Can be cut in any direction; generally, are rough or irregular surfaces
Specific Gravity	Equal to its weight divided by the weight of an equal volume of water	Similar to density but has no units since comparison of weights

Most minerals occur as compounds. Minerals are, however, often classified into two different groups based on the compound composition: silicates and non-silicates. Let's look at the silicates as they are the most common in the Earth's crust and certainly makes up most of the rocks. The silicate minerals are the largest and most important group that make up the Earth's crust. The silicate minerals that make up rocks on the Earth's crust include quartz, feldspar, mica, olivine, and many clay minerals. Almost all these minerals are made up of a combination of oxygen and silicon atoms in a specific arrangement, 4 oxygen to 1 silicon. That special organization of silicon: oxygen molecules form a variety of chemical structures that allow silicates to be classified into several major groups. Each group demonstrates a specific chemical structure and represents a variety of minerals. For example, nesosilicate's structure is an isolated silicon tetrahedra and the examples are garnet and zircon. Phylllosiliciates form in sheets and an example is mica. Each of the seven major groups have a specific chemical structure that impacts the physical properties.

Non-silicates are minerals that do not contain silicon. There are a variety of minerals groups in that category. One type are the native elements. Those are minerals that are composed of one type of atom, such as gold, silver and copper. Another group are the oxides. Oxides are composed of oxygen and at least one other element combines to form a compound, such as corundum. Oxide ores, such as iron ore or tin ore, are sources of valuable metals. Other valuable ores are present in the sulfides, which are minerals where various elements combine with sulfur. Carbonates are combinations of carbon and oxygen. Mostly these minerals are combinations of oxygen and carbonates. An example of a carbonate mineral is calcite, which, when combined with acidic water can form limestone caves. Halides result when fluorine, chlorine, iodine or bromine combine with sodium, potassium or calcium. Non-silicates are minerals that have multiple uses, including in construction, electronics, cosmetics, and medicine. Here are some examples of silicate and non-silicate minerals:



https://www.911metallurgist.com/blog/classification-silicates-minerals
https://www.megatruenet.com/?k=examples-of-silicate-minerals-10-dd-edObPguV

Summary of Minerals

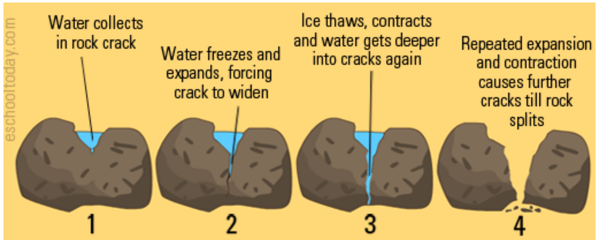
- Minerals have specific physical and chemical properties that can be used to help identify them.
- Color and luster describe the mineral's outer appearance.
- Streak is the color of the powder.
- Mohs Hardness Scale is used to compare the hardness of minerals.
- Cleavage, or the characteristic way a mineral breaks, depends on the crystal structure of the mineral.

Weathering , Erosion and Deposition

To add to your knowledge base about rocks, let's learn a little more about come of the actions that impact rock and soil formation. Weathering is the breakdown of rocks, soils and minerals as a result of environmental or human factors. It occurs when rocks (or other objects) are exposed to water, wind, or other environmental factors. There are two main types of weathering. First is mechanical weathering and the second is chemical weathering.

Mechanical weathering is also called physical weathering. This type causes rocks to break down into smaller particles without changing the composition of the original material. As you probably recall, the smaller particles are often called sediments and are part of the rock cycle when forming sedimentary rock. Several factors can impact mechanical weathering. Water can seep into rock crevices, freeze and expand and cause the rocks to break into smaller particles. This ongoing freezing and thawing results in the rock cracking and breaking into smaller pieces. Another name for the freezing and thawing mechanical weathering is called frost wedging.

Frost wedging occurs when water seeps into cracks in the rock, expands on freezing, and causes the cracks to enlarge and break the rock apart.



https://express.adobe.com/page/h1SJSPdfHHBk8/

https://study.com/learn/lesson/ice-wedging-examples-causes-what-is-frost-wedging.html

Rocks are also impacted by hot temperature changes, causing expansion and contraction. Again, this results in rocks breaking down into smaller sediments. This is especially true in rocks that contain large amounts of clay that retain water and then shrink and swell, depending on if it is wet or dry. In deserts, where the temperatures fluctuate a great deal from night to day, rocks undergo thermal stress. The tocks expand and contract due to the extremes in temperature and, if there is not adequate space to expand, the rocks will end up breaking due to the ongoing thermal stress. Mechanical weather can occur from abrasion. As rocks are exposed to wind, to humans and animals walking n the rocks, and other types of grinding away of the rock, the parent rock breaks down into smaller particles. Finally, plants, like mosses and lichen, can grow into the tiny crack on rocks and split the rocks. You have seen trees growing out of the side of rocky cliffs and probably wondered how they got there. It is part of the weathering process. The lichen in this picture helped prepare a place for future trees!

