

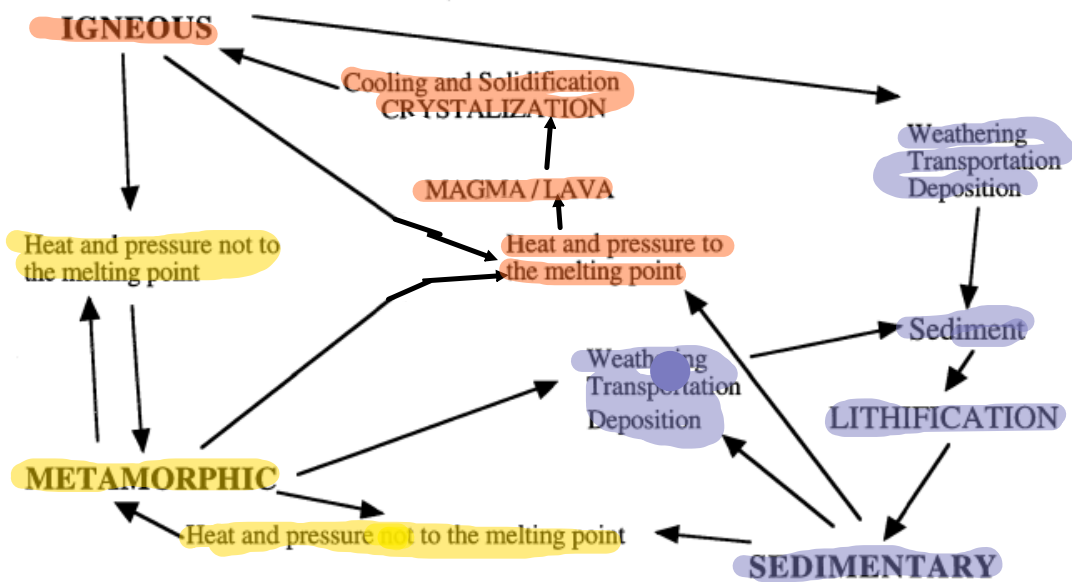
Science - proposes that the Earth is 4.6 Billion yrs old  
 Religion - proposes that Earth is only about 6000 yrs old  
 (Formed in the year 4004 B.C on October 24 at 9:00am)

### Rocks: Materials of the Lithosphere

#### I. Rock Cycle

- A. Shows the relations among the three rock types  
 Uniformitarianism - "The present is the key to the past."
- B. Proposed by James Hutton in the late 1700s  
 Catastrophism - Big, sudden events / changes
- C. The rock cycle is diagramed below:

Igneous  
 Sedimentary  
 Metamorphic



Any Rock can become any other rock or it can become itself

#### II. Igneous rocks Parent rock of all other rock types

##### A. Form as magma cools and crystallizes

1. Rocks formed inside Earth are called plutonic or intrusive rocks
  2. Rocks formed on the surface
    - a. Formed from lava (a material similar to magma, but without gas)
    - b. Called volcanic or extrusive rocks
- Magma - molten rock under the Earth's surface  
 Lava - molten rock on the Earth's surface

The more accurate difference between these types of molten rock is the percentage of dissolved gases found within.

B. Crystallization of magma

1. Ions are arranged into orderly patterns

2. Crystal size of the rock is determined by the rate of cooling

- a. Slow rate forms large crystals
- b. Fast rate forms microscopic crystals
- c. Very fast rate forms glass No crystals

C. Classification is based on the rock's texture and mineral composition

1. Texture how the mineral crystals LOOK

a. Size and arrangement of crystals

b. Types

- 1. Fine-grained—fast rate of cooling small crystals
- 2. Coarse-grained—slow rate of cooling large crystals
- 3. Porphyritic (two crystal sizes two rates of cooling)
- 4. Glassy—very fast rate of cooling no crystals

**PHANERITIC** (Crystals easily visible)

Coarse grained



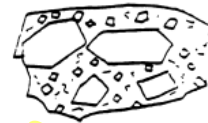
**PEGMATITIC**  
Very large crystals

ex: Gabbro



**GRANITIC**  
Moderately large  
(Close to the same size)

ex: Granite



**PORPHYRITIC**  
Two different sizes of  
crystals (Both visible)

ex: Porphyry

**APHANITIC** (Crystals not visible to the unaided eye)

Fine grained



**FELSITIC**  
All crystals very small

ex: Basalt / Rhyolite



**PORPHYRITIC**  
two different sized crystals  
(one visible, one not visible)

ex: Porphyry



**VESICULAR**  
Very fine-grained rock  
containing holes

ex: Scoria

**GLASSY** (No Crystals)



**GLASSY**  
Has conchoidal fracture  
(dense)

ex: Obsidian



**PUMICEOUS**  
glassy foam full of holes

ex: Pumice



**VESICULAR**  
holes in glass

Mafic - contain Iron / magnesium  
Dark, black coloring

Defined by their mineral composition

Felsic - do not contain Iron and magnesium  
Light, white coloring

2. Mineral composition
  - a. Explained by Bowen's reaction series which shows the order of mineral crystallization
  - b. Influenced by crystal settling in the magma

