Name: _____ Date: _____
Regents Earth Science Per: _____

Class Notes: Chapter 2: Minerals, Minerals, and Resources (Completed Copy)

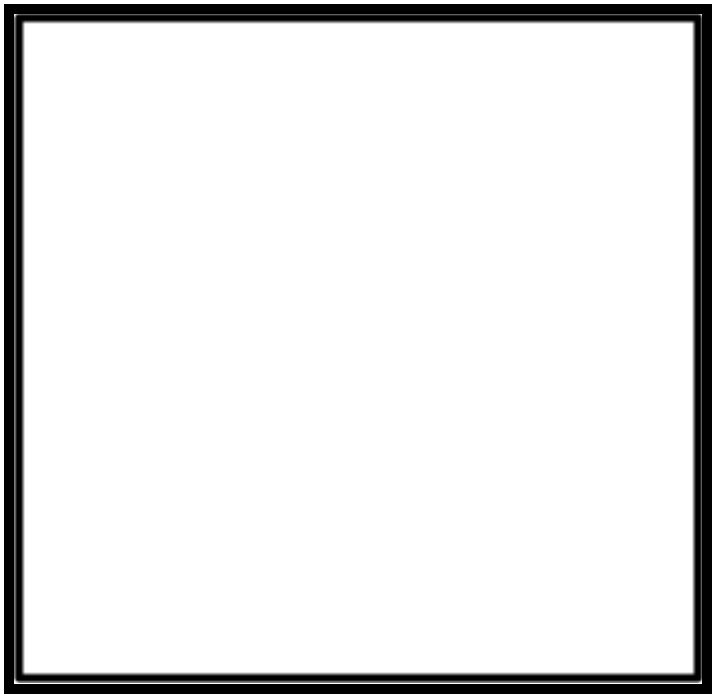
What Are Minerals?

- **Minerals** are naturally occurring, inorganic, homogenous (uniform) solid substances.
  - **Inorganic** means it was not formed from plants or animals
  - Minerals are the building blocks of rocks.
  - The “ingredients for rocks” may be composed of single or many different elements combined.
  - Examples of elements: _____
- Each element has a specific amount of electron, protons and neutrons.

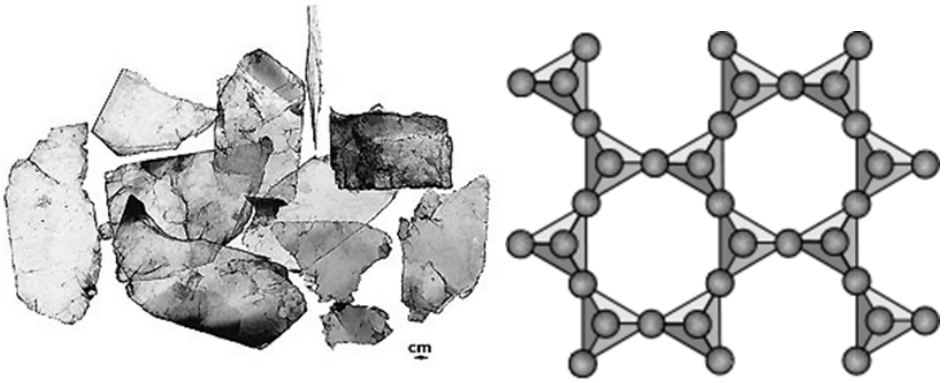
Electron: A tiny negatively charged particle that surrounds the nucleus of an atom. Electrons can only be found in different shells or energy levels.

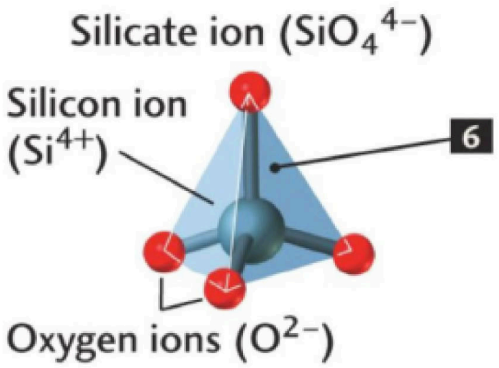
- 75% of the materials found on the crust of planet Earth are composed of two elements: Silicon and Oxygen.
- Together, the two elements form the silicon-oxygen tetrahedron (SiO_4). This “tetrahedron” makes up 90% of all minerals in the crust.
- The tetrahedrons are held together by covalent bonds.
- The sheets in turn are connected to other sheets above or below them with weak ionic bonds

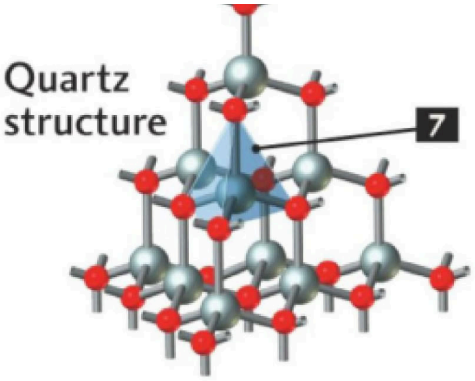
Silicon-Tetrahedron Model:

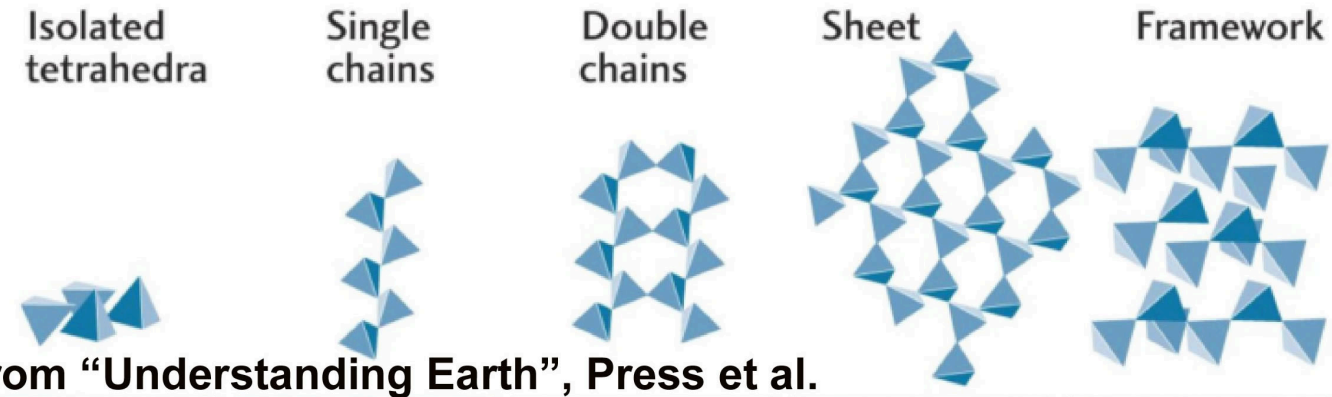


Mica:

