(Photo by Art Wolfe, Inc.)

PART 1

# Geology

EXERCISE **1**

# The Study of Minerals

The ability to identify minerals using the simplest of techniques is a necessity for the Earth scientist, especially those scientists working in the field. In this exercise you will become familiar with the common physical properties of minerals and learn how to use these properties to identify minerals (Figure 1.1). In order to understand the origin, classification, and alteration of rocks, which are for the most part aggregates (mixtures) of minerals, you must first be able to identify the minerals that comprise them.


**Figure 1.1** Quartz crystals. Slender, six-sided, transparent crystals that will scratch glass. The shape of the crystals and their hardness are two physical properties used to identify this mineral. (Photo by E. J. Tarbuck)

## Objectives

After you have completed this exercise, you should be able to:

1. Recognize and describe the physical properties of minerals.
2. Use a mineral identification key to name minerals.
3. Identify several minerals by sight.
4. List the uses of several minerals that are mined.

## Materials

hand lens

*Materials Supplied by Your Instructor*

| | |
|---|---|
| mineral samples | dilute hydrochloric acid |
| streak plate | set of quartz crystals (various sizes) |
| magnet | contact goniometer |
| glass plate | crystal growth solution(s) |
| binocular microscope | |

## Terms

| | | |
|---|---|---|
| mineral | translucent | cleavage plane |
| rock-forming mineral | transparent | direction of cleavage |
| luster | color | fracture |
| metallic luster | streak | specific gravity |
| nonmetallic luster | hardness | magnetism |
| opaque | crystal form | striations |
| | contact goniometer | tenacity |
| | cleavage | |

## Introduction

A **mineral** is a naturally occurring, inorganic solid with an orderly internal arrangement of atoms (called *crystalline structure*) and a definite, but not fixed, chemical composition. Some minerals, such as gold and diamond, are single chemical elements. However, most minerals are compounds consisting of two or more elements. For example, the mineral halite is composed

**Table 1.1 Mineral Uses**

| MINERAL | USE |
|---|---|
| Chalcopyrite | Mined for copper |
| Feldspar | Ceramics and porcelain |
| Fluorite | Used in steel manufacturing |
| Galena | Mined for lead |
| Graphite | Pencil "lead," lubricant |
| Gypsum | Drywall, plaster of paris, wallboard |
| Halite | Table salt, road salt, source of sodium and chlorine |
| Hematite | Mined for iron |
| Magnetite | Mined for iron |
| Pyrite | Mined for sulfur and iron |
| Quartz | In the pure form, for making glass |
| Sphalerite | Mined for zinc |
| Talc | Used in ceramics, paint, talcum powder |

of the elements sodium and chlorine. The distinctive crystalline structure and chemical composition of a mineral give it a unique set of physical properties such as its luster, its hardness, and how it breaks. The fact that each mineral has its own characteristic physical and chemical properties can be used to distinguish one mineral from another.

Of the nearly 4,000 known minerals, only a few hundred have any current economic value. An example would be the mineral gypsum, used for making drywall and wallboard. Table 1.1 lists a few of the minerals that are mined as well as their uses. Of the remaining minerals, no more than a few dozen are abundant. Collectively, these few often occur with each other in the rocks of Earth's crust and are classified as the **rock-forming minerals**.

## Physical Properties of Minerals

The physical properties of minerals are those properties that can be determined by observation or by performing some simple tests. The primary physical properties that are determined for all minerals include optical properties (in particular, luster, the ability to transmit light, color, and streak), hardness, crystal form, cleavage or fracture, and specific gravity. Secondary (or "special") properties, including magnetism, taste, feel, striations, tenacity, and the reaction with dilute hydrochloric acid, are also useful in identifying certain minerals.

### Optical Properties

Of the many optical properties of minerals, four—luster, the ability to transmit light, color, and streak—are frequently determined for hand specimens.

*Luster* Luster describes the manner in which light is reflected from the surface of a mineral. Any mineral that shines with a metal-like appearance has a **metallic luster**. Those minerals that do not have a metallic luster are termed **nonmetallic** and may have one of a variety of lusters that include vitreous (glassy), pearly (like a pearl), or earthy (dull, like soil or concrete). In general, many minerals with metallic luster produce a dark gray, black, or other distinctively colored powder when they are rubbed on a hard porcelain plate (this property, called *streak*, will be investigated later).

Observe the mineral photographs shown in Figures 1.2 through 1.13. The minerals illustrated in Figures 1.5 and 1.6 have definite metallic lusters. The minerals in Figure 1.9 have nonmetallic, vitreous (glassy) lusters. Some minerals, such as hematite (Figure 1.7), occur in both metallic and nonmetallic varieties.

*Transmission of Light* The ability of a mineral to transmit light can be described as either **opaque**, when no light is transmitted (e.g., Figure 1.3); **translucent**, when light but not an image is transmitted; or, **transparent**, when an image is visible through the mineral (e.g., Figure 1.1). In general, most minerals with a metallic luster are opaque, while vitreous minerals are either translucent or transparent.

Examine the mineral specimens provided by your instructor, and answer the following questions.

1. How many of your specimens can be grouped into each of the following luster types?

   Metallic: _____ Nonmetallic-glassy: _____

2. How many of your specimens are transparent, and how many are opaque?

   Transparent: _____ Opaque: _____

*Color* Color, although an obvious feature of minerals, may also be misleading. For example, slight impurities in a mineral may result in one sample of the mineral having one color while a different sample of the same mineral may have an entirely different color. *Thus, color is one of the least reliable physical properties.*

3. Observe the minerals in Figure 1.8. Both of the minerals shown are varieties of the same mineral, quartz. What is the reason for the variety of colors that quartz exhibits?

