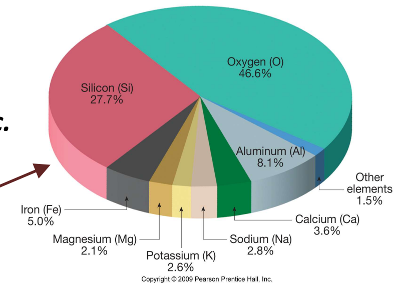
Chapter Outlines

NOTE: This is intended to help students 'organize' their understanding of each topic. It is <u>not</u> a comprehensive study guide for quizzes or midterms, i.e. <u>study your text!</u>



Breakdown of elements in Earth's crust

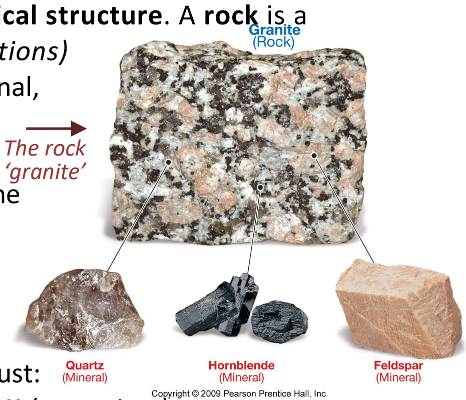
Minerals

I. Minerals are the building blocks of Earth. A **mineral** is a combination of one or more elements that forms an **inorganic**, **naturally occurring crystalline solid** of a **definite chemical structure**. A **rock** is a solid material that is composed of various mineral *(with just a couple exceptions)*

A. There are over 4,000 minerals. Only 100 are common, 50 more are occasional, and the remainder are rare. AND, only ±20 minerals form the majority of all rocks *(the rock-forming minerals)*

B. A mineral's chemistry and the architecture of its internal structure determine the physical properties used to distinguish it from other minerals

The rock 'granite'

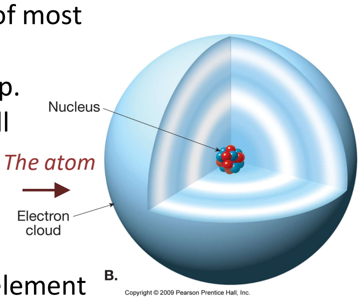


II. Minerals are composed of one or more **elements**

A. Elements cannot be broken down by ordinary chemical methods, and are displayed in the periodic table. **Eight elements** compose 98% or Earth's crust: **O** *(oxygen)*, **Si** *(silicon)*, **Al** *(aluminum)*, **Fe** *(iron)*, **Ca** *(calcium)*, **Na** *(sodium)*, **K** *(potassium)*, **Mg** *(magnesium)*. At 46%, oxygen is the most abundant and an important part of most common minerals. The combination of oxygen and silicon *(the **silicon-oxygen tetrahedron**, SiO_4)* is the building block of the **silicates**, the largest mineral group.

B. Basic building block of an element is the **atom**, it is the smallest particle that still contains the identity of that element

The atom



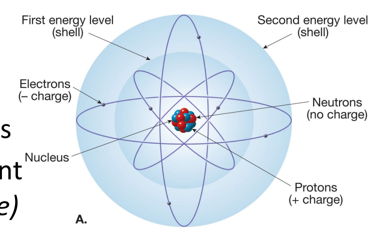
III. Structure of atoms

A. **Nucleus** *(extremely small compared to overall size of the atom)* contains:

1. **Protons**—positive electrical charge, the number of protons identifies the element
2. **Neutrons** —electrically neutral

B. **Energy levels**, or shells

1. Surround nucleus
2. Contain electrons *(negative electrical charge)* existing in different energy levels



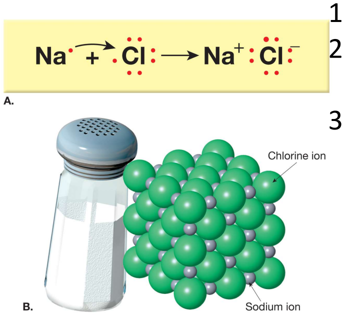
C. **Atomic number** - the number of protons in an atom's nucleus, identifies the element

D. **Atomic mass** – sum of the mass of protons & neutrons *(electron's mass is negligible)*

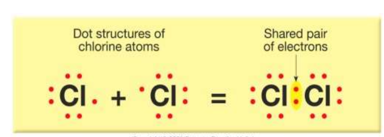
E. **Bonding of atoms** *(chemical reaction)*

1. Compounds are formed from the bonding of atoms of two or more elements
2. Atoms are naturally neutral. If an atom gains or losses an electron, it becomes an **ion** with an electrical charge
3. Atoms bond to other atoms as a result of electrical attraction *(as ions)* and the number of electrons in its outer shell *(**valence shell**)*. A full valence shell is most stable. Atoms can obtain a full outer energy level *(valence shell)* by either exchanging electrons with other atoms *(**ionic bonding**)* or sharing electrons *(**covalent and metallic bonding)***

