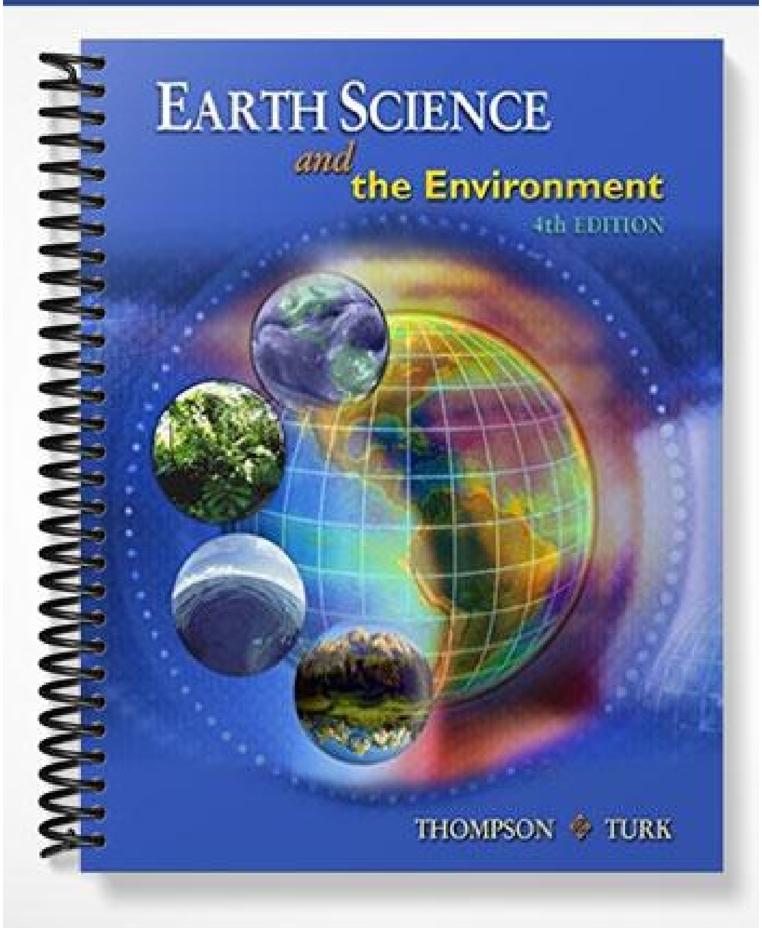
SOLUTIONS MANUAL



Chapter 2: Minerals

Discussion

Chapters 2 and 3 discuss minerals and rocks, the materials that make up the solid Earth, or geosphere. We discuss the nature of minerals and rocks, the processes by which they form and change, and the many ways in which they effect humans and our environment.

We open Chapter 2 with a description of vermiculite mining in northwestern Montana, to stress that minerals are an important aspect of our environment, but that environmental problems arise when we extract them. We return to the environmental aspects of minerals throughout the chapter.

We continue the discussion of minerals by pointing out that all rocks are made of one or more minerals. Therefore, minerals are the fundamental building blocks of the Earth. For this reason, an appreciation of the nature of minerals and a basic knowledge of the few, common, rock-forming minerals lays a foundation for the study of the Earth.

We describe two aspects of minerals that commonly fascinate introductory geology students because they are familiar: crystals and gems. Class interest can be stimulated by pointing out that the striking crystal faces of diamonds and other gems results from the perfect ordering of atoms in the crystals, and that many gems are simply beautiful varieties of common minerals.

The knowledge that only a few minerals are common, and that they can be identified correctly with a bit of practice, is another aspect of the study of minerals that draws most students into the subject. It seems to give students a good feeling to know that only a few minerals are abundant, and therefore they can easily learn to identify most minerals in most rocks.

The chapter explains that the essential nature of a mineral is that it has a crystalline structure -- an orderly, repetitive, arrangement of atoms -- and a definite chemical composition. We then describe the physical properties of minerals and explain how these properties can be used to identify minerals. We stress the point, however, that the most important aspect of field identification is recognition of common minerals, aided by a few simple tests of physical properties. The common rock-forming minerals, along with a few examples of accessory minerals, gems, ore minerals, and industrial minerals, are then described.

A Focus On box describes chemical bonding in minerals and the controls that the chemical bonds have on physical properties of minerals.

Answers to Discussion Questions

1. Two properties differentiate one mineral from all others: chemical composition and crystal structure. If diamond and graphite are different minerals, but have identical chemical compositions, they must have different crystal structures. Diamond is cubic, and all carbon-carbon bonds are strong covalent bonds. Graphite is hexagonal, and each carbon is bonded to three other carbons by similar covalent bonds, but to a fourth carbon with a weak van der Waals bond. It is this weak bond that is responsible for the softness and cleavage of graphite, and for its properties of electrical conductance and opacity as well.