   ______________________________

   ______________________________

4. Examine the mineral specimens supplied by your instructor, and describe those that appear to be the same mineral but with variable colors.

   ______________________________

   ______________________________

*Streak* The streak of a mineral is the color of the fine powder of a mineral obtained by rubbing a corner across a piece of unglazed porcelain—called a *streak plate*. Whereas the color of a mineral may vary from sample to sample, its streak usually does not and is

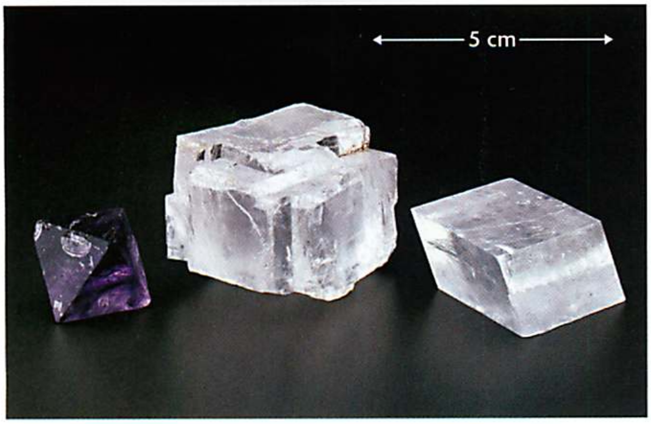


**Figure 1.2** Fluorite (left), halite (center), and calcite (right) exhibit smooth cleavage planes that are produced when the mineral is broken. (Photo by GeoScience Resources/American Geological Institute).

