CHAPTER 1

Minerals

INTRODUCTION

Geology deals with the physical and historical aspects of the Earth. Physical geology is the study of the composition, behavior, and processes that affect the Earth's lithosphere. The science of geology also provides the means to discover and utilize the Earth's natural resources (coal, gas, petroleum, minerals, etc.). Geologists also study the Earth and its processes so that they can better understand and predict potentially dangerous geologic situations (earthquakes, volcanic eruptions, floods, etc.), which results in the saving of lives. Historical geology, the second introductory course, deals with geology as it relates to the Earth's history.

This laboratory manual begins with the study of common Earth materials, minerals, and rocks that make up the lithosphere, and proceeds to the kinds of forces and situations that can alter (build up or tear down) the surface of the planet.

MINERALS

Minerals are the basic building blocks of nearly all Earth materials for most geological purposes. A mineral is a naturally occurring, solid, inorganic combination (compound) of one or more elements, whose atoms are arranged in an orderly fashion (crystallinity), and has an established chemical composition that can vary slightly within specific limits. Minerals also have a set of physical properties (hardness, color, etc.) that distinguish them from each other. *"Inorganic"* means that the compound was not the result of organic processes.

Natural compounds are not "pure" in the pharmaceutical sense, particularly if modern analytical methods are used. Most chemical elements can be shown to consist of several "isotopes," atoms of different atomic weights that have a closely similar set of chemical properties. Minerals as natural compounds are fairly complicated. They consist of one or more elements that consist of one or more isotopes, are not absolutely "pure" compounds, and show some variation, even within materials called by the same mineral name. The guideline geologists have agreed on to define a particular mineral is the nature of the internal geometric arrangement (the crystallinity) of the atoms. This arrangement is usually called the crystal structure (technically, the term "crystal structure" is redundant—the word "crystal" by itself is sufficient). Materials such as glass and opal have no particular geometric arrangement of their atoms, and are not true minerals because they lack crystallinity. The term "mineraloid" is used for these materials, and some mineraloids are simply called rocks (natural glass, obsidian, is a kind of volcanic rock).

SUMMARY: a material must be/have the following characteristics to be classified as a mineral:

1. be naturally occurring (not man-made).
2. be solid.
3. be inorganic (not compounds that can be produced only by living organisms).
4. have **a** geometric arrangement of its atoms—crystallinity.
5. have a chemical composition that can vary only according to specific limits.

A substance that satisfies these requirements will have a characteristic set of physical properties that can be used for identification.

Common Minerals

Many of the minerals studied in the laboratory (Table 1.1) are familiar to nongeologists. Some elemental materials (sulfur, graphite, and diamond) are classified as minerals when found in large, natural cohesive quantities. Quartz ($Si0_2$, silicon dioxide) is the most commonly known mineral. Varieties of quartz include: rose quartz, milky quartz, chert (in many different colors), flint, agate, rock crystal (clear), amethyst (purple), aventurine (green), jasper (red), etc. Halite (NaCl, sodium chloride) is probably the most commonly used mineral and is found in most spice cabinets as table salt. Minerals have many unexpected uses and a list of some of these uses is found at the end of this chapter.

Physical Properties of Minerals

All minerals have **a** set of distinctive physical properties that can be used to identify them. The goal of the student is to become familiar with geological terminology and apply the terms to unknown mineral specimens in order to correctly identify them.

Students should note that the physical properties of each different mineral group are not absolutes. Hardness is one property that can vary from sample to sample of the same mineral. The mineral magnetite has a hardness of 6, but it can actually range between 5.5 and 6.5. Therefore, some specimens of magnetite will easily scratch a glass plate (hardness Ss 6) and some specimens may barely scratch glass or not scratch it at all. Color is another property of minerals that can vary widely and thus should not be the only criterion used for identification of an unknown mineral specimen. Quartz comes in many different colors and is easily confused with other minerals of similar color. Amethyst purple quartz is easily mistaken for purple fluorite, and vice versa. The student should not use any one property alone to identify unknown minerals. A group of physical properties leads to a more accurate identification.

Crystal Form

Crystal form is the geometric arrangement of plane ("flat") surfaces on the outside of a mineral that reflect the internal crystallinity of the mineral (Fig. 1.1a and Fig. 1.1b). Crystal faces develop only when the crystal has enough room to grow without interference. The planar (flat) sides of a cube, for example, are called **faces.** A cube is a crystal form that has six faces (flat sides) (Fig. 1.1a). Halite and fluorite often have *cubic ciystal form,* while garnet and pyrite have more complicated crystal forms that are variations on the cube. Corundum, quartz, and calcite show different variations on the *hexagonal (six-sided) ciystal form* (Fig. 1.1b). The hexagonal form of calcite (Fig 1.1b) is the most difficult of these to see, but **a** calcite crystal will have one or two sharp points, and if one looks along the line between these two points, the visible outline is hexagonal. Minerals without an external crystal form are referred to as massive (chert, limonite, etc.).

