

Chapter 3

Minerals The Building Blocks of Rocks

Introduction

- What is a mineral?
 - Naturally Occurring
 - Inorganic
 - Crystalline solid
 - w/Characteristic physical properties
 - narrowly defined chemical composition




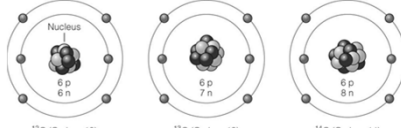
Fig. 3.1-5, p. 65

Matter – What is It?

- Atoms and Elements
 - Composition of Matter
 - Atoms
 - Elements
 - Atomic Number, Atomic Mass Number, Atomic Weight

Matter – What is It?

- The number of protons in an atom's nucleus determines its atomic number, whereas an atom's atomic mass number is the total number of protons and neutrons in the nucleus.
- Atoms with different numbers of neutrons are called isotopes.



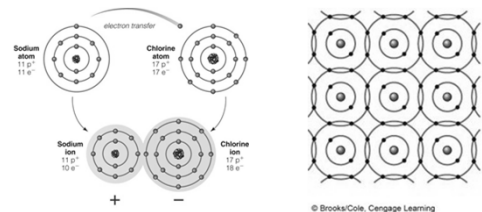
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Fig. 3.4, p. 66

Matter – What is It?

Fig. 3.5a, 3.6a p. 68

- Bonding and Compounds

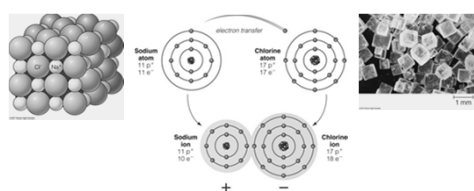


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Matter – What is It?

Fig. 3.5, p. 65

- Bonding and Compounds – Ionic Bonds



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Matter – What is It?

- Bonding and Compounds – Ionic Bonds
- The formation of ions is controlled by the number of electrons in the outermost shell (valence electrons).
- The Octet Rule states that outermost shells with eight electrons are more chemically stable, and therefore will be less likely to form ions.
- Less than this number and elements are more likely to form either positive or negative ions. We can predict the type of ion if we look carefully at the periodic chart.

Why do atoms form ions?

To fill their outermost shell with electrons.

The Periodic Chart of the Elements

Matter – What is It?

- Bonding and Compounds – Covalent Bonds

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Fig. 3.6, p. 66

Matter – What is It?

- Bonding and Compounds – Other Bonds
- Metallic Bonds
- Van der Waals “bonds”

Explore the World of Minerals

- Mineral Crystals

Why is it that not all mineral specimens show well-developed crystals but all are crystalline solids?

Space and Time

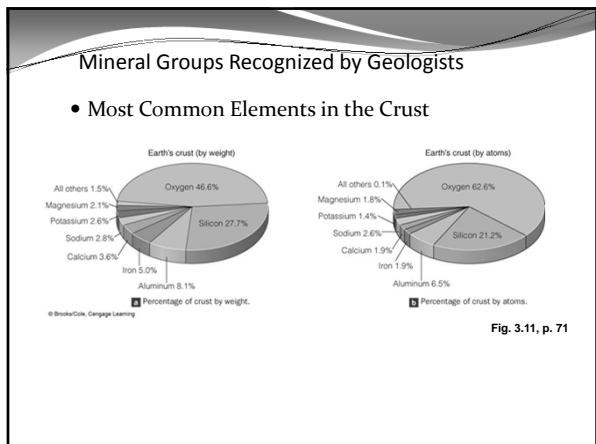
Fig. 3.8 a-b, p. 67

Explore the World of Minerals

- Chemical Composition of Minerals

Most minerals are compounds, but some are native elements.

Geo-Insight 3-1., p. 64



Mineral Groups Recognized by Geologists

- Most of the more than 4,000 known minerals are silicates
- Additional common mineral groups include carbonates, oxides, sulfides, sulfates, and halides.