| Temperature | Minerals in Bowen's Series                |                       | Rocks made of these minerals |                           |
|-------------|---|-----------------------|------------------------------|---------------------------|
|             | Common Silicate Minerals in Igneous rocks |                       | Color                        | Name for Major Rock Group |
|             |   |                       | Coarse Grained               | Fine Grained              |
| 1100°C      | Olivine                                   | Ca-rich Plagioclase   | Dark                         | Gabbro                    |
| Cooling ↓   | Pyroxene                                  | Discontinuous Series  |                              |                           |
|             | Amphibole                                 | Continuous Series     |                              |                           |
|             | Biotite                                   | Plagioclase feldspars | Na-rich Plagioclase          | Andesite                  |
| 800°C       | Potassium Feldspar                        |                       | Light                        | Granite                   |
|             | Muscovite                                 |                       |                              | Rhyolite                  |
|             | Quartz                                    |                       |                              |                           |

#### D. Naming igneous rocks

##### 1. Basaltic rocks (Mafic)

- a. Derived from first minerals that cool and crystallize
- b. Rich in Fe (iron) and Mg (magnesium)
- c. Low in silica
- d. Common rock is Basalt (Diabase)

##### 2. Granitic rocks (Felsic)

- a. Formed from the last minerals to cool and crystallize
- b. Mainly Feldspar and Quartz (no Fe or Mg)
- c. High in silica
- d. Common rock is Granite

Keys for Igneous Rock Identification:

**Mineral Texture:** size of the mineral crystals  
 Coarse / Phaneritic - Large visible  
 Fine / Aphanitic - small / microscopic  
 Glassy - no crystals

Cooling time

**Mineral composition:** minerals that a rock contains

Mafic - rich in iron / magnesium (Dark / black)

Felsic - no iron or magnesium (Light / white)

### III. Sedimentary rocks

- A. Form from sediment (weathered products)
- B. Form about 75 percent of the rock outcrops on the continents
- C. Used to construct much of Earth's history
  - 1. Clues to past environments Water , wind, ice, gravity
  - 2. Provide information about sediment transport
  - 3. Rocks often contain fossils
- D. Economic importance
  - 1. Coal raw materials for cement
  - 2. Petroleum and natural gas
  - 3. Sources of iron and aluminum
- E. Classification
  - 1. Two groups based on the source of the material
    - a. Detrital rocks rock is composed of pieces of other rocks
      - 1. Material is solid particles
      - 2. Classified by particle size
      - 3. Common rocks are
        - a. Shale (most abundant)
        - b. Sandstone
        - c. Conglomerate
        - d. Siltstone

| <u>COMMON<br/>SEDIMENT NAME</u> | <u>PARTICLE<br/>NAME</u> | <u>SIZE<br/>RANGE (MM)</u> | <u>DETRITAL ROCK</u> |
|---------------------------------|--------------------------|----------------------------|----------------------|
| GRAVEL                          | Boulder                  | >256                       |                      |
|                                 | Cobble                   | 64 - 256                   | Rounded CONGLOMERATE |
|                                 | Pebble                   | 4 - 64                     | Angular OR BRECCIA   |
|                                 | Granular                 | 2 - 4                      |                      |
| SAND                            | Medium sand              | .175 - 2                   | SANDSTONE            |
| MUD                             | Silt                     | 0.004 - .175               | SHALE                |
|                                 | Clay                     | <.004                      |                      |

b. **Chemical rocks**

environmental change: temperature / chemical evaporation

1. **Derived from material that was once in solution and precipitates to form sediment**
  - a. Directly precipitated or
  - b. Through life processes (biochemical origin)
2. Common rocks are
  - a. Limestone—the most abundant chemical rock
  - b. Travertine mineral salt : Mammoth Hot Springs
  - c. Microcrystalline quartz
    1. Chert
    2. Flint
    3. Jasper
    4. Agate
  - d. Evaporites
    1. Rock salt Great Salt Flats, Utah
    2. Gypsum White Sands, New Mexico
  - e. **Coal**
    1. **Lignite** organic remains plants
    2. **Bituminous** 100s of millions of yrs old

F. Produced through lithification

Peat - -> Lignite - -> Bituminous - -> Pressure and time

1. **Loose sediments are transformed into solid rock**

2. **Lithification processes**

- a. Compaction
- b. Cementation by the materials
  1. **Calcite**
  2. **Silica**
  3. **Iron oxide**

Sedimentary rock is only as strong as the cement that holds it together.