TABLE 1.1 Chemical Groups of Selected Minerals

Chemical Class	Mineral/Mineraloid	Chemical Composition	
Natives Only one kind of element present, "naturally pure"	Sulfur Graphite/diamond (not available)	S C	(Sulfur) (Carbon)
Oxides (A metal bonds directly with oxygen as the nonmetal)	Quartz (quartz crystal, milky, rose, chert, smoky, agate, etc.) Oxides of Iron: Oolitic Hematite Specular Hematite Goethite Limonite (mineraloid) Magnetite Corundum Bauxite (mineraloid)	$Si0_2$ Fe_20_3 Fe_20_3 FeO(OH) $Fe_20_3nH_20$ Fe_30_4 $A1_20_3$ $Al_20_3nH_20$	(Silicon dioxide) (Iron oxide) (Iron oxide) (Hydrous iron oxide) (Hydrous iron oxide) (Iron oxide) (Aluminum oxide) (Hydrous Al oxide)
Sulphides (A metal bonds directly with sulfur as the nonmetal)	Pyrite Galena Sphalerite	FeS_2 PbS ZnS	(Iron sulfide) (Lead sulfide) (Zinc sulfide)
Sulfates (A metal bonds with the $S0_4$ complex ion acting as a nonmetal)	Gypsum (Selenite, Satin spar, Alabaster) Anhydrite	$CaS0_4$ $2H_20$ $CaS0_4$	(Hydrous calcium sulfate) (Calcium sulfate)
Carbonates (A metal bonds with the $C0_3$ complex ion acting as a nonmetal)	Calcite Dolomite	$GaC0_3$ $MgCaC0_3$	(Calcium carbonate) (Calcium-magnesium carbonate)
Halides (A metal bonds with a halogen [CI, F, Br or I] as the nonmetal)	Halite Fluorite	NaCl CaF_2	(Sodium chloride) (Calcium fluoride)

Silicates (A metal bonds with the $Si0_4$ complex ion as the nonmetal)

Nesosilicates (island silicates)	Olivine Garnet	(Fe, Mg)$Si0_4$ (Iron magnesium silicate) Complex Ca, Mg, Fe, Al silicate
Inosilicates (chain silicates)	Hornblende Augite	Ca, Na, Fe, Mg, Al silicate $(Ca,Na)(Mg,Fe,Al)(Si,Al)_20_6$
Phyllosilicates (sheet silicates)	Muscovite Biotite Chlorite Talc Kaolinite	OH, K, Al silicate (Hydrous potassium-aluminum silicate) OH, K, Mg, Fe, Al silicate OH, Mg, Fe, Al silicate OH, Mg silicate OH, Al silicate
Tectosilicates (3-D silicates)	Orthoclase Plagioclase (Albite, Labradorite) Quartz	K, Al silicate Ca, Na, Al silicate SiQ_2

Crystal Systems

Crystal systems are groups of crystals based on the symmetry of crystal faces. There are six crystal systems and within these systems there are the thirty-two classes of minerals. The six crystal systems are cubic (isometric), hexagonal, tetragonal, orthorhombic, monoclinic, and triclinic (Fig. 1.1a and Fig. Lib).

The cubic (isometric) crystal system consists of three equal-length axes intersecting at 90° angles from one another. The hexagonal crystal system consists of three equal-length axes that intersect at 120° angles to one another and a fourth axis perpendicular the first three axes. The tetragonal crystal system consists of two equal-length axes and a third axes of a different length, all at 90° angles to one another. The orthorhombic crystal system consists of three axes of different lengths that intersect at 90° angles to one another. The monoclinic crystal system consists of two unequal-length axes that intersect at 90° angles and a third that intersects obliquely. The triclinic crystal system consists of three unequal-length axes that intersect obliquely. Crystal systems are studied in more detail in the upper-level Mineralogy course.

Crystals "grow" as "invisible atoms" of a solution bond together in a given geometric framework that is consistent with the atoms' electrical or size characteristics. As the geometric framework enlarges with continued "growth," that geometry becomes visible as smooth surfaces that are called crystal faces. The smooth crystal faces give crystals of various minerals their characteristic shape and beauty.

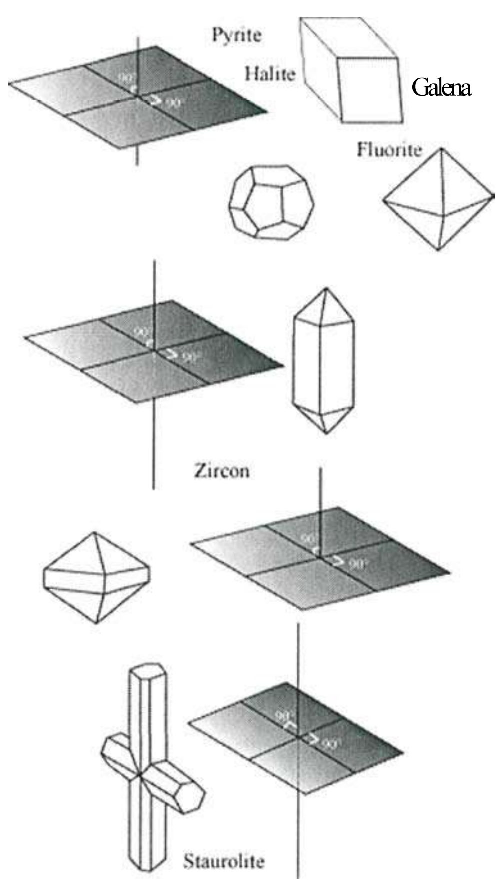


FIGURE 1.1a Crystal Systems, Crystal Forms, and Typical Minerals.