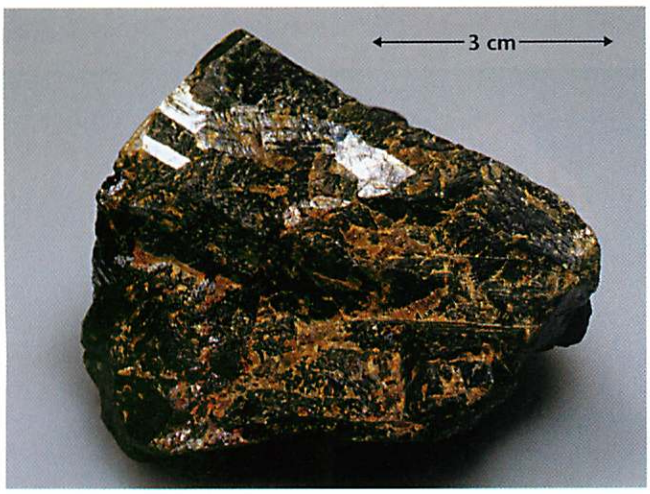


**Figure 1.3** Sphalerite. An ore of zinc.


**Figure 1.4** Graphite. A soft silver-gray mineral.

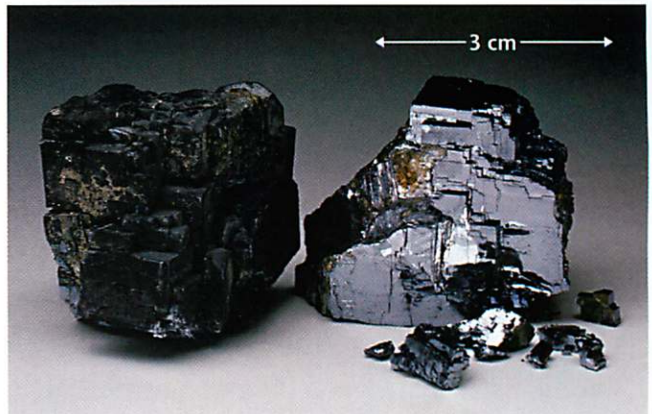


**Figure 1.5** Galena. An ore of lead with a high specific gravity.

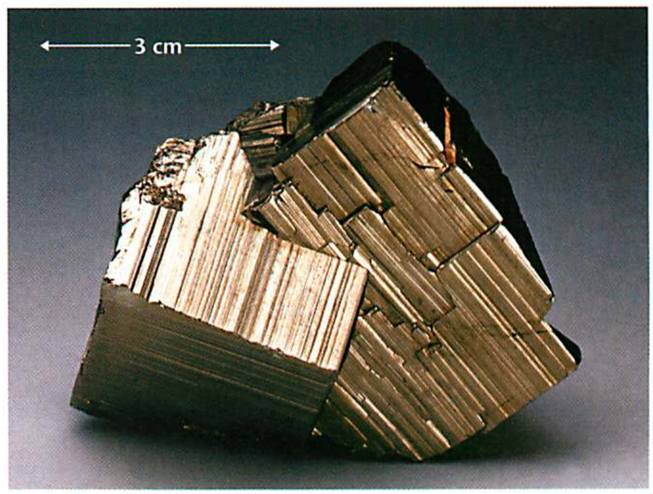


**Figure 1.6** Pyrite. A brassy-yellow mineral with a metallic luster that is commonly known as "fool's gold."

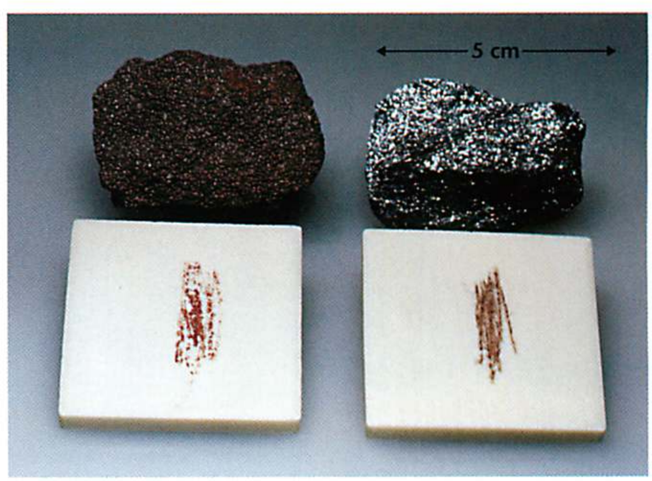


**Figure 1.7** Hematite. An ore of iron that has both a metallic (right) and nonmetallic (left) form.


**Figure 1.8** Two varieties of the mineral quartz. Rose quartz (right) and smoky quartz (left).

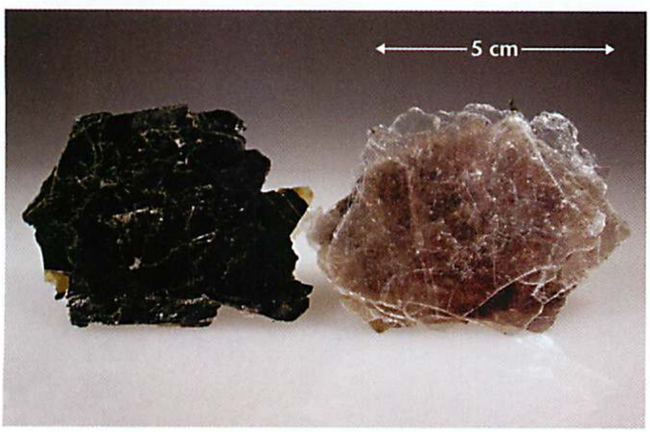


**Figure 1.9** Biotite mica (black) and muscovite mica (light color) are similar in appearance, except for color.


**Figure 1.10** Hornblende. A generally green to black, rock-forming, amphibole mineral.


**Figure 1.11** Augite. A dark green to black, rock-forming, pyroxene mineral.

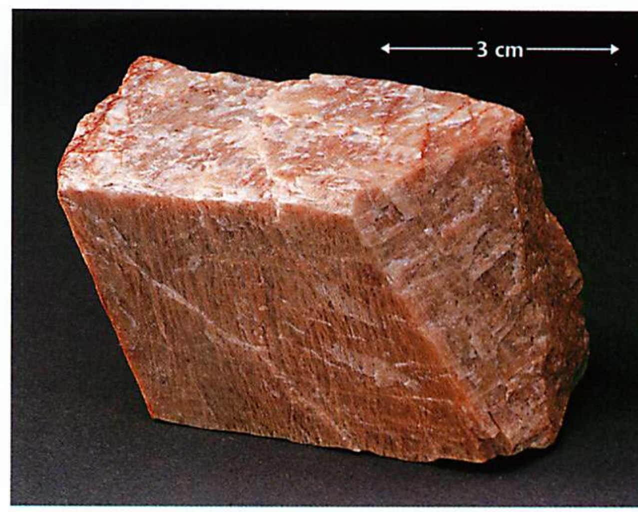


**Figure 1.12** Potassium feldspar, variety microcline.

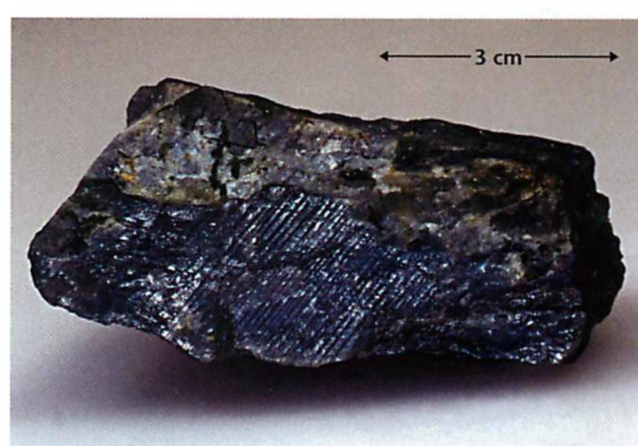


**Figure 1.13** Plagioclase feldspar, variety labradorite.

therefore the more reliable property (see Figure 1.7). In many cases, the color of a mineral's streak may not be the same as the color of the mineral. [*Note:* Minerals that have about the same hardness as, or are harder than, a streak plate (about 7 on Mohs scale of hardness), may not powder or produce a streak.]

5. Select three of the mineral specimens provided by your instructor. Do they exhibit a streak? If so, is the streak the same color as the mineral specimen?

| | COLOR OF SPECIMEN | STREAK |
|---|---|---|
| Specimen 1: | ________ | ________ |
| Specimen 2: | ________ | ________ |
| Specimen 3: | ________ | ________ |

## Hardness

**Hardness**, one of the most useful diagnostic properties of a mineral, is a measure of the resistance of a mineral to abrasion or scratching. It is a relative property in that a harder substance will scratch, or cut into, a softer one.

In order to establish a common system for determining hardness, Friedrich Mohs (1773–1839), a German mineralogist, developed a reference scale of mineral hardness. The Mohs scale of hardness (Figure 1.14), widely used today by geologists and engineers, uses 10 index minerals as a reference set to determine the hardness of other minerals. The hardness value of 1 is assigned to the softest mineral in the set, talc, and 10 is assigned to the hardest mineral, diamond. Higher-numbered minerals will scratch lower-numbered minerals. For example, quartz, with a hardness of 7, will scratch calcite, which has a hardness of 3. It should be remembered that Mohs scale is a *relative ranking* and does *not* imply that mineral number 2, gypsum, is twice as hard as mineral 1, talc.

Most people do not have a set of Mohs reference minerals available. However, by knowing the hardness of some common objects, such as those listed on Mohs scale in Figure 1.14, a hardness value can be assigned to a mineral. For example, a mineral that has a hardness greater than 5.5 will scratch glass. Table 1.2 can serve as a guide for determining the hardness of a mineral.

