

# Essentials of Geology

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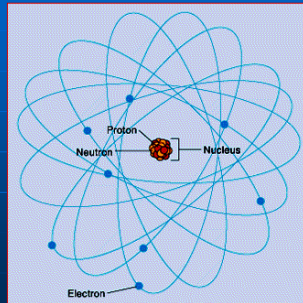
Chapter 2



## Minerals: Building Blocks of Rocks

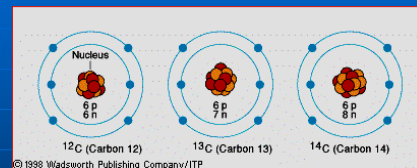
## Matter-What is it and What Does it Consist of?

- Elements and Atoms
  - Elements cannot be split into substances of different composition. They are composed of atoms, the smallest particle that still retains the properties of the element.



- Atoms consist of : Protons, Neutrons, & Electrons

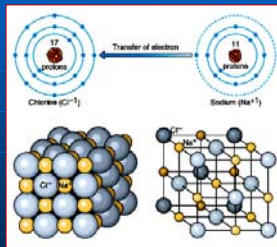
## Matter-What is it and What Does it Consist of?



- Protons: have a positive charge and contribute mass
  - located in the nucleus
- Electrons: have a negative charge and little mass
  - orbit the nucleus in shells
- Neutrons: electrically neutral, found in the nucleus
- Isotopes: atoms with varying numbers of neutrons

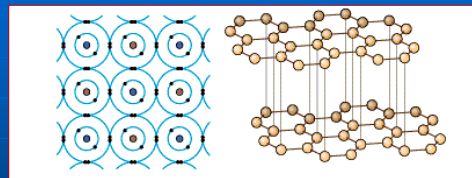
## Bonding and Compounds

Compounds are formed by the bonding of two or more atoms.



**Ionic Bonding**  
The electron in the outermost shell of sodium is transferred to the outermost shell of the chlorine atom. Once the transfer is made, the atoms are positively and negatively charged ions.

## Bonding and Compounds



**Covalent Bonding**  
Formed by adjacent atoms sharing electrons in diamond and graphite. Van der Waals bonding between sheets of covalently bonded carbon atoms are weak, while the sheets themselves are strong. Metallic bonding results from extreme electron sharing.

## What are Minerals?

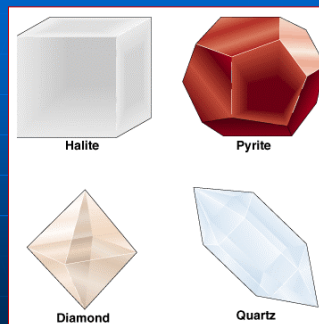
- Naturally Occurring
- Inorganic
- Crystalline Solids
- Narrowly defined chemical composition
- Characteristic Physical properties



calcite

## What are Minerals?

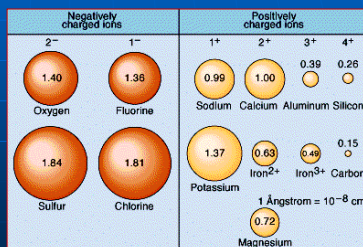
- Mineral Crystals
  - Can occur in a variety of shapes which reflect the orderly internal arrangement of atoms.



## What are Minerals?

### Chemical Composition of Minerals

- Shown by a chemical formula such as NaCl or SiO<sub>2</sub> (Halite, Quartz)
- A range of compositions may be indicated as in (Mg,Fe)<sub>2</sub>SiO<sub>4</sub> (Olivine), where either magnesium, iron, or a combination of both make up the molecular structure

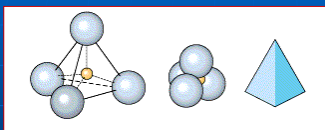


## How Many Minerals are Known?

- More than 3,500 identified
  - Less than 25 are common as rock forming minerals
  - 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

## Mineral Groups Recognized by Geologists

### The Silicate Minerals



- 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 silica tetrahedron is the basic building block for all the silicate minerals.