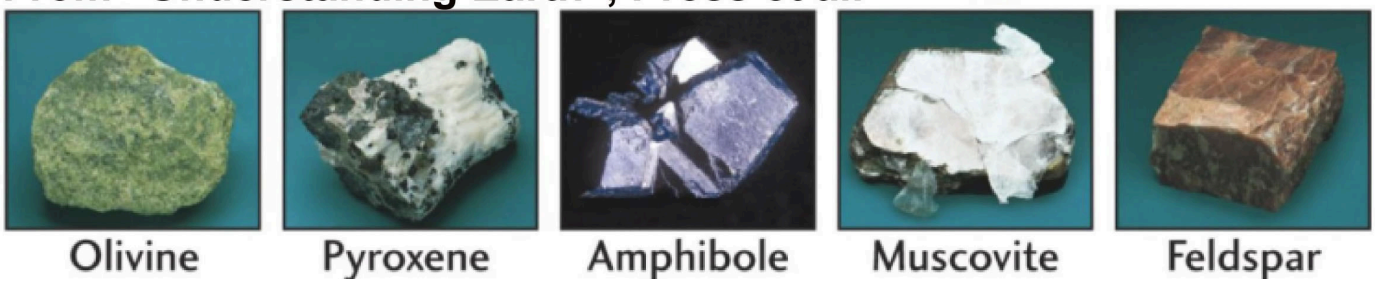






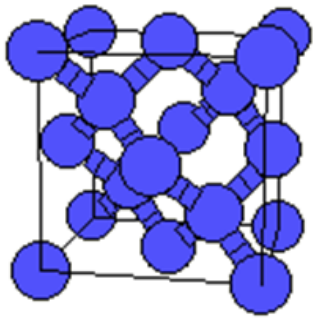


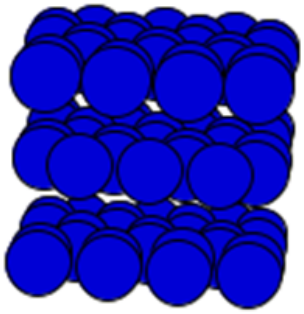
From "Understanding Earth", Press et al.



- Minerals can have the same chemical composition (Carbon) but different physical properties because of their arrangement of atoms

Example: Diamond **Graphite**





What is Considered a Mineral?

In order to be considered a mineral, it must meet the following criteria:

- Naturally occurring (not man-made)
- Solid (not a liquid or a gas)
- Inorganic (not from living organisms)
- Definite chemical composition (specific chemical make-up)
- Definite crystalline structure (specific arrangement of atoms)

Monomineralic: Rocks composed of one mineral only.

- Examples: Magnetite, Fluorite & Calcite

Examples of Minerals:

Quartz (SiO_2)

Galena (PbS)

Graphite (C)

Azurite $Cu_3(CO_3)_2(OH)_2$

How Do We Identify Minerals?

1. Color
2. Streak
3. Fracture/ Cleavage (the way the mineral breaks)
4. Hardness, Luster
5. Other characteristics

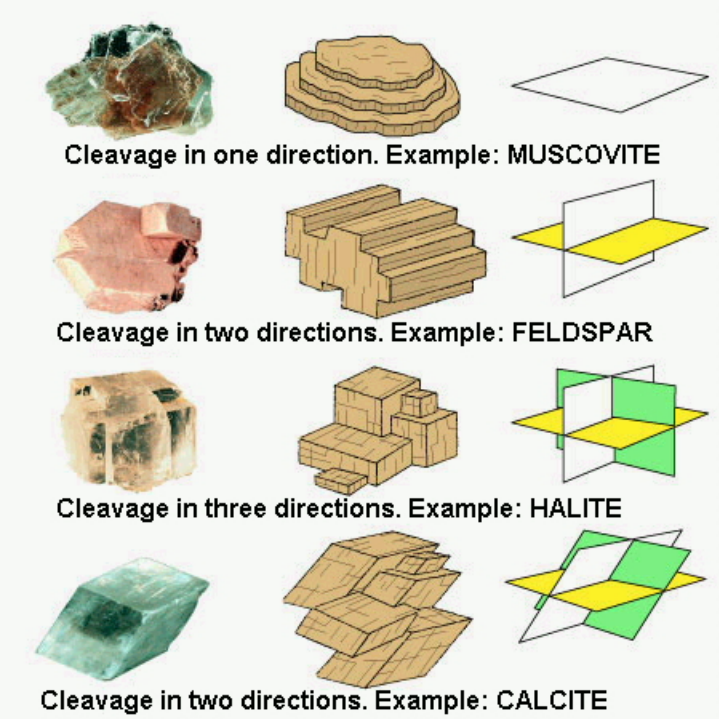
Cleavage Vs. Fracture

Cleavage: The way that a mineral splits between layers of atoms that are joined by weak bonds.

- Cleavage= “To Cut”