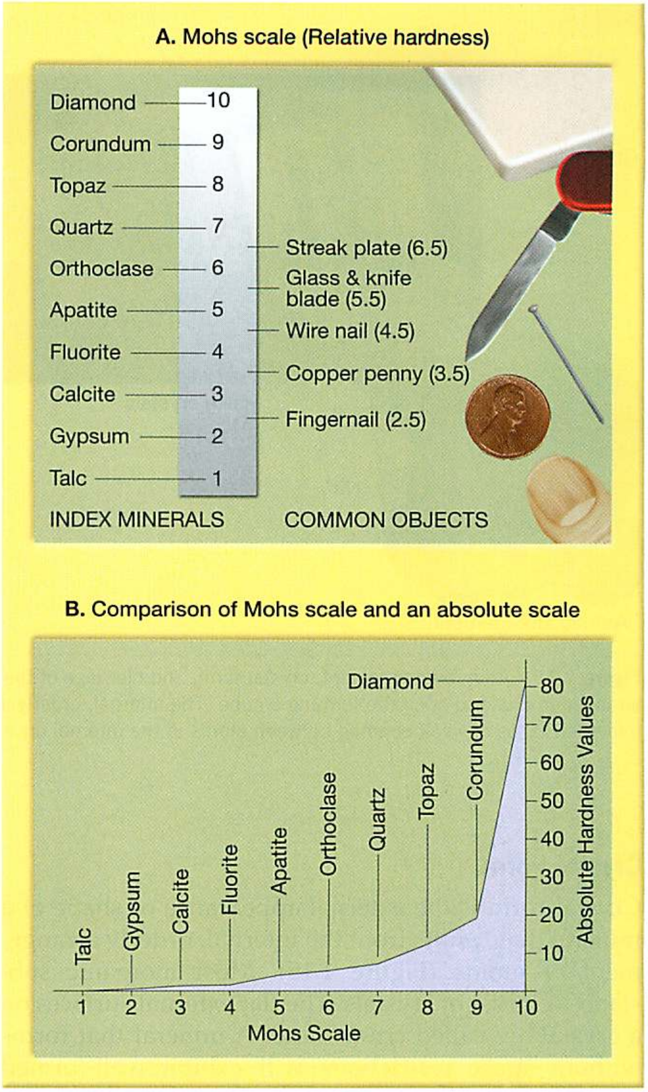


**Figure 1.14** Hardness scales. **A.** Mohs scale of hardness, with the hardness of some common objects. **B.** Relationship between Mohs relative hardness scale and an absolute hardness scale.

6. Test the hardness of several of the mineral specimens provided by your instructor by rubbing any two together to determine which are hard (the minerals that do the scratching) and which are soft (the minerals that are scratched). Doing this will give you an indication of what is meant by the term "relative hardness" of minerals.

7. Use the hardness guide in Table 1.2 to find an example of a mineral supplied by your instructor that falls in each of the three categories.

**Table 1.2** Hardness guide

| HARDNESS | DESCRIPTION |
|---|---|
| Less than 2.5 | A mineral that can be scratched by your fingernail (hardness = 2.5). |
| 2.5 to 5.5 | A mineral that cannot be scratched by your fingernail (hardness = 2.5), and cannot scratch glass (hardness = 5.5). |
| Greater than 5.5 | A mineral that scratches glass (hardness = 5.5). |

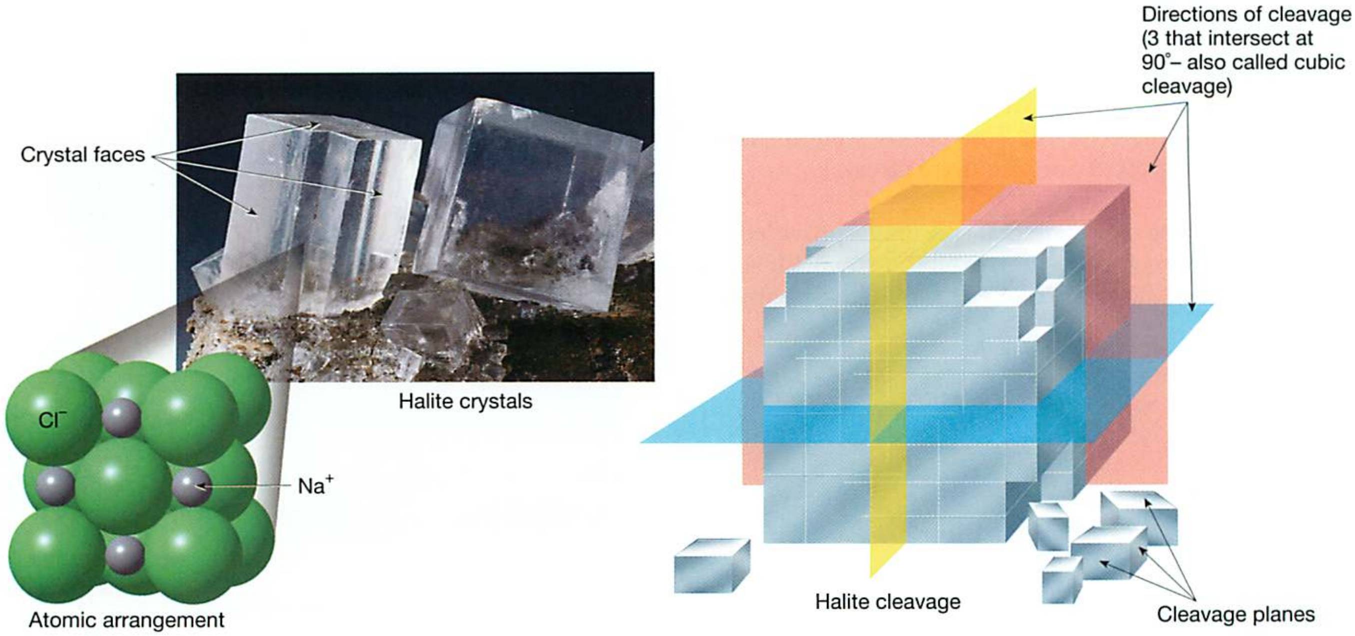


**Figure 1.15** Atomic arrangement, crystal form, and cleavage of the mineral halite. Halite (NaCl) contains sodium and chlorine atoms arranged in a one-to-one ratio forming a cube. The internal, orderly arrangement of atoms produces the external cubic crystal form of the mineral. Planes of weak bonding between atoms in the internal crystalline structure are responsible for halite's cubic cleavage.