Isometric (Cubic) Ciystal System Three equal-length axes that intersect at 90" angles. Two of the axes intersect on the same plane, and the third is perpendicular.

Typical Minerals

- Pyrite
- Malite
- Fluorite
- Galena
- Magnetite

Tetragonal Ciystal System Two equal-length axes and a third, either longer or shorter, that intersect at 90" angles. Two of the axes intersect on the same plane, and the third is perpendicular.

Typical Mineral

- Zircon

Orthorhombic Ciystal System Three axes of different lengths that intersect at 90" angles. Two of the axes intersect on the same plane, and the third is perpendicular.

Typical Minerals

- Topaz
- Staurolite

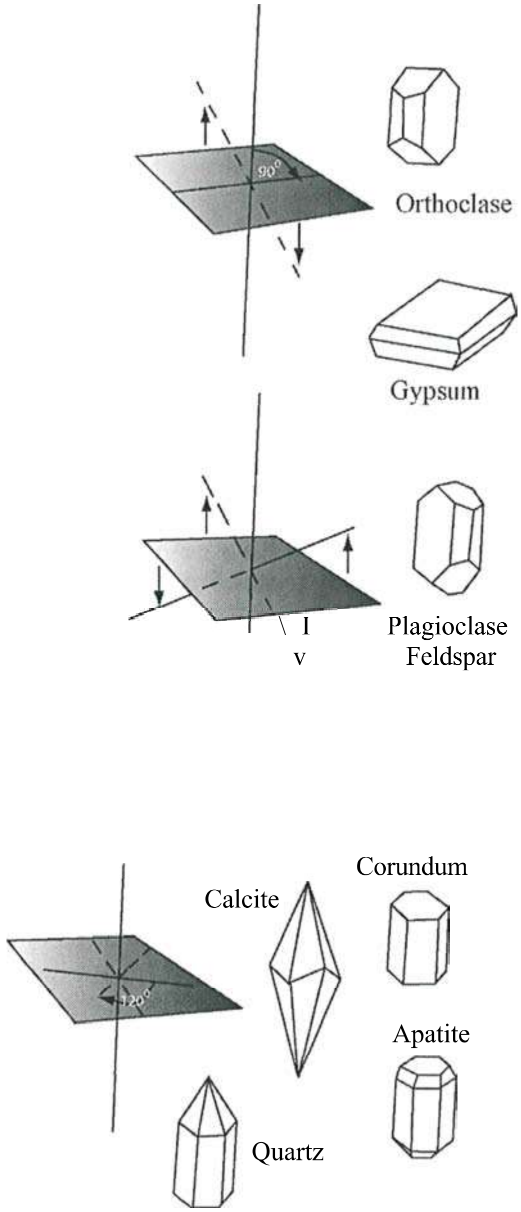


FIGURE 1.1b Crystal Systems, Crystal Forms, and Typical Minerals.

Monoclinic *Crystal System* Two unequal-length axes that intersect at 90° angles on the same plane, and a third that intersects obliquely.

Typical Minerals

Orthodase

Gypsum

Triclinic *Crystal System* Three unequal-length axes that intersect obliquely.

Typical Minerals

Plagioclase Feldspar

Hexagonal Crystal System Three unequal-length axes that intersect at 120° angles on the same plane, and a fourth that is perpendicular to the other three.

Typical Minerals

Quartz

Corundum

Apatite

Calcite

Cleavage

Cleavage is the tendency of a mineral to break in a systematic (regular, ordered) way, along planes of weakness determined by the type and strength of the chemical bonds (see lecture book) between the atoms that make up the mineral (Fig. 1.2a and Fig. 1.2b). The cleavages (planes of weakness) represent layers between rows or sets of planar atoms where the atomic bonds are weaker. Some minerals (micas and gypsum) have one direction of cleavage (Fig. 1.2a) but most minerals have multiple cleavage directions. *Not all specimens of a given mineral will have readily identifiable cleavage planes,* although it is a useful identifying feature when present. Even when cleavage planes are not visible on a particular hand specimen, it does not mean that the mineral lacks cleavage. Look at other examples of the same mineral. Some cleavage surfaces are microscopic and therefore invisible to the naked eye. Since many minerals do not have cleavage or have microscopic cleavage (not visible to the naked eye), you can use the presence of visible cleavage to eliminate those minerals that do not have cleavage. Some minerals always demonstrate cleavage, such as muscovite and biotite, which have cleavage in one direction. Muscovite and biotite easily cleave (split) into flat, flexible sheets.

Unfortunately, cleavage and crystal form are easily confused. They both result in flat planes, but for different reasons. Some minerals have both crystal form and cleavage (halite, fluorite, calcite, etc.), some only have cleavage (muscovite), and some only have crystal form (quartz). *Minerals with cleavage will break in the same direction or set of directions every time and form flat planes or a stair-step pattern on the mineral face.* A mineral with only crystal form will break in no particular direction and develop irregular (uneven) surfaces when broken.

