

# EARTH SCIENCE

## INTRODUCTION

### COMPONENTS OF STUDY

1. **Geology:** Both physical & historical
2. **Meteorology:** Weather & climate
3. **Oceanography:** The oceans
4. **Astronomy:** What is external to the atmosphere

### THE FOUR SPHERES (See The Water Cycle)

1. **Lithosphere:** The solid earth
2. **Hydrosphere:** The liquid earth
3. **Atmosphere:** The gaseous earth
4. **Biosphere:** Where life exists

### CONCERNS IN OUR PHYSICAL ENVIRONMENT

1. **Resources:** Water, soil, metallic & non-metallic elements, sunlight, wind, etc.
2. **Per-capita use of metallic and non-metallic elements is 11 tons per year**
3. **Renewable vs. non-renewable resources**
4. **Environmental and population problems**

## MINERALS

- A **mineral** is a naturally occurring, inorganic, solid material with a definite atomic structure.
- An **ore** is a useful metallic mineral.

### A. Atoms and Forces

1. **Atom:** In ancient Greek, means "un-cut" i.e., the Ancient believed the atom to be the smallest particle of matter.
2. **Atoms** are composed of neutrons, protons and electrons.
  - a. **Atomic number:** Number of protons in nucleus
  - b. **Atomic weight:** Average weight of an atom
  - c. **Isotope:** Forms of an element with identical atomic numbers, but different numbers of neutrons in the nucleus
3. **Forces:** Strong, weak, electromagnetic and gravity

### B. Properties of Minerals

1. **Luster:** Appearance or quality of light from surface
  2. **Color:** Nature of light and cause of color
  3. **Streak:** Color of mineral in powdered form
  4. **Hardness:** Moh's Scale (See Figure below)
- Scratch Test: Higher numbered materials can scratch lower numbered materials.
5. **Shape:** is determined by cleavage, crystal form and fracture.
  6. **Specific Gravity:**
    - a. The ratio of the weight of a mineral to the weight of an equal volume of water
    - b. **Density of water = 1 gm/cm<sup>3</sup> = 1 gm/ml.**  
 Ex., **gold = 19.3, aluminum = 2.7, carbon = 2.2**

### MOH'S SCALE

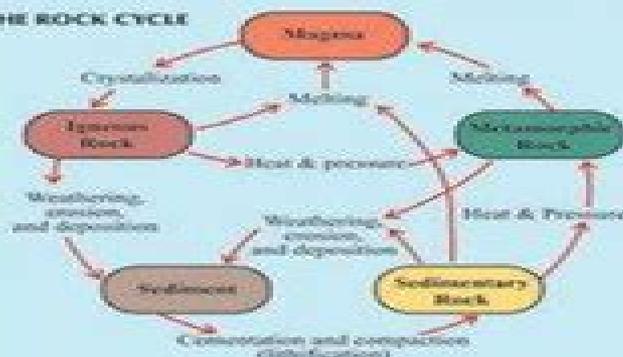
Hardness	Mineral
10	Diamond
9	Corundum
8	Topaz
7	Quartz
6	Feldspar
5	Apatite
4	Fluorite
3	Calcite
2	Gypsum
Softest	Talc

### C. Mineral Groups

1. **Silicates:** Minerals with silicon and oxygen
  - a. **Silicon** is a semi-metal which forms a pyramid-shaped structure with oxygen.
  - b. Other forms include single tetrahedrons (olivine), chains (amphibole, asbestos mineral), 3-D structures (feldspar and quartz)
2. **Non-Silicates**
  - a. Make up one-fourth of continental crust
  - b. **Carbonates:** Minerals with carbon and oxygen including calcite, from which we produce limestone (roads) and marble (decorative slabs)
  - c. **Oxides:** Oxygen based solids, i.e., **iron**
  - d. **sulfides** (all sulfides) (Sb<sub>2</sub>S<sub>3</sub>, Bi<sub>2</sub>S<sub>3</sub>) (Cu, Fe)
  - e. **Sulfate:** Mineral form of salt
  - f. **Gypsum:** Fluorite, calcium
  - g. **Noble metals:** **inc, zinc, gold, silver, nickel**