## Crystal Form

**Crystal form** is the external appearance or shape of a mineral that results from the internal, orderly arrangement of atoms (Figure 1.15). Most inorganic substances consist of crystals. The flat external surfaces on a crystal are called *crystal faces.* A mineral that forms without space restrictions will exhibit well-formed crystal faces. However, most of the time, minerals must compete for space, and the result is a dense intergrown mass in which crystals do not exhibit their crystal form, especially to the unaided eye.

8. At the discretion of your instructor, you may be asked to grow crystals by evaporating prepared concentrated solutions. Following the specific directions of your instructor, and after you have completed your experiment(s), write a brief paragraph summarizing your observations.

______________________________________

______________________________________

______________________________________

One of the most useful instruments for measuring the angle between crystal faces on large crystals is the **contact goniometer** (Figure 1.16).

9. The mineral shown in Figure 1.1 has a well-developed crystal form with six faces that intersect at about 120° and come to a point. Two varieties of the same mineral are shown in Figure 1.8. Why do those in Figure 1.8 not exhibit crystal form?

______________________________________

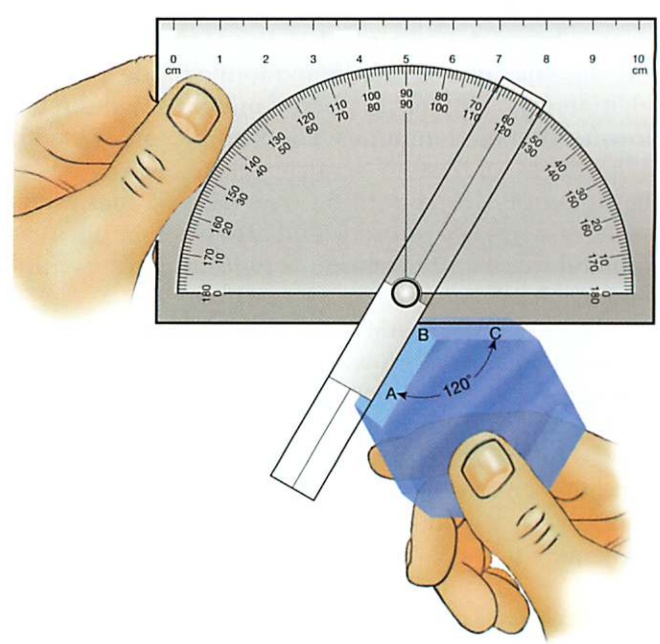


**Figure 1.16** Contact goniometer. To use the instrument, hold the straight edge of the protractor in contact with one crystal face and the edge of the celluloid strip in contact with the other face. The angle is read where the fine line on the celluloid strip overlaps the degrees on the protractor. For example, the angle between the adjacent crystal faces on the mineral illustrated (angle ABC) is 120°.

10. Select one of the photographed minerals, other than Figure 1.1, that exhibits its crystal form and describe its shape.

    Figure ______ : ______________________________

11. Observe the various size crystals of the mineral quartz on display in the lab. Use the contact goniometer to measure the angle between similar, adjacent crystal faces on several crystals. Then write a statement relating the angle between adjacent crystal faces to the size of the crystal.

    ______________________________________________

    ______________________________________________

## Cleavage and Fracture

**Cleavage** is the tendency of some minerals to break along regular planes of weak bonding between atoms in the internal crystalline structure (see Figure 1.15). When broken, minerals that exhibit cleavage produce smooth, flat surfaces, called **cleavage planes**.

Cleavage is described by (1) noting the number of **directions of cleavage**, which is the number of different sets of planes that form the surfaces of a mineral crystal when it cleaves, and (2) the angle(s) at which the directions of cleavage meet (see Figure 1.15). Each cleavage plane of a mineral crystal that has a different orientation is counted as a different direction of cleavage. When two or more cleavage planes are parallel or line up with each other, they are counted only once, as one direction of cleavage. Minerals may have one, two, three, four, or more directions of cleavage (Figure 1.17).