Fracture

Fracture is the nonsystematic and irregular way some minerals break. The fracture surface is rough or uneven, unlike cleavage planes, which are smooth and flat. **Conchoidal fracture** is a special kind of breakage that results in a curved parting surface. When a bullet passes through glass, a curved or listric surface is produced (conchoidal fracture). Conchoidal fracture is characteristic of homogenous materials that lack planes of weakness, thus the material is about equally strong in all directions (e.g., glass). Quartz commonly shows conchoidal fracture.

NOTE: Some minerals display both fracture and cleavage. Albite, for example, has two directions of cleavage (two flat sides) and two opposing sides with fracture (rough sides).

Striations

Striations are very fine, parallel lines visible on the cleavage planes or crystal faces of some minerals due to their crystal structure and growth patterns. Albite and labradorite, both plagioclase feldspars, commonly exhibit striations on one cleavage plane. The striations on plagioclase become increasingly obvious as the calcium content of the feldspar increases. Striations may also be visible on the crystal faces of other minerals such as pyrite, quartz, and garnet. Striations become more visible when the mineral is slightly rotated back and forth in the light. As the mineral is turned, the striations reflect the light.

Cleavage: Cleavage is the tendency of certain minerals to split (cleave) along planes of weakness, between layers of weak bonds that unite the atoms of which the mineral is made, when the mineral is broken. Some minerals cleave in only one direction, others have two, three, four, or even six directions of cleavage. Examples are shown below.

CAUTION: Beginning geology students often confuse the smooth cleavages surfaces with the smooth crystal faces of minerals crystals, and thus often believe that cleavage "chunks" are crystals. Crystal faces are produced when minerals "grow" as invisible "atoms" of various elements within a solution and bond together in a given geometric framework called crystallinity. The cleavage surfaces of cleavage "chunks" form when the mineral breaks.

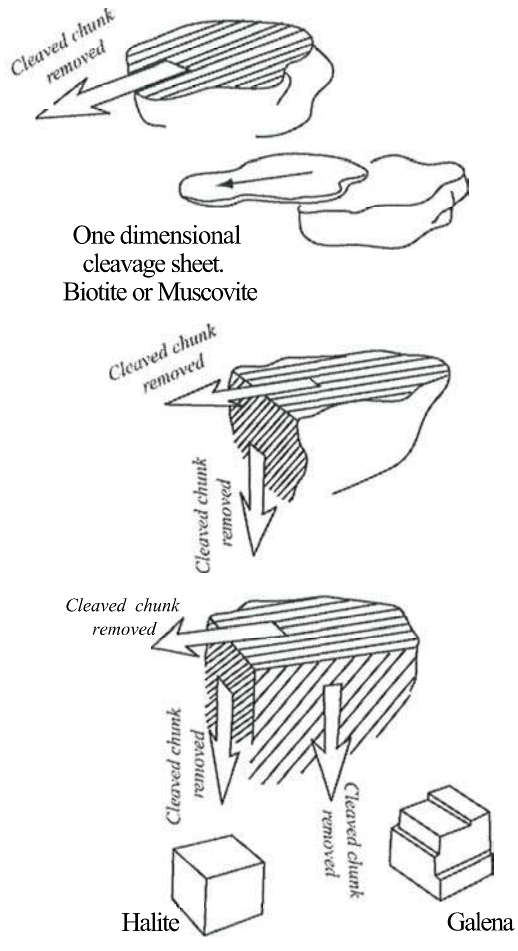


FIGURE 1.2a Cleavage

One Direction of Cleavage Certain minerals, when broken, break only along one plane.

Typical Minerals

- Biotite
- Muscovite
- Chlorite
- Talc
- Selenite Gypsum

Two Directions of Cleavage Certain minerals, when broken, break along two plane surfaces that intersect at a 90° angle to each other.

Typical Minerals

- Orthoclase Feldspar
- Plagioclase Feldspar

Three Directions of Cleavage Certain minerals, when broken, break along three plane surfaces that intersect at a 90° angle to each other.

Typical Minerals

- Galena
- Halite

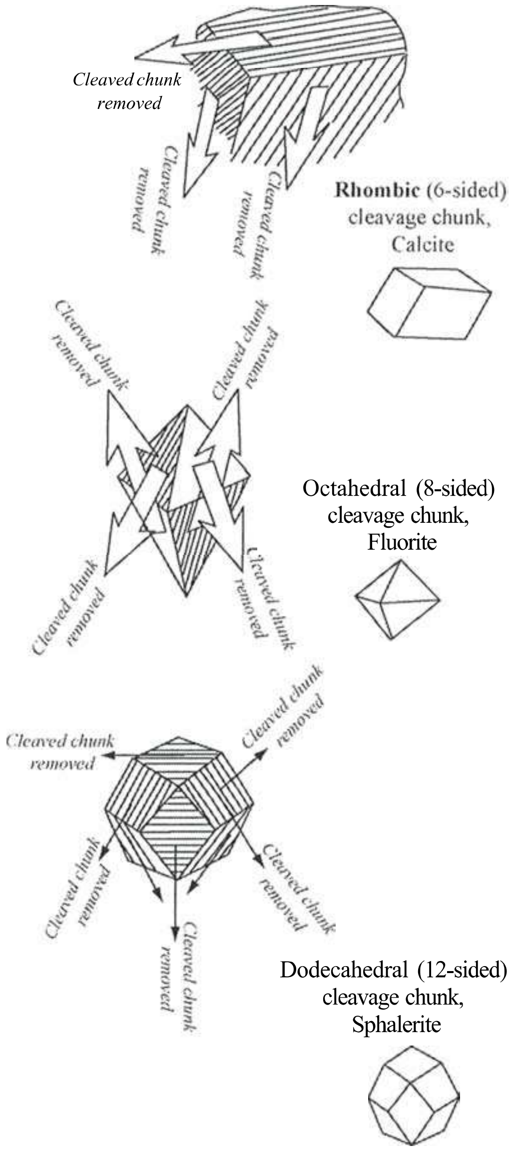


FIGURE 1.2b Cleavage.

