ROCKS & MINERALS UNIT

8th Grade Earth & Space Science

Characteristics of Minerals

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Class Notes

Mineral Characteristics

- *Naturally occurring* – formed by natural processes
- *Inorganic* – not alive; does not come from anything living
- *Solid, crystalline structure* – atoms arranged in in a regular geometric pattern
- *Specific composition* – unique chemical formula (can be an element or compound)

Examples of Minerals

Halite
(NaCl)

Galena
(PbS)

Pyrite
(FeS_2)

How Minerals Form

- Minerals form during crystallization
  - Process by which atoms are arranged into a specific, repeating structure
- There are two ways minerals can form:
  - Crystallization of magma
  - Crystallization of materials dissolved in solution

Crystallization of Magma

- When magma cools from a liquid state crystals form.
  - Size of the crystals depends on:
    - Rate of cooling
    - Amount of gas in the magma
    - Chemical composition of the magma

Crystallization from Solutions

- When a solution becomes supersaturated minerals will form through precipitation.

- Minerals can also crystallize when the solution evaporates.

Identifying Minerals

- All minerals have unique characteristics.

- You must use a combination of characteristics to correctly identify a mineral!



Crystal Form

- Some minerals form distinct crystal shapes.

Halite always forms cubes.

Quartz forms six-sided crystals with double pointed ends.

Luster

- The way a mineral reflects light
  - Metallic luster – shiny faces that reflect light
  - Nonmetallic luster – does not shine like a metal; can be *dull, pearly, waxy, silky, or earthy*

Metallic luster

Nonmetallic luster (earthy)

Hardness

- Measure of how easily a mineral can be scratched
  - Friedrich Mohs developed the Mohs Scale of Hardness
  - See page 91 in book
  - Scale goes from 1 to 10

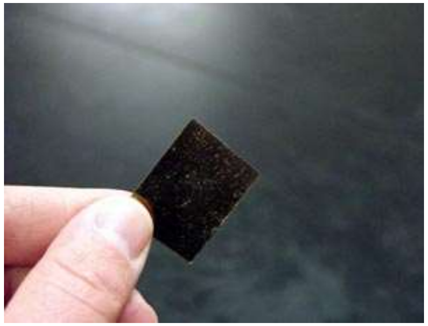
Hardness

- Mineral that can be scratched with fingernail = 2 or less
- Mineral that cannot be scratched with fingernail but cannot scratch glass = Between 2.5 – 5.5
- Mineral that can scratch glass = 5.5

Cleavage and Fracture

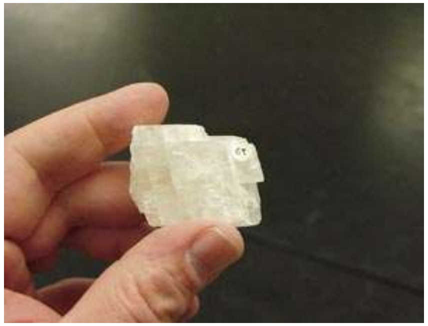
- *Cleavage* – describes the way a mineral breaks along its plane of weakness
- *Fracture* – when a mineral breaks into pieces with rough or jagged edges

Cleavage Examples



One directional cleavage

Two directional cleavage



Three directional cleavage

Cubic cleavage (halite)

Octahedral cleavage

Fracture Examples

Conchodial Fracture
(arch like patterns)

Non conchodial fracture
(no archlike patterns)

Color

- Most noticeable characteristic of a mineral; usually caused by presence of trace elements
- Examples: obsidian – black; sulfur - yellow

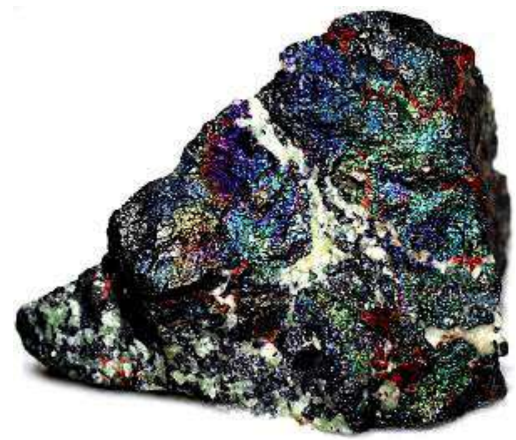
Special Properties

- Can sometimes be used for identification

- *Double refraction* – light that travels through the mineral is split in two ways
- *Effervescence* – reacts with hydrochloric acid
- *Magnetism* – occurs between minerals that contain iron
- *Iridescence* – play of colors caused by the bending of light rays
- *Fluorescence* – glows in the dark when exposed to ultraviolet light

Examples of Special Properties

Double refraction in Calcite



Iridescence in Franklinite

Fluorescence in Fluorite

Streak

- Color of the mineral when it is broken up and powdered

- Example: Sulfur – white; hematite - red

Texture

- How a mineral feels to the touch
- Examples: obsidian – smooth, talc - greasy

Density and Specific Gravity

- Sometimes, two minerals of the same size have different weights (result of density)
- Density = mass/volume; reflects the atomic mass and structure of the mineral
- Specific gravity – ratio of the mass of a substance to the mass of an equal volume of water at 4 C.
  - We measure by picking up the mineral and determining how "heavy it feels" compares to how "heavy it looks."

Formation of Igneous Rocks

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Igneous Rock Formation

- All igneous rocks form from magma.
- The type of igneous rock that forms depends on the chemical composition of the magma.

- ***Magma*** – slushy mix of molten rock, dissolved gases, and mineral crystals.

- ***Lava*** – magma that flows out onto the Earth's surface
  - Chemical composition may be different from magma because gases escape into the atmosphere

All About Magma

- The common elements in magma are the same that are common in the Earth's crust.
  - O, Si, Al, Fe, Mg, Ca, K, Na

- There are three main types of magma and they are classified based on their silica content.

