Section 2.3

1 FOCUS

Section Objectives

2.10 **Explain** why color is often not a useful property in identifying minerals.

2.11 **Define** the terms *luster, crystal form, streak,* and Mohs scale.

2.12 **Distinguish** between cleavage and fracture.

2.13 **Explain** density and how it can be used to identify substances.

2.14 **Describe** some other properties that can be used to identify minerals.

Reading Focus

Build Vocabulary L2

Paraphrase As students read the section, have them look for the vocabulary terms that describe properties of minerals. For each term, have students write a definition in their own words. If students are having trouble, use mineral samples to demonstrate each of the properties.

Reading Strategy L2

A.1 Often not used to identify minerals
A.2 Small amounts of different elements can give the same mineral different colors.
B.1 Describes how light is reflected from surface
B.2 Metallic and nonmetallic lusters

2 INSTRUCT

Color

Build Reading Literacy L1

Refer to **p. 32D** in this chapter, which provides guidelines for this strategy.

Preview Before they read the section, have students skim the headings, visuals, and boldfaced sentences and terms to preview how the text is organized. Have students note any unfamiliar terms and concepts and make notes about these as they read the section.
Verbal

2.3 Properties of Minerals

Reading Focus

Key Concepts

- What properties can be used to identify minerals?
- What is the Mohs scale?
- What are some distinctive properties of minerals?

Vocabulary

- streak
- luster
- crystal form
- hardness
- Mohs scale
- cleavage
- fracture
- density

Reading Strategy

Outlining Before you read, make an outline of this section, following the format below. Use the green headings as the main topics. As you read, add supporting details.

I. Properties of Minerals
  A. Color
    1. ________
    2. ________
  B. Luster
    1. ________
    2. ________

As you can see from the photographs in this chapter, minerals occur in different colors and shapes. Now you will learn that minerals vary in the way they reflect light and in the way in which they break. You will also find out that some minerals are harder than others and that some minerals smell like rotten eggs. All of these characteristics, or properties, of minerals can be used to identify them.

Color

One of the first things you might notice about a mineral is its color. While color is unique to some minerals, this property is often not useful in identifying many minerals. **Small amounts of different elements can give the same mineral different colors.** You can see examples of this in Figure 16.

Figure 16 Small amounts of different elements give these sapphires their distinct colors. **Observing** ***Why is color often not a useful property in mineral identification?***

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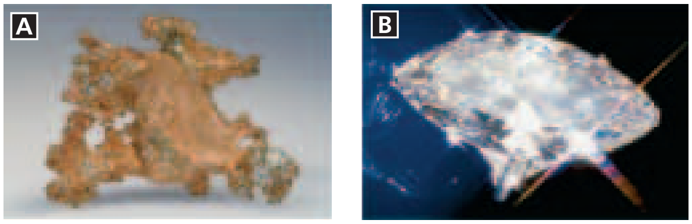

Figure 17 **A** The mineral copper has a metallic luster. **B** The brilliant luster of diamond is also known as an adamantine luster.

Streak

Streak is the color of a mineral in its powdered form. Streak is obtained by rubbing a mineral across a streak plate, a piece of unglazed porcelain. While the color of a mineral may vary from sample to sample, the streak usually doesn't. Therefore, streak can be a good indicator. Streak can also help to see the difference between minerals with metallic lusters and minerals with nonmetallic lusters. Metallic minerals generally have a dense, dark streak. Minerals with nonmetallic lusters do not have such streaks.

Luster

Luster is used to describe how light is reflected from the surface of a mineral. Minerals that have the appearance of metals, regardless of their color, are said to have a metallic luster. The piece of copper shown in Figure 17A has a metallic luster. Minerals with a nonmetallic luster are described by many adjectives. These include vitreous or glassy, like the quartz crystals in Figure 13A. Other lusters include pearly, silky, and earthy. Diamond has an adamantine, or brilliant, luster. Some minerals appear *somewhat* metallic and are said to have a sub-metallic luster.