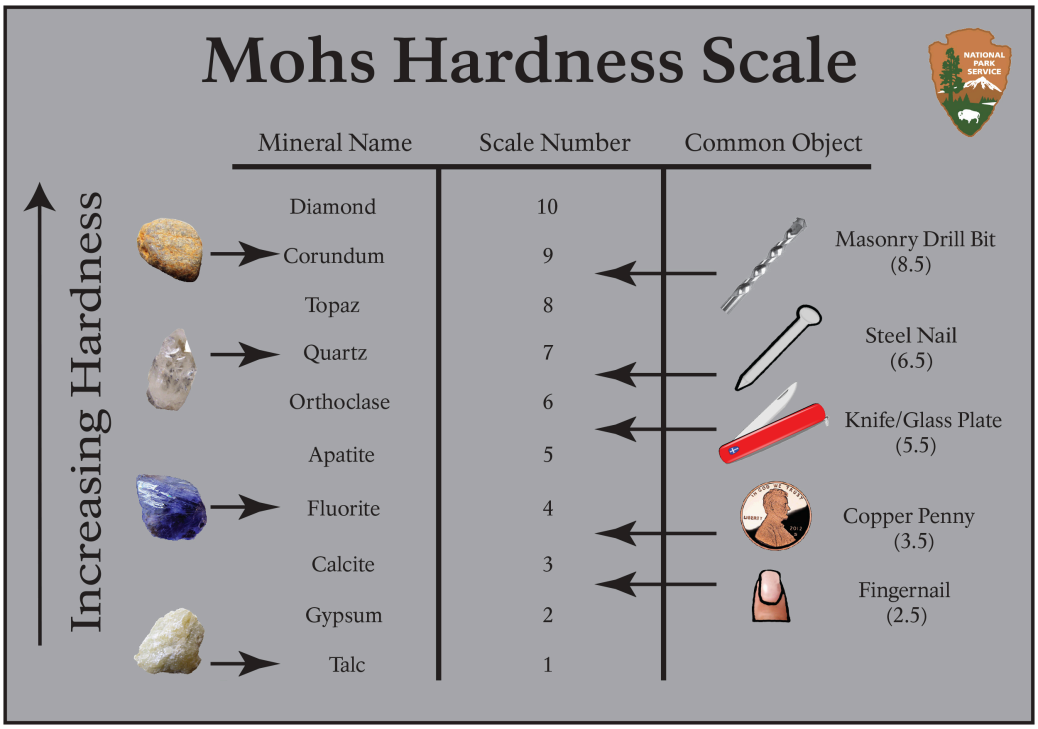
Fracture: Uneven splitting of a mineral

- Think of when you fracture a bone. It is not a perfect split.



Hardness

- Each mineral has a specific hardness based on Moh's Hardness Scale.
- Determining the hardness of a mineral can be found by using various materials.



Luster

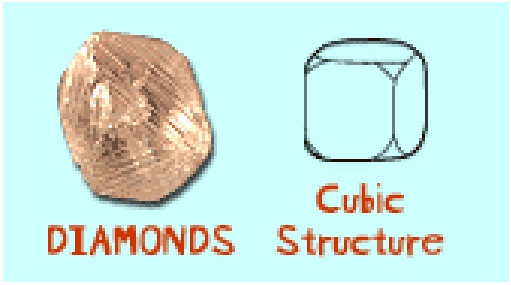
Luster: The way in which a mineral reflects light.

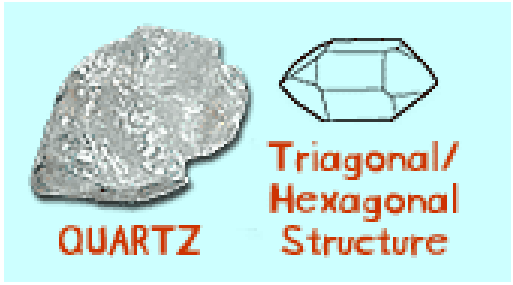
- **Metallic:** Shiny, like it is polished metal.
  Examples: Pyrite, galena, silicon, graphite

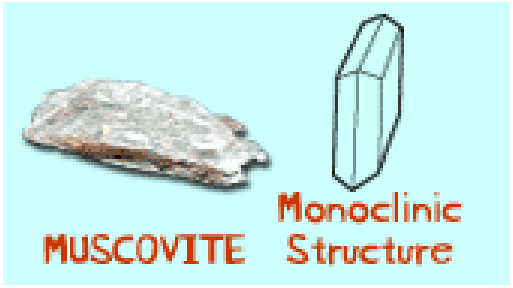
- **Non-Metallic:** Can be described as glassy, pearly, earthy, greasy or dull.
  Examples: Dolomite, feldspar, mica, graphite (greasy)

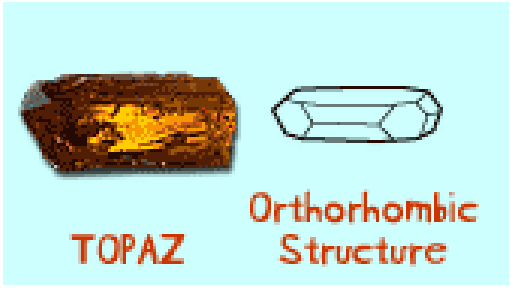
Other

- When allowed to grow freely (not in a confined area), minerals will grow in a specific crystallic shape.
- For example, quartz crystals are 6-sized or “hexahedral.”
- Due to atomic arrangement.
- Some minerals can be magnetic
- Some minerals are radioactive
  - Some are used to make bombs or are used in medical procedures.
- Some minerals are fluorescent under ultraviolet light









Specific Gravity

- It is a mineral’s density compared to water.
  Imagine there are equal volumes of material present in each of the following bottles…..

1) There is a gallon bottle filled with water
2) A gallon bottle filled with feathers
3) A gallon bottle filled with lead weights

In order of increasing specific gravity, these materials would be: **feathers, water, lead**

Families of Minerals

→ Carbonates

- The carbonates minerals are formed at the Earth's surface through chemical or biochemical activity.

- Many marine organisms make their skeletal parts from **calcite**. (Seashells!)
- This material accumulates to form the sedimentary rock **limestone**.
- The rock-forming carbonates are **calcite** and **dolomite**.
- Carbonates "fizz" when **hydrochloric acid** is placed on them. The acid reacts with the mineral releasing **carbon dioxide** gas.

→ Silicates

- The silicates are the most abundant mineral group.
- The crust and mantle of the Earth, about 75% of the volume of the planet are predominantly made of silicates.

→ Sulfates

- Any mineral that has a sulfur atom connected to 4 oxygens. (The rotten egg element)
    - This includes gypsum, which you will see in lab.

How are Minerals Formed?

- Some minerals are formed from evaporation, like gypsum. When salt water evaporates, the mineral gypsum is made from the material that did not evaporate.
- Some minerals are made through volcanic processes.
- Quartz is a perfect example of a mineral made through volcanism. Thousands of other minerals are made in the same way.
- Based on the temperature of the lava/formation, it produces a different type of mineral.
- Look at your note sheet on the tetrahedral shapes and how to relates to temperature.
- Some minerals form deep within caves over thousands of years. (Precipitation)

Ores

- An ore is a **NATURALLY OCCURRING, SOLID** material that contains a valuable mineral and/or metal.
- In order to extract the valuable mineral/metal, we must take it out of the Earth.