Types of Magma

Magma Type	Silica Content	Example
Basaltic	42 – 52%	Hawaiian Islands
Andesitic	52 – 66%	Cascades
Rhyolitic	66% and up	Yellowstone

Basaltic

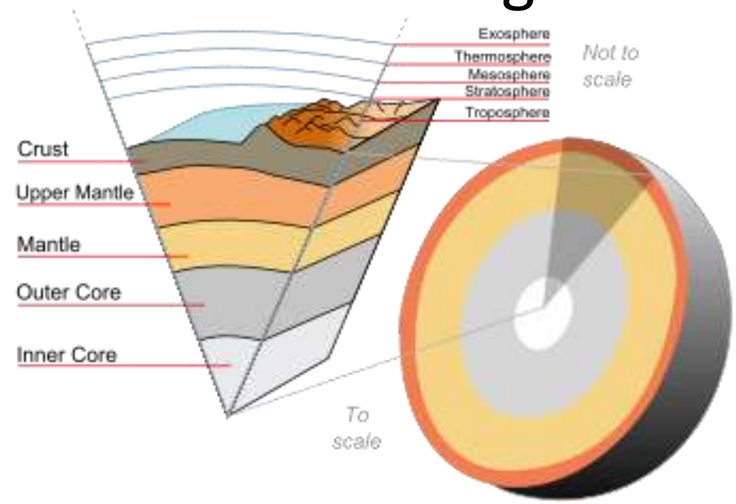
Andesitic

Rhyolitic

How Does Magma Form?

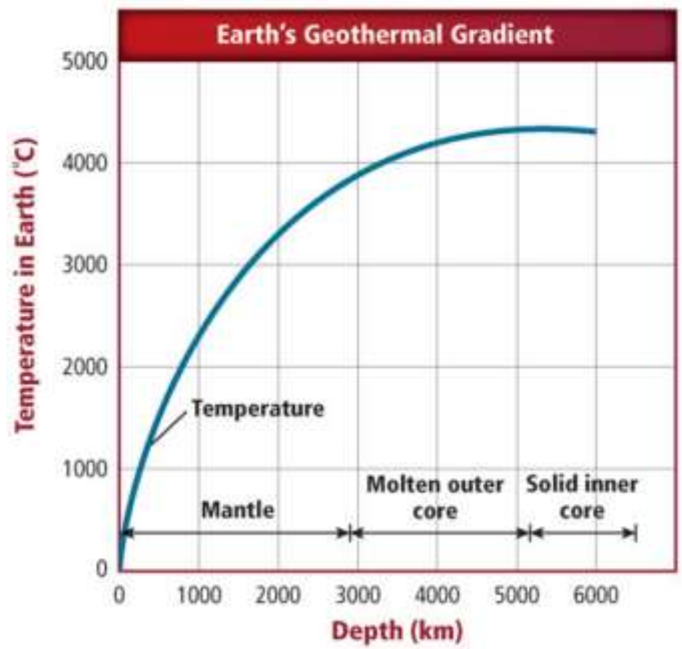
- Forms from the melting of the Earth's crust or melting of rock in the mantle.

- Four factors are involved in the formation of magma:
  - temperature
  - pressure
  - water content
  - mineral content



Temperature and Magma Formation

- Temperature increases with depth in Earth's crust.
- This temperature increase is known as the geothermal gradient.
- For magma to form, the temperature must be high enough to melt the rock.



Pressure and Magma Formation

- Pressure also increases with depth as a result of the weight of overlying rock.
- The increased pressure on a rock will increase the rock’s melting point and require higher temperatures to melt.

Water Content and Magma Formation

- Rocks and minerals often contain small amounts of water, which changes the melting point of the rocks.
- As water content increases, the melting point decreases so rock will melt at a lower temperature.

Mineral Content and Magma Formation

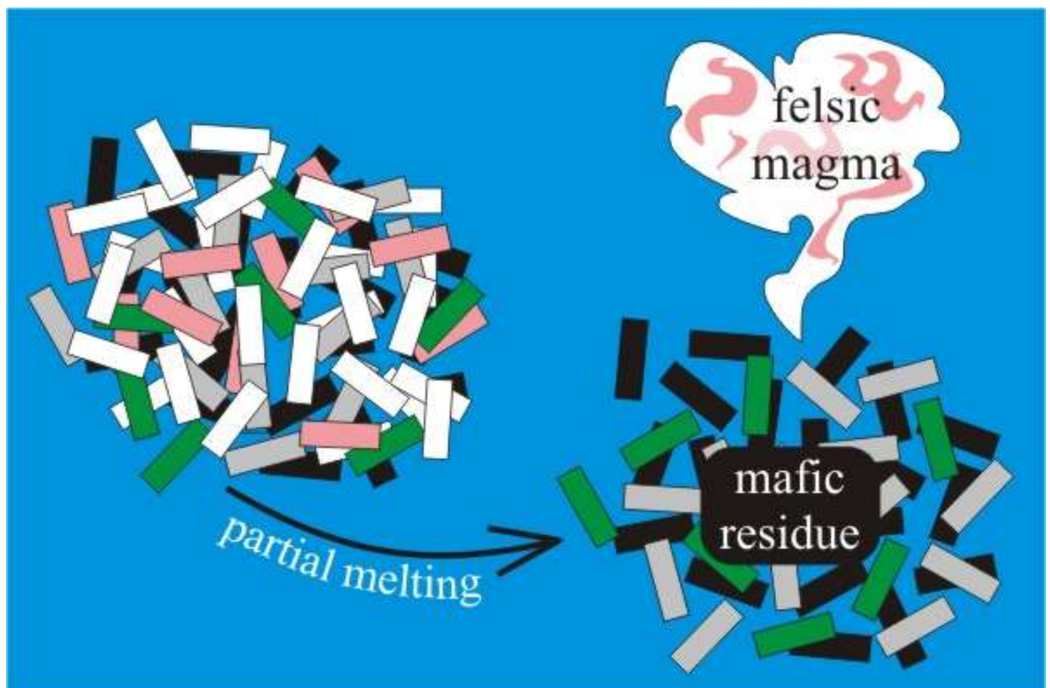
- Different minerals have different melting points.
- Rocks that are rich in iron and magnesium melt at higher temperatures than rocks that contain higher levels of silicon.