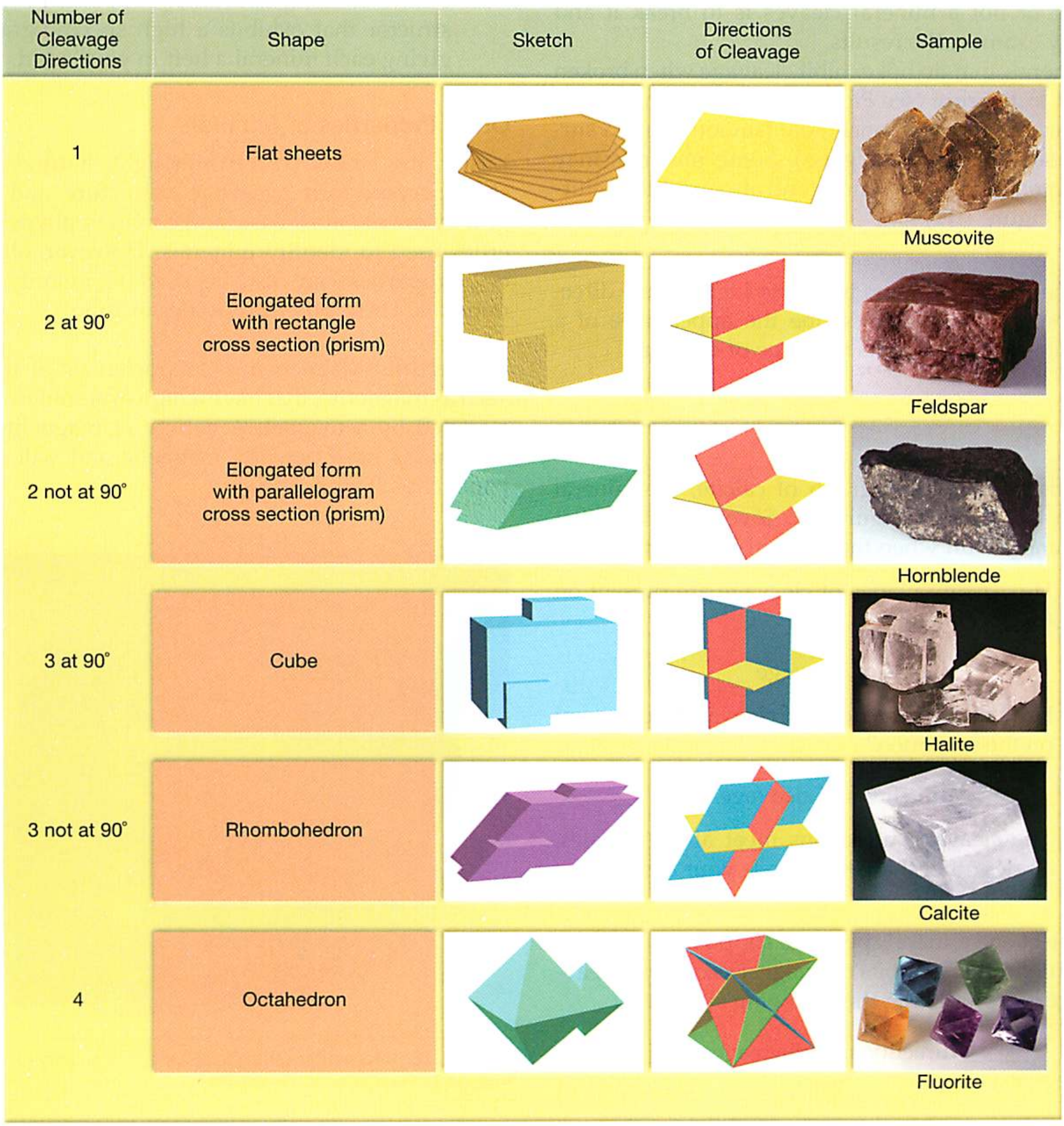


**Figure 1.17** Common cleavage directions of minerals.

Observe the minerals shown in Figures 1.5 and 1.15. These minerals have broken with regularity and exhibit cleavage. The specimens shown are in the form of a cube. Although there are six planes of cleavage surrounding each specimen, each exhibits only three directions of cleavage: top and bottom form one parallel set of planes—hence the first direction of cleavage; the two sides are a second parallel set—a second direction of cleavage; and the front and back form the third direction of cleavage. The cleavage of both minerals is described as three directions of cleavage that intersect at 90° (also commonly called *cubic cleavage*) (see Figure 1.17).

Cleavage and crystal form are *not* the same. Some mineral crystals cleave while others do not. Cleavage is determined by the bonds that hold atoms together, while crystal form results from the internal, orderly arrangement of the atoms. The best way to determine whether or not a mineral cleaves is to break it and carefully examine the results.

Minerals that do not exhibit cleavage when broken are said to **fracture** (see Figure 1.4). Fracturing can be irregular, splintery, or conchoidal (smooth curved surfaces resembling broken glass). Some minerals may cleave in one or two directions and also exhibit fracturing (see Figure 1.12).

12. The minerals shown in Figure 1.9 have one direction of cleavage. Describe the appearance of a mineral that exhibits this type of cleavage.

_______________________________________

13. Observe the photograph of calcite, the mineral on the right in Figure 1.2. Several smooth, flat planes result when the mineral is broken.

    a. How many planes of cleavage are present on the specimen?

    ________ planes of cleavage

    b. How many directions of cleavage are present on the specimen?

    ________ directions of cleavage

    c. The cleavage directions meet at (90° angles, angles other than 90°). Circle your answer.

14. Select one mineral specimen supplied by your instructor that exhibits cleavage. Describe its cleavage by completing the following statement.

    ________ directions of cleavage at ________ degrees

## Specific Gravity

**Specific gravity** is a number that represents the ratio of the weight of a mineral to the weight of an equal volume of water. For example, the mineral quartz, Figures 1.1 and 1.8, has a specific gravity of 2.65; this means it weighs 2.65 times more than an equal volume of water. The mineral galena, Figure 1.5, with a specific gravity of 7.4, feels heavy when held in your hand. With a little practice, you can estimate the specific gravity of a mineral by hefting it in your hand. The average specific gravity of minerals is about 2.7, but some metallic minerals have a specific gravity two or three times greater than the average. (*Note:* Exercise 23, "The Metric System, Measurements, and Scientific Inquiry," contains a simple experiment for estimating the specific gravity of a solid.)

15. Find a mineral specimen supplied by your instructor that exhibits a high specific gravity by giving each mineral a heft in your hand.