Ionic bonding



Covalent bonding



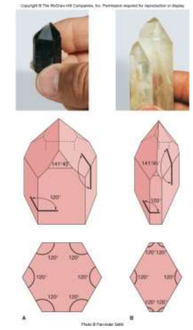
E. **Isotopes**

1. An atom becomes an isotope of that element if neutrons are gained or lost and no longer equal the number of protons
2. Isotopes have different mass numbers—the sum of the neutrons plus protons
3. '**Unstable**' isotopes are radioactive and emit energy and particles as they 'decay' to new *(daughter)* isotopes or elements

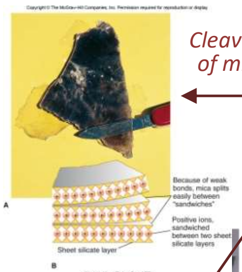
IV. Mineral Properties

A. Properties of minerals can be used to identify it. It is not always possible to identify a mineral without additional laboratory work. Properties include:

1. **External Crystal form –** the result of its internal arrangement of atoms *(often not obvious).* This consists of a set of crystal faces *(external geometric form)* unique to a mineral
2. **Streak** – color of the mineral in powdered form left on a streak plate
3. **Luster** – examples: glassy, vitreous, metallic, earthy, etc.
4. **Color** - the visible hue of a mineral. Color can be misleading, but generally lighter in minerals with more silica and darker in minerals with more iron and magnesium
5. **Hardness** – scratch resistance. Use Moh's hardness scale (talc = 1, diamond = 10)
6. **Cleavage –** tendency to break along preferred planar fractures. Cleavage planes are always parallel to a crystal face, but not all crystal faces have corresponding cleavage planes.
7. **Fracture** – breakage which is not controlled by cleavage. Examples are: conchoidal, irregular, etc.
8. **Specific gravity *(density)*** – can be measured accurately, or estimated *(how heavy it feels)*
9. Some other properties:
   a. Taste
   b. Smell
   c. Elasticity
   d. Malleability
   e. Feel
   f. Magnetism
   g. Double refraction
   h. Reaction to hydrochloric acid

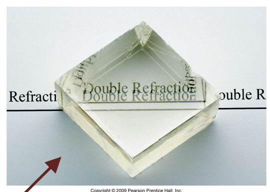


Crystal form of quartz



Cleavage of mica

Cleavage of halite



Conchoidal fracture.

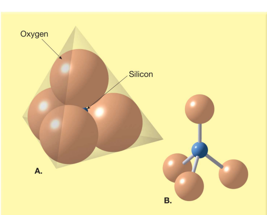
Glass has conchoidal fracture

B. A few dozen minerals are called the *rock-forming minerals*

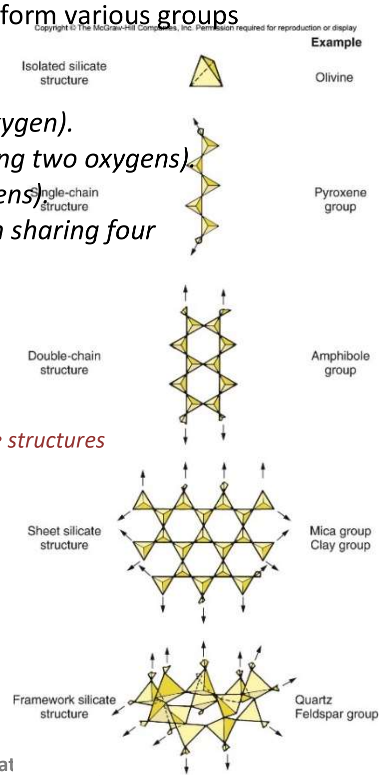
1. The **eight elements** that compose most rock-forming minerals *(also on previous page)* are: oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg)
2. The most abundant atoms in Earth's crust are:
   a. **Oxygen** *(46.6% by weight)* b. **Silicon** *(27.7% by weight)*

C. Mineral groups

1. **Silicate minerals -** Most common mineral group, all contain the silicon–oxygen tetrahedron
   a. Four oxygen atoms surrounding a much smaller silicon atom
   b. The **silicon–oxygen tetrahedron** joins together in a variety of ways to form various groups of silicate minerals. Five main silicate groups include:
      i. **Olivine** group *(tetrahedrons are '**isolated**', no shared oxygens).*
      ii. **Pyroxene** group *(tetrahedrons are in '**chains**', each sharing one oxygen).*
      iii. **Amphibole** group *(tetrahedrons are in '**double chains'**, each sharing two oxygens).*
      iv. **Mica** group *(tetrahedrons are in '**sheets**', each sharing three oxygens).*
      v. **Quartz** & **Feldspar** group *(tetrahedrons are in a '**framework**', each sharing four oxygens).*



Two ways to view the silicon-oxygen tetrahedron



Silicate structures

2. Main **Non-silicate** mineral groups are *(with one example of each):*
   a. **Carbonate** group (calcite, $CaCO_3$)
   b. **Chloride** group (halite, NaCl)
   c. **Sulfide** group (pyrite, FeS_2)
   d. ***Sulfate** group (gypsum, $CaSO_4 \cdot H_2O$)*
   e. ***Oxide** group (hematite, Fe_2O_3)*
   f. ***Native elements** (gold - Au, silver – Ag, diamond – C, etc.)*

D. **Mineral resources** (*much of our mineral resources come from the non-silicates)*

1. **Reserves**—profitable, identified deposits
2. **Ores**—metallic minerals that can be mined at a profit
3. Changing economic factors can change these classifications

Open pit copper mine in Utah