Melting point of hematite = 1565 °C

Boiling point of muscovite = 1250 °C

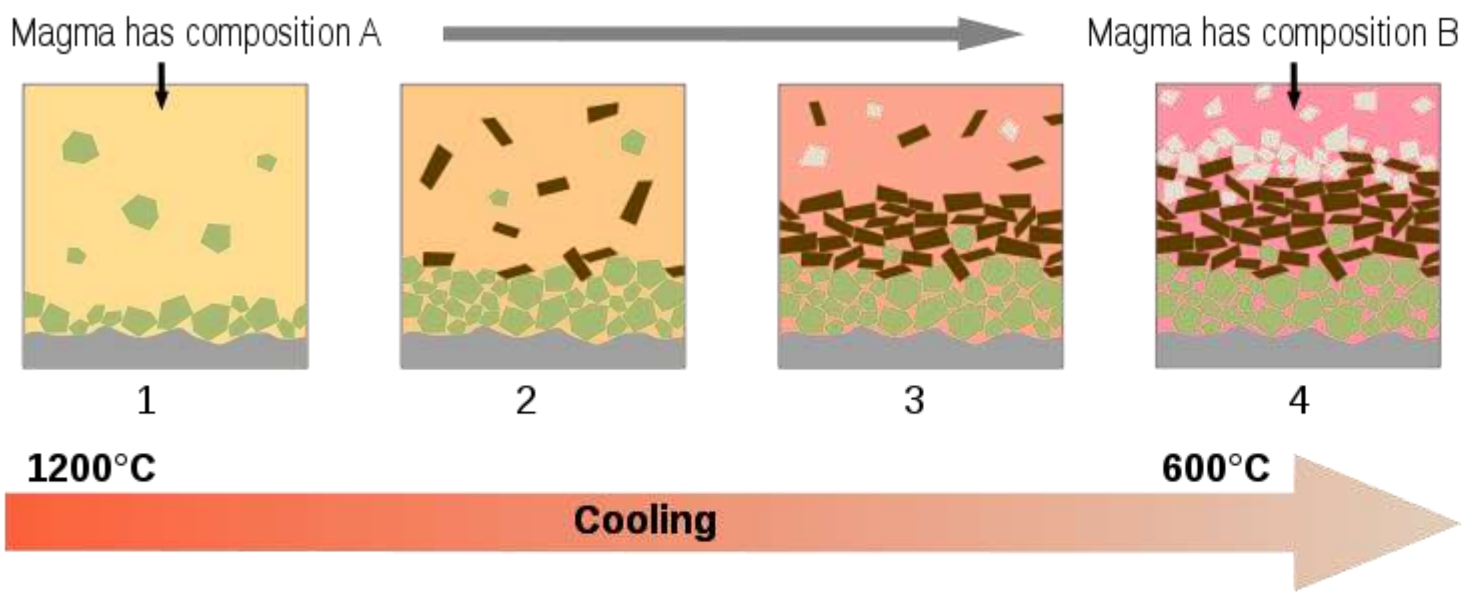
Partial Melting

- Some minerals will melt while others remain solid.
- This changes the composition of the magma and rocks.



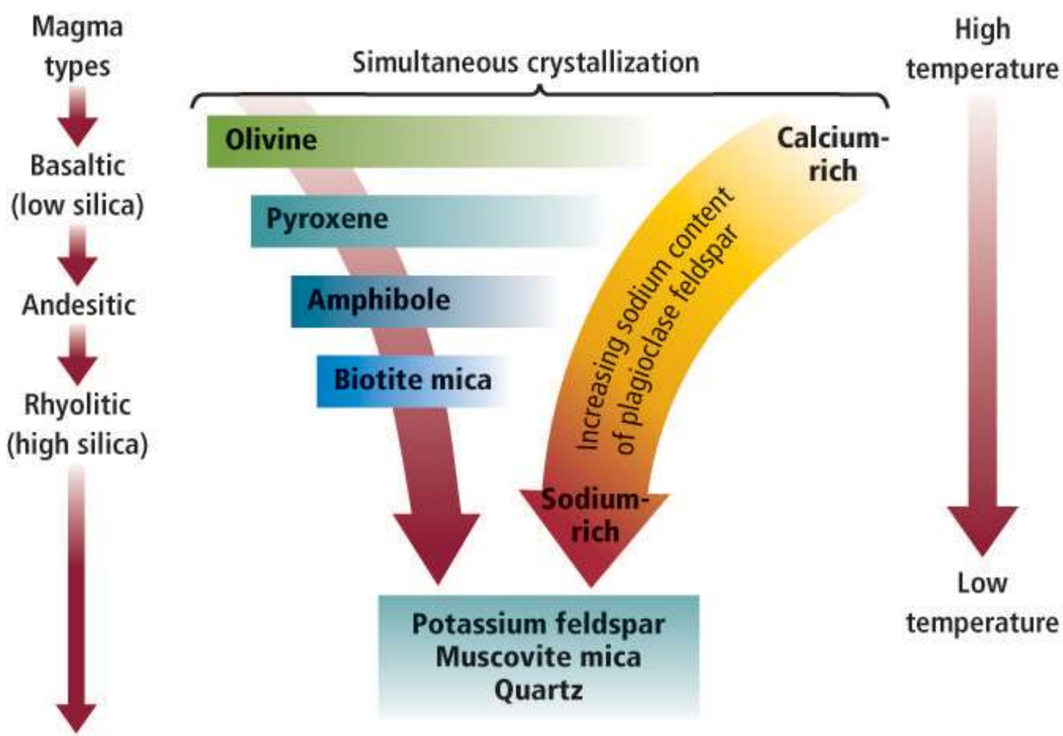
Fractional Crystallization

- Opposite of partial melting
- Minerals that melted last will crystallize first
  - These get removed from the magma and cannot react with the magma and change its composition