Mineral Group	Negatively Charged Ion or Radical	Examples	Composition
Carbonate	(CO ₃) ²⁻	Calcite	CaCO ₃
Halide	Cl ⁻ , F ⁻	Dolomite	CaMgCO ₃
		Halite	NaCl
Fluoride	(OH) ⁻	Fluorite	CaF ₂
		Borate	Mg ₂ B ₂ O ₇
Native element	—	Gold	Au
		Silver	Ag*
Diamond	C	Diamond	C
		Graphite	C
Phosphate	(PO ₄) ³⁻	Apatite	Ca ₅ (PO ₄) ₃ (F,Cl)
		Hemimorphite	Zn ₅ (OH) ₆ (SO ₄) ₂
Oxide	O ²⁻	Magnetite	Fe ₃ O ₄
		Quartz	SiO ₂
Silicate	(SiO ₄) ⁴⁻	Potassium feldspar	KAlSi ₃ O ₈
		Olivine	(Mg,Fe) ₂ SiO ₄
Sulfate	(SO ₄) ²⁻	Anhydrite	CaSO ₄
		Gypsum	CaSO ₄ · 2H ₂ O
Sulfide	S ²⁻	Galena	PbS
		Pyrite	FeS ₂
		Argentite	Ag ₂ S*

*Note that silver is found as both a native element and a sulfide mineral.

Table 3.1, p. 72

Mineral Groups Recognized by Geologists

- Silicate Minerals
 - composed of the silica tetrahedra

Fig. 3.13a-b, p. 73

Silicate Mineral Structures

Structure	Formula of negatively charged ion group	Example
Isolated tetrahedra	(SiO ₄) ⁴⁻	Olivine
Continuous chains of tetrahedra	(SiO ₃) ²⁻	Pyroxene group (augite)
	(Si ₂ O ₇) ⁶⁻	Amphibole group (hornblende)
Continuous sheets	(Si ₂ O ₅) ⁴⁻	Micas (muscovite)
Three-dimensional networks	(SiO ₂) ⁰	Quartz Potassium feldspars Plagioclase feldspars

Fig. 3.13c-f, p. 73

Mineral Groups Recognized by Geologists

Silicate Minerals - Ferromagnesian silicates

Fig. 3.13a-b, p. 73

Mineral Groups Recognized by Geologists


Silicate Minerals - Nonferromagnesian silicates

Fig. 3.13c-f, p. 73

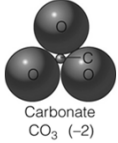
Mineral Groups Recognized by Geologists

Carbonate Minerals – contain $(\text{CO}_3)^{2-}$

Examples: Calcite (CaCO_3) and dolomite [$\text{CaMg}(\text{CO}_3)_2$].



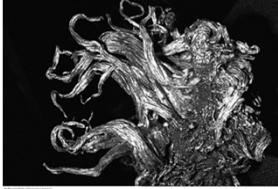
Calcite



Carbonate
 CO_3^{2-}

Mineral Groups Recognized by Geologists

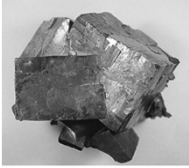
- Other Mineral Groups - Native Elements



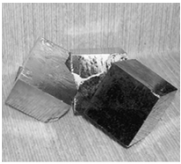
Silver

Mineral Groups Recognized by Geologists

- Other Mineral Groups - Sulfides



Galena

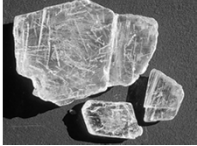


Pyrite

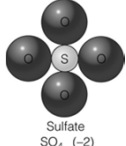
Galena

Mineral Groups Recognized by Geologists

- Other Mineral Groups - Sulfates



Gypsum (www.pitt.edu)



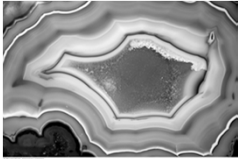
Sulfate
 SO_4^{2-}

Gypsum

Physical Properties of Minerals

- Mineral composition and structure produce unique physical properties.

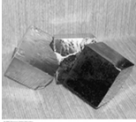
- Color
- Hardness
- Cleavage
- Crystal form
- Specific gravity




Physical Properties of Minerals

- Luster and Color

- Luster is the quality and intensity of light reflected from a mineral and is characterized as metallic or nonmetallic.
- Color, in contrast, is a visual quality of minerals that results from the way they absorb or transmit light.