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Crystal Form

Crystal form is the visible expression of a mineral's internal arrangement of atoms. Every mineral has a crystal form based on one of six distinct crystal systems. All the minerals that belong to a given crystal system have crystals of the same shape. For example, the fluorite in Figure 18 belongs to the cubic crystal system. Quartz has hexagonal (six-sided) crystals and belongs to the hexagonal crystal system.

Usually, when a mineral forms slowly and without space restrictions, it will develop into a crystal with well-formed faces—sides, top, and bottom. Most of the time, however, minerals compete for space. This crowding results in an intergrown mass of small crystals. None of these crystals shows its crystal form.

Figure 18 Crystal Form Fluorite often forms cubic crystals.

Reading Checkpoint *What two conditions produce crystals with well-defined faces?*

Streak

Integrate Chemistry L2

Streak Color There are several reasons why a mineral's streak color may differ from the color of the mineral itself. Some translucent minerals are colored by trace impurities of other elements. These colors are visible in a large sample because light passes through the impurities before reaching the eye. A streak will often not show this coloring effect and will appear white instead. Also, the structure and surface coatings of a sample may affect its color. Again, the streak will not show these effects and will instead show the true color of the mineral. Have students research how streak can be used to distinguish gold from iron pyrite. *(Samples of both have a gold color. Gold has a golden streak but iron pyrite has a black streak.)*
Logical

Luster

Integrate Physics L2

Causes of Luster The type of luster a mineral displays depends on how light interacts with the surface of the sample. If most of the light is reflected or absorbed, the mineral will have a metallic luster. A few minerals allow a small amount of light to penetrate, and have submetallic luster. Nonmetallic luster occurs when light can pass through the sample. If the mineral has a high index of refraction (the amount that light bends when it is passing through the mineral), such as diamond, the luster is described as adamantine. Minerals with lower indices of refraction have glassy or vitreous luster.
Logical, Visual

Crystal Form

Use Visuals L1

Figure 18 Show students a sample of rock salt. Have students compare these crystals with the fluorite crystals in Figure 18. Ask: **How are the crystals similar? How are they different?** *(Similar: both cubic; Different: colors)*
Visual

Customize for Inclusion Students

Behaviorally Disordered For students who have difficulty concentrating on reading or class lectures, have them explore mineral samples on their own to learn about the properties of minerals. Students can work on their own or in small groups to explore three to five minerals. Encourage students to take notes about each mineral's color, luster, crystal form, streak, hardness, cleavage, fracture, and density.

Answer to . . .

Figure 16 *The same mineral can be different colors.*

Reading Checkpoint *unrestricted space and a slow rate of formation*

Hardness

Use Visuals L1

Figure 19 Have students use the Mohs scale of hardness to give the hardness ranges for the following descriptions: a mineral that can be scratched by your fingernail *(less than 2.5)*, a mineral that cannot be scratched by your fingernail and cannot scratch glass *(2.5 to 5.5)*, a mineral that scratches glass *(greater than 5.5)*.
Visual

Build Science Skills L1

Inferring Ask: **What does the use of a pencil tell you about the hardness of graphite?** *(Graphite, or pencil "lead," is a very soft mineral because it leaves a mark, or streak, when rubbed against paper or most surfaces.)* **What can you say about the hardness of chalk versus the hardness of a chalkboard?** *(Chalk is softer than the board.)* **What kind of minerals could you not test for streak when using a streak plate?** *(Minerals that are harder than the streak plate will not leave a streak; instead they will scratch the plate.)*
Logical

Cleavage

Integrate Language Arts L2

Origin of the Names Mica and Muscovite Tell students that the name "mica" probably came from the Latin word *micare*, which means "to shine" and refers to mica's appearance. Muscovite, a common type of mica, was named after the old Russian state of Muscovy. In the 1300s, it was common in Muscovy to use mica as a substitute for glass, so it was called muscovy glass. Biotite is another common type of mica. Have students research the origin of that name. *(It was named for J. B. Biot, a French physicist.)*
Verbal