G. Features

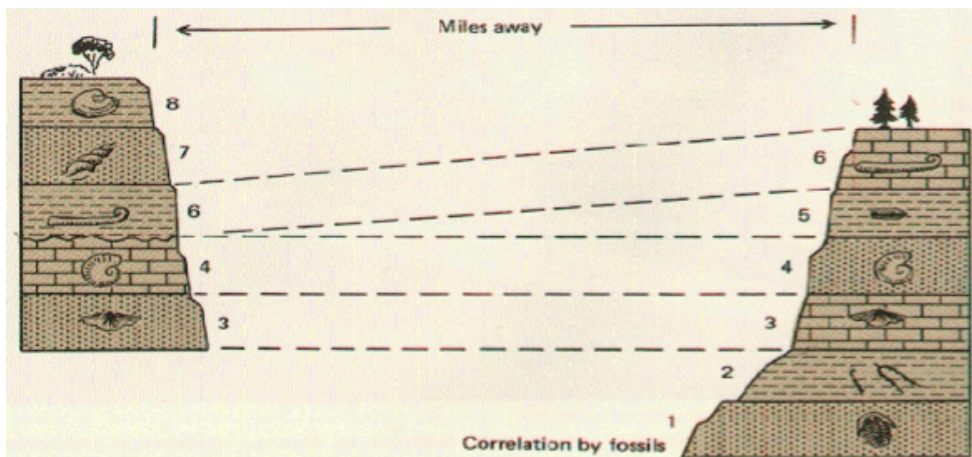
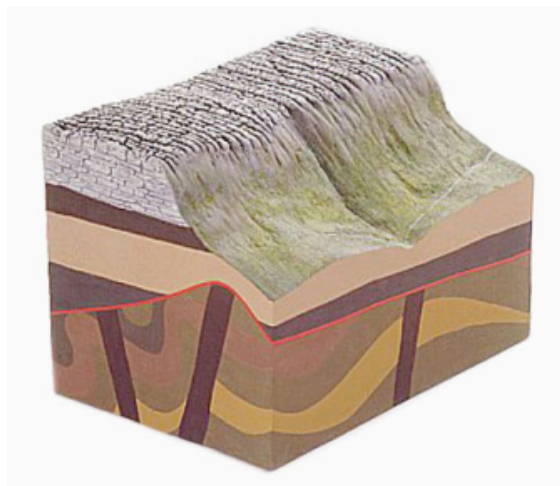
1. Strata, or beds (most characteristic)
2. Bedding planes separate strata



Strata - rock layers



Bedding Planes



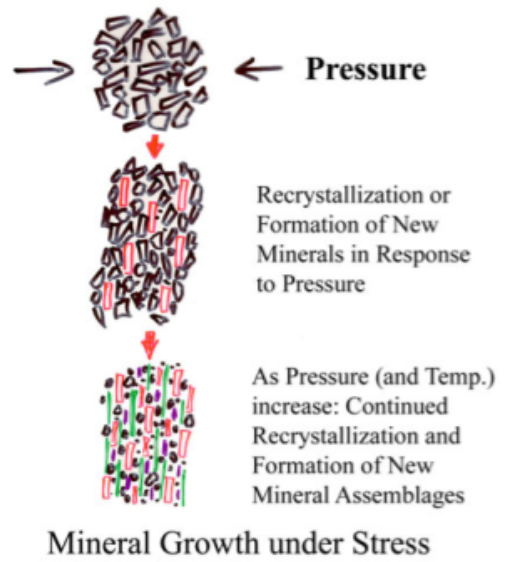
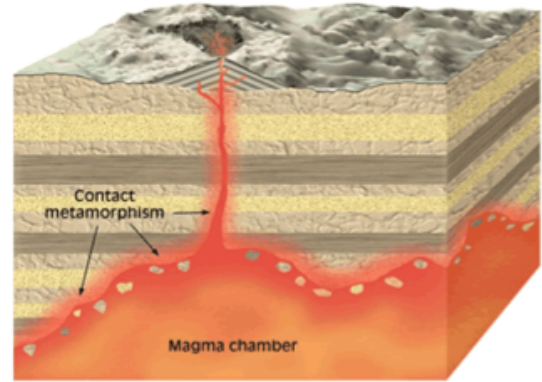
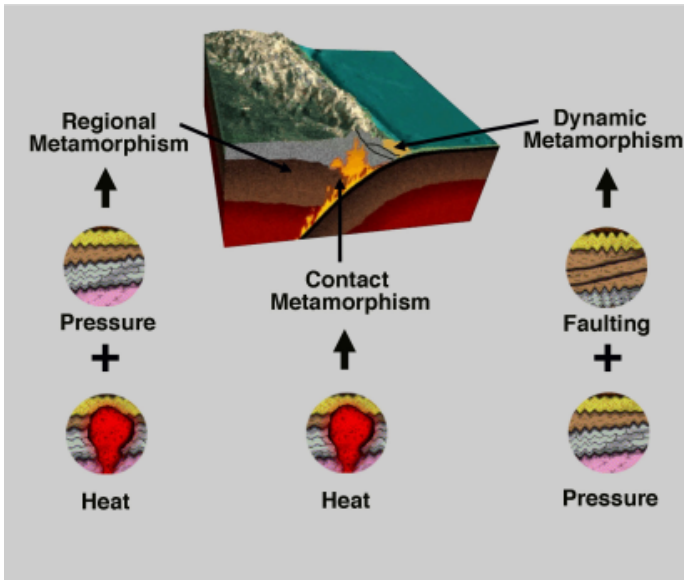
3. Fossils
  - a. Traces or remains of prehistoric life
  - b. Are the most important inclusions
  - c. Help determine past environments
  - d. Used as time indicators
  - e. Used for matching rocks from different places