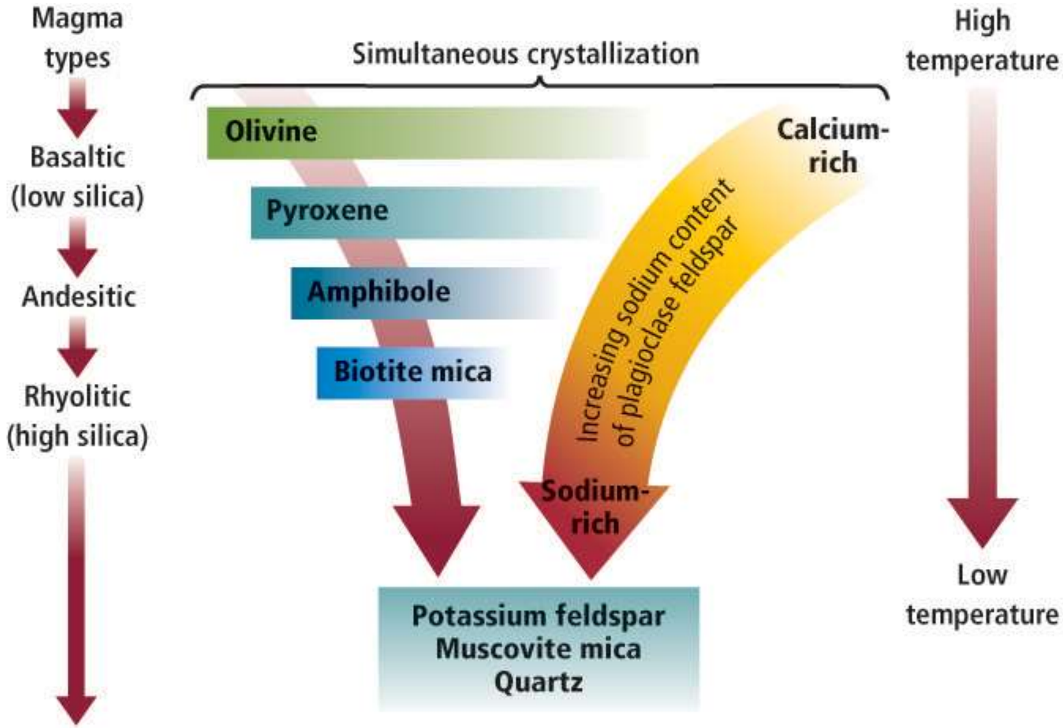
Bowen's Reaction Series

- Shows the relationship between cooling magma and the formation of minerals that make up igneous rock



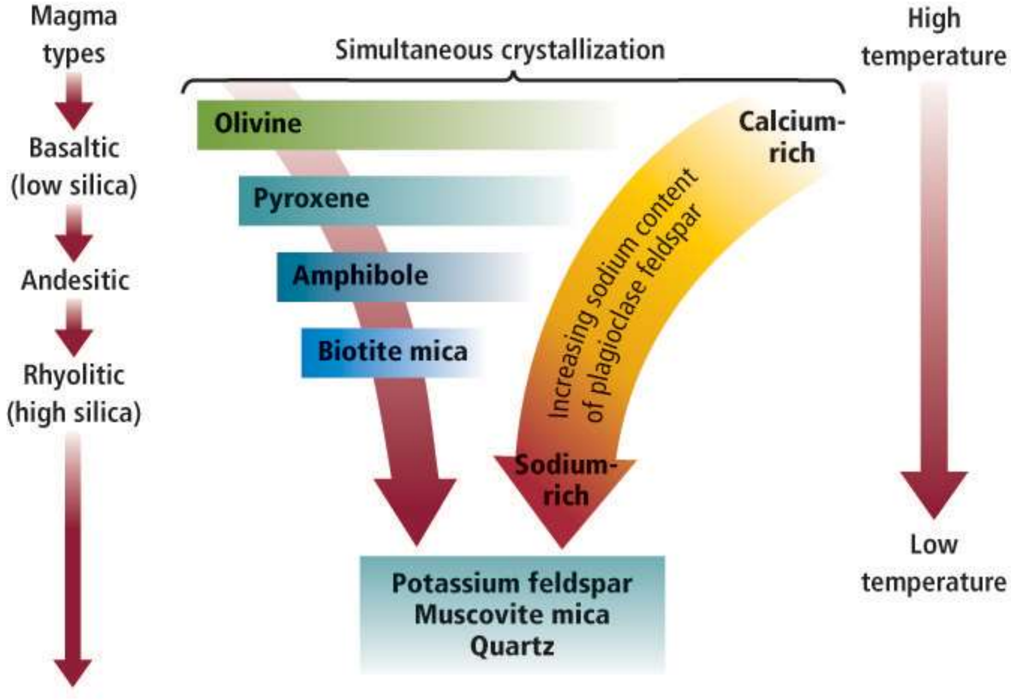
Reactions of Iron-Rich Minerals

- Undergoes abrupt changes
  - As minerals form they react with the magma to become new minerals



Reactions of Feldspars

- Undergo continuous changes
- Start with calcium-rich compositions that slowly become sodium-rich as magma cools



Igneous Rock Classification

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Formation and Texture

- ***Intrusive*** – forms under the Earth's surface
  - Large grain → magma cools slowly and large crystals form
- ***Extrusive*** - forms on top of the Earth's surface
  - Small grain→ magma cools too quickly and small or no crystals form

Extrusive

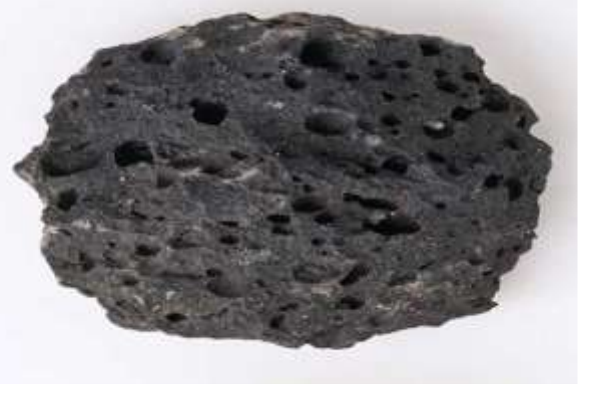
Intrusive

Formation and Texture

- ***Porphyritic*** – two different crystal sizes
  - Caused by cooling in different environments

- ***Vesicular*** – spongy appearance
  - Caused by gas bubbles

Porphyritic texture



Vesicular texture

Mineral Content

- ***Basaltic*** – dark color, low silica content
- ***Granitic*** – light color, high silica content
- ***Intermediate*** – in between basaltic and granitic
- ***Ultrabasic*** – very dark, only iron-rich minerals

Basaltic

Granitic

Intermediate

Ultrabasic

Rocks as Resources

- ***<u>Veins</u>*** – also called "igneous intrusions"; small spaces that contain valuable ores
- ***<u>Pegmatites</u>*** – veins of very large grained minerals that contain rare elements

Gold Vein

Beryl Crystal in Pegmatite

Rocks as Resources

- ***Kimberlites*** – type of peridotite (ultrabasic rock) that contains diamonds

Formation of Sedimentary Rocks

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Sedimentary Rocks Form Through a Process

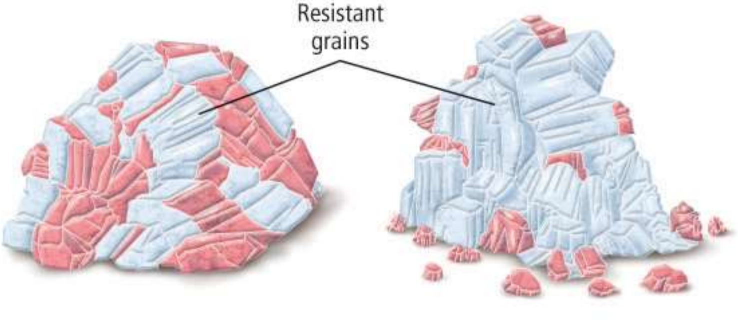
1. Weathering and Erosion
2. Deposition and Sorting
3. Lithification

Let’s look at each step of this process!