Class Notes: Chapter 2: Igneous Rocks (Completed Copy)

What Are Igneous Rocks?

- Igneous rocks are formed from the crystallization of magma.
- They are volcanic in origin.
- In Latin, "*ignis*" means fire. This is where "*ign*eous" comes from.
- **Magma:** Molten, melted rock inside of a volcano.
- **Lava:** Molten, melted rock outside of a volcano.
- *Any rock formed from magma is considered plutonic. Plutonic is interchangeable with "intrusive."

Plutonic Extrusive

Composition of Magma

- Magma is often a slushy mix of molten rock, gases and mineral crystals.
- The elements found in magma are the same as the elements found on the crust.
- Magma is often categorized by the amount of SiO_2 it contains.
- The silica (SiO_2) composition affects the melting temperature and how the magma will flow.
- Magmas are classified as basaltic, andesitic and rhyolitic. This is again, based on the amount of SiO_2 it contains.
- The magma composition affects the type of volcanic eruption as well
- High Silica (SiO2) (Explosive) Low Silica (Effusive)

Characteristics of Igneous Rocks

Felsic igneous rocks are:

→ light in color
→ contain feldspars and silicon (SiO2)

Mafic igneous rocks are:
→ dark in color
→ contain magnesium and iron

Felsic (light)
→ Lots of SiO_2 and feldspars

Mafic (Dark)
→ Rich in Fe (Iron) and Mg (Magnesium)

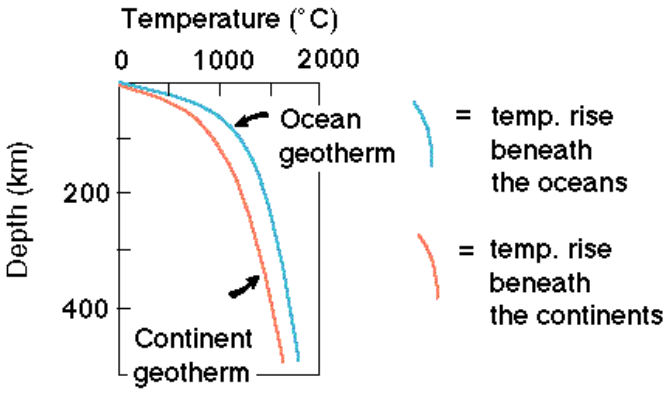
Magma

- Magma needs to be heated to temperatures of 800℃ to 1200℃. This heat comes from the upper mantle and lower crust. There are two sources of heat:
  1. Radioactive materials decay and they give off heat.
  2. Leftover energy when the Earth formed 4.6 billion years ago.

- The main factors involved in the mineral/rock formation of magma are temperature, pressure, water content and mineral composition.
- Temperature usually increases as you dig deeper into the Earth. This is known as the geothermal gradient.

Geothermal Gradient

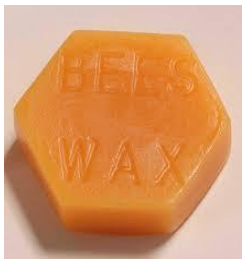
- Differences in mineral composition causes the geothermal gradient to be higher in the oceanic crust.



3 Factors that Affect Magma Formation

1. **Temperature/Pressure:** As you go deeper into the Earth, temperature and pressure steadily increases. Refer to geothermal gradient to see the relationship between pressure and temperature.
2. **Water Content:** Rocks and minerals contain a small percentage of water, which changes the melting point of rocks. As water content increases, the melting point increases.
3. **Mineral Composition:** Differences in mineral composition can change the melting point. For example, rocks containing pyroxene and olivine melt at higher temps.

Question: If you had ice cubes and frozen beeswax, which one would melt faster? Why?

Answer: The ice would melt faster because it's melting point is lower than the wax. They have different melting temperatures.

Rocks melt in the same way because rocks are made of thousands of different combinations of minerals!

How Rocks Melt

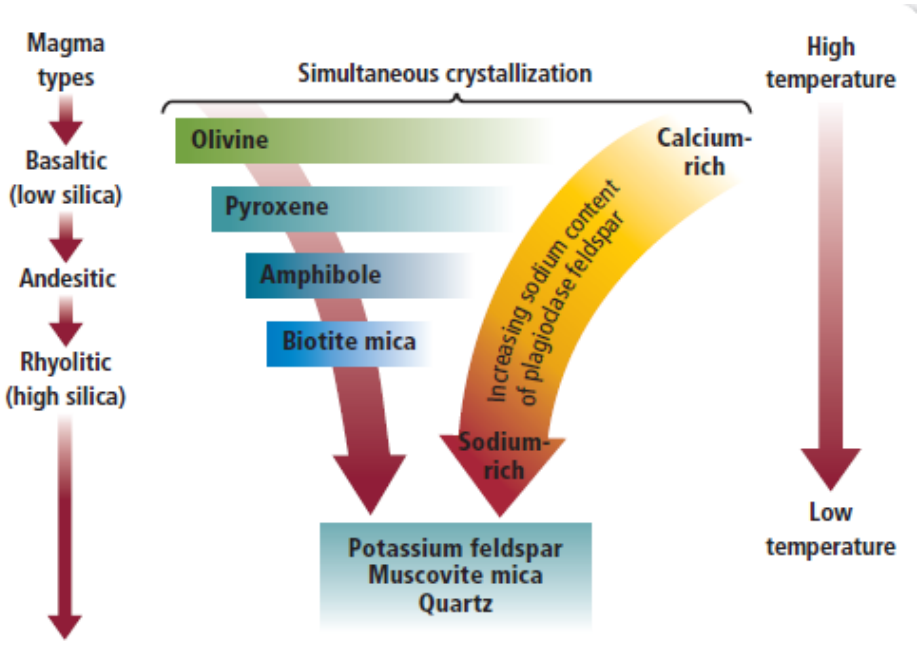
Partial Melting: When part of one rock melts, but not all of it. This is due to the different minerals having different melting temps. This makes a "magma stew."

Fractional Crystallization: Elements/minerals within the molten magma may come together to form

new crystals. They will crystallize and leave behind melted rock. Basically, crystals form while some of it is still melted. This is the opposite of partial melting.

Bowen's Reaction Series

- In the early 1900's, a Canadian geologist N. L. Bowen found out that as magma cools, minerals form in **predictable** patterns.
- There are **two** main branches of crystallization.