Three Directions of Cleavage Certain minerals when broken, break along three planer surfaces that intersect obliquely to each other.

Typical Minerals

Calcite

Four Directions of Cleavage Certain minerals, when broken, break along four planar surfaces that intersect at different angles.

Typical Minerals

Fluorite

Six Directions of Cleavage Certain minerals, when broken, break along six planar surfaces that intersect at different angles to each other.

Typical Minerals

Sphalerite

Tenacity

Tenacity is the resistance of a mineral to breakage. Some minerals are very hard to break, whereas others are easily broken. Terms used to describe tenacity include brittle, elastic, and malleable. Gold, a soft mineral, is malleable and easily deformed when hit. Diamond, the hardest known mineral, is very brittle and will shatter when hit. Do not test the tenacity of mineral specimens unless instructed to do so.

TABLE 1.2 Mohs' Scale of Hardness

10	Diamond		
9	Corundum		
8	Topaz		
7	Quartz		
6	Orthoclase Feldspar	5.5	Steel Nail/Knife Glass Plate
5	Apatite		
4	Fluorite	3.5	Copper Penny
3	Calcite	2.5	Fingernail
2	Gypsum		
1	Talc		

Hardness

Hardness is a mineral's resistance to being scratched. Some minerals are soft enough that they can be scratched with a fingernail, while others are hard enough to scratch glass. The relative hardness of a mineral is determined with the use of **Mohs Scale of Hardness.** The hardness scale is named after Freidrich Mohs (1773-1839), the German mineralogist who developed it. Mohs arranged common or certain unique minerals in order of their increasing relative hardness to provide a standard (or scale) to which all other minerals can be compared. Mohs chose talc to represent the softest mineral and diamond to represent the hardest mineral (Table 1.2). Some common everyday materials also fit conveniently into the Mohs scale. These include fingernails, copper pennies, steel nails and knives, and glass plates.

The best way to determine hardness is to find the softest material that will scratch the mineral being tested. For example, a fingernail cannot scratch calcite but a copper penny can; therefore the hardness of calcite is between that of a fingernail and that of a penny (2.5-3.5). Since calcite is one of the minerals on the Mohs scale its exact hardness is known (3). For minerals that aren't included on the Mohs scale, the student should use the smallest hardness range possible. The Mineral Property List at the end of the chapter lists the hardness or hardness range of each mineral. You do not have to memorize the exact hardness of every mineral, although you should learn those that are on the Mohs scale. In general, minerals can be separated into two groups, those that are harder than the glass plate (scratch the glass) and those that are softer than the glass plate (do not scratch the glass). The student can then begin the process of identification of mineral unknowns by separating the minerals into hardness groups. Then determine the other physical properties (crystal form, cleavage, fracture, etc.) to identify the unknown minerals.

Color

Color is a function of how the surface of a mineral reflects or absorbs white light. It is one of the least helpful physical properties of minerals because very few have a consistent color. The mineral sulfur is an exception—it is always bright yellow—as is pyrite, which is a brassy yellow. Both calcite and quartz are good examples of how color is varies within a mineral. They can be green, yellow, red, brown, blue, clear, etc. There are three general causes of color variation in minerals.

1. Impurities within the mineral change the color.
2. The disturbance of the crystallinity of the mineral can cause variations in color.
3. The size of the mineral pieces can affect color. Thin pieces usually are lighter in color than thicker pieces (one of the most common causes of color variation).

Although minerals can be grouped into groups of darker and lighter hues, do not count on color alone to identify unknown minerals.

Streak

Streak is the color of a mineral's powder (or the color of the mineral when the crystals are very **small).** The streak is obtained by rubbing the mineral on an unglazed ceramic or porcelain plate. Gently shake or blow off as much as possible of the powdered mineral formed in this way. *The color of the powder that sticks to the streak plate is the actual streak.* The mineral hematite illustrates the importance of streak in mineral identification. Varieties of hematite often have a visibly different color from one another (specular hematite is silvery and oolitic hematite is reddish brown), yet both have a red-brown streak.

Luster

Luster is the way that a mineral reflects light. It is described as either **metallic** (like fresh, untarnished metal) or **nonmetallic** (pearly, waxy, greasy, vitreous [like glass], earthy, rusty, etc.).

Reaction to Dilute Hydrochloric Acid

Some minerals will chemically react (fizz, give off H_20 and bubbles of $C0_2$) in the presence of a dilute solution of hydrochloric acid (HO). This test is primarily used to identify calcite ($CaC0_3$) and dolomite [$CaMg(C0_3)_2$]. Calcite reacts strongly with cool, dilute HC1, and *most* dolomites only react when powdered. Scratch dolomite with a nail to produce enough powder to test its reaction with acid. Apply one to two drops of acid on the powder. *After the acid is applied and the result noted, wipe the excess acid off the mineral and/or streak plate with a paper towel.*

> **CAUTION:** All students are to wear safety goggles when using acid. Apply acid one drop at a time to the specimen and wipe the acid off the specimen before putting it back in its place.