Weathering and Erosion

- ***Weathering*** – the set of physical and chemical changes that breaks rocks into smaller pieces

- Size can range from microscopic to huge boulders.
- Physical weathering →rock fragments break off
- Chemical weathering →minerals in a rock are dissolved or are chemically changed



Weathering and Erosion

- ***Erosion*** – the removal and transport of sediment

- Four Main Agents:
  - Glaciers
  - Wind
  - Water
  - Gravity

- For these reasons eroded sediment will eventually wind up downhill

Deposition and Sorting

- Occurs when sediments settle on the ground or sink to the bottom of water (deposition)
- Usually large grains will settle to the bottom and finer grains on top (sorting)

- Sorted deposits → water and wind
- Unsorted deposits → glaciers and mudslides

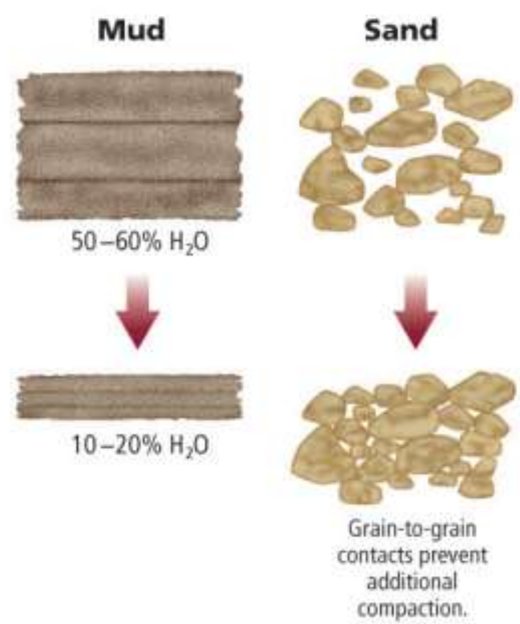
Lithification

- Most sediments wind up at low points (valleys or bottom of ocean basin)
- As sediment builds up, pressure and temperature increase in bottom layers
- This leads to compaction and cementation!

Lithification

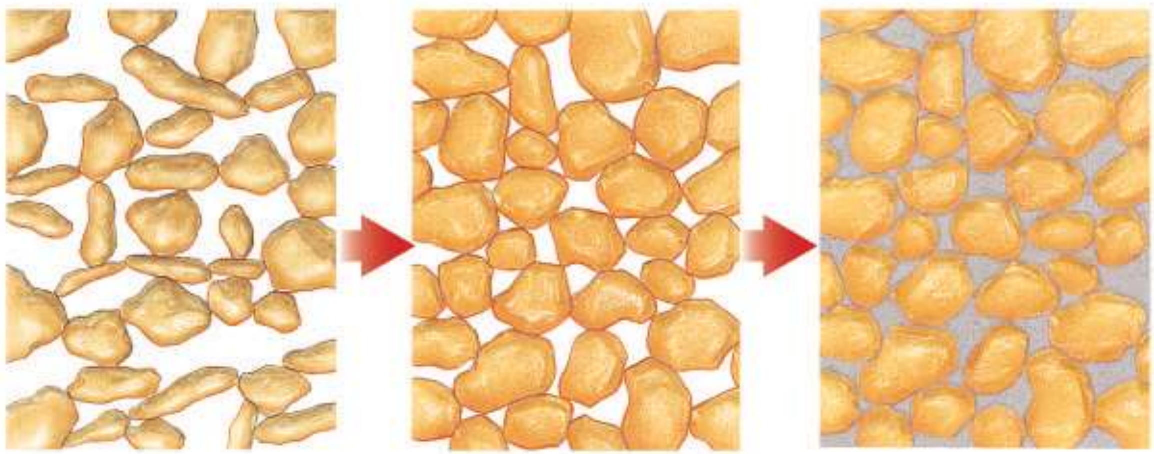
Steps in Lithification:

1. ***Compaction*** – layers of sediment are pushed together
   - Some materials compact better than others



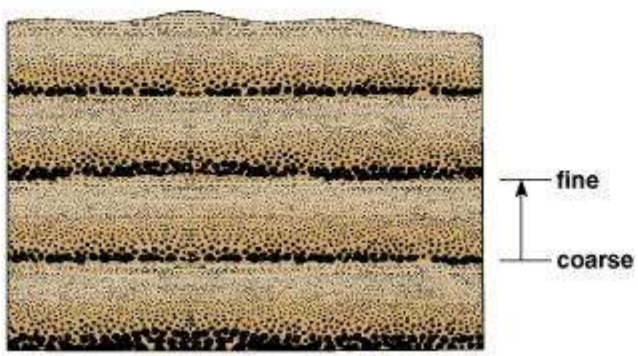
Lithification

2. Cementation – mineral growth glues sediments together into solid rock



Sedimentary Features

- The primary feature of sedimentary rock is horizontal layering called **bedding.**
  - results from the way sediment settles out of water or wind



Graded – coarser particles towards the bottom

Cross – inclined layers of sediment

Sedimentary Features

- When sediment is moved into small ridges by wind or wave action or by a river current, **ripple marks** form.

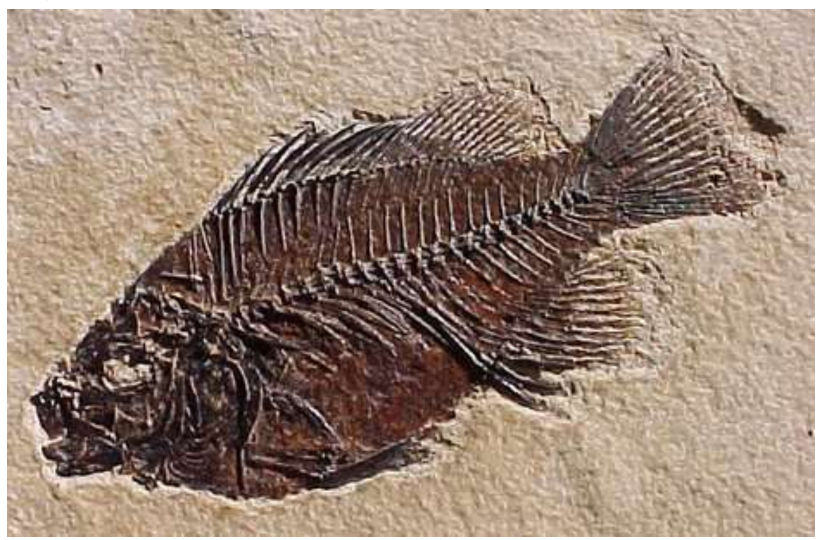
Sedimentary Features

- As sediment is transported, pieces that began with an angular shape knock into each other and become rounded as their edges are broken off.
- Harder materials → more rounded
- Further distance traveled → more rounded

Rounded Grains

Sedimentary Features

- ***Fossils*** are the preserved remains, impressions, or any other evidence of once-living organisms.
- During lithification, parts of an organism can be replaced by minerals and turned into rock.