- The right branch represents feldspar minerals which undergo a **continuous** change change of composition.
- The left branch represents iron-rich minerals. These minerals undergo fractional crystallization. This makes **one new mineral after another**.
    - Direct evidence can be seen in some rocks where layers of rock are layered in the same exact order as Bowen's reaction series.

Intrusive Vs. Extrusive Rocks

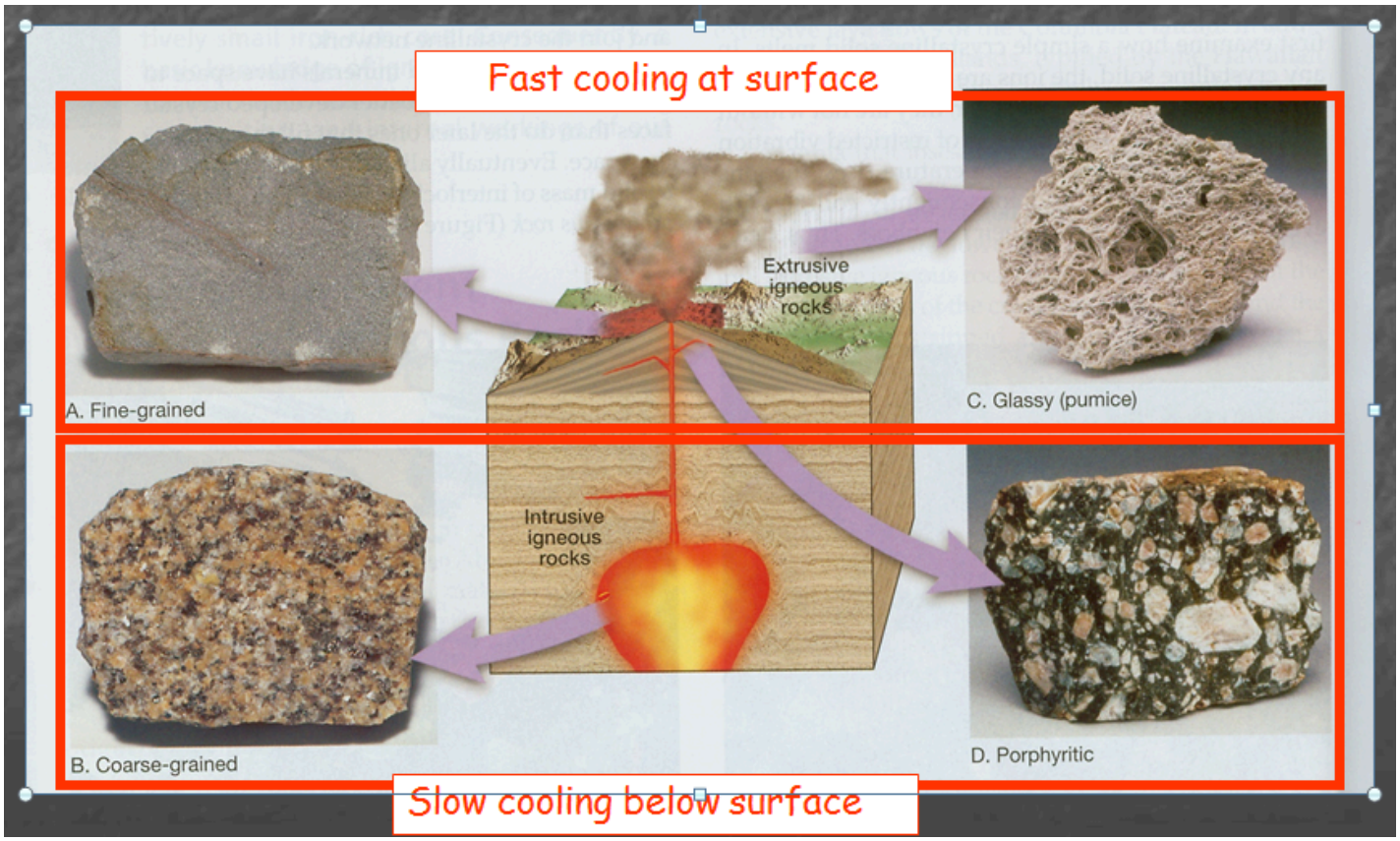
- If an igneous rock is formed INSIDE of a volcano, it is considered **intrusive.**

    → Intrusive rocks are formed from *magma*

- If an igneous rock is formed OUTSIDE of a volcano, it is considered **extrusive.**

    → Extrusive rocks are formed from *lava*

- For intrusive rocks, crystals are “baked” long enough to grow visible crystals.
- Think of intrusive rocks being cooked as if they were in a pressure cooker/crockpot.
    - Examples of Intrusive Igneous Rocks: Granite, Diorite, Gabbro
- For extrusive igneous rocks, the molten rock escapes from the inside of the volcano and cools.
- Crystals will be very hard/impossible to see with the naked eye since it cooled so quickly.
    - Examples of Extrusive Igneous Rocks: Pumice, Rhyolite, Basalt, Vesicular Basalt, Obsidian



Mineral Composition

There are 3 main groups of igneous rocks:

1. **Felsic-** Light colored, high silica rocks. Example = Granite
2. **Intermediate-**Rocks in between felsic and mafic rocks. Example = Diorite
3. **Mafic-** Dark colored, low silica rocks. They are high in iron/magnesium. Example = Gabbro and Basalt

Texture

- Every igneous rock has a particular texture depending on its formation.

- We also classify igneous rocks on their grain sizes.
    - Grain size is directly related to the cooling rate.

Cooling Rate

- When lava is exposed to the air and moisture, it cools quickly.
- When magma is trapped under the Earth's surface, it may take THOUSANDS of years to cool.

Texture Types

Fine Grained

→ Fast cooling rate

→ Extrusive

Coarse-grained

→ Slow cooling rate

→ Intrusive

Porphyritic-Grained

→ Mix of fine and coarse grain

→ Magma started to cool, making the big crystals then suddenly erupted and the rest cooled quickly.

→ Looks like a chocolate chip cookie

Pegmatitic Grained

→ Extremely large crystals

→ "Pegmatites" contain valuable minerals

"Vesicular" is a texture associated with extrusive rocks.

→ Bubbly and full of gas pockets

→ This lava cooled so fast that the gas couldn't escape. This leaves behind bubbles.

→ Example- Scoria, vesicular basalt, pumice and vesicular rhyolite.

Glassy - An extrusive igneous rock description. The lava cooled so fast that it looks like glass.