#### IV. Metamorphic rocks

- A. "Changed form" rocks
- B. Can form from
  1. Igneous rocks
  2. Sedimentary rocks
  3. Other metamorphic rocks
- C. Degrees of metamorphism
  1. Show in the rock's texture and mineralogy
  2. Types
    - a. Low grade - shale turning into slate
    - b. High grade - causes the original features to be completely destroyed (Limestone - Marble) (Granite - Gneiss)
- D. Metamorphic settings
  1. Regional metamorphism
    - a. Over extensive areas ( large scale) Mountain building
    - b. Produces large quantities of metamorphic rock  
High grade metamorphic rock
  2. Contact metamorphism
    - a. Near a mass of molten rock
    - b. Bakes the surrounding rock (smaller volumes of metamorphic rock)  
Low grade metamorphic rock







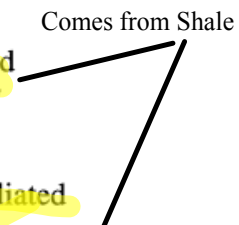
## E. Metamorphic agents

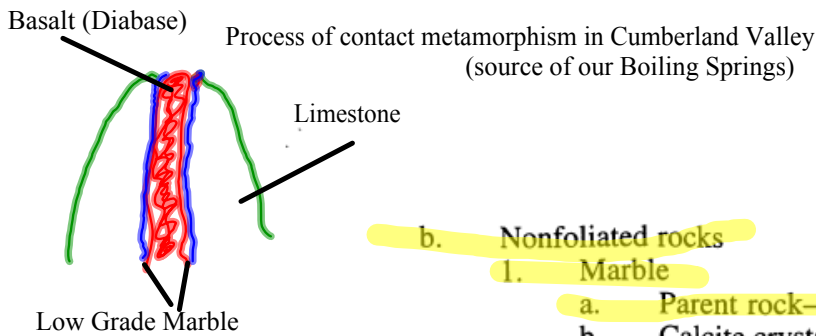
1. Heat
2. Pressure
  - a. From burial
  - b. From stress
3. Chemically active fluids
  - a. Water (most common fluid)
  - b. Ion exchange among minerals

## F. Textures

1. Foliated
  - a. Minerals are in a parallel alignment
  - b. Minerals are perpendicular to the force
2. Nonfoliated
  - a. Contain equidimensional crystals
  - b. Resembles a coarse igneous rock

## G. Classification

1. Based on texture
  2. Two groups
    - a. Foliated rocks
      1. Slate
        - a. Fine-grained
        - b. Splits easily
      2. Schist
        - a. Strongly foliated
        - b. "Platy"
        - c. Types based on composition (e.g., mica schist)
      3. Gneiss
        - a. Strong segregation of silicate minerals
        - b. "Banded" texture
- Comes from Shale
- 



b. Nonfoliated rocks

1. Marble

- a. Parent rock—limestone
- b. Calcite crystals
- c. Used as a building stone
- d. Variety of colors

2. Quartzite

- a. Parent rock—quartz sandstone
- b. Quartz grains are fused

V. Resources from rocks and minerals

A. Metallic mineral resources

- 1. e.g., Gold, silver, copper
- 2. Produced by
  - a. Igneous processes
  - b. Metamorphic processes
- 3. Hydrothermal (hot-water) solutions
  - a. Hot
  - b. Contain metal-rich fluids
  - c. Associated with cooling magma bodies
  - d. Types
    - 1. Vein deposits occur in fractures or bedding planes
    - 2. Disseminated deposits are distributed throughout the rock

Black Smokers

B. Nonmetallic mineral resources

- 1. Make use of the materials
  - a. Nonmetallic elements
  - b. Physical or chemical properties
- 2. Two broad groups
  - a. Building materials (e.g., limestone, gypsum)
  - b. Industrial minerals (e.g., fluorite, corundum, sylvite)