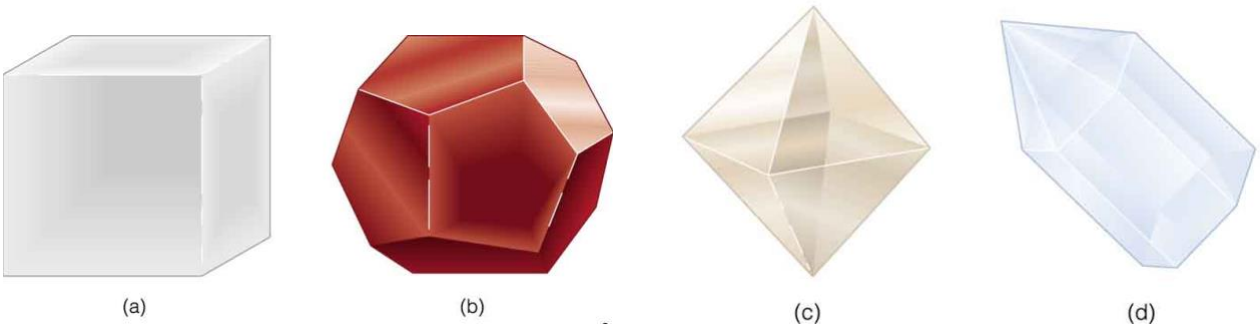
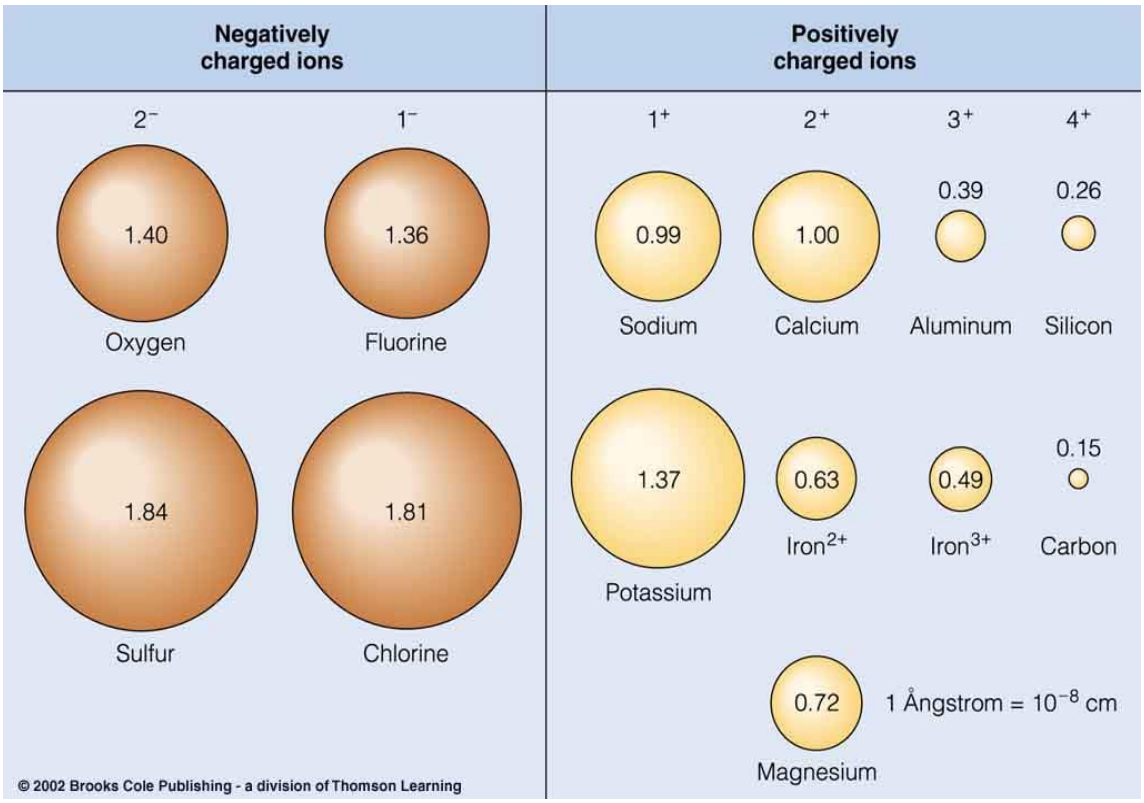
Ch 4 Minerals

Minerals: a solid that includes the following

1. naturally occurring
2. inorganic solid
3. definite crystalline structure: compounds whose atoms are arranged in a regular, orderly, periodically repeated pattern. Well defined crystals are uncommon/rare.