Types of Sedimentary Rocks

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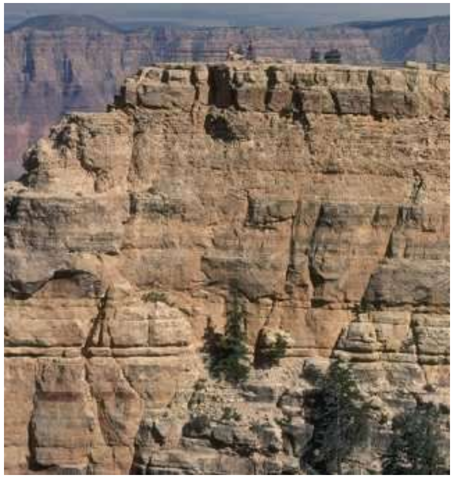
Types of Sedimentary Rocks

- Sedimentary rocks fall into one of three categories:
  - Clastic
  - Chemical
  - Biochemical



Clastic Sedimentary Rocks

- Formed from the abundant deposits of loose sediments that accumulate on the Earth's surface – most common type
- Classified based on the sediment size:
  - Coarse-grained
  - Medium-grained
  - Fine-grained

Clastic Sedimentary Rocks

Coarse-grained Rocks – contain gravel sized rock and mineral fragments

Conglomerate
- Rounded particles

Breccia
- angular particles

Clastic Sedimentary Rocks

Medium-grained Rocks – contain sand sized rock and mineral fragments

Sandstone

- Contains quartz and rock
- High porosity so often contains oil, gas, and ground water

Arkose

- Contains quartz, potassium feldspar and rock

Clastic Sedimentary Rocks

Fine-grained Rocks – contains silt and clay sized particles

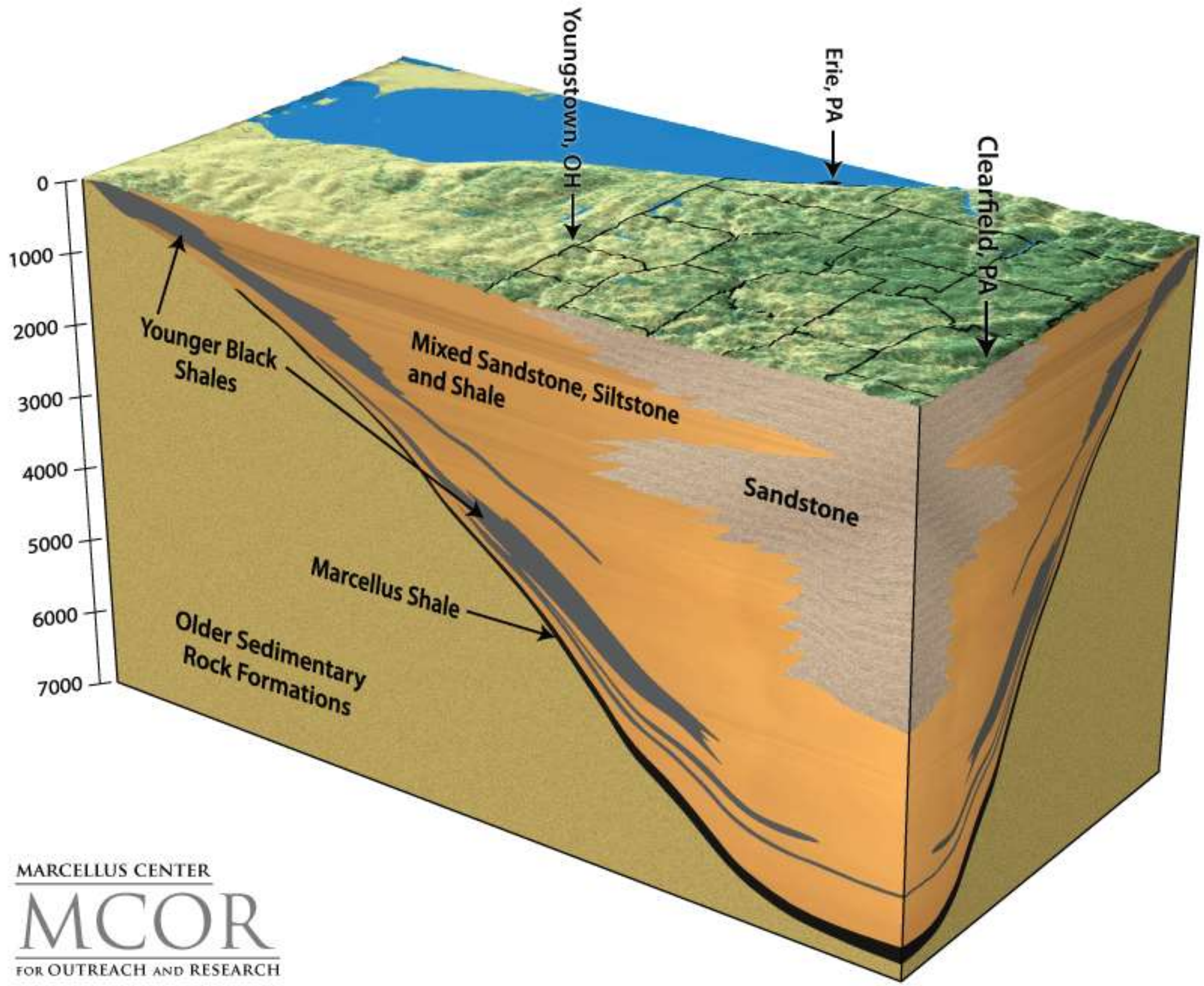
Siltstone

- Quartz and clay
- Fine-grained

Shale

- Quartz and clay
- Very fine-grained

Generalized Geologic Cross Section Showing Marcellus Shale in Western Pennsylvania



