Minerals: Big Ideas

- Earth scientists use the structure, sequence, and properties of rocks, sediments, and fossils to reconstruct events in Earth's history
- Earth's systems continually react to changing influences from geological, hydrological, physical, chemical, and biological processes
- rocks and minerals provide essential metals and other materials

Mineral

- naturally occurring
- solid crystalline substance
- generally inorganic
- specific chemical composition

Ionic Bonding

- **ions of opposite charges attracted (total charge must add to zero)**
- **90% of minerals are essentially ionic compounds**

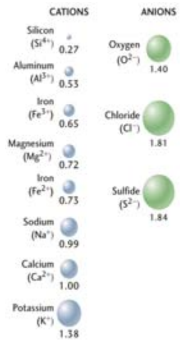


Fig. 3.7

Many Common Elements form Ions

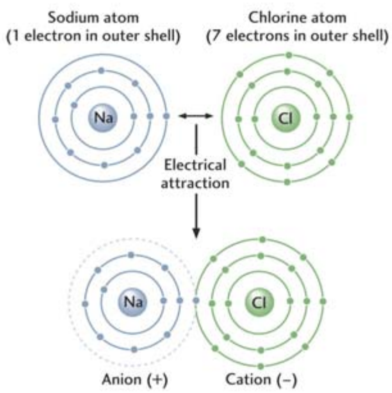


Fig 3.4

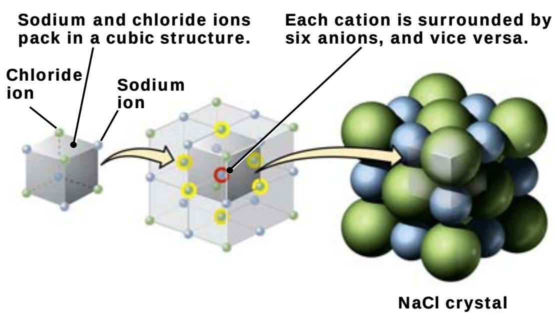
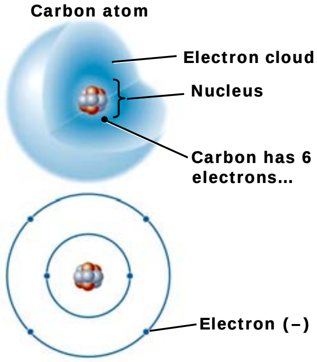
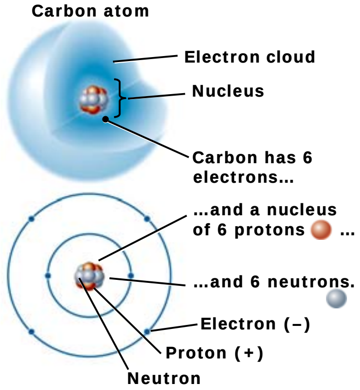


Table salt, halite

Covalent Bonding

- **Electrons shared between atoms**
- **Much more stable than ionic bonds**





Atomic Structure of Diamond

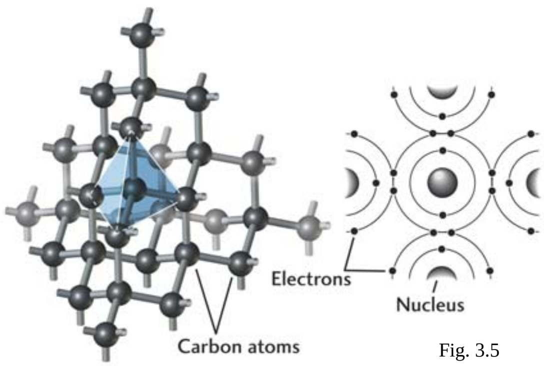
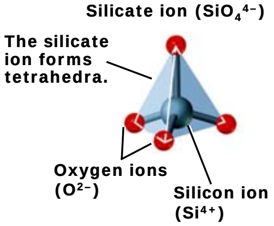
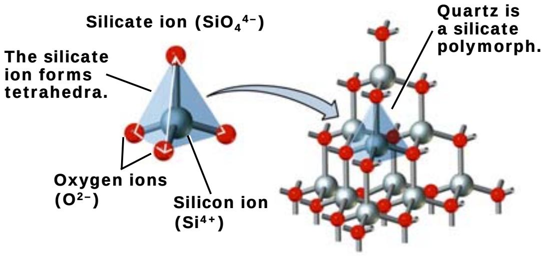
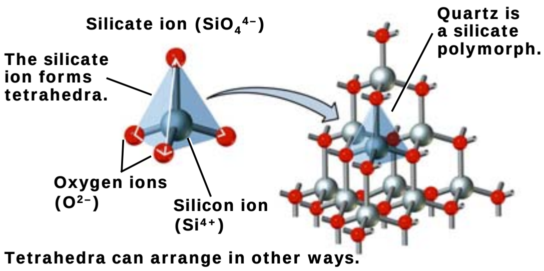