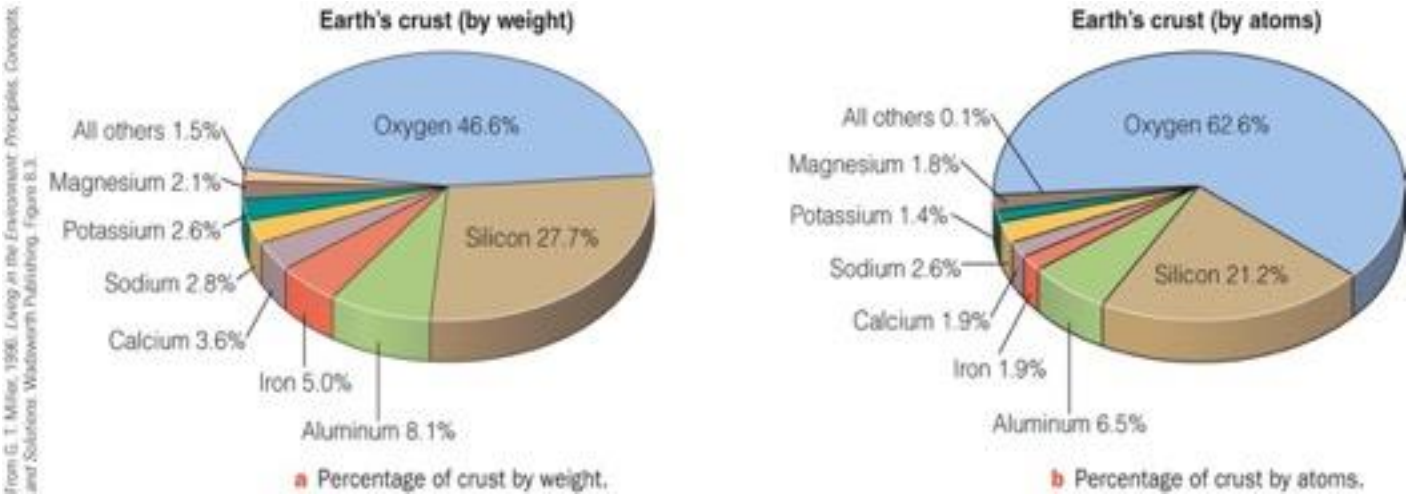
4. solids with specific chemical composition
   – NaCl or SiO_2 (Halite, Quartz)
   – Variations in compositions may occur as in $(Mg, Fe)_2SiO_4$ Olivine



How Many Minerals are Known?

- More than 5400 identified
  - – Less than 30 are common
  - – About 10 minerals are referred to as **rock-forming minerals**. These rocks make up most of the earth's crust.
  - – They are composed of the most abundant elements found in the crust.
    - Most abundant elements in the crust (% weight)

      - – Oxygen- 46.6
      - – Silicon- 27.7
      - – Aluminum- 8.1
      - – Iron- 5.0
      - – Calcium- 3.6
      - – Sodium- 2.8
      - – Potassium- 2.6
      - – Magnesium- 2.1
      - – all others- 1.5



Where and How do Minerals Originate?

- Crystallization of molten rock material (**magma**)
- Precipitation from hot water associated with magma in hydrothermal veins
- Precipitation from sea or lake water. These minerals are referred to as **evaporites**
- During metamorphism

How Are Minerals Identified?