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Chemical Sedimentary Rocks

- Forms after the concentration of dissolved minerals reaches saturation and crystal grains settle out

- Water evaporates and the minerals become more concentrated leading to thick layers on the bottom of a body of water.
  - Usually forms in areas that lack precipitation

- See Table 6.1 in your textbook for examples and classification

Chemical Sedimentary Rock Examples

Rock Salt

Microcrystalline Gypsum

Biochemical Sedimentary Rocks

- Form from the remains of once-living organisms
- Most abundant is limestone (made of calcite)
- Many contain fossils
- See Table 6.1 for examples and classification

Biochemical Sedimentary Rock Examples

Limestone

Coquina

Metamorphic Rocks

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Metamorphic Rocks and Minerals

- Sometimes rock are subject to pressure and heat but do not melt.
- Instead the mineral composition, texture, or chemical composition of the rock changes
- *Metamorphic rock* – rocks that changes form while remaining solid
- *Metamorphic mineral* – minerals that form during metamorphism

Metamorphic Rocks and Minerals

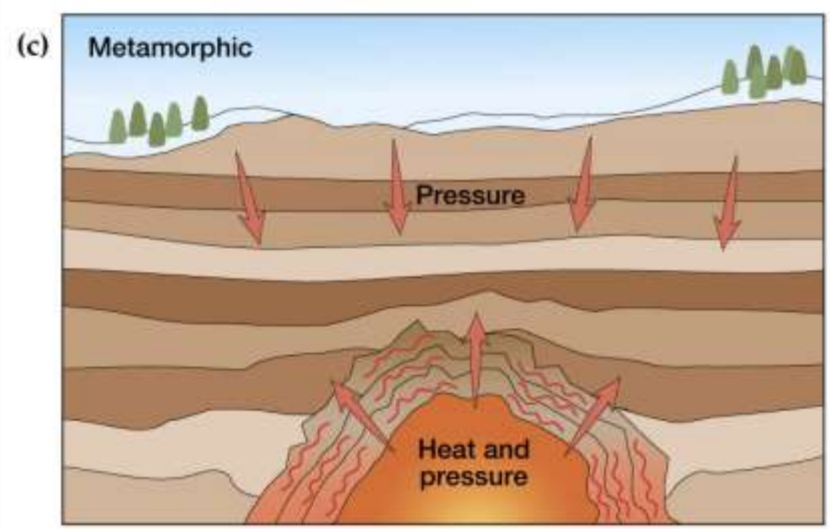
Granite Gneiss forms from Granite

Some example metamorphic minerals.

These minerals are
stable at different conditions than other minerals!

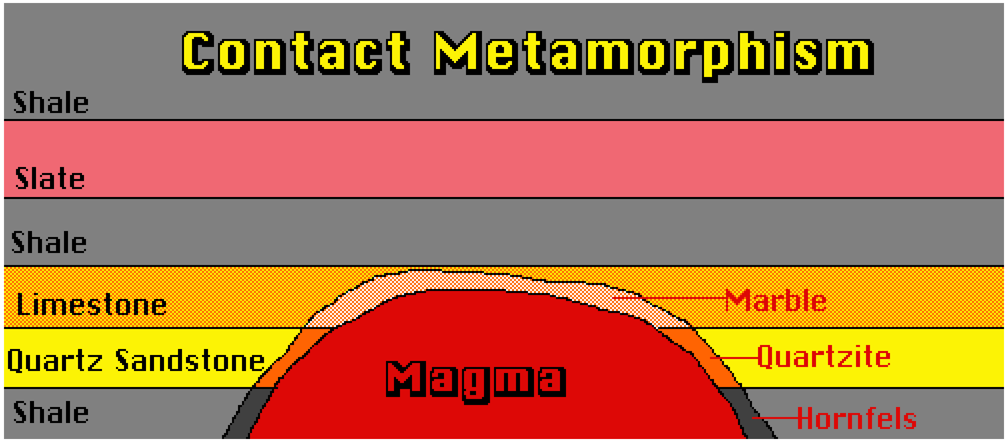
Metamorphic Textures

- *<u>Foliated</u>* – layers and bands of minerals
  - Forms when pressure is applied in opposite directions



Metamorphic Textures

- *Nonfoliated* – blocky, crystal shapes
  - Forms when pressure is not applied in opposite directions



Example – marble from limestone

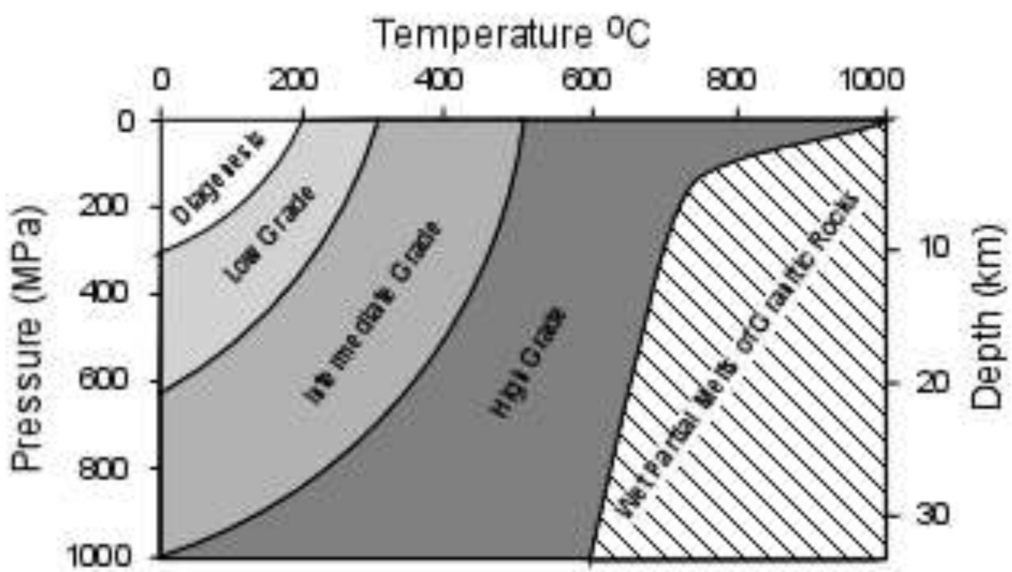
Porphyroblasts

- Mineral growth that results from the rearrangement of atoms during metamorphism

