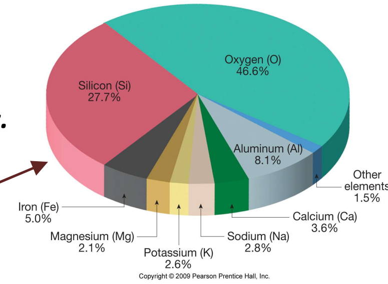
Chapter Outlines

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



Breakdown of elements in Earth's crust

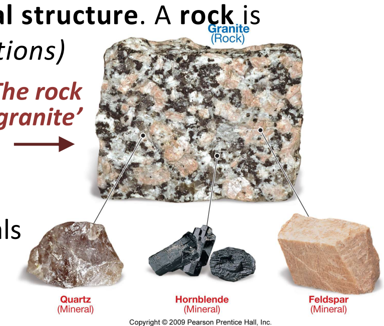
Minerals

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'

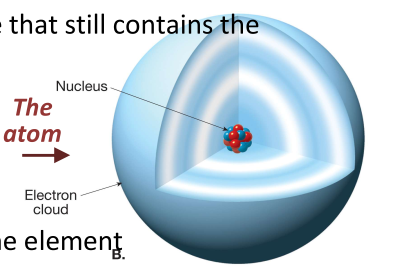


II. Minerals are composed of one or more **elements**

   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

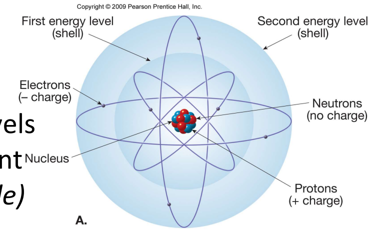
   A. **Nucleus** *(extremely small compared to overall size of the atom)* contains:
   - **Protons**—positive electrical charge, the number of protons identifies the element
   - **Neutrons** —electrically neutral

   B. **Energy levels**, or shells
   - Surround nucleus
   - Contain electrons *(negative electrical charge)* existing in different energy levels

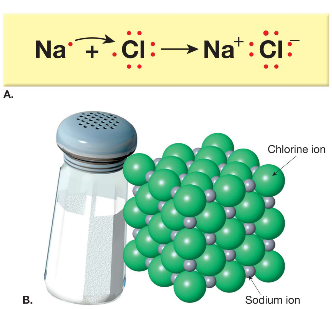
   C. **Atomic number** - the number of protons in an atom's nucleus, identifies the element

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

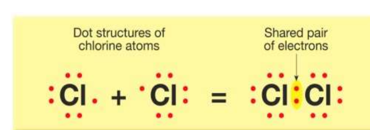
   E. **Bonding of atoms** *(chemical reaction)*
   - Compounds are formed from the bonding of atoms of two or more elements
   - Atoms are naturally neutral. If an atom gains or losses an electron, it becomes an **ion** with an electrical charge
   - Atoms bond to other atoms as a result of electrical 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



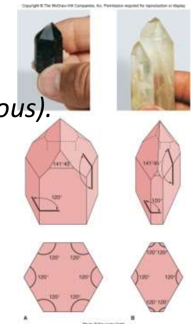
Covalent bonding



   E. **Isotopes**
   - An atom becomes an isotope of that element if neutrons are gained or lost and no longer equal the number of protons
   - Isotopes have different mass numbers—the sum of the neutrons plus protons
   - '**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:

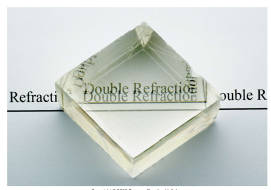


Crystal form of quartz

- **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
- **Streak** – color of the mineral in powder form left on a streak plate
- **Luster** – examples: glassy, vitreous, metallic, earthy
- **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
- **Hardness** – scratch resistance. Use Moh's hardness scale (talc = 1, diamond = 10)
- **Cleavage –** tendency to break along preferred planar fractures *(this may be different from crystal form)*. Cleavage planes are always parallel to a crystal face *(but not always formed)*.
- **Fracture** – breakage which is not controlled by cleavage. Examples are: conchoidal, irregular
- **Specific gravity *(density)*** – can be measured accurately, or estimated *(how heavy it feels)*
- Other properties
  - Taste
  - Smell
  - Elasticity
  - Malleability
  - Feel
  - Magnetism
  - Double refraction
  - Reaction to hydrochloric acid