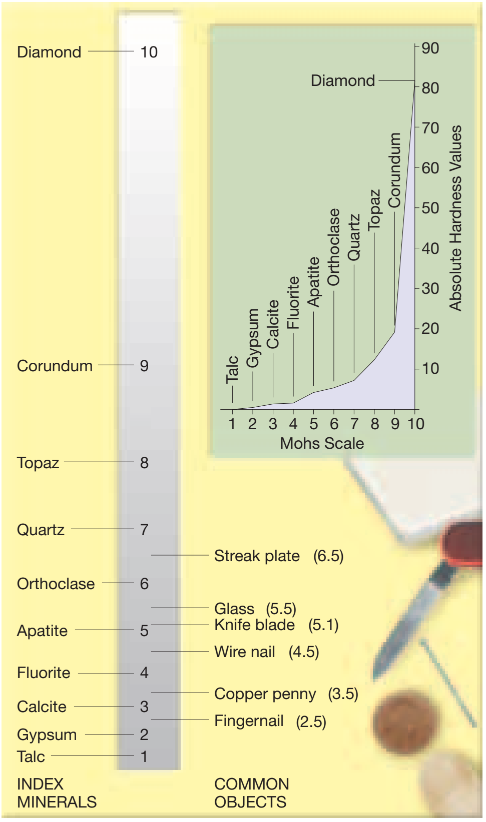

Figure 19 Mohs Scale of Hardness Common objects can be used with the Mohs scale to determine mineral hardness.
Using Tables and Graphs ***A mineral has a hardness of 4.2. Which common items on the chart will that mineral scratch?***

Hardness

One of the most useful properties to identify a mineral is hardness. **Hardness** is a measure of the resistance of a mineral to being scratched. You can find this property by rubbing the mineral against another mineral of known hardness. One will scratch the other, unless they have the same hardness.

Geologists use a standard hardness scale called the Mohs scale. **The Mohs scale consists of 10 minerals arranged from 10 (hardest) to 1 (softest).** See Figure 19. Any mineral of unknown hardness can be rubbed against these to determine its hardness. Other objects can also be used to determine hardness. Your fingernail, for example, has a hardness of 2.5. A copper penny has a hardness of 3.5. A piece of glass has a hardness of about 5.5. Look again at Figure 19. The mineral gypsum, which has a Mohs hardness of 2, can be easily scratched by your fingernail. The mineral calcite, which resembles gypsum, has a hardness of 3. Calcite cannot be scratched by your fingernail. Calcite, which can resemble the mineral quartz, cannot scratch glass, because its hardness is less than 5.5. Quartz, the hardest of the common minerals with a Mohs hardness of 7, will scratch a glass plate. Diamond, the hardest mineral on Earth, can scratch anything.

Reading Checkpoint ***Describe three or four of the most useful properties for identifying unknown minerals.***

Cleavage

In the atomic structure of a mineral, some bonds are weaker than others. These weak bonds are places where a mineral will break when it is stressed. **Cleavage is the tendency of a mineral to cleave, or break, along flat, even surfaces.**

Minerals called micas show the simplest type of cleavage. Because the micas have weak bonds in one direction, they cleave to form thin, flat sheets, as shown in Figure 20A. Look again at Figure 14. Can you see the relationship between mica's internal structure and the cleavage it shows? Mica, and all other silicates, tend to cleave between the silicon-oxygen structures rather than across them. This is because the silicon-oxygen bonds are strong. The micas' sheet structure causes them to cleave into flat plates. Quartz has equally strong silicon-oxygen bonds in all directions. Therefore, quartz has no cleavage but fractures instead.

Some minerals have cleavage in more than one direction. Look again at Figure 11. Halite (11A) has three directions of cleavage. The cleavage planes of halite meet at 90-degree angles. Calcite (11B) also has three directions of cleavage. The cleavage planes of calcite, however, meet at 75-degree angles.

Fracture

Minerals that do not show cleavage when broken are said to fracture. Fracture is the uneven breakage of a mineral. For example, quartz shows a curvy and glassy fracture. Like cleavage, there are different kinds of fracture. Minerals that break into smooth, curved surfaces like the quartz in Figure 20B have a conchoidal fracture. Other minerals, such as asbestos, break into splinters or fibers. Many minerals have an irregular fracture.