→ Example= Obsidian

Ores

- People mine specific igneous rocks (called igneous intrusions) for profitable minerals.
- Profitable minerals are usually found in pegmatites and kimberlites. They can also be found in "veins."
- **Vein:** A crack in a rock where the leftover mineral-rich water (from Bowen's Reaction Series) fills in the gap and solidifies.

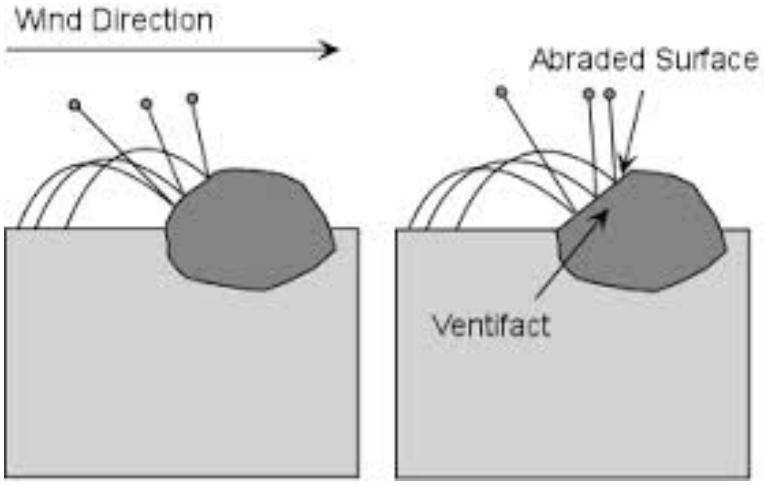
  → The mineral-rich water is full of leftover minerals, like gold.
- **Kimberlites:** Unique ultramafic rock that contains diamonds. It is a variety of peridotite.

Class Notes: Chapter 2: Sedimentary Rocks (Completed Copy)

What Are Sedimentary Rocks?

- Made from sediments or rock material that has been broken down in some way.
- Rocks on the surface are exposed to **weathering**, which breaks them down.
- Smaller rock fragments are called grains.
- Grains are formed through **compaction** and **cementation** of grains.
- Sedimentary rocks are usually formed in a watery environment.
- Often **layered**
- Are the only rocks that contain fossils
- Grains (individual pieces of old, weathered rock in a sedimentary rock) are rounded by **abrasion**.
- Abrasion: Form of physical weathering caused by friction between rock particles.
- After they are abraded, the grains are deposited in layers.

Abrasion



Types of Sedimentary Rock- Clastic

- **Clastic (fragmental)** –made by compaction and cementation of sediments.
    - Clastic rocks are identified by the size of the fragments.
    - **Conglomerate:** Rounded pebbles surrounded by calcite. Calcite is the “glue” that holds it together.
    - **Breccia:** Similar to conglomerate but has angular fragments.

    - **Sandstone:** Sand that has welded together by compaction and cementation. Particle sizes are fine to coarse.
    - **Siltstone:** Similar to sandstone but the grain sizes are smaller. It is extremely fine grained.
    - **Shale:** Compact, may split easily. This rock is made of clay, which is the smallest particle.
        - Fossils are most frequently found in this rock!

Types of Sedimentary Rock- Crystalline (Evaporites)

- **Evaporites (Crystalline):** Formed when water carrying minerals evaporates and leaves the minerals behind.
    - Are identified by the minerals present
        - Example: Halite (hardness of 2.5)
- **Rock Salt:** A form of halite that was formed from ocean/salt water evaporating, leaving only the salt behind.
- **Rock Gypsum:** Also forms when an ocean or salt water body dries up. (Remember selenite gypsum from minerals?)
- **Dolostone:** Rock made of the mineral dolomite. It is produced when magnesium-rich water evaporates.

Types of Sedimentary Rock- Bioclastic

Bioclastic Rocks:

- **Bio =** Life
- **Clastic =** Fragments
    - Made from accumulated shells (limestone) and plants (coal).
- **Limestone:** Contains calcite. The calcite comes from ancient dead organism’s shells and skeletons. Also made from crushed coral.
- **Special Variety of Limestone:** Coquina (Made almost entirely out of sea shells!
- **Coal:** Made from dead plants (carbon!). It is combustible and is a fossilized form of decayed plants.

Scheme for Sedimentary Rock Identification

INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	**Conglomerate**	
			Angular fragments	**Breccia**	
	Sand (0.006 to 0.2 cm)		Fine to coarse	**Sandstone**	
	Silt (0.0004 to 0.006 cm)		Very fine grain	**Siltstone**	
	Clay (less than 0.0004 cm)		Compact; may split easily	**Shale**	
CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Crystalline	Fine to coarse crystals	Halite	Crystals from chemical precipitates and evaporites	**Rock salt**	
		Gypsum		**Rock gypsum**	
		Dolomite		**Dolostone**	
Crystalline or bioclastic	Microscopic to very coarse	Calcite	Precipitates of biologic origin or cemented shell fragments	**Limestone**	
Bioclastic		Carbon	Compacted plant remains	**Bituminous coal**	

Class Notes: Chapter 2: Metamorphic Rocks (Completed Copy)

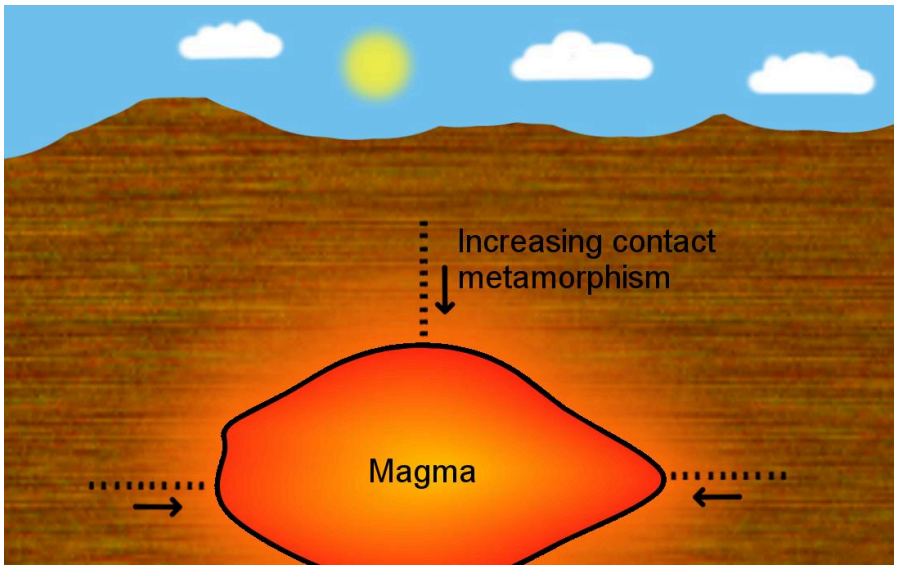
What Are Metamorphic Rocks?