## Other Properties of Minerals

Luster, the ability to transmit light, hardness, color, streak, crystal form, cleavage or fracture, and specific gravity are the most basic and common physical properties used to identify minerals. However, other special properties can also be used to identify certain minerals. These other properties include:

***Magnetism*** Magnetism is characteristic of minerals, such as magnetite, that have a high iron content and are attracted by a magnet. A variety of magnetite called *lodestone* is itself actually magnetic and will pick up paper clips (Figure 1.18).

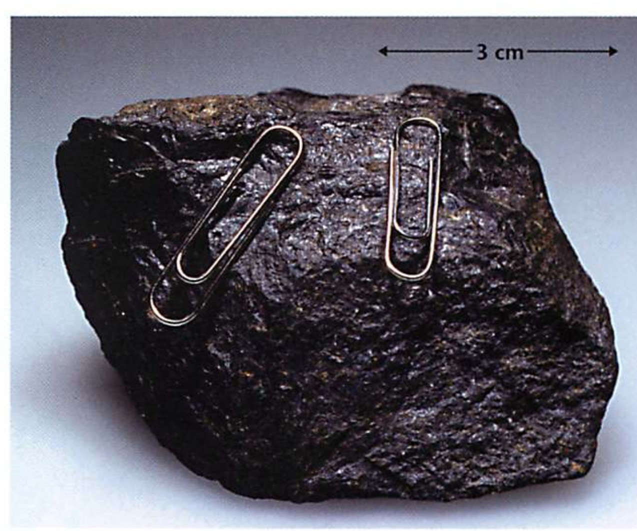


**Figure 1.18** Magnetite, variety lodestone, has polarity like a magnet and will attract iron objects.

| Specimen Number | Luster | Hardness | Color | Streak | Fracture or Cleavage (number of directions and angle of intersection) | Other Properties | Name | Economic Use or Rock-forming |
|---|---|---|---|---|---|---|---|---|
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**Figure 1.19** Mineral identification chart.

| METALLIC MINERALS | | | |
|---|---|---|---|
| **Hardness** | **Streak** | **Other Diagnostic Properties** | **Name (Chemical Composition)** |
| Harder than glass | Black | Black; magnetic; hardness = 6; specific gravity = 5.2; often granular | Magnetite ($Fe_3O_4$) |
| | Greenish-black | Brass yellow; hardness = 6; specific gravity = 5.2; generally an aggregate of cubic crystals | Pyrite ($FeS_2$)-fool's gold |
| | Red-brown | Gray or reddish brown; hardness = 5–6; specific gravity = 5; platy appearance | Hematite ($Fe_2O_3$) |
| Softer than glass but harder than a finger nail | Greenish-black | Golden yellow; hardness = 4; specific gravity = 4.2; massive | Chalcopyrite ($CuFeS_2$) |
| | Gray-black | Silvery gray; hardness = 2.5; specific gravity = 7.6 (very heavy); good cubic cleavage | Galena (PbS) |
| | Yellow-brown | Yellow brown to dark brown; hardness variable (1–6); specific gravity = 3.5–4; often found in rounded masses; earthy appearance | Limonite ($Fe_2O_3 \cdot H_2O$) |
| | Gray-black | Black to bronze; tarnishes to purples and greens; hardness = 3; specific gravity = 5; massive | Bornite ($Cu_5FeS_4$) |
| Softer than your fingernail | Dark gray | Silvery gray; hardness = 1 (very soft); specific gravity = 2.2; massive to platy; writes on paper (pencil lead); feels greasy | Graphite (C) |

| NONMETALLIC MINERALS | | | | |
|---|---|---|---|---|
| | **Hardness** | **Cleavage** | **Other Diagnostic Properties** | **Name (Chemical Composition)** |
| Dark colored | Harder than glass | Cleavage Present | Greenish black to black; hardness = 5–6; specific gravity = 3.4; fair cleavage, two directions at nearly 90 degrees | Augite (Ca, Mg, Fe, Al silicate) |
| | | | Black to greenish black; hardness = 5–6; specific gravity = 3.2; fair cleavage, two directions at nearly 60 degrees and 120 degrees | Hornblende (Ca, Na, Mg, Fe, OH, Al silicate) |
| | | | Red to reddish brown; hardness = 6.5–7.5; conchoidal fracture; glassy luster | Garnet (Fe, Mg, Ca, Al silicate) |
| | | Cleavage not prominent | Gray to brown; hardness = 9; specific gravity = 4; hexagonal crystals common | Corundum ($Al_2O_3$) |
| | | | Dark brown to black; hardness = 7; conchoidal fracture; glassy luster | Smoky quartz ($SiO_2$) |
| | | | Olive green; hardness = 6.5–7; small glassy grains | Olivine $(Mg, Fe)_2SiO_4$ |