## ROCK TYPES

### THE ROCK CYCLE



### IGNEOUS ROCKS

#### A. Formation

1. **Extrusive igneous rocks** are formed in volcanic eruptions at surface.
2. **Intrusive (or plutonic) igneous rocks** are produced within the earth.
3. **Magma**
  - a. Consists mainly of silicate materials
  - b. Has gases, such as water vapor
  - c. Originates from as deep as 200 km
  - d. Differs in rate of cooling, chemical composition, and amount of gases.

- c. Produces intrusive (plutonic) igneous rocks
4. **Lava**
  - a. Similar to magma
  - b. Most gaseous elements have escaped
  - c. Produces extrusive (volcanic) igneous rocks

#### B. Structure

1. **Crystallization (ordered pattern of ions)**
  - a. The rate of cooling strongly affects crystal size
  - b. slow cooling = large crystals
  - c. quick cooling = small crystals
2. **Amorphous (unordered pattern of ions)**
  - a. occurs with instant cooling (quenching)
  - b. produces rocks referred to as glass

#### C. Classifying Igneous Rocks

1. **By texture, size and arrangement of interlocking crystals**
  - a. **fine-grained**
    - i. Forms at surface or within upper crust
    - ii. openings left by gas bubbles are called vesicles
  - b. **coarse-grained** - formed deep within the interior
  - c. **porphyritic** - large crystals embedded in matrix of smaller crystals
2. **By mineral composition**
  - a. Depends on composition of magma and cooling
  - b. Some magma can create rocks of varying mineral content.
  - c. As magma cools, certain minerals crystallize first (at very high temperatures).

### METAMORPHIC ROCKS

#### A. Formation

1. **Metamorphic:** To change form
2. **Regional metamorphism:** Material under intense stresses, high temperatures
3. **Contact (thermal) metamorphism:** Changes caused by proximity to magma
4. **Low grade metamorphism:** Shale becomes slate
5. **High grade metamorphism:** Gneiss becomes rock
6. **Diagenesis** during mountain building
7. Most metamorphic rocks are harder than sedimentary rocks.
8. **Metamorphism changes texture.**
9. **Low-grade metamorphism** makes material more compact, more dense.
10. **Foliated texture:** Particles of material are brought into line with one another

#### B. Agents of Metamorphism

1. **Heat**
  - a. most important agent
  - b. provides energy for chemical reactions
  - c. For example, clay recrystallizes into a mineral at great temperature
2. **Pressure**
3. **Chemical Activity:** Most common chemical agent is water

#### C. Types of Metamorphic Rocks

1. **Schistite:** Fine grained, dark flinty rock with randomly arranged minerals
2. **Slate:** Fine grained, often gray, foliated rock split easily along cleavage, planes of mica flakes aligned by pressure
3. **Marble:** Granular or sugary-textured rock formed from limestone
4. **Phyllite:** Silty, foliated rock more coarsely grained than slate
5. **Schist:** Foliated rock, more coarsely grained and of higher metamorphic grade than phyllite
6. **Gneiss:** Foliated, banded rock of the highest metamorphic grade
7. **Quartzite:** Very hard, granular quartz rock, formed from sandstone

### BOWEN'S REACTION SERIES

If a mineral, which has already formed, remains in the magma, it will react with the remaining magma to produce the next mineral in the sequence. For example, **olivine** forms first; **olivine** then reacts with remaining magma to form **pyroxene**.

#### A. Right Side of the Bowen Series

1. Calcium rich parts of the magma form small crystals of **olivine**.
2. These react with sodium in the magma to become more and more sodium rich.

#### B. End of Cooling

1. When everything is almost cool, remaining magma will have high silicate content, and quartz will form.
2. When cooling is complete, everything that cooled at the same time will usually be close to one another (olivine, mica and quartz cool near one another to make granite).



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