Reading Checkpoint *How are cleavage and fracture different?*

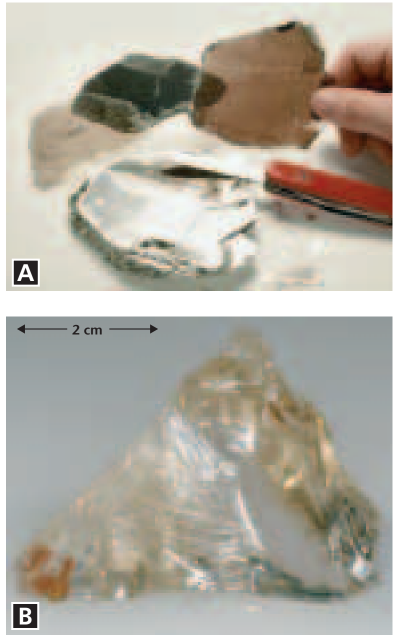

Figure 20 **A** Mica has cleavage in one direction and therefore cleaves into thin sheets. **B** The bonds in quartz are very strong in all directions, causing quartz to display conchoidal fracture.

Density

Density is a property of all matter that is the ratio of an object's mass to its volume. Density is a ratio and can be expressed using the following equation.

$$Density\ (D) = \frac{mass\ (m)}{Volume\ (V)}$$

Density is expressed using derived units with a unit of mass over a unit of volume. For example, the density of copper is 8.96 g/cm^3 (grams per cubic centimeter). Therefore, any sample of pure copper with a volume of one cubic centimeter will have a mass of 8.96 grams.

Many common minerals have densities between 2 and 5 g/cm^3. Some metallic minerals have densities that are often greater than rock-forming minerals. Galena, the ore of lead, has a density around 7.5 g/cm^3. The density of gold is 19.3 g/cm^3. The density of a pure mineral is a constant value. Thus, density can be used to determine the purity or identity of some minerals.

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Facts and Figures

Like mica, asbestos is a sheet-forming mineral. However, unlike flat sheets of mica, sheets of asbestos roll up in a tight needle-like formation. These needles can cause serious damage to lungs if inhaled. Before people realized that asbestos caused a health risk, it was a popular insulation material. Now, many older buildings must undergo expensive asbestos removal in order to be safe.

Fracture

Use Visuals L1

Figure 20 Use these photographs to explain fracture and cleavage. Ask: **What is cleavage?** *(the tendency of a mineral to break along flat, even surfaces)* **Which mineral shows cleavage?** *(mica)* **What is fracture?** *(the uneven breakage of a mineral)* **Which mineral shows fracture?** *(quartz)*
Visual

Density

Integrate Chemistry L2

Density and Atomic Mass Specific gravity was once used to distinguish minerals. However, today geologists use density. The specific gravity of a mineral depends on its density. (Density is mass per unit of volume and is expressed in grams per cubic centimeter.) Density in turn depends mainly on the chemical composition of a mineral. Minerals made of elements with high atomic masses generally have higher densities than minerals made of atoms with low atomic masses. Tell students that the mineral galena contains large amounts of lead, which has a high atomic mass. Ask: **Would you expect the density of galena to be relatively low or high?** *(high)* Tell students that the mineral quartz is made up of silicon and oxygen, which have low atomic masses. **Would you expect the density of quartz to be relatively low or high?** *(low)*
Logical

Go Online NSTA SCI LINKS

Download a worksheet on mineral identification for students to complete, and find additional teacher support from NSTA SciLinks.

Answer to . .

Figure 19 *copper penny and fingernail*

Reading Checkpoint *Hardness, streak, luster, and density are the most definitive properties that can be used to identify minerals*

Reading Checkpoint *Cleavage is the tendency for a mineral to break along flat, even surfaces. Fracture is the uneven breakage of a mineral.*

Distinctive Properties of Minerals

Use Community Resources L2

As noted on p. 49, invite a geologist from a local college or company to visit the classroom and discuss properties of minerals with students. Ask the geologist to bring in samples of unusual minerals and demonstrate their properties to students.
Visual, Interpersonal