Fig. 3.5







Mineral Formation

- Crystallization from a magma
- Crystal growth in the solid state
- Precipitation from solution

Crystal Structure

- Anions are generally larger than cations
- Structure of mineral determined largely by how the anions are arranged and how the cations fit between them

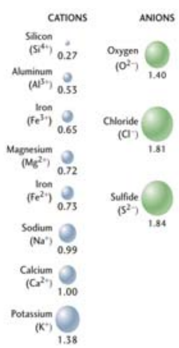


Fig. 3.7

Ionic Radius And Charge

Minerals: Lots and Lots of 'Em

- There are some 3,500 recognized minerals found on Earth.
- We can focus on just a few types:
  - Silicates - Si, O combined with other cations
  - Carbonates - Ca, Mg and CO_3
  - Oxides - O^{2-} and metallic cations
  - Sulfides - S^{2-} and metallic cations
  - Sulfates - $(SO_4)^{2-}$ and metallic cations

Isolated Tetrahedra

Olivine group

Fig. 3.11

Chains of Tetrahedra

Pyroxene group

Fig. 3.11

Chains of Tetrahedra

Amphibole group

Fig. 3.11

Sheets of Tetrahedra

Mica group

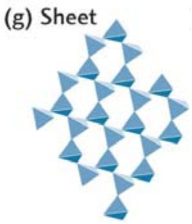


Fig. 3.11/3.17

3-D Frameworks of Tetrahedra

Feldspar group

Fig. 3.11

Abundant Mineral Groups

Name	**Important constituents** (other than Oxygen)
Olivine	**Si, Fe, Mg**
Pyroxene	**Si, Fe, Mg, Ca**
Amphibole	**Si, Ca, Mg, Fe, Na, K**
Micas	**Si, Al, K, Fe, Mg**
Feldspars	**Si, Al, Ca, Na, K**
Carbonates	**C, Ca, Mg**
Evaporites	**K, Cl, Ca, S**

Carbonates

- **Second most abundant group in the Earth's crust**
- **Major component of limestone**
- **Three major minerals:**
  - **Calcite: $CaCO_3$** } Polymorphs
  - **Aragonite: $CaCO_3$**
  - **Dolomite: $(Ca,Mg)CO_3$**

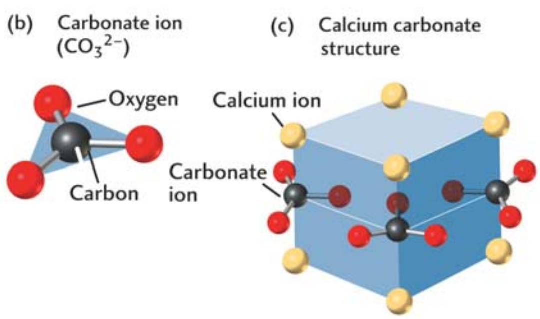


Fig. 3.12

calcite

The Acid Test for Calcite

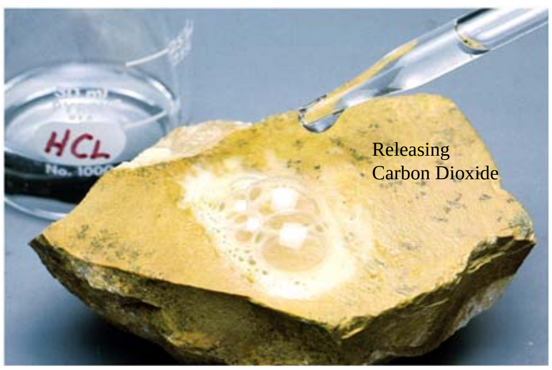
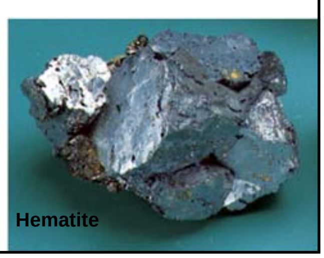