**Figure 1.20** Mineral identification key.

| NONMETALLIC MINERALS | | | | |
|---|---|---|---|---|
| | Hardness | Cleavage | Other Diagnostic Properties | Name (Chemical Composition) |
| Dark colored (continued) | Softer than glass but harder than a fingernail | Cleavage present | Yellow brown to black; hardness = 4; good cleavage in six directions, light yellow streak that has the smell of sulfur | Sphalerite (ZnS) |
| | | | Dark brown to black; hardness = 2.5–3, excellent cleavage in one direction; elastic in thin sheets; black mica | Biotite mica (K, Mg, Fe, OH, Al silicate) |
| | | Cleavage absent | Generally tarnished to brown or green; hardness = 2.5; specific gravity = 9; massive | Native copper (Cu) |
| | Softer than your fingernail | Cleavage not prominent | Reddish brown; hardness = 1–5; specific gravity = 4–5; red streak; earthy appearance | Hematite ($Fe_2O_3$) |
| | | | Yellow brown; hardness = 1–3; specific gravity = 3.5; earthy appearance; powders easily | Limonite ($Fe_2O_3 \cdot H_2O$) |
| Light Colored | Harder than glass | Cleavage present | Pink or white to gray; hardness = 6; specific gravity = 2.6; two directions of cleavage at nearly right angles | Potassium feldspar ($KAlSi_3O_8$) (pink) |
| | | | | Plagioclase feldspar ($NaAlSi_3O_8$ to $CaAl_2Si_2O_8$) (white to gray) |
| | | Cleavage absent | Any color; hardness = 7; specific gravity = 2.65; conchoidal fracture; glassy appearance; varieties: milky (white), rose (pink), smoky (gray), amethyst (violet) | Quartz ($SiO_2$) |
| | Softer than glass but harder than a finger nail | Cleavage present | White, yellowish to colorless; hardness = 3; three directions of cleavage at 75 degrees (rhombohedral); effervesces in HCl; often transparent | Calcite ($CaCO_3$) |
| | | | White to colorless; hardness = 2.5; three directions of cleavage at 90 degrees (cubic); salty taste | Halite (NaCl) |
| | | | Yellow, purple, green, colorless; hardness = 4; white streak; translucent to transparent; four directions of cleavage | Fluorite ($CaF_2$) |
| | Softer than your fingernail | Cleavage present | Colorless; hardness = 2–2.5; transparent and elastic in thin sheets; excellent cleavage in one direction; light mica | Muscovite mica (K, OH, Al silicate) |
| | | | White to transparent, hardness = 2; when in sheets; is flexible but not elastic; varieties: selenite (transparent, three directions of cleavage); satin spar (fibrous, silky luster); alabaster (aggregate of small crystals) | Gypsum ($CaSO_4 \cdot 2H_2O$) |
| | | Cleavage not prominent | White, pink, green; hardness = 1–2; forms in thin plates; soapy feel; pearly luster | Talc (Mg silicate) |
| | | | Yellow; hardness = 1–2.5 | Sulfur (S) |
| | | | White; hardness = 2; smooth feel; earthy odor; when moistened, has typical clay texture | Kaolinite (Hydrous Al silicate) |
| | | | Pale to dark reddish brown; hardness = 1–3; dull luster; earthy; often contains spheroidal-shaped particles; not a true mineral | Bauxite (Hydrous Al oxide) |

**Figure 1.20** Mineral identification key (*continued*)

**Notes and calculations.**

# The Study of Minerals

Date Due: ____________________

Name: ____________________

Date: ____________________

Class: ____________________

After you have finished Exercise 1, complete the following questions. You may have to refer to the exercise for assistance or to locate specific answers. Be prepared to submit this summary/report to your instructor at the designated time.

1. Describe the procedure for identifying a mineral and arriving at its name.

____________________

____________________

____________________

2. Name the physical property of a mineral that is described by each of the following statements.

**PHYSICAL PROPERTY**

Breaks along smooth planes: ____________________

Scratches glass: ____________________

Shines like a metal: ____________________

A red-colored powder on unglazed porcelain:

____________________

3. Describe the shape of a mineral that has three directions of cleavage that intersect at 90°.

____________________

4. Name two minerals you identified that have good cleavage. Describe the cleavage of each mineral.

| MINERAL | | CLEAVAGE |
|---|---|---|
| ________ | : | ____________________ |
| ________ | : | ____________________ |

5. Select five minerals you identified, and list their names and physical properties.

________ : ____________________

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6. Name one mineral that you identified that has an economic use.

| MINERAL | | MINED FOR |
|---|---|---|
| ________ | : | ____________________ |

7. List the name and hardness of two minerals you identified.

MINERAL HARDNESS

_________ : ______________________________

_________ : ______________________________

8. How many directions of cleavage do the feldspar minerals—potassium feldspar and plagioclase feldspar—have?

___ directions of cleavage

9. What was your conclusion concerning the angles between similar crystal faces on different size crystals of the same mineral?

______________________________

10. List the name(s) of the minerals you identified that had a special property such as magnetism or feel. Write the special property that you observed next to the name of the mineral.

MINERAL SPECIAL PROPERTY

_________ : ______________________________

_________ : ______________________________

_________ : ______________________________

11. What physical property most distinguishes biotite mica from muscovite mica?

______________________________

12. Selecting from the minerals illustrated in Figures 1.1 through 1.13, list, by name, one mineral that exhibits each of the following:

one direction of cleavage: ______________

striations: ______________

multiple colors: ______________

cubic cleavage: ______________

nonmetallic, vitreous luster: ______________

fracture: ______________

metallic luster: ______________

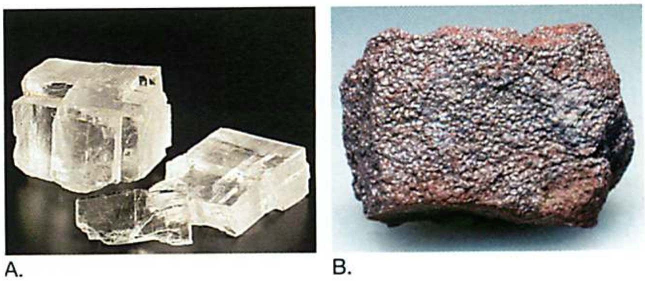


Figure 1.21 Two mineral specimens for use with question 13.

13. Referring to the minerals illustrated in Figure 1.21, list the physical properties of each mineral that can be determined from its photograph.

A: ______________________________

______________________________

______________________________

______________________________

B: ______________________________

______________________________

______________________________

______________________________

14. The mineral identification key, Figure 1.20, uses the property of luster as its primary division of minerals. Develop and describe an alternative classification key that uses another property, or properties, to divide minerals into groups.

______________________________

______________________________

______________________________

______________________________

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