Physical Properties of Minerals

- Crystal Form

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Physical Properties of Minerals

- Cleavage and Fracture

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Physical Properties of Minerals

- Hardness – Geologists use Mohs hardness scale

Hardness	Mineral	Hardness of Some Common Objects
10	Diamond	
9	Corundum	
8	Topaz	
7	Quartz	
6	Orthoclase	Steel file (6½)
5	Apatite	Glass (5½-6)
4	Fluorite	
3	Calcite	Copper penny (3)
2	Gypsum	Fingernail (2½)
1	Talc	

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Physical Properties of Minerals

- Specific Gravity (Density) is the ratio of the weight of a mineral to an equal volume of water.

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Physical Properties of Minerals

- Other Useful Mineral Properties
 - Feel
 - Taste
 - Magnetism
 - Double refraction
 - React to dilute acid

Rock-Forming Minerals

Mineral	Primary Occurrence
Ferromagnesian silicates	
Olivine	Igneous and metamorphic rocks
Pyroxene group	Igneous and metamorphic rocks
Amphibole group	Igneous and metamorphic rocks
Biotite	All rock types
Nonferromagnesian silicates	
Quartz	All rock types
Potassium feldspar group	All rock types
Orthoclase, microcline	All rock types
Plagioclase feldspar group	All rock types
Muscovite	Soils, sedimentary rocks, and some metamorphic rocks
Clay mineral group	
Carbonates	
Calcite	Sedimentary rocks
Dolomite	Sedimentary rocks
Sulfates	
Anhydrite	Sedimentary rocks
Gypsum	Sedimentary rocks
Halides	
Halite	Sedimentary rocks

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How Do Minerals Form?

Minerals form through various natural processes, including:

- Cooling of molten material (magma or lava)
- Precipitation
- Accumulation due to biological processes
- Weathering
- Metamorphism
- Sublimation

Natural Resources and Reserves

- How does a resource differ from a reserve?
 - A **resource** is any solid, liquid, or gaseous substance in rocks whose profitable extraction is potentially feasible.
 - A **reserve** is only that part of the resource base that can be extracted economically.

Natural Resources and Reserves

- What factors affect the status of a resource?
 - Market price
 - Geographic location
 - Labor costs
 - Technological developments

Natural Resources and Reserves

Commodity	Percentage Imported	Major Import Sources	Uses
Bauxite	100%	Jamaica, Brazil, Guinea, Australia	One of aluminum
Nickel	100%	Brazil, Canada, Germany, Estonia	Carbon steel, superalloys
Graphite	100%	China, Mexico, Canada, Brazil	Brake linings, lubricants
Manganese	100%	South Africa, Gabon, China, Australia	Steel production, dry cell batteries
Vanadium	100%	Russia, El Salvador, Canada, Austria, Czech Republic	Steel alloys
Platinum	100%	Germany, South Africa, United Kingdom, Canada	Catalytic converters, jewelry
Tin	100%	Peru, Bolivia, Indonesia, China	Tin cans and containers
Cobalt	100%	China, Norway, Russia, Canada	Superalloys
Tungsten	100%	China, Bolivia, Canada, Germany	Carbide parts for cutting tools
Chromium	100%	South Africa, Kazakhstan, Russia, China	Stainless and heat-resistant steel
Silver	100%	Mexico, Canada, Peru, Chile	Silver halide film, jewelry
Zinc	100%	Canada, Peru, Mexico, Ireland	Galvanized metal, zinc alloys
Gold	100%	Canada, Dominican Republic, Peru, Brazil	Jewelry and arts, electrical industry
Nickel	100%	Canada, Russia, Australia, Norway	Stainless steel, electroplating
Copper	100%	Chile, Canada, Peru, Mexico	Copper and copper alloys, wiring
Lead	100%	Canada, China, Mexico, Australia	Lead for batteries, protective coatings
Iron ore	100%	Canada, European Union, China, Mexico	Steel, cast iron

Source: USGS Mineral Information: <http://minerals.usgs.gov/minerals/>
 USGS Mineral Commodity Summaries 2011: <http://minerals.usgs.gov/minerals/sumsum/>