


1  **Matter and Minerals**


Earth 9th edition
Chapter 3

2  **Minerals: summary in haiku form**

"Mineral" defined:
natural, inorganic,
solid (and two more).

continued...

Also crystalline,
chemically specific.
There! I fit it in!

3  **Key Concepts**

- Definitions and differences between minerals and rocks.
- Basics of minerals: Elements, atoms and atomic bonds.
- Building minerals: Atomic structure and factors of crystal form.
- Primary and secondary diagnostic properties of minerals.
- The rock-forming minerals and the composition of the crust.
- The Si-O tetrahedron and silicate minerals.
- Non-silicate minerals.

4  **Figure 3.1**

5  **Minerals: Building blocks of rocks**

- By definition a mineral is
 1. Naturally occurring
 2. Inorganic
 3. Solid
 4. Ordered internal molecular structure
 5. Definite chemical composition
- Rock
 - A solid aggregate of minerals

6  **Composition of minerals**

- Elements
 - Basic building blocks of minerals
 - Over 100 are known (92 naturally occurring)
- Atoms
 - Smallest particles of matter
 - Retains all the characteristics of an element


7  **The Periodic Table**

8  **Composition of minerals**

- Atomic structure
 - Central region called the nucleus
 - Consists of protons (+ charges) and neutrons (NO charges)
 - Electrons
 - Negatively charged particles that surround the nucleus
 - Located in discrete energy levels called shells

9  **Structure of an atom**

10  **Figure 3.5**

11  **Figure 3.5A**

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13 **Figure 3.5B**

14 **Composition of minerals**

- Chemical bonding
 - Formation of a compound by combining two or more elements
- Ionic bonding
 - Atoms gain or lose outermost (valence) electrons to form ions
 - Ionic compounds consist of an orderly arrangement of oppositely charged ions

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16 **Halite (NaCl) – An example of ionic bonding**

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18 **Composition of minerals**

- Covalent bonding
 - Atoms share electrons to achieve electrical neutrality
 - Generally stronger than ionic bonds
 - Both ionic and covalent bonds typically occur in the same compound

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Covalent bonding

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Composition of minerals

- Other types of bonding
 - Metallic bonding
 - Valence electrons are free to migrate among atoms
 - Weaker and less common than other bonds

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Composition of minerals

- Isotopes and radioactive decay
 - Mass number = sum of neutrons + protons in an atom
 - Isotope = atom that exhibits variation in its mass number
 - Unstable isotopes emit particles and energy in a process known as radioactive decay

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Structure of minerals

- Minerals consist of an orderly array of atoms chemically bonded to form a particular crystalline structure
- Internal atomic arrangement in ionic compounds is determined by ionic size

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Geometric packing of various ions

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Figure 3.14

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Octahedron (magnetite)

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Dodecahedron (garnet)

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Structure of minerals

- Polymorphs
 - Minerals with the same composition but different crystalline structures
 - Examples include:
 - diamond and graphite (C)
 - Calcite and aragonite (CaCO₃)
 - Phase change = one polymorph changing into another

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Physical properties of minerals

- Primary diagnostic properties
 - Determined by observation or performing a simple test
 - Several physical properties are used to identify hand samples of minerals

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Physical properties of minerals

- Crystal form
 - External expression of a mineral's internal structure

- Often interrupted due to competition for space and rapid loss of heat

32 **Bladed**

33 **Prismatic**

34 **Banded**

35 **Botryoidal**

36 **Fibrous (asbestos)**

37 **Amethyst Geode**

38 *A garnet crystal*

39 *Cubic crystals of pyrite*

40 **Physical properties
of minerals**

41 *Galena (PbS) displays metallic luster*

42 *Vitreous Luster (quartz)*

43 **Physical properties
of minerals**

- Color

- Generally unreliable for mineral identification

- Often highly variable due to slight changes in mineral chemistry

- Exotic colorations of certain minerals produce gemstones

44 *Quartz (SiO₂) exhibits a variety of colors*

45 **Physical properties
of minerals**

- Streak

- Color of a mineral in its powdered form

- Hardness

- Resistance of a mineral to abrasion or scratching

- All minerals are compared to a standard scale called the Mohs scale of hardness

46 **Streak is obtained on an unglazed porcelain plate**

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48 **Physical properties
of minerals**

- Cleavage

- Tendency to break along planes of weak bonding

- Produces flat, shiny surfaces

- Described by resulting geometric shapes

–Number of planes

–Angles between adjacent planes

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52 **Fluorite, halite, and calcite all exhibit perfect cleavage**