Magnetism

Magnetism is the attraction of a magnet to the mineral. Minerals vary from nonmagnetic (most minerals) to weakly magnetic (some hematite) to strongly magnetic (magnetite).

Density

Density is mass per unit volume. **Specific gravity** is the ratio of the density of a given material to the density of an equal volume of water (at 4° C). Minerals that have a high specific gravity, such as galena, feel unusually heavy for their size, whereas those with low specific gravity feel lightweight.

Diaphaneity

Diaphaneity refers to how and to what extent light is transmitted through a mineral. A thin section is a 0.03-mm slice of a mineral that is thin enough to allow light to pass through it. Although diaphaneity is usually applied to thin sections, we will apply the same terms to the hand samples seen in the laboratory. The diaphaneity for each mineral is determined simply by looking at it.

1. **Transparent:** light passes easily through the mineral, thus images can be *clearly seen* through it. Clear quartz is an example.
2. **Translucent:** some light passes through the mineral but the light is diffused and absorbed internally by the mineral, thus images cannot be seen clearly. Translucency is, in part, a matter of the thickness and purity of the mineral. Hematite is usually thought of as opaque, but extremely small, pure crystals are translucent. Although pure quartz is clear and colorless, the presence of large numbers of very small bubbles (milky or vein quartz) can make it translucent. Disturbance of the crystal by radiation from decaying radioactive elements can make quartz gray, brown, or black, and the crystal, particularly if thick, may be translucent, or nearly opaque (see below).
3. **Opaque:** the mineral allows no light to pass, thus *images cannot be seen through the mineral.* Opacity ("opaqueness") is, in part, a matter of the thickness and purity of the crystal. Very pure minerals with metallic or submetallic luster (pyrite, magnetite) are opaque even in very thin slices (thin sections). Luster and opacity are tied together by the extreme ability of these minerals to bend light.

Double Refraction

Double refraction is the doubling of a single image seen through a transparent mineral. Minerals, except the cubic ones (such as fluorite, halite, and diamond), split light rays into two parts that follow different paths as they pass through the crystal. Optical quality calcite crystals are the best example of this because the two parts of the light follow very different paths. To see double refraction, place an example of optical quality calcite on this page and look at the words. Special microscopes and specially prepared specimens are used in serious work with double refraction, but geologists frequently make use of this property in hand specimen mineral identification.

Other Identifying Properties

There are other properties that help identify unknown minerals. Many minerals have a strong smell, such as sulfur (like rotten eggs). A fresh streak of sphalerite smells strongly of sulfur. The way minerals feel can also be used in conjunction with other properties. The longer a person handles halite, the greasier it feels. Taste can also be used for identification purposes. Halite (salt) tastes salty. **DO NOT TASTE ANY MINERALS IN LAB.**

IDENTIFICATION OF MINERAL UNKNOWNS

The identification of mineral unknowns is easier for the beginning geology student if a logical step-by-step procedure is followed.

- **Step** one: Separate the minerals into like shades of color. See the "Mineral Identification Key" (Fig. 1.3). Put all the white or light-colored minerals in one pile, the dark-colored minerals in another pile, and the metallic minerals in a third pile.
- **Step** two: Determine the relative hardness of each mineral. Place the light-colored minerals that have a hardness of less than 5 V2 m t o a subpile and all the minerals greater than 5'/2 m t o another. Repeat this step with the dark-colored and metallic minerals.
- **Step three:** Separate the minerals into groups that have and do not have visible cleavage.
- **Step four:** Suggest a tentative identification of the mineral and then consider the other physical characteristics of the mineral to make a positive identification. Place the minerals on the figures as you determine their identity, and your instructor will verify your identification.