Garnet growing in quartzite

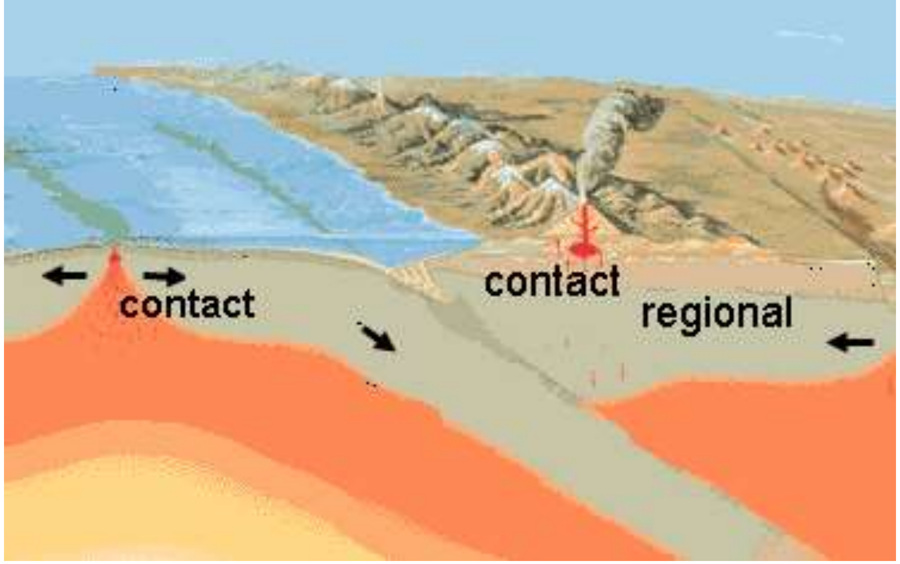
Grades of Metamorphism

- Low grade → low temperature and pressure
- Intermediate grade → in-between
- High grade → high temperature and pressure



Types of Metamorphism

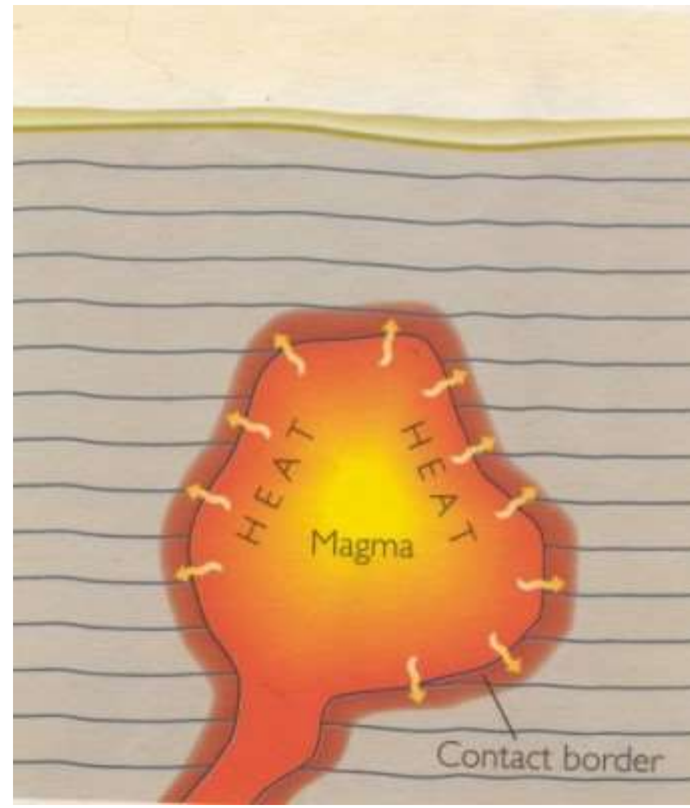
- *Regional* – caused by high temperature and pressure in large regions of the Earth's crust



- Can range from high to low grade
- Changes in mineral & rock types
- Folding & deforming of rock layers

Types of Metamorphism

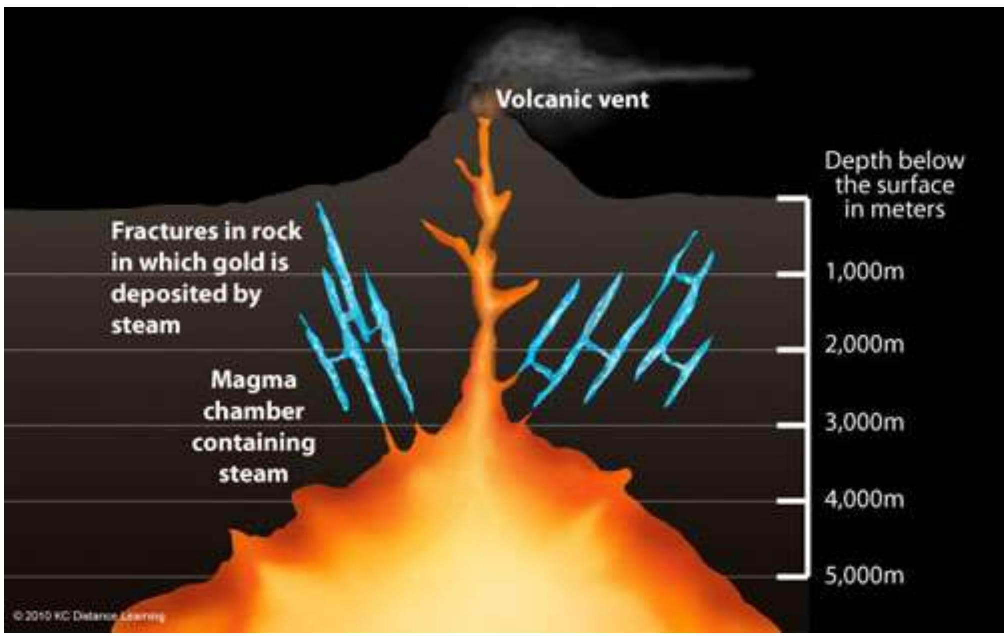
- *Contact* – when molten material comes in contact with solid rock



- High temperatures
- High to low pressure
- Metamorphic effects decrease with distance

Types of Metamorphism

- *Hydrothermal* – when very hot water interacts with rock



- Original texture and mineral composition can change
- Ore deposits of gold, copper, zinc, tungsten, and lead form this way

Economic Importance

- Metallic resources – gold, silver, copper and other metallic minerals form through hydrothermal metal deposits

- Nonmetallic resources – Talc, asbestos, and graphite form through metamorphism

The Rock Cycle

- Rocks are continually changing above and below the Earth's surface.
- This continuous changing is called ***<u>The Rock Cycle.</u>***