Build Science Skills L2

Designing Experiments Give each student or group of students two mineral samples. Tell them only that one is calcite and the other is dolomite. Have students design an activity they could do without any additional materials or equipment to determine the identities of the two samples. *(Try to scratch the samples with each other. The one that is scratched is softer and is calcite.)* Then ask students how they might identify the samples using additional materials. *(Place dilute hydrochloric acid on each sample to see if it fizzes.)* Have them carry out their experiment. Be sure students wear safety goggles and gloves when using the hydrochloric acid. Dispense the acid in small dropper bottles and be sure it is diluted.
Logical

Table 2 Some Common Minerals and Their Properties

Name	Chemical Formula and Mineral Group	Common Color(s)	Density (g/cm^3)	Hardness	Comments
Quartz	SiO_2 silicates	colorless, milky white, pink, brown	2.65	7	glassy luster; conchoidal fractures
Orthoclase feldspar	$KAlSi_3O_8$ silicates	white to pink	2.57	6	cleaves in two directions at 90°
Plagioclase feldspar	$(Na,Ca)AlSi_3O_8$ silicates	white to gray	2.69*	6	cleaves in two directions at 90°; striations common
Galena	PbS sulfides	metallic silver	7.5*	2.5	cleaves in three directions at 90°; lead gray streak
Pyrite	FeS_2 sulfides	brassy yellow	5.02	6–6.5	fractures; forms cubic crystals; greenish-black streak
Sulfur	S native elements	yellow	2.07*	1.5–2.5	fractures; yellow streak smells like rotten eggs
Fluorite	CaF_2 halides	colorless, purple	3.18	4	perfect cleavage in three directions; glassy luster
Olivine	$(Mg,Fe)_2SiO_4$ silicates	green, yellowish-green	3.82*	6.5–7	fractures; glassy luster; often has granular texture
Calcite	$CaCO_3$ carbonates	colorless, gray	2.71	3	bubbles with HCl; cleaves in three directions
Talc	$Mg_3Si_4O_{10}(OH)_2$ silicates	pale green, gray, white	2.75*	1	pearly luster; feels greasy; cleaves in one direction
Gypsum	$CaSO_4 \cdot 2H_2O$ sulfates	colorless, white, gray	2.32	2	glassy or pearly luster; cleaves in three directions
Muscovite mica	$KAl_3Si_3O_{10}(OH)_2$ silicates	colorless in thin sheets to brown	2.82*	2–2.5	silky to pearly luster; cleaves in one direction to form flexible sheets

* Average density of the mineral

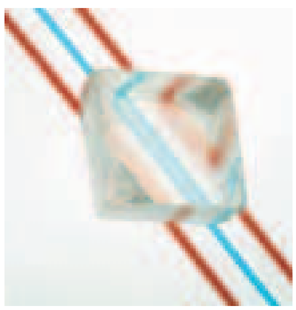

Figure 21 Calcite shows the property of double refraction.

Distinctive Properties of Minerals

Some minerals can be recognized by other distinctive properties. Talc and graphite, for example, both have distinctive feels. Talc feels soapy. Graphite feels greasy. Metallic minerals, such as gold, silver, and copper, are easily shaped. Some minerals, such as magnetite and hematite, are magnetic. Magnetite will attract paper clips and small nails. When a piece of transparent calcite is placed over printed material, the lines appear doubled, as Figure 21 shows. This property is called double refraction. Streaks of a few minerals that contain sulfur smell like rotten eggs. A droplet of hydrochloric acid will cause carbonate minerals, such as calcite, to fizz.

A mineral's properties depend on the elements that compose the mineral (its composition) and its structure (how its atoms are arranged). Table 2 lists some of the more common minerals and their properties. You will use this table to identify minerals in the lab on pages 58 and 59.