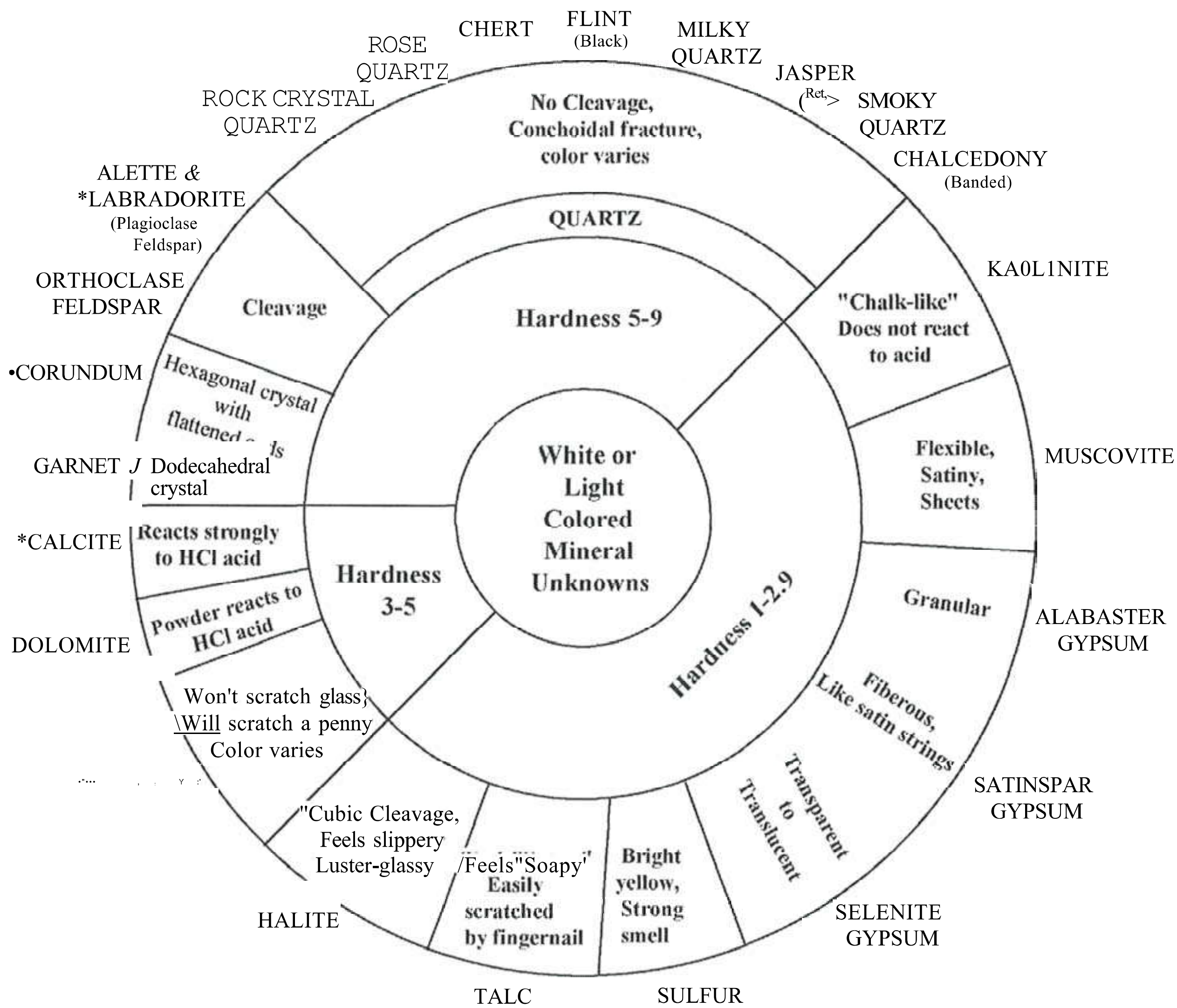
Use the "Guide to the Identification of White or Light Colored Minerals" and "Guide to the Identification of Dark, Metallic or Green Unknowns" as study guides for review.

Mineral pictures can be found on the Earth & Space Sciences website (http://ess.lamar.edu/). Click on People, Staff, Woods, Karen M., Teaching, Physical Geology Lab, Minerals.

	[Hardness >5J		[Hardness <5j	
	[Cleavage]	[No Cleavage)	[Cleavage 1	[No Cleavage]
Nonmetallic Luster Light Colored Minerals	Alb'ne (Plagioclase Feldspar) Labrador! te (Plagioclase Feldspar) Orthoclase Feldspar	Corundum Cheri Milky Quartz Rock Crystal Quartz. Rose Quartz Smokey Quartz	Calcite Dolomite Fluortte Halite Muscovite Selenite Gypsum	Alabaster Gypsum Kaolinite Saiin Spar Gypsum Sulfur *Tale
Nonmetallic Luster Dark Colored Minerals	Augiie Labradoite (Plagioclase Feldspar) Hornblende	Chert Corundum Garnet Limonite **Magnetite ()olitJC Hematite Olivine Smokey Quartz	Biotite Calcite •Chlorite Fluorite "'Sphalerite	Bauxite *Goethite *Talc
Metallic Luster		"'Magnetite Pyrite Specular Hematite	Galena Graphite	*Clcavage not visible ••Luster can be cither metallic or nomnctaltic ***Subi!ieta!lie luster (shim like plastic)

FIGURE 1.3 Mineral Identification Key.