Fig. 3.16

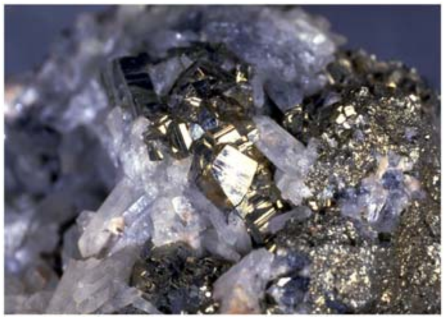
Oxides

Hematite Fe_2O_3
Magnetite Fe_3O_4
Spinel $MgAl_2O_4$



Sulfides

Pyrite **FeS_2**



Sulfates

Gypsum **$CaSO_4$**
Anhydrite **$CaSO_4 \cdot 2H_2O$**

Important Minerals

- **Quartz SiO_2**
- **Calcite $CaCO_3$**
- **Olivine $(Mg,Fe)_2SiO_4$**

- **Plagioclase feldspar**
- **K-feldspar**
- **Micas**
- **Amphiboles**
- **Pyroxenes**

Mineral Properties

- Hardness
- Cleavage
- Fracture
- Luster
- Color
- Density
- Crystal habit

Table 3-2 Mohs Scale of Hardness

Mineral	Scale Number	Common Objects
Talc	1	
Gypsum	2	— — — Fingernail
Calcite	3	— — — Copper coin
Fluorite	4	
Apatite	5	— — — Knife blade
Orthoclase	6	— — — Window glass
Quartz	7	— — — Steel file
Topaz	8	
Corundum	9	
Diamond	10	

Cleavage – Zone of Weakness

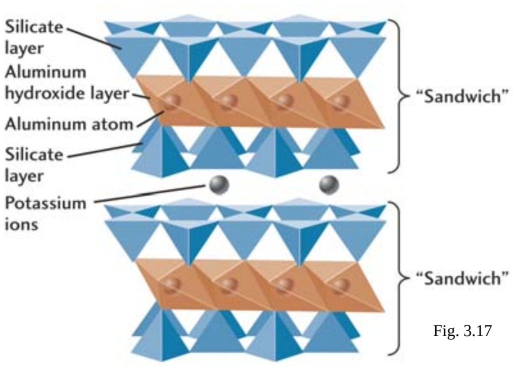


Fig. 3.17

Fig. 3.18

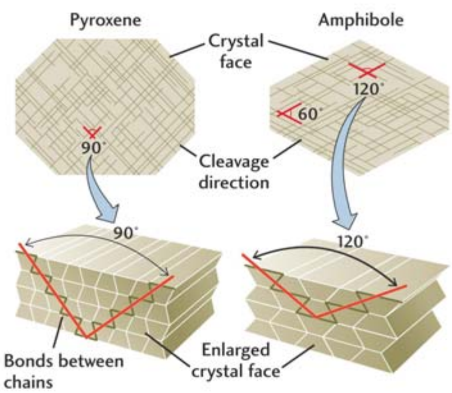


Fig. 3.19

Table 3-3 Mineral Luster

Luster	Characteristics
Metallic	Strong reflections produced by opaque substances
Vitreous	Bright, as in glass
Resinous	Characteristic of resins, such as amber
Greasy	The appearance of being coated with an oily substance
Pearly	The whitish iridescence of such materials as pearl
Silky	The sheen of fibrous materials such as silk
Adamantine	The brilliant luster of diamond and similar minerals

Streak

Fig. 3.20

Crystal Habit

Table 3-4 Physical Properties of Minerals

Property	Relation to Composition and Crystal Structure
Hardness	Strong chemical bonds give high hardness. Covalently bonded minerals are generally harder than ionically bonded minerals.
Cleavage	Cleavage is poor if bonds in crystal structure are strong, good if bonds are weak. Covalent bonds generally give poor or no cleavage; ionic bonds are weak and so give excellent cleavage.
Fracture	Type is related to distribution of bond strengths across irregular surfaces other than cleavage planes.
Luster	Tends to be glassy for ionically bonded crystals, more variable for covalently bonded crystals.
Color	Determined by kinds of atoms and trace impurities. Many ionically bonded crystals are colorless. Iron tends to color strongly.
Streak	Color of fine powder is more characteristic than that of massive mineral because of uniformly small size of grains.
Density	Depends on atomic weight of atoms and their closeness of packing in crystal structure. Iron minerals and metals have high density; covalently bonded minerals have more open packing and so have lower density.
Crystal habit	Depends on planes of atoms or ions in a mineral s crystal structure and the typical speed and direction of crystal growth.

Cullinan Diamond (Great Star of Africa)

Gemstones (diamonds and sapphires)

(each diamond was processed from 40 pickup trucks full of ore)