Chapter 2

Matter and Minerals

Matter and Minerals begins with an explanation of what defines a mineral by listing the characteristics one looks for when determining if something is a mineral. It continues to describe what defines a rock and briefly compares and contrasts rocks versus minerals. The chapter continues with a discussion of atoms and how elements are the building blocks of minerals. Parts of an atom are discussed and the periodic table of the elements is introduced in the context of mineralogy. Atomic bonding is examined as a lead in to discussing mineral properties. The various properties that define a mineral are presented in detail. These properties include luster, color, light transmittance, streak, crystal shape or habit, hardness, cleavage, fracture, tenacity, and specific gravity.

After discussing these introductory concepts, the chapter identifies the various mineral groups, differentiating between silicate and nonsilicate minerals. The most abundant elements from the periodic table are presented as the major constituents of Earth's crust. The structure and other properties of major silicate minerals are shown, and the names of these minerals are presented. A distinction is made between light and dark silicates and the reasons for these color variations. Important nonsilicate minerals are then presented.

There is a brief discussion of natural resources, and mineral resources are examined in this context. Economics of minerals and mineral extraction methods end this chapter.

FOCUS ON CONCEPTS

After reading, studying, and discussing the chapter, students should be able to:

2.1 List the main characteristics that an Earth material must possess to be considered a mineral and describe each.
2.2 Compare and contrast the three primary particles contained in atoms.
2.3 Distinguish among ionic bonds, covalent bonds, and metallic bonds.
2.4 List and describe the properties that are used in mineral identification.
2.5 List the common silicate and nonsilicate minerals and describe the characteristics of each group.
2.6 Discuss Earth's natural resources in terms of renewability. Differentiate between mineral resources and ore deposits.

TEACHING TIPS

Chapter 2 contains what, for many students, is a great deal of new information coupled with a lot of new vocabulary. Pace yourself and be sure any new information, such as mineral names and characteristics, are presented clearly. Having lots of hand samples as visual aids retains student interest as well as helps you to illustrate your points. Much of what there is to learn about minerals is visual so visuals are very important for this chapter in particular.

- If you discuss the periodic table, atoms, and bonding, be sure to make references to how these topics relate to minerals. Students tend to think of these topics as being "chemistry" so

giving them a relationship to Earth science will keep these concepts fresh and give students a different perspective.

- When explaining the difference between a mineral and a rock, have a large hand sample of something that is clearly a mineral, e.g. feldspar, and a hand sample of a rock that clearly is an aggregate of minerals, e.g. granite. This helps illustrate how minerals can be constituents of rocks or rocks in and of themselves.
- You can simultaneously introduce the concepts of mineral cleavage and internal bonding by bringing to class a large hand sample of a readily and obviously cleaved mineral such as halite, calcite, or feldspar. Also bring a rock hammer and safety goggles. Show how when hit with a hammer, the mineral cleaves along consistent planes. Use this to explain how it reflects patterns of weak atomic bonding within the mineral.
- Students often confuse the crystal form of quartz for cleavage, when quartz only exhibits fracture. If you have a quartz sample to spare, you might hit it with a rock hammer to demonstrate fracture and reinforce the fact that crystal form and cleavage are two very different things, but both are a reflection of internal atomic structure.
- If you do not have the capacity to demonstrate fracture or cleavage in your classroom, consider using short YouTube video clips where these properties are demonstrated by others.
- If your course has a laboratory component, leave the heavy duty teaching and memorization of mineral names to the lab. In the laboratory, students will have several hours with hands-on access to the samples and be able to observe the minerals' properties for themselves while associating them with names.
- Whether or not your course has a laboratory component, consider bringing examples of minerals to class. When illustrating different properties, select classic examples of minerals that show these properties. For example:
    - Metallic luster – galena
    - Streak – chalk or hematite
    - Hardness – scratch glass with quartz and scratch talc with a fingernail. Challenge a student to try to scratch glass with talc or some other soft mineral.
    - Crystal form – halite or quartz
- When discussing the 8 most abundant elements in Earth's crust, it can be useful to show this list in conjunction with a Periodic Table so that students can see how very few elements are responsible for what we know of as Earth.
- Some students are already familiar with some gemstones. Framing minerals in the context of gems that they may know can be useful for some.
- Before you talk about natural resources, have students in groups or individually look around them and try to determine what things in the room or building might have been extracted from the Earth. Quartz clocks and watches, silicon in computers, and metals used to construct various items are a few of the things they may come up with.

Teaching Strategy Summary for Chapter 2

Use lots of visual aids. Either engage students in hands-on interaction with minerals or prepare demonstrations of the various qualities associated with minerals.

CONCEPT CHECK ANSWERS

Concept Check 2.1

1. List two characteristics an Earth material must have in order to be considered a mineral.

- Naturally occurring
- Generally inorganic
- Solid
- Orderly crystalline structure
- Definite chemical composition.