## Mineral Groups Recognized by Geologists

### Silicates

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

		Formula of negatively charged ion group	Silicon to oxygen ratio	Example
Isolated tetrahedra		(SiO <sub>4</sub> ) <sup>4-</sup>	1:4	Olivine
Continuous chains of tetrahedra	Single chain	(SiO <sub>3</sub> ) <sup>2-</sup>	1:3	Pyroxene group
	Double chain	(Si <sub>4</sub> O <sub>11</sub> ) <sup>6-</sup>	4:11	Amphibole group
Continuous sheets		(Si <sub>2</sub> O <sub>5</sub> ) <sup>4-</sup>	2:5	Micas
Three-dimensional networks	Too complex to be shown by a single two-dimensional drawing	(SiO <sub>2</sub> ) <sup>0</sup>	1:2	Quartz

## Mineral Groups Recognized by Geologists



Nonferromagnesian silicates  
generally light in color,  
lower density

Ferromagnesian silicates  
generally dark in color,  
higher density



## Mineral Groups Recognized by Geologists



### Carbonate Minerals

- Contain the negatively charged carbonate ion  $(\text{CO}_3)^{-2}$ , which bonds with a positively charged ion
- Common carbonates are calcite ( $\text{CaCO}_3$ ), and dolomite  $[\text{CaMg}(\text{CO}_3)_2]$ , the predominant minerals in the sedimentary rocks limestone and dolostone

## Mineral Groups Recognized by Geologists

### Other Mineral Groups

- Oxides ( $\text{Fe}_2\text{O}_3$ )
- Sulfides (PbS)
- Sulfates ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ )
- Halides (NaCl)



Galena, a lead sulfide



Halite, a halide



Gypsum, a sulfate

## 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

## How are Minerals Identified?

- Color and Luster
  - Color may vary because of impurities or variations in the range of the chemical formula
  - Luster is the appearance of the mineral in reflected light



Color (light vs. dark) and Luster (metallic vs. nonmetallic)

## How are Minerals Identified?



### Crystal Form

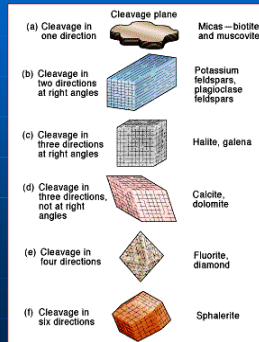
- External form is a reflection of the internal geometry and composition
- Perfect crystals are rare, but may be useful in identification



## How are Minerals Identified?

### Cleavage and Fracture

- Cleavage is the tendency of a mineral to break along planes that exist between weak bonds in the internal geometric structure
- Fracture is breakage along irregular surfaces when no weak planes exist



## How are Minerals Identified?



Quartz has a hardness of 7 and shows conchoidal fracture

- **Hardness**
  - The resistance of a mineral to abrasion
  - Determined by internal structure and strength of bonds
  - Based on the Mohs scale from 1 to 10
  - An important lab test in the identification of minerals

## Mohs Scale of Hardness



In 1812, Mohs arranged ten minerals in order of hardness, so each will scratch those lower in the scale. This is still used today. It is not a regular scale. There is a far greater gap between diamond and corundum, than between any other two. But it is a useful way to measure the property of hardness.

## How are Minerals Identified?

- **Specific Gravity**
  - The ratio of a mineral's weight to the weight of an equal volume of water
- **Other Useful Mineral Properties**
  - Taste
  - Feel
  - Magnetism
  - Double refraction
  - Reaction with dilute hydrochloric acid

## 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
- Material metabolized by organisms to construct shells
- During metamorphism

## 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
  - **Nonsilicates**
- **Common silicates**
  - Quartz, feldspars, muscovite mica
  - Pyroxene, amphibole, biotite mica
- **Common nonsilicates**
  - Calcite, dolomite, gypsum, halite

## What are Rock-Forming Minerals?



- Mineral composition of granite
  - Quartz
  - Potassium feldspar
  - Biotite



- Mineral composition of basalt
  - Pyroxene
  - Calcium plagioclase feldspar
  - Olivine

## Mineral Resources and 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** are the part of the resource base that can be economically extracted.
- **Geologists play a leading role in the exploration and exploitation of resources and reserves.**