Table 2 Some Common Minerals and Their Properties, *continued*

Name	Chemical Formula and Mineral Group	Common Color(s)	Density (g/cm^3)	Hardness	Comments
Biotite mica	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$ silicates	dark green to brown to black	3.0*	2.5–3	perfect cleavage in one direction to form flexible sheets
Halite	$NaCl$ halides	colorless, white	2.16	2.5	has a salty taste; dissolves in water; cleaves in three directions
Augite	$(Ca, Na)(Mg, Fe, Al)(Si, Al)_2O_6$ silicates	dark green to black	3.3*	5–6	glassy luster; cleaves in two directions; crystals have 8-sided cross section
Hornblende	$(Ca, Na)_{2-3}(Mg, Fe, Al)_5Si_6(Si, Al)_2O_{22}(OH)_2$ silicates	dark green to black	3.2*	5–6	glassy luster; cleaves in two directions; crystals have 6-sided cross section
Hematite	Fe_2O_3 oxides	reddish brown to black	5.26	5.5–6.5	metallic luster in crystals; dull luster in earthy variety; dark red streak; weakly magnetic
Dolomite	$CaMg(CO_3)_2$ carbonates	pink, colorless, white, gray	2.85	3.5–4	does not react to HCl as quickly as calcite; cleaves in three directions
Magnetite	Fe_3O_4 oxides	black	5.18	6	metallic luster; black streak; strongly magnetic
Copper	Cu native elements	copper-red on fresh surface	8.9	2.5–3	metallic luster; fractures; can be easily shaped
Graphite	C native elements	black to gray	2.3	1–2	black to gray streak; marks paper; feels slippery

Section 2.3 Assessment

Reviewing Concepts

1. Describe five common properties of minerals that can be used to identify them.
2. How is the Mohs scale used?
3. What are some unique properties that can be used to identify minerals?

Critical Thinking

4. **Applying Concepts** What kind of luster do the minerals shown in Figure 15 have? Explain your choice.
5. **Applying Concepts** Hornblende is a double-chain silicate. How many planes of cleavage do you think hornblende has when it breaks? Explain your answer.
6. **Applying Concepts** A mineral scratches a piece of fluorite but cannot be scratched by a piece of glass. What is this mineral's hardness?

Connecting Concepts

Mineral Properties Choose one of the minerals pictured in this chapter. Find out to which mineral system it belongs as well as its luster, streak, hardness, specific gravity, and whether it cleaves or fractures. Also note any unique properties of the mineral.

Integrate Social Studies L2

Mining Economics Mineral resources are Earth's storehouse of minerals that can be recovered for use. The term *ore* refers to useful metallic minerals that can be mined at a profit. For pure elements, the element must be concentrated well above the level of its average crustal abundance to be worth mining. Copper must be present at about 100 times its average concentration, whereas for aluminum the ratio is only 4. Have students research the history of the copper mine at Bingham Canyon, Utah. *(It is one of the largest open-pit mines on Earth. Mining was halted in 1985 because it was uneconomic but later restarted with new equipment that made it profitable.)*
Verbal, Logical

3 ASSESS

Evaluate Understanding L2

Provide students with 4 or 5 unidentified minerals. Challenge students to place the minerals in order of hardness from softest to hardest. They should rub any two of the minerals together and repeat this process until they can determine the order of hardness. Remind students that a harder mineral will scratch a softer mineral and a softer mineral may leave a streak on a harder mineral. After rubbing two minerals together, students may need to rub the mark with their finger to tell if it is a scratch or a streak.

Connecting Concepts

Answers will vary. Most of the minerals pictured in this chapter are described in Table 4. Many are shown on the GEODe CD-ROM as well.

Section 2.3 Assessment

1. Sample answers: luster, crystal form, streak, Mohs hardness, magnetism, density, odor, double refraction, cleavage, and fracture.
2. The Mohs scale is an ordering of minerals according to hardness.
3. Feel, magnetism, double refraction, odor, and reaction to HCl are a few properties unique to only some minerals.
4. Both minerals have metallic luster because they appear to shine like metals.
5. Hornblende cleaves in two directions when the two sets of bonds in the double chain structure break.
6. The mineral's hardness is greater than 4 but less than 5.5 on the Mohs hardness scale.