2. The discussion of this question depends on each student's familiarity with the elements. Most will at least be familiar with the names of the 8 most abundant elements (those being; O, Si, Al, Fe, Ca, Na, K, Mg.) Other elements that are familiar, but less abundant, include hydrogen, gold, silver, other precious and industrial metals, carbon, sulfur, nitrogen, etc. Each is familiar because it is important to humans for industrial use, jewelry, or, as is the case with hydrogen, survival (as a component of water).

3. Silicon and oxygen combine to form the silicate tetrahedron. Since all of the Earth's silicon, and most of its oxygen, combine in this way, the silicate tetrahedron accounts for nearly 75 weight percent of the Earth's crust. But the silicate tetrahedron has a minus 4 charge; it is a complex anion. Its charge must be satisfied by sharing oxygens and the bonding of additional cations to the silicate tetrahedron. Those cations make up the difference between 75 and 95 percent.

4. No mineral exists with the composition SiO_3 because any compound with that composition would have a -2 charge, and all minerals are electrostatically neutral. In addition, the stereochemistry of silicon in a strong ligand field demands that it be surrounded by 4 anions.

5. The difference in hardnesses of the two would be diagnostic. Other important differences include crystal habit and differences in the indices of refraction.

6. The compositions of the Moon, Mars, and Venus are similar to that of Earth, and the laws of physics and chemistry are identical everywhere. Therefore, the minerals should be identical, although due to different chemical environments and histories, the abundances of minerals are different.

7. In nature most environmentally hazardous rocks and minerals are buried beneath the surface, where they are unavailable to plants and animals. Natural weathering and erosion expose them so slowly that they do little harm. Most minerals that contain toxic metals or other elements such as lead, mercury, and arsenic, are also relatively insoluble. In their natural environments they weather so slowly that they release the toxic materials in low concentrations. However, if pollution controls are inadequate, mining, milling, and smelting can concentrate and release hazardous natural materials at greatly accelerated rates, poisoning humans and other organisms.

Most common minerals such as feldspar and quartz are harmless in their natural states in hard, solid rock. However, if these minerals are ground to fine powders they can enter the lungs to cause serious and even fatal inflammation and scarring of the lung tissue, called "silicosis." In advanced cases, the lungs become very inflamed and may fill with fluid, causing severe breathing difficulty and low blood oxygen levels. On-the-job exposure to silica dust can occur in mining, stone cutting, quarrying, building and road construction, working with abrasives, sand blasting, and other occupations and hobbies. Intense exposure to silica may produce silicosis in a year or less, but it usually takes at least 10 or 15 years of exposure before symptoms develop.

Coal dust, inhaled by coal miners in large quantities before federal laws required dust suppression in coal mines, has similar effects and causes a disease called "black lung."

Selected Reading

A useful, short text on minerals is:
Cornelius S. Hurlbut and W. Edwin Sharp, *Dana's Minerals and How to Study Them, Fourth edition*. New York: John Wiley & Sons, 1998, 235 pages.

A recent addition to mineral reference texts is:
Richard V. Gaines, H. Catherine, W. Skinner, Eugene E. Ford, Brian Moore, and Abraham Rosenzweig, *Dana's New Mineralogy: the System of Mineralogy of James Dwight Dana and Edward Salisbury Dana*. New York: John Wiley and Sons, 1997, 1872 pages.

A text that may be useful for laboratory study is:
Joseph C. Cepeda, *Introduction to Minerals and Rocks*. New York: Macmillan Publishing, 1994, 217 pp.

Two excellent, upper-level, mineralogy texts are:
Cornelius Klein and Cornelius S. Hurlbut, *Manual of Mineralogy*, *22nd edition*. New York: John Wiley & Sons, Inc., 2002, 641 pages.

M. J.Hibbard, *Mineralogy: A Geologist's Point of View*. New York: McGraw-Hill, 2002, 562 pages.

Three books that describe minerals and rocks at the introductory level are:
Joel Arem, *Rocks and Minerals*. Phoenix: Geoscience Press, 1991, 159 pages.

George W. Robinson, *Minerals: An Illustrated Exploration of the Dynamic World of Minerals and Their Properties*. New York: Simon and Schuster, 1994.

Chris Pellant, *Rocks and Minerals*. Boston: Dorling Kindersley, 1992, 256 pages.

Attractive microscopic views of both rocks and minerals are found in: W. S. MacKenzie and A. E. Adams, *A Color Atlas of Rocks and Minerals in Thin Section*. New York: John Wiley & Sons, 1994, 192 pages.

Chapter relevant internet resources:

http://en.wikipedia.org/wiki/Chemical_bond http://webmineral.com/

http://www.portobello.com.au/timerock/library/minerals/mineral_class.asp