- A rock that has undergone a change due to heat and/or pressure.
- The Greek word “meta” means change, and “morph” means form.
- When exposed to intense heat and/or pressure inside the earth, rocks (ANY type) will be changed (morphed) into a new rock.
- They do not melt, they recrystallize when exposed to heat and pressure

Forms of Metamorphism

- **Regional:** Forms over large areas such as mountain ranges. Formed from INTENSE pressure from plate tectonic activity. The crystals are “squished.”
- **Contact:** Occurs at the edges of magma or lava. This can happen extrusively or intrusively.
- **Hydrothermal:** When extremely hot water remelts minerals and morphs/changes the chemistry.

Contact Metamorphism:

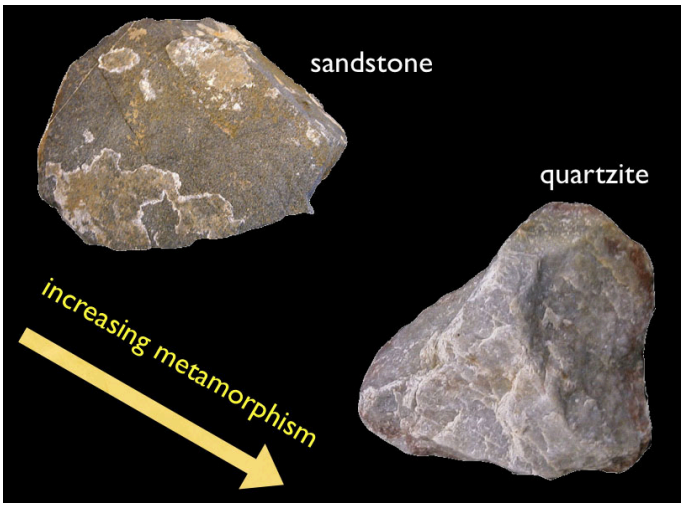


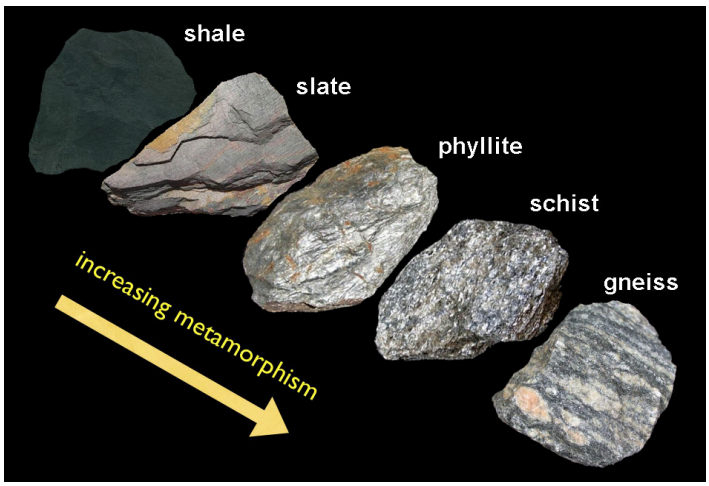
Metamorphic Textures

- **Foliated:** When all of the minerals within the rock are squeezed into one direction.
    - Foliated Rocks: Slate, Phyllite, Schist
- **Banding:** Wavy layers and bands of minerals. In foliated rocks you can see this banding of the minerals.
- Rocks With Banding (Always Called Gneiss)

- **Nonfoliated:** Rocks where the minerals have **not** been squished into flat pancake-looking structures.
- Instead, the individual crystals within the rock are blocky.
    - Formed from contact metamorphism
    - Examples: Marcle, Quartzite, Hornfels


limestone
marble
increasing metamorphism


sandstone
quartzite
increasing metamorphism


shale
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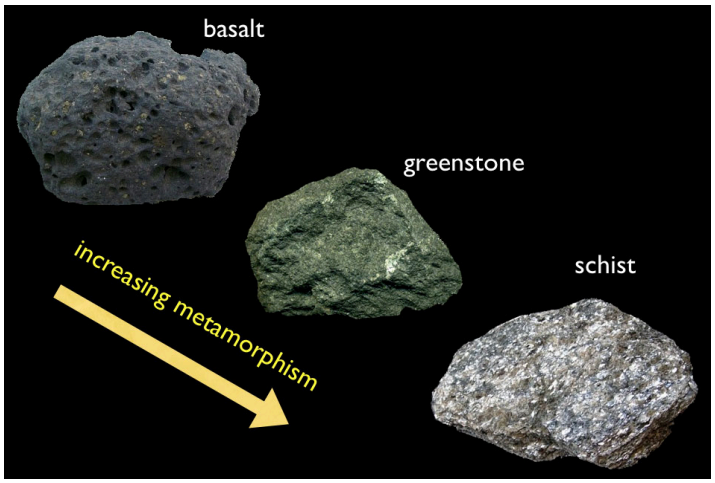
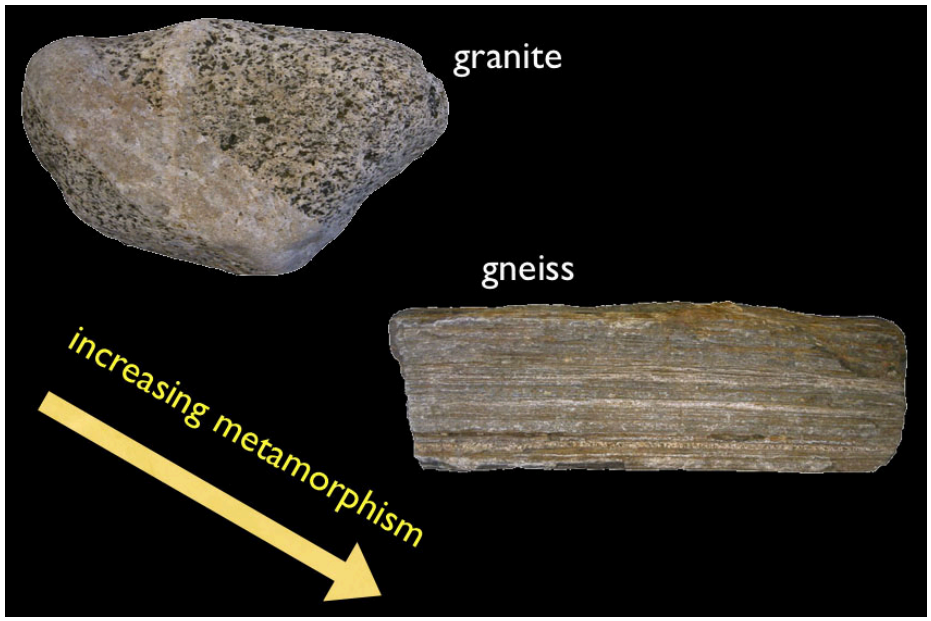
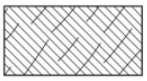
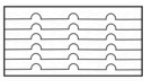
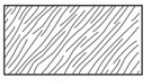
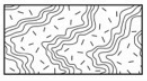
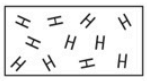