https://www.fs.usda.gov/wildflowers/beauty/lichens/habitat.shtml

https://www.123rf.com/stock-photo/tree_on_cliff.html?page=2

Mechanical weathering also occurs as a result of wind and water. Wind carries small particles of abrasive materials and can slowly, or rapidly, wear away at different land forms and rocks. This is especially true in the desert where winds carry particles of sand and are very abrasive to the existing rocks. The wind wears away at the rocks and the result is often very interesting formations. Water has the same effect on rocks. The source can be acidic rain or rivers – the result is the same. The water in fast moving rivers or streams wears away at the rocks and causes them to break down into smaller sediments or particles. Those same particles can also abrade rocks as the water runs downstream. Near shore lines, the waves can pound on rock formations as well. The end result, again, can be very interesting rock formations.

Please note that physical weathering is the break down of the rocks in place. It is officially erosion when the smaller particles are transported and deposited in another location. Look at these pictures that are the result of wind and water mechanical weathering:

Caused by Wind Caused by Water

https://www.nationalgeographic.com/science/article/weathering-erosion

https://www.legendsoflearning.com/learning-objectives/weathering-and-erosion-science-games/

Besides mechanical weathering, rocks and minerals are exposed to chemical weathering. Chemical weathering occurs when the rocks and/or minerals are chemically changed into new substances. Chemical weathering may occur more in warm, moist climates because of the presence of water, oxygen, carbon dioxide. These conditions result in a weak carbonic acid which supports faster rates of chemical weathering. For example, rocks and minerals in warm areas are exposed to more rain, humidity and heat which allows weathering to occur at a faster rate. Other factors, like runoff and groundwater can have an impact on chemical weathering as well. In addition to environmental factors, the chemical composition of the rocks and minerals can impact the rate of chemical weathering. One example is gravestones. When those are made from marble, they are susceptible to chemical weathering. Granite headstones seem to last longer. Examine the picture on the right. It shows the weathered headstone as well as how it originally looked before chemical weathering!

https://genealogy.stackexchange.com/questions/9212/how-to-recover-information-from-a-well-weathered-limestone-tombstone

Weathering is impacted by several factors. As we discussed, it is impacted by climate and temperature. The composition of the original object also determines the rate of weathering. The amount of rock that is exposed to the elements can determine how fast the weathering can occur. Think about Mount Rushmore and how weathering will change the landscape of presidential features:

https://www.nps.gov/moru/index.htm

While weathering occurs when the rocks are in a specific location, erosion occurs when particles or sediments are moved from one location to another. This generally occurs when wind, water or gravity move the particles and they end up in a new location. When the wind, water or gravity no longer are moving the sediments, the loss of force allows the sediments to drop and be deposited in the new location. When the sediments are deposited the process is called deposition and often results in a variety of landforms.

Water in streams and rivers provides an effective way to move sediments. Since erosion is almost always the downward movement of sediments, moving water provides the perfect way to support erosion. The sediments are often dissolved in the running water and the materials are suspended in solution. As the running water slows down, the particles also slow down and heavy (or large) sediments are deposited first. The particles continue downstream until the water is barely moving and the smaller sediments are deposited. The term for the dissolved materials in the running water, or stream, is called the stream load and can be defined as small sediments to larger rocks that are being moved. Streams also erode the stream beds. The running water cuts into the sides and bottoms of the streams and erodes parts of the bank. There are times when the running water meets areas that cause the stream to bend or meander. That causes the stream or running water to have curves, sometimes small islands appear in the stream as well. When the stream finally enters a larger lake or ocean, the sediments are deposited and often form a delta. This area, or the delta, is rich in soil and nutrients and is good for farming.

Meandering stream or river
https://www.quora.com/What-is-a-meandering-river

Delta Landforms
https://www.nps.gov/articles/delta-landforms.htm

Summary

Geology is the study of the Earth. The first part of the word, "geo", means earth; ology means the "study of." So, while geologist study the Earth, they are looking for clues from the past in the rocks that compose the Earth's crust, as well as the minerals that make up rocks.

Knowing about the past from the rocks and minerals helps scientists know more about the future. This is known as uniformitarianism: the present is the key to the past. The idea was developed by James Hutton around 1784. His ideas included that the Earth is continually being formed (weathering and erosion, the rock cycle), sedimentation takes place very slowly (the rock cycle and sedimentary rock), heat from the Earth is involved in making rock layers (metamorphic and igneous rock). He is now known as the "father of geology."