53 **Basal Cleavage (1 direction)**

54 **Physical properties
of minerals**

- Fracture

- Absence of cleavage when a mineral is broken

- Specific Gravity

- Weight of a mineral / weight of an equal volume of water

- Average value = 2.7


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55 **Conchoidal fracture**

56 **Physical properties**

of minerals

- Other properties
 - Magnetism
 - Reaction to hydrochloric acid
 - Malleability
 - Double refraction
 - Taste
 - Smell
 - Elasticity

57  **Magnetite (a.k.a. lodestone)**

58  **Effervescence in HCl**

59  **Optical Calcite**

60  **Rock Salt (halite, NaCl)**

61  ***Mineral groups***

- Nearly 4000 minerals have been named
- Rock-forming minerals
 - Common minerals that make up most of the rocks of Earth's crust
 - Only a few dozen members
 - Composed mainly of the 8 elements that make up over 98% of the continental crust

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63  ***Elemental abundances in continental crust***


64  ***Mineral groups***

- Silicates
 - Most important mineral group
 - Comprise most rock-forming minerals
 - Very abundant due to large % of silicon and oxygen in Earth's crust
 - Silicon-oxygen tetrahedron
 - Fundamental building block
 - Four oxygen ions surrounding a much smaller silicon ion

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66  ***Mineral groups***

- Joining silicate structures
 - Single tetrahedra are linked together to form various structures including
 - Isolated tetrahedra
 - Ring structures
 - Single and double chain structures
 - Sheet or layered structures
 - Complex 3-dimensional structures

67  ***Three types of silicate structures***


68  **Common Silicate Minerals**












69  **Common Silicate Minerals**

70  ***Mineral groups***

- Common silicate minerals
 - Light silicates: Feldspar group
 - Most common mineral group
 - Exhibit two directions of perfect cleavage at 90 degrees
 - Orthoclase (potassium feldspar) and Plagioclase (sodium and calcium feldspar) are the two most common members


71  ***Potassium feldspar***

72  ***Plagioclase feldspar***












- 73  **Mineral groups**
- Common silicate minerals
 - Light silicates: Quartz
 - Only common silicate composed entirely of oxygen and silicon
 - Hard and resistant to weathering
 - Conchoidal fracture
 - Often forms hexagonal crystals
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- 74  **Mineral groups**
- Common silicate minerals
 - Light silicates: Muscovite
 - Common member of the mica family
 - Excellent cleavage in one direction
 - Produces the “glimmering” brilliance often seen in beach sand
- 75  **Mineral groups**
- Common silicate minerals
 - Light silicates: Clay minerals
 - Clay is a general term used to describe a variety of complex minerals
 - Clay minerals all have a sheet or layered structure
 - Most originate as products of chemical weathering
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- 76  **Mineral groups**
- Common silicate minerals
 - Dark silicates: Olivine group
 - High temperature Fe-Mg silicates
 - Individual tetrahedra linked together by iron and magnesium ions
 - Forms small, rounded crystals with no cleavage
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- 77  **Mineral groups**
- Common silicate minerals
 - Dark silicates: Pyroxene group
 - Single chain structures involving iron and magnesium
 - Two distinctive cleavages at nearly 90 degrees
 - Augite is the most common mineral in the pyroxene group
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- 78  **Mineral groups**
- Common silicate minerals
 - Dark silicates: Amphibole group
 - Double chain structures involving a variety of ions
 - Two perfect cleavages exhibiting angles of 124 and 56 degrees
 - Hornblende is the most common mineral in the amphibole group
- 79  **Hornblende, an amphibole**
- 80  **Cleavage angles for augite and hornblende**
- 81  **Mineral groups**
- Important nonsilicate minerals
 - Typically divided into classes based on anions
 - Comprise only 8% of Earth’s crust
 - Often occur as constituents in sedimentary rocks
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- 83  **Mineral groups**

- Important nonsilicate minerals
 - Carbonates
 - Primary constituents in limestone and dolostone
 - Calcite (CaCO_3) and dolomite ($\text{Ca,Mg}(\text{CO}_3)_2$) are the two most important carbonate minerals

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84  **Mineral groups**

- Important nonsilicate minerals
 - Many nonsilicate minerals have economic value
 - Examples
 - Hematite (oxide mined for iron ore)
 - Halite (halide mined for salt)
 - Sphalerite (sulfide mined for zinc ore)
 - Native copper (native element mined for copper)
 - Gypsum (sulfate mined for sheetrock, etc.)

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Native copper
End of Chapter