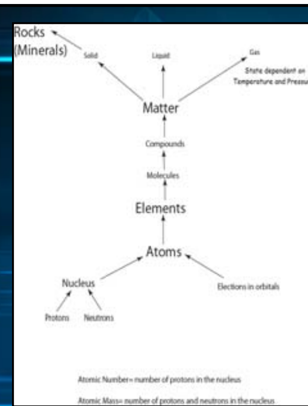
Rock Forming Minerals

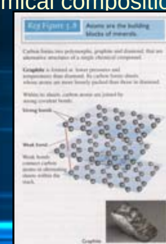


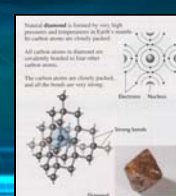
Definition of a Mineral

- Naturally occurring inorganic solid *with a*
- diagnostic chemical composition *and a*
- characteristic crystal structure

Polymorphs:

- Different crystal structure for the same chemical composition





Physical Properties of Minerals

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 or ions 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 or ions 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.

Properties of Minerals: Crystal form

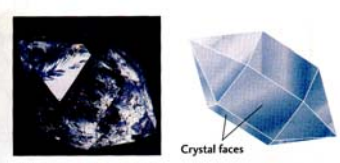


Figure 3.6 A perfect crystal. A perfect crystal is rare, but no matter how irregular the shapes of the faces may be, the angles are always exactly the same. [Breck P. Kent.]

Properties of Minerals: Cleavage

- Tendency of a mineral to break along a smooth planar surface in a preferred direction

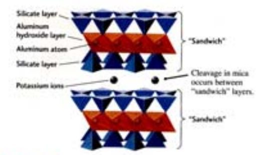


Figure 3.15 Cleavage of mica. The diagram shows the cleavage planes in the mineral structure, oriented perpendicular to the plane of the page. Horizontal lines mark the interfaces of silica-oxygen tetrahedral sheets and sheets of aluminum hydroxide

Properties of a Mineral: Hardness

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	

Properties of Minerals: Density

- Density= mass/unit volume
  - Reflects the closeness of packing of the atoms and what elements are present

Properties of Minerals: Color

Figure 3.19 Minerals can be gems. Rubies and sapphires are formed of the same common mineral, corundum (aluminum oxide). Small amounts of impurities produce the intense color that we value. Ruby, for example, is red because of small amounts of chromium, the same element that gives emeralds their green color. [John Grotzinger/Ramón Rivera-Moret/Harvard Mineralogical Museum.]

Properties of a Mineral: Streak

Figure 3.18 Hematite may be black, red, or brown, but it always leaves a reddish brown streak when scratched along a ceramic plate. [Breck P. Kent.]

Properties of Minerals: Luster

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

Properties of Minerals: Effervescence

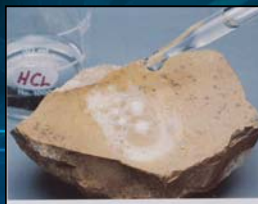


Figure 3.14 The acid test. One easy but effective way to identify certain minerals is to drop diluted hydrochloric acid (HCl) on the substance. If it fizzes, indicating the escape of carbon dioxide, the mineral is likely to be calcite. [Chip Clark.]

Mineral Classes

- Based on chemical composition of anion

Table 3.1 Some Chemical Classes of Minerals

Class	Defining Anions	Example
Native elements	None: no charged ions	Copper metal (Cu)
Oxides and hydroxides	Oxygen ion (O^{2-}) Hydroxyl ion (OH^-)	Hematite (Fe_2O_3) Brucite ($Mg[OH]_2$)
Halides	Chloride (Cl^-), fluoride (F^-), bromide (Br^-), iodide (I^-)	Halite (NaCl)
Carbonates	Carbonate ion (CO_3^{2-})	Calcite ($CaCO_3$)
Sulfates	Sulfate ion (SO_4^{-2})	Anhydrite ($CaSO_4$)
Silicates	Silicate ion (SiO_4^{-4})	Olivine (Mg_2SiO_4)

Mineral Classes: Native Elements

- Single element forming mineral and contains no ions (Cu, Au, Ag).

Mineral Classes: Halides

– Cation + halogen element anion (Cl, I, Br, F)
  - Halite (NaCl)

igure 3.7 Halite crystals precipitating within a modern ypersaline lagoon, San Salvador Island, Bahamas. Note cubic hape of salt crystals. [John Grotzinger]

Mineral Classes: Oxides

– Cation + O anion
  - Hemetite (Fe_2O_3)

Mineral Classes: Sulfides

- Cation + sulfur anion
  - Pyrite “fools gold” (FeS_2)

Mineral Classes: Sulfates

- Cation + sulfate complex anion
  - Gypsum ($CaSO_4$, H_2O)

Mineral Classes: Carbonates

- Cation + carbonate complex anion
  - Calcite ($CaCO_3$)

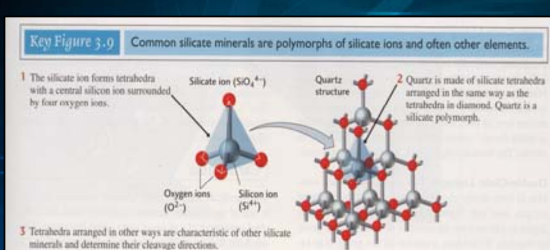
Mineral Classes: Phosphates

- Cation + phosphate complex anion
  - Apatite ($CaPO_4$)

Mineral Classes: Silicates

- Cation + silicate complex anion (SiO_4)
  - Constitute more than 90% of rock-forming minerals

Silica Tetrahedron



Silicate Mineral Groups