2. Define the term *rock*. How do rocks differ from minerals?

Rocks are more loosely defined as aggregates of different minerals. Rocks differ from minerals because they may be of varied mineral content and they may contain nonmineral matter.

Concept Check 2.2

1. List the three main particles of an atom and explain how they differ from one another.

- Proton – positively charged particle in the nucleus of the atom. The number of protons is the same as the element number.
- Neutron – particle in the nucleus of the atom. It has no charge associated with it.
- Electron – negatively charged particle that orbits the nucleus. There are the same number of electrons as protons in a given element.

2. Make a simple sketch of an atom and label its three main particles.

See Figure 2.4.

3. What is the significance of valence electrons?

The valence shell of an atom is its outermost shell and responsible for bonding with other atoms. The electrons of the valence shell are those that are shared with other atoms in the bonding process.

Concept Check 2.3

1. What is the difference between an atom and an ion?

An atom does not have a charge because it has an equal number of protons or electrons. Ions have either given up or taken on more electrons, giving the ion a positive or negative charge.

2. What occurs in an atom to produce a positive ion? A negative ion?

An atom that has given up one or more valence electrons becomes a positive ion. An atom that has taken on extra valence electrons becomes a negative ion.

3. Briefly distinguish among ionic, covalent, and metallic bonding and describe the role that electrons play in each.

- Ionic bonding – one atom "donates" its electrons to another, creating two ions bonded to each other.
- Covalent bonding – two atoms equally share valence electrons.
- Metallic bonding – several atoms contribute their valence electrons to a pool of electrons that are free to move through the entire structure.

Concept Check 2.4

1. **Define *luster.***
   Luster describes the quality of light reflected from a mineral's surface. It may be metallic or nonmetallic, with several subdistinctions among nonmetallic lusters.

2. **Why is color not always a useful property in mineral identification? Give an example of a mineral that supports your answer.**
   There may be small impurities in the mineral that will alter its color. Quartz is a notable example, with rose quartz (pink) and amethyst (purple) being only two examples of color variants.

3. **What differentiates cleavage from fracture?**
   Cleavage occurs when a mineral breaks cleanly along a plane. This is due to a plane of weak atomic bonding within the mineral. Fracture occurs when there is no distinct plane along which the mineral can break; when hit with a rock hammer, the mineral will fracture into irregular pieces.

4. **What do we mean when we refer to a mineral's tenacity? List three terms that describe tenacity.**
   Tenacity is a mineral's resistance to cutting, breaking, and other forms of deformation. Three terms that describe tenacity are *brittle, malleable,* and *sectile. Elastic* is another term.

5. **What simple chemical test is useful in the identification of the mineral calcite?**
   Putting a drop of weak acid, such as HCl, on the mineral will create a visible reaction with bubbling on the surface.

Concept Check 2.5

1. **List the eight most common elements in Earth's crust, in order of abundance (most to least).**
   Oxygen, silicon, aluminum, iron, calcium, sodium, potassium, magnesium.

2. **Explain the difference between *silicon* and *silicate*.**
   Silicon is an element. Silicates contain silicon and oxygen and are the major constituents of continental crust.

3. **Draw a sketch of the silicon-oxygen tetrahedron.**
   See Figure 2.23.

4. **What is the most abundant mineral in Earth's crust?**
   Feldspar

5. **List six common nonsilicate mineral groups. What key ion(s) or element(s) define each group?**
   - Carbonates – CO_3 ion
   - Halides – F, Cl, Br
   - Oxides – O
   - Sulfides – S
   - Sulfates – SO_4 ion
   - Native elements – various single elements such as gold and copper.

6. **What is the most common carbonate mineral?**
   Calcite

7. **List eight common nonsilicate minerals and their economic uses.**
   - Calcite – Portland cement, lime
   - Halite – salt

- Fluorite – steelmaking
- Hematite – Ore of iron
- Galena – Ore of lead
- Sphalerite – Ore of zinc
- Chalcopyrite – Ore of copper
- Silver – Jewelry

Concept Check 2.6

1. **List three examples of renewable resources and three examples of nonrenewable resources.**
   - Renewable – solar, forests and trees, water
   - Nonrenewable – Metals, oil, coal

2. **Compare and contrast a mineral resource and an ore deposit.**
   Mineral resources are occurrences of useful minerals in such large amounts that extraction is reasonably certain. An ore deposit is a naturally occurring concentration of one or more minerals with economic value. Mineral resources include deposits that are not economically viable to recover where ore deposits are.

3. **Explain how a mineral deposit that previously could not be mined profitably might be upgraded to an ore deposit.**
   Demand for a metal may increase its value or technological advances may make it more profitable to extract the metal than previously.

