GLG 101 - CHAPTER 3 - MATTER AND MINERALS

- **Mineral** – a material that possesses the following characteristics:
    - naturally occurring
    - inorganic
    - solid
    - orderly internal structure with atoms arranged in a definite pattern (crystalline)
    - definite chemical composition (can vary within specific, well-defined limits)

- **Rock** – any naturally occurring aggregate of solid material composed of minerals and/or glass and/or organic materials. Most (though not all) rocks are composed of two or more minerals.
- The building blocks of minerals are called **elements**. The smallest particle of an element that retains the characteristics of the element is called an **atom**.
- **Atoms** are composed of **protons** (with a charge of +1) and **neutrons** (with a charge of zero) in the **nucleus**, and **electrons** (with a charge of –1) in the electron cloud orbiting the nucleus.
- All chemical reactions involved in forming minerals through bonding involve only the **outermost** electron shell.
- The periodic table is arranged such that the **number of electron shells** in an element is given by its **row number**, and the **number of electrons in its outermost shell** is given by the **column number** in which it is found (we ignore the metals region for our purposes).
- There are 92 naturally occurring elements on Earth. These elements can combine together through chemical **bonding**. **Ionic** and **covalent** bonding are the two most common types in minerals.
- **Ionic bonding** occurs when electrons are **transferred** from one atom to another to form charged **ions**. Positively charged ions are called **cations**. Negatively charged ions are called **anions**. The total charge on a bonded **molecule** formed from combined ions must be zero (negatives and positives must exactly balance).
- In ionic bonding, the elements will combine so that each has a full outermost shell. This will involve transferring of one to three electrons away from the nucleus of the atom that forms the **cation**. These electrons will then be added to fill the outermost shell of the atom that becomes the **anion**.
- **Covalent bonding** occurs when electrons are **shared** between atoms (that is, they can be thought of as orbiting one of the nuclei part of the time and the other nucleus the rest of the time).
- The 8 most common elements in the Earth's crust are O, Si, Al, Fe, Ca, Mg, Na, and K. Although nearly 4,000 minerals have been identified, only a few dozen are common.
- The most common mineral group is the **silicate** group, based on the **SiO_4^{4-} anion**. This silicate anion forms as **tetrahedra** with four oxygen anions surrounding a silicon cation, arranged like the corners of a triangular pyramid.
- Silicate bonding ranges from **isolated** tetrahedra, through **single chains** and **double chains**, to **sheets** and **framework** structures.
- The silicate structure will determine whether there are planes of weakness that can be expressed as **cleavage directions** when minerals are broken.
- The **physical properties** of minerals (hardness, color, cleavage vs. fracture, luster, etc.) are based on chemical bonding within the mineral.
- Non-silicate mineral groups include metal oxides (mined for iron), sulfides (mined for zinc and lead), halides (like halite, which is common table salt), sulfates (mined for fertilizer and drywall), carbonates (for building materials like concrete), and native elements like copper, silver, gold, and platinum.
- There are three minerals from which most commercial **asbestos** (the name for a family of fibrous minerals): **chrysotile** (white asbestos), **amosite** (brown asbestos) and **crocidolite** (blue asbestos). About 95% of the world's commercial asbestos was once chrysotile, which has been demonstrated to be generally safe and non-carcinogenic. This is the type in most commercial buildings (including schools) built in the U.S. in the 1950s and 1960s. Brown and blue asbestos are dangerous, but are largely absent in U.S. facilities. Despite these facts billions of dollars have been needlessly spent and buildings needlessly ripped apart due to misinformed public policies.