Review: Think About It

1. Draw, label and explain the main parts of the rock cycle.
2. Describe how the rock cycle demonstrates recycling.
3. Describe the biogeochemical cycles that have a direct impact on rock formation.
4. Describe the characteristics of the three types of rocks.
5. Explain luster. If a mineral looks dry and chalky, what sort of luster does it have?
6. Apatite scratches the surface of an unknown mineral. Which mineral would you use next to test the mineral's hardness — fluorite or feldspar? Explain your reasoning.
7. What is streak and why is it more reliable than color when identifying a mineral?
8. Explain erosion and deposition and use that information to explain why land at the delta so rich in nutrients.
9. Explain the difference between weathering and erosion.
10. Compare and contrast mechanical and chemical weathering.

References

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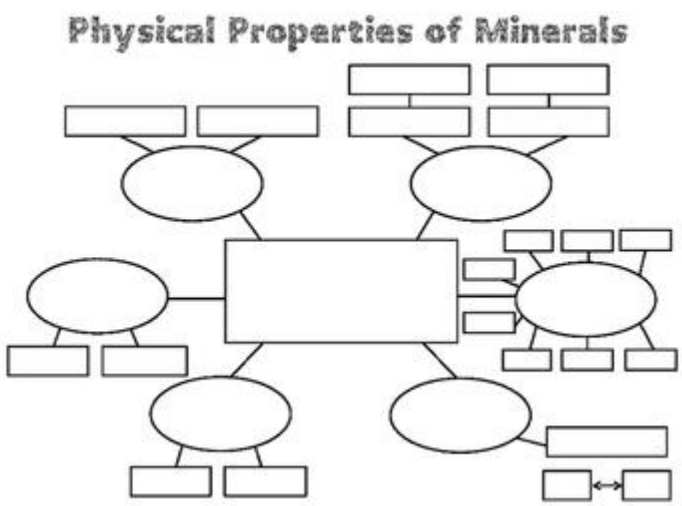
Suggested Instructional Strategies

- Small group projects
  - Jig Saw: Divide the students into small groups and assign specific topics to each group. For example, the characteristics of minerals – each group would get one characteristic (luster, specific gravity, hardness, etc.) to research. Then the individual groups would do a presentation to the whole group on the specific topic. That allows one small group to share the new content with the entire

class and practice teaching others (peer teaching and doing presentations skills are improved as well).

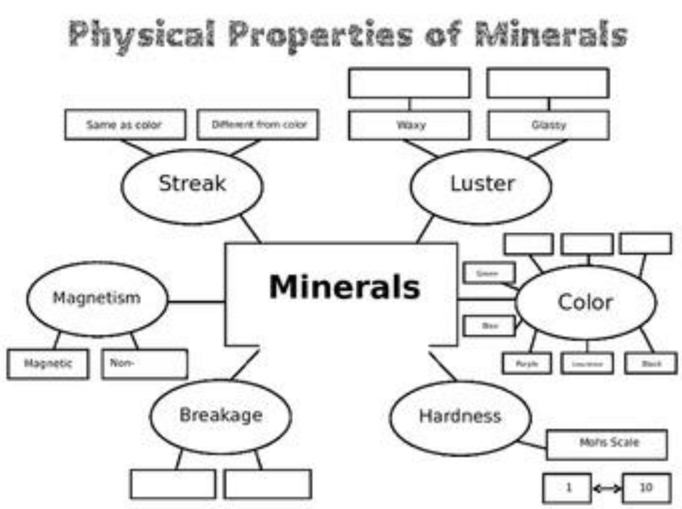
- Concept maps/Graphic Organizers
    - Allows students to see the relationships among the concepts.
- Guided Notes
    - Supports students who struggle with note taking. The teacher creates a model for the daily notes and allows the students to complete the worksheet during the lecture. It shows students how to take notes and highlights the most important concepts.

Worksheets for Rocks and Minerals



Key:

https://www.pinterest.com/pin/physical-properties-of-minerals-graphic-organizer--377739487475805855/



This concept map could be modified to emphasize other concepts as well.

Labs in Rocks and Minerals
Https://youtu.be/7MvXv66b5h4 mineral identification (get data from Dr. Mason)

https://youtu.be/7MvXv66b5h4 earth science labs with great directions and suggestions

https://geo.libretexts.org/Bookshelves/Geography_(Physical)/Physical_Geography_Lab_Manual_(Ray_et_al.)/01%3A_Labs/1.12%3A_Lab_12_-_Introduction_to_Minerals_and_Rocks

https://storymaps.arcgis.com/stories/b28e82893a244558a20e1de4aae543f4