Cleavage of mica

Cleavage of halite



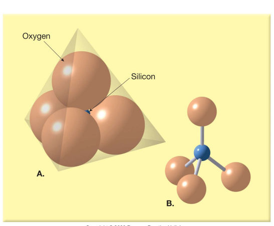
Conchoidal fracture.

Glass has conchoidal fracture

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

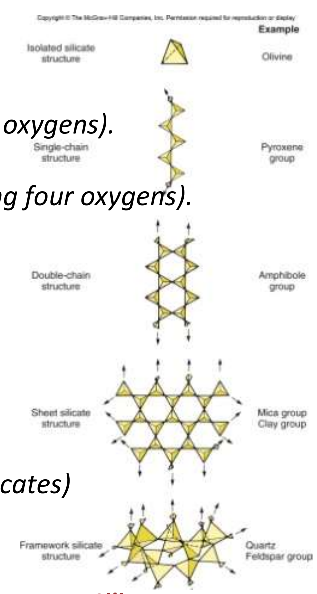
- The **eight elements** that compose most rock-forming minerals *(also on previous page)* are: oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg)
- The most abundant atoms in Earth's crust are:
  a. **Oxygen** *(46.6% by weight)* b. **Silicon**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

C. Mineral groups



Two ways to view the silicon-oxygen tetrahedron

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



Silicate structures

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

Open pit copper mine in Utah

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

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

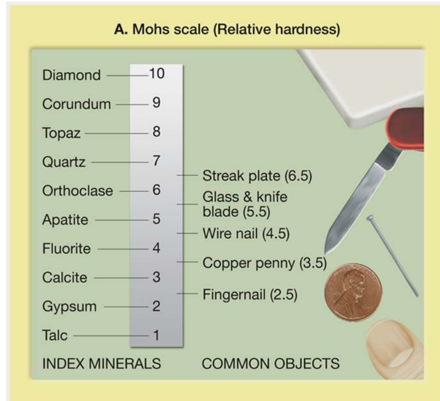


TABLE 2.1 Common Nonsilicate Mineral Groups

Mineral Groups [key ion(s) or element(s)]	Mineral Name	Chemical Formula	Economic Use
Carbonates (CO_3^{2-})	Calcite	$CaCO_3$	Portland cement, lime
	Dolomite	$CaMg(CO_3)_2$	Portland cement, lime
Halides (Cl^-, F^-, Br^-)	Halite	$NaCl$	Common salt
	Fluorite (Fluorspar)	CaF_2	Hydrofluoric acid production, steelmaking
	Sylvite	KCl	Fertilizer
Oxides (O^{2-})	Hematite	Fe_2O_3	Ore of iron, pigment
	Magnetite	Fe_3O_4	Ore of iron
	Corundum	Al_2O_3	Gemstone, abrasive
	Ice	H_2O	Solid form of water
Sulfides (S^{2-})	Galena	PbS	Ore of lead
	Sphalerite	ZnS	Ore of zinc
	Pyrite	FeS_2	Sulfuric acid production
	Chalcopyrite	$CuFeS_2$	Ore of copper
	Cinnabar	HgS	Ore of mercury
Sulfates (SO_4^{2-})	Gypsum	$CaSO_4 \cdot 2H_2O$	Plaster
	Anhydrite	$CaSO_4$	Plaster
	Barite	$BaSO_4$	Drilling mud
Native elements (single elements)	Gold	Au	Trade, jewelry
	Copper	Cu	Electrical conductor
	Diamond	C	Gemstone, abrasive
	Sulfur	S	Sulfa drugs, chemicals
	Graphite	C	Pencil lead, dry lubricant
	Silver	Ag	Jewelry, photography
	Platinum	Pt	Catalyst