basalt
greenstone
schist
increasing metamorphism


granite
gneiss
increasing metamorphism

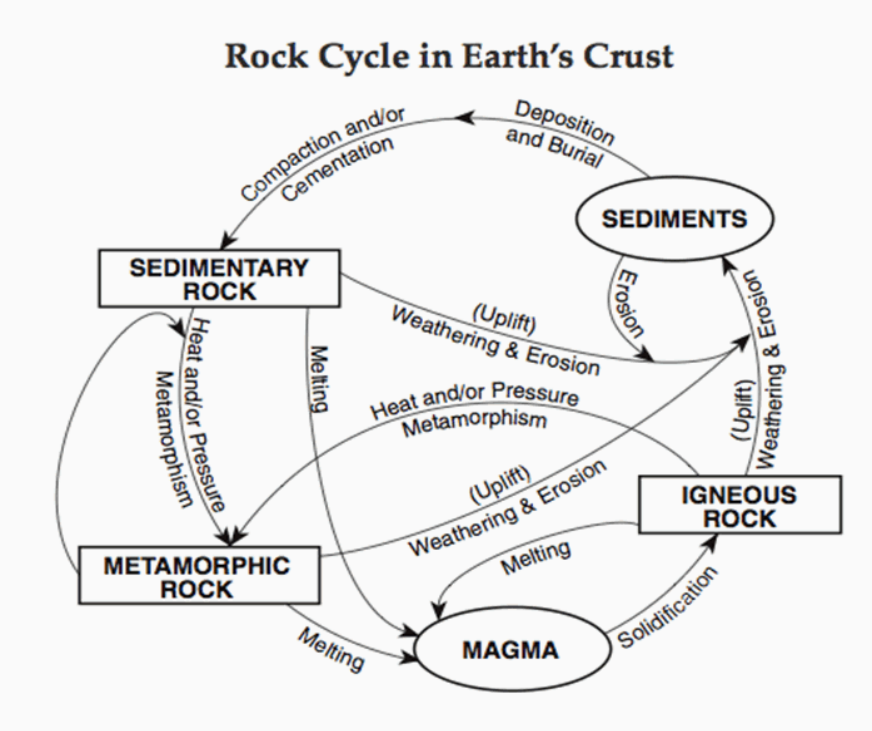
Scheme for Metamorphic Rock Identification

TEXTURE		GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED	MINERAL ALIGNMENT	Fine	MICA, QUARTZ, FELDSPAR, AMPHIBOLE, GARNET, PYROXENE	Regional (Heat and pressure increases) ↓	Low-grade metamorphism of shale	**Slate**	
		Fine to medium			Foliation surfaces shiny from microscopic mica crystals	**Phyllite**	
					Platy mica crystals visible from metamorphism of clay or feldspars	**Schist**	
	BAND-ING	Medium to coarse			High-grade metamorphism; mineral types segregated into bands	**Gneiss**	
NONFOLIATED		Fine	Carbon	Regional	Metamorphism of bituminous coal	**Anthracite coal**	
		Fine	Various minerals	Contact (heat)	Various rocks changed by heat from nearby magma/lava	**Hornfels**	
		Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	**Quartzite**	
			Calcite and/or dolomite		Metamorphism of limestone or dolostone	**Marble**	
		Coarse	Various minerals		Pebbles may be distorted or stretched	**Metaconglomerate**	

Name: _____ Date: _____

Regents Earth Science Per: _____

Class Notes: Chapter 2: The Rock Cycle



- The rock cycle is a summary of how rocks can change into another type of rock. (Pg. 6 in ESRT)

→ Igneous rock can change into sedimentary rock or into metamorphic rock

→ Sedimentary rock can change into metamorphic rock or into igneous rock.

→ Metamorphic rock can change into igneous or sedimentary rock.

The Basics: Igneous Rocks

- Recall that igneous rocks are "fire born" and are the ONLY rocks that are formed from the crystallization of molten rock (magma or lava).
- Igneous rocks can either turn into sediments, magma or metamorphic rock.

The Basics: Weathering and Erosion

Weathering: The breaking down of a rock. It must be exposed to the hydrosphere (water) or the atmosphere (air) in order to be weathered.

Erosion: The transportation of weathered rock. This can be through running water (streams), gravity, waves, glaciers and wind.

The Basics: Sediments

Sediments: It can be…

- Material, originally suspended in a liquid, that settles at the bottom of the liquid when it is left standing for a long time.
- Material eroded from pre existing rocks that is transported by water, wind, or ice and deposited elsewhere.
- Sediments turn into sedimentary rocks through COMPACTION AND CEMENTATION. Also, DEPOSITION and BURIAL has to happen.
- Deposition: A process where geologic material is added to a landform.

The Basics: Sedimentary Rocks

- Recall that sedimentary rocks is the “recycled” material from any other rock type.
- Sediments are compacted and cemented to become a sedimentary rock.
- Metamorphic and igneous rocks can become a sedimentary rock if they are uplifted through WEATHERING and EROSION.

The Basics: Metamorphic Rocks

- Recall that metamorphic rocks are rocks made through heat and/or pressure.
- The minerals do not change, but they rearrange themselves due to the pressure or heat.
- If the metamorphic rock melts, it becomes magma, which solidifies to become an igneous rock.