GIVE IT SOME THOUGHT ANSWERS

1. **Using the geologic definition of *mineral* as your guide, determine which of the items in this list are minerals and which are not. If something in this list is not a mineral, explain.**
   a. mineral – gold is an example of a mineral classified as a native element; b. seawater is not a mineral – minerals by definition are solids; c. quartz is a mineral; d. cubic zirconia is not a mineral – it is not naturally occurring; e. obsidian is not a mineral because it lacks an internal arrangement of atoms, however, it is an igneous rock; f. ruby is a mineral – it is a gemstone variety of the mineral corundum; g. glacial ice is a mineral as it meets all of the criteria; h. amber is not a mineral since it has an organic origin.

2. **Assume that the number of protons in a neutral atom is 92 and its mass number is 238.**
   a. What is the element?
   b. How many electrons does it have?
   c. How many neutrons does it have?
   a. The element is uranium. b. 92 electrons c. 146 neutrons

3. **Which of the following elements is more likely to form chemical bonds: xenon (Xe) or sodium (Na)? Explain why.**
   Sodium is more likely to form chemical bonds because of its tendency to lose one electron, resulting in an overall +1 charge.

4. **Referring to the accompanying photos of five minerals, determine which of these specimens exhibit a metallic luster and which have a nonmetallic luster.**
   Specimens A, B, and D have a nonmetallic luster. Specimens C and E have a metallic luster.

5. **Gold has a specific gravity of almost 20. A 5-gallon bucket of water weighs 40 pounds. How much would a 5-gallon bucket of gold weigh?**
   5 gallons of water = 40 lbs. × 20 (specific gravity of gold) = 800 lbs.

6. **Examine the accompanying photo of a mineral that has several smooth, flat surfaces that resulted when the specimen was broken.**
   a. **How many flat surfaces are present on this specimen?**
   b. **How many different directions of cleavage does this specimen have?**
   c. **Do the cleavage directions meet at 90-degree angles?**
   a. 6 b. 3 c. no

7. **Each of the following statements describes a silicate mineral or mineral group. In each case, provide the appropriate name.**
   a. **The most common member of the amphibole group**
   b. **The most common light-colored member of the mica family**
   c. **The only common silicate mineral made entirely of silicon and oxygen**
   d. **A silicate mineral with a name that is based on its color**
   e. **A silicate mineral that is characterized by striations**
   f. **A silicate mineral that originates as a product of chemical weathering**
   a. Hornblende b. Muscovite c. Quartz d. Rose quartz e. Feldspar f. Calcite

8. **What mineral property is illustrated in the accompanying photo?**
   Cleavage.

9. **Do an Internet search to determine what minerals are extracted from the ground during the manufacture of the following products.**
   a. **Stainless steel utensils**
   b. **Cat litter**
   c. **Tums brand antacid tablets**
   d. **Lithium batteries**
   e. **Aluminum beverage cans**
   Answers may vary slightly depending on which websites are utilized by students.

10. **Most states have designated a state mineral, rock, or gemstone to promote interest in the state's natural resources. Describe your state mineral, rock, or gemstone and explain why it was selected. If your state does not have a state mineral, rock, or gemstone, complete the exercise by selecting one from a state adjacent to yours.**
    Answers will vary.

DISCUSSION TOPICS

- What are some renewable and nonrenewable resources you use regularly?
- How many of the elements of the Periodic Table have you used or encountered? How many of those elements are one of the 8 major constituents of Earth's crust?
- Why do you think a mineral has to be non-organic?
- Why do you think a mineral has to be naturally occurring to be classified as a mineral?
- What are some minerals you use regularly?

ADDITIONAL RESOURCES

DVDs or Movies

- *Rocking Around the Silicates,* Performed by Richard Alley, Penn State University, 4 minutes, 23 seconds. http://www.youtube.com/watch?v=utypgC7h6f4
- *Earth Revealed, Episode 12: Minerals: The Materials of Earth* (1992) Annenberg Media, 30 minutes. Available on DVD or for free streaming video on demand from http://www.learner.org/resources/series78.html

Websites

- Name that Atom Interactive Game. http://www.learner.org/interactives/periodic/basics_interactive.html
- Online Mineral Identification – Contains pictures of minerals. Students decide which properties to "test" to identify the mineral. http://facweb.bhc.edu/academics/science/harwoodr/geol101/labs/minerals/
- Mineral Identification Key – From the Mineralogical Society of America. Takes the student step by step through the identification process for a sample that the student has in his/her possession. http://www.minsocam.org/msa/collectors_corner/id/mineral_id_keyq1.htm
- Online Mineral Museum – Comprehensive listing of minerals with pictures, chemical formulas, and where they are commonly found. http://www.johnbetts-fineminerals.com/museum.htm
- The Dynamic Earth from the Smithsonian Institution's National Museum of Natural History – Choose "*Gems and Minerals*" Interactive exhibit where students can learn about mineral growth and formation, and about gemstones. Highlights specimens found at the museum in Washington, D.C. but also a good stand-alone website for learning. http://www.mnh.si.edu/earth/main_frames.html