- Physical properties of minerals

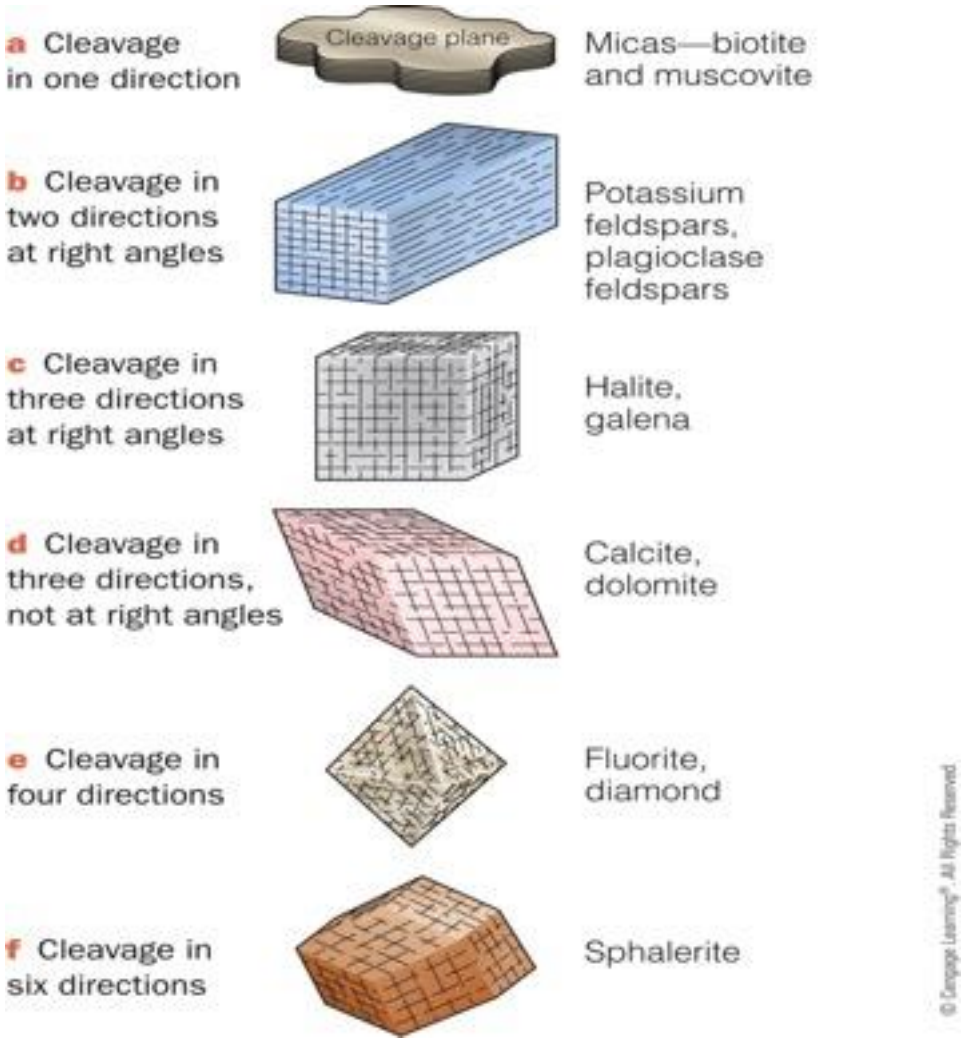
  -All minerals have characteristic properties which can be observed or tested
  - These properties are determined by the internal structure and chemical composition
  - Most properties are constant for each specimen of a mineral, but some variation exists, especially in color
  - The following is a list of physical properties that is typically used for identification of minerals

    1. crystal form (habit)
    2. cleavage
    3. fracture
    4. hardness
    5. color
    6. specific gravity
    7. streak
    8. luster

1. **Crystal Form** – shape in which individual crystals grow and how they grow in aggregates

   - External form reflects the internal geometry and composition
   - Different conditions during growth a single mineral may occur in more than one habit or shape
   - Perfect crystals are rare, but may be useful in identification

2. **Cleavage -** Cleavage is the tendency of a mineral to break along planes that exist between weak bonds in the internal geometric structure



3. **Fracture** - breakage along irregular surfaces when no weak planes exist

- Conchoidal: smooth, curved fractured surfaces. ex. quartz
- Irregular: no pattern. ex. migmatite