understanding EARTH

Gemstones

L2

Background

- Why can diamond and graphite be made of the same material (carbon) but form such different minerals? You could make a diamond out of your pencil if you could squeeze it hard enough. The pressure would compress the carbon atoms of the graphite together until they eventually formed the strong covalent bonds of diamond. In fact, this is roughly how synthetic diamonds are made: by squeezing carbon very tightly. Natural diamonds are thought to form more than 150 km beneath the surface, where the pressures are very high. The diamonds that we find at the surface have been brought up from deep within Earth by geologic processes.
- Pure quartz, containing only SiO_2, is clear and colorless. However, natural quartz comes in many color varieties that form when different elements are contained in the crystal structure. If small amounts of titanium and iron are included, the result is rose quartz. The inclusion of manganese produces purple amethyst. The inclusion of aluminum produces smoky quartz.
- A precious gemstone that has gained in popularity in recent years is tanzanite. Mined only in the east-African country of Tanzania, tanzanite was discovered in 1967. Its color ranges from a light purplish blue to the more prized deep blues. The most prized stones are deep blue rimmed in a purplish hue. This hydrated calcium aluminum silicate is actually the blue variety of the gemstone called zoisite. But the jeweler Louis Comfort Tiffany, who popularized the gem after its discovery, thought that the correct name of *blue zoisite* was too reminiscent of the word *suicide*. So he suggested *tanzanite* instead.

understanding EARTH

Gemstones

Precious stones have been prized by people since ancient times. Unfortunately, much misinformation exists about the nature of gems and the minerals of which they are composed. Part of the misinformation stems from the ancient practice of grouping precious stones by color rather than mineral makeup. For example, the more common red spinels were often passed off to royalty as rubies, which are more valuable gems. Even today, when modern techniques of mineral identification are commonplace, yellow quartz is frequently sold as topaz.

What's In a Name?

Compounding the confusion is the fact that many gems have names that are different from their mineral names. For example, diamond is composed of the mineral of the same name, whereas sapphire is a form of corundum, an aluminum oxide-rich mineral. Although pure aluminum oxide is colorless, a tiny amount of a foreign element can produce a vividly colored gemstone. Therefore, depending on the impurity, sapphires of nearly every color exist. Pure aluminum oxide with trace amounts of titanium and iron produce the most prized blue sapphires. If the mineral corundum contains enough chromium, it exhibits a brilliant red color, and the gem is called ruby. Large gem-quality rubies are much rarer than diamonds and thus command a very high price.

If the specimen is not suitable as a gem, it simply goes by the mineral name corundum. Although common corundum is not a gemstone, it does have value as an abrasive material. Whereas two gems—rubies and sapphires—are composed of the mineral corundum, quartz is the parent mineral of more than a dozen gems. Table 3 lists some well-known gemstones and their mineral names.

Precious or Semiprecious?

What makes a gem a gem instead of just another mineral? Basically, certain mineral specimens, when cut and polished, possess beauty of such quality that they can command a price that makes the process of producing the gem profitable. Gemstones can be divided into two categories: precious and semiprecious. A *precious* gem has beauty, durability, size, and rarity, whereas a *semiprecious* gem usually has only one or two of these qualities. The gems that have traditionally enjoyed the highest esteem are diamonds, rubies, sapphires, emeralds, and some varieties of opal. All other gemstones are classified as semiprecious. It should be noted, however, that large, high-quality specimens of semiprecious stones can often command a very high price.

Obviously, beauty is the most important quality that a gem can possess. Today we prefer translucent stones with evenly tinted colors. The most favored hues appear to be red, blue, green, purple, rose,