4. **Hardness** – resistance to being scratched

- Determined by internal structure and strength of bonds
- An important lab test in the identification of minerals
- Based on the Mohs scale from 1 to 10

1 = talc	6 = orthoclase
2 = gypsum	7 = quartz
3 = calcite	8 = topaz
4 = fluorite	9 = corundum
5 = apatite	10 = diamond

fingernail = 2.5	knife = 5
copper penny = 3.5	glass = 5.5
nail/steel file = 6.5	streak plate = 7

5. **Specific Gravity** - The ratio of a mineral's weight to the weight of an equal volume of water

   ex. water = 1
   garnet = 4.32

6. **Color**

   - Color may vary because of trace elements or variations in the range of the chemical formula
   - Not always a good way of identifying a mineral

     ex. plagioclase feldspars: white, gray, brown

7. **Streak –** the color of the powder after it is rubbed on a streak plate

   ex. sphalerite = white
   galena = dark gray / black

8. **Luster** - the appearance of the mineral in reflected light

   - ex. metallic, glassy, pearly, earthy, resinous

Other Useful Mineral Properties

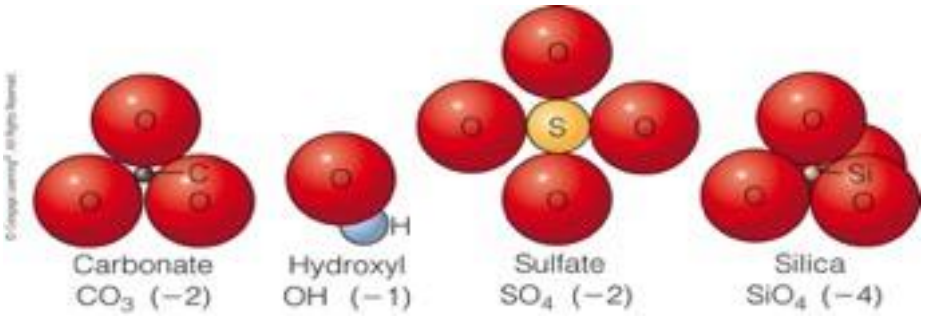
Taste	Radioactivity
Feel/texture	Fluorescence/ Phosphorescence
Magnetism	Iridescence
Double refraction	Effervescence/fizz with dilute hydrochloric acid

Mineral Classification

Geologists recognize mineral classes/groups in two ways

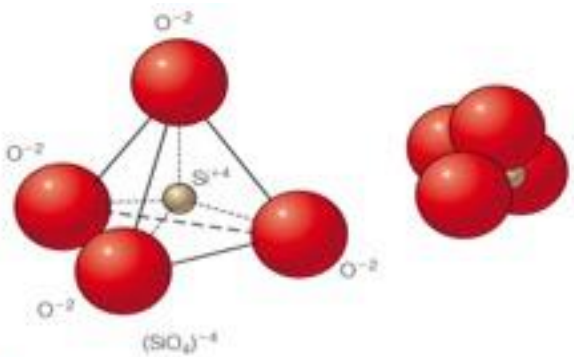
1) The first way, minerals are identified by their negatively charge ion
   ex: Halides, Oxides & Sulfides

2) The second way, minerals are identified by the negative ion group they contain. They make and break bonds as if they were a single atom.
   ex: Silicates $(SiO_4)^{-4}$, Carbonates $(CO_3)^{-2}$, Hydroxyl $(OH)^{-1}$ & Sulfate $(SO_4)^{-2}$

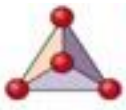


The Silicate Minerals

- Most abundant group. 96% of all minerals in the crust are silicates
- Makes up 90% of crust by volume
- Built from the two most abundant elements in the earth's crust, atoms are arranged in a tetrahedron, with oxygen atoms at the four corners.
- The **silicon - oxygen tetrahedron** or **silica tetrahedron** is the basic building block for all the silicate minerals.
  - silica tetrahedron = 4 equal triangles with base SiO_4^{-4}

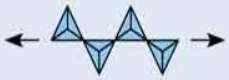
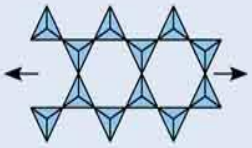
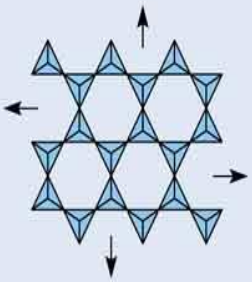


a Expanded view of the silica tetrahedron (left) and how it actually exists with its oxygen atoms touching.



b View of the silica tetrahedron from above. Only the oxygen atoms are visible.