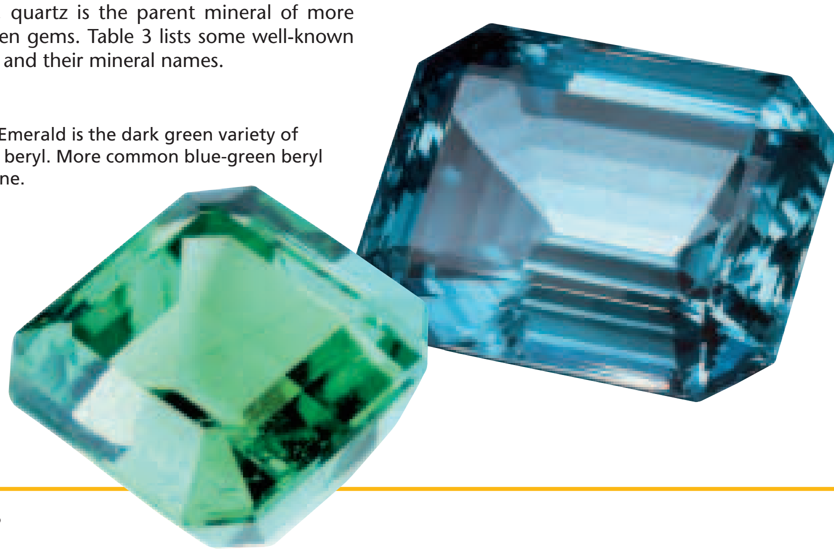

Figure 22 Emerald is the dark green variety of the mineral beryl. More common blue-green beryl is aquamarine.

 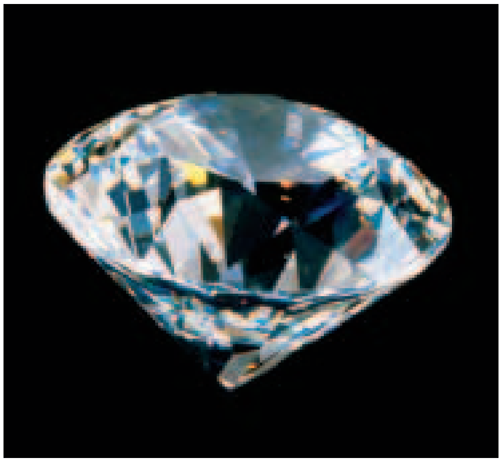

Figure 23 A diamond in the rough looks very different from the brilliant, multi-faceted gem it can become.

and yellow. The most prized stones are deep red rubies, blue sapphires, grass-green emeralds, and canary-yellow diamonds. Colorless gems are generally less than desirable except in the case of diamonds that display "flashes of color" known as brilliance.

Notice in figure 23 that gemstones in the "rough" are dull and would be passed over by most people as "just another mineral." Gemstones must be cut and polished by experienced artisans before their true beauty can be displayed.

The durability of a gem depends on its hardness—that is, its resistance to abrasion by objects normally encountered in everyday living. For good durability, gems should be as hard or harder than quartz, as defined by the Mohs scale of hardness. One notable exception is opal, which is comparatively soft (hardness 5 to 6.5) and brittle. Opal's esteem comes from its fire, which is a display of a variety of brilliant colors including greens, blues, and reds.

It seems to be human nature to treasure that which is rare. In the case of gemstones, large, high-quality specimens are much rarer than smaller stones. Thus, large rubies, diamonds, and emeralds, which are rare in addition to being beautiful and durable, command the very highest prices.

Table 3 Some Important Gemstones

Gem	Mineral Name	Prized Hues
Precious		
Diamond	Diamond	Colorless, yellows
Emerald	Beryl	Greens
Opal	Opal	Brilliant hues
Ruby	Corundum	Reds
Sapphire	Corundum	Blues
Semiprecious		
Alexandrite	Chrysoberyl	Variable
Amethyst	Quartz	Purples
Aquamarine	Beryl	Blue-greens
Cat's-eye	Chrysoberyl	Yellows
Chalcedony	Quartz (agate)	Banded
Citrine	Quartz	Yellows
Garnet	Garnet	Reds, greens
Jade	Jadeite or nephrite	Greens
Moonstone	Feldspar	Transparent blues
Peridot	Olivine	Olive greens
Smoky quartz	Quartz	Browns
Spinel	Spinel	Reds
Topaz	Topaz	Purples, reds
Tourmaline	Tourmaline	Reds, blue-greens
Turquoise	Turquoise	Blues
Zircon	Zircon	Reds

Teaching Tips

- Stories of mystery, adventure, and intrigue surround some of the more famous gemstones, such as the Hope Diamond. Invite students to research some of these stories and share them with the class. You might suggest some students create a booklet for distribution among the class.
- Invite a jeweler, gem cutter, or gemologist to the class to discuss how a rough stone is turned into a beautifully cut gem. Note how hardness, cleavage, and refraction are taken into account when cutting gems.

Verbal, Interpersonal