- Silica tetrahedra combine with positively charged ions or share electrons. The result of different bonding possibilities produces the silicate structures shown.

			Formula of negatively charged ion group	Silicon-to-oxygen ratio	Example
(a)	Isolated tetrahedra		$(SiO_4)^{-4}$	1:4	Olivine
(b)	Continuous chains of tetrahedra	 Single chain	$(SiO_3)^{-2}$	1:3	Pyroxene group
		 Double chain	$(Si_4O_{11})^{-6}$	4:11	Amphibole group
(c)	Continuous sheets		$(Si_4O_{10})^{-4}$	2:5	Micas
(d)	Three-dimensional networks	Too complex to be shown by a simple two-dimensional drawing	$(SiO_2)^0$	1:2	Quartz

- Two subgroups of Silicates

1) **ferromagnesian**: silicates containing Fe and/or Mg

- darker and denser than the nonferromagnesian silicates
ex. olivine, pyroxenes (augite), amphiboles (hornblende) and biotite

2) **nonferromagnesian**: silicates lacking Fe and Mg

- lighter in color and are less dense than ferromagnesian silicates
  ex. quartz, plagioclase feldspar, potassium feldspar (k-spar) and muscovite

Nonsilicate Minerals: about 10% of crust by volume

Carbonate Minerals

- Contain the negatively charged carbonate ion $(CO_3)^{-2}$, which bonds with a positively charged ion

- Common carbonates are **calcite** ($CaCO_3$), and **dolomite** [$CaMg(CO_3)_2$], the predominant minerals in the sedimentary rocks limestone and dolostone

Other Mineral Groups

- Oxides (Fe_2O_3)
  ex. magnetite, hematite, corundum, opal
- Native Elements
  ex. C, Ag, Au, Cu
- Phosphate $(PO)^{-4}$
  ex. apatite, used in fertilizers
- Sulfides (PbS)
  ex. galena, pyrite, sphalerite
- Sulfates ($CaSO_4 \cdot 2H_2O$)
  ex. gypsum
- Halides (NaCl)
  ex. halite, fluorite
- Hydroxides: type of oxide that gives up water when heated
  ex. limonite, bauxite

What are Rock-Forming Minerals?

- Rocks are solid aggregates of one or more minerals
- Rock-forming minerals are those that occur commonly

    - **Silicates**
        - ferromagnesian and non-ferromagnesian
            - Common silicates
                quartz, feldspars, muscovite mica, pyroxene, amphibole, biotite mica

    - **Nonsilicates**
            - Common nonsilicates
                calcite, dolomite, gypsum, halite

- **Common Rocks**

    - Granite
        - mineral composition of granite
            - quartz
            - potassium & plagioclase feldspar
            - biotite

- Basalt
    - mineral composition of basalt
        - pyroxene
        - calcium plagioclase feldspar
        - olivine

b A specimen of basalt measuring about 4 cm across.

c Magnified view of basalt showing its minerals, none of which exceed about 0.5 mm long. The grey minerals are plagioclase feldspar, the bluish green to green minerals near the top are olivine, and the rest is mostly calcium-rich pyroxene.

Mineral Resources vs Reserves

- ***Resources***: consist of both discovered and undiscovered materials that can be currently or potentially extracted.

    - Metals, sand, stone, sulfur, salt, and others
    - Nonmetals and energy resources

- ***Reserves***: a resource that can be economically extracted.

    - **Ore**: a mineral is an ore if it contains a valuable substance that can be mined for profit. Example: Hematite is an ore because it contains iron
        - If hematite is too expensive to mine/obtain it is no longer considered an ore. It is now a resource.

- **Gems**: minerals that are rare, hard, pretty/desirable