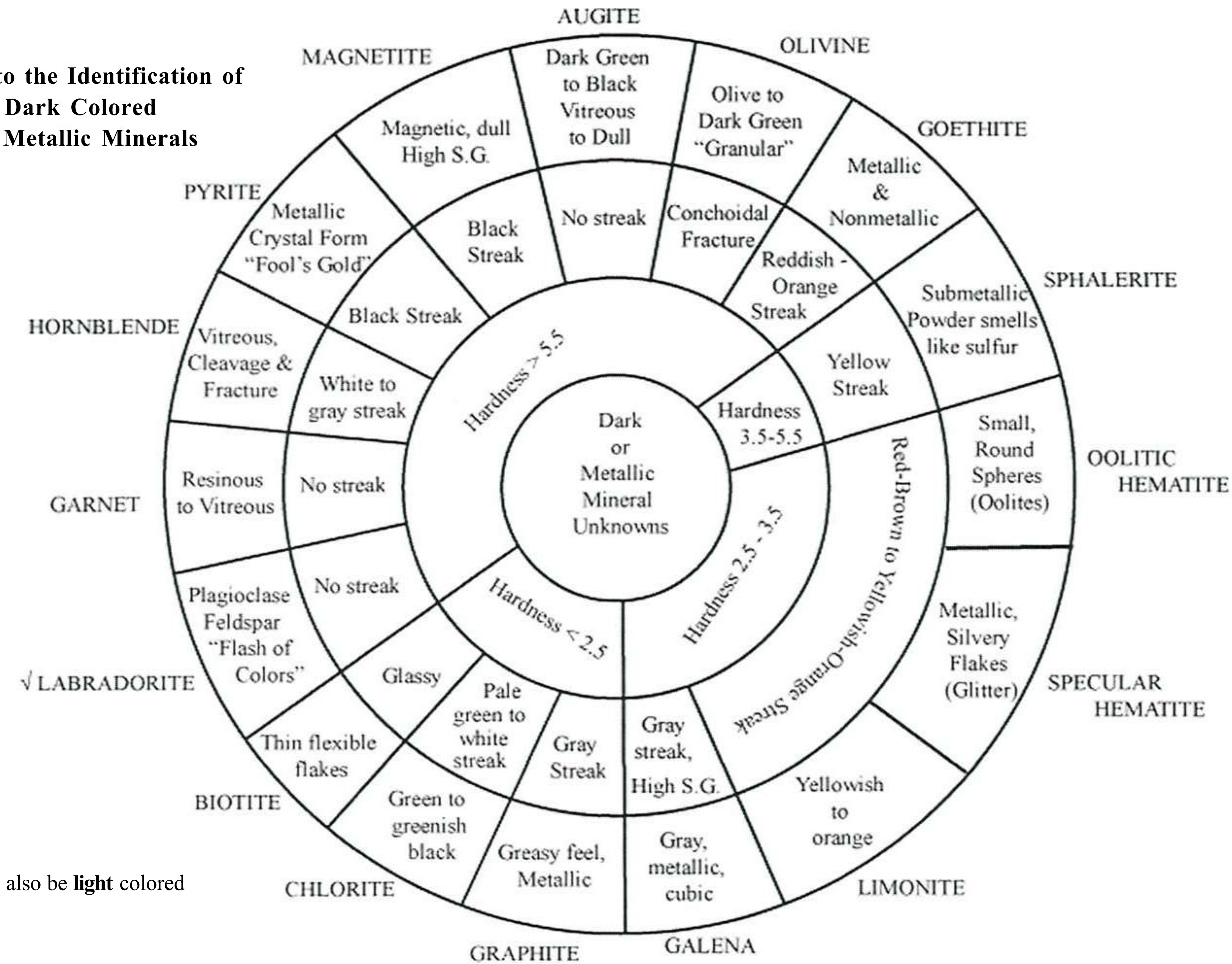
Guide to the Identification of White or Light Colored Unknown Minerals



How to Use: 1. Determine the general hardness of the unknown mineral.
2. Match the unknown mineral to the characteristics in the outer circle that correspond with the hardness determined.

*May also be dark in color

Guide to the Identification of Dark Colored or Metallic Minerals



V May also be **light** colored

MINERAL PROPERTY LIST

Augite—Augite is a pyroxene with two cleavage planes, one at 87° and the other at 93°. Augite is dark green to black, has a vitreous to dull luster, a specific gravity of 3 to 3.5, a hardness that ranges from 5 to 6, and lacks a streak. Other identifiable properties include a hackly or splintery fracture opposite to the cleavage direction. Crystal system: monoclinic. Chemical formula: $(Ca,Na)(Mg,Fe,Al)(Si,Al)_2 0_6$ (calcium, sodium, magnesium, iron, aluminum silicate).

Bauxite—Bauxite (a mineraloid) is brown, gray, white, or yellow, has a dull to earthy luster, no cleavage, a white to yellow-brown streak, and a hardness that ranges from 1 to 3. Bauxite usually occurs in compact masses of pisoliths (pea-sized concretions, spheres coarser than ooliths). Fracture is uneven. Chemical formula: AlO(OH) (hydrous aluminum oxide).

Biotite—Biotite is a black to dark brown mineral with a vitreous to pearly luster. Biotite has perfect cleavage in one direction, allowing it to be separated into thin sheets. Biotite has a brown to dark green streak if the specimen is big enough, and a hardness of 2.5 to 3. Fracture is uneven perpendicular to cleavage direction. Crystal system: monoclinic. Chemical formula: $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$, (hydrous potassium, magnesium, iron, aluminum silicate).

Calcite—Calcite is usually white to colorless, but may be yellow, green, blue, red, black, etc. due to impurities. Calcite has perfect rhombohedral cleavage (see photo), hexagonal crystal form (if present), a white to gray streak, and a vitreous to earthy luster. Hardness is 3 on the Mohs scale. Specific gravity is 2.71. Calcite is soluble in dilute hydrochloric acid with a strong effervescence (fizz). Double refraction **is** visible through colorless rhombs. Crystal system: hexagonal. Chemical formula: $CaC0_3$ (calcium carbonate).

Chlorite—Chlorite is a green to greenish-black mineral with a waxy to earthy luster. Chlorite has a perfect basal cleavage (not apparent in massive pieces), and a pale green to white streak. The specific gravity is 3 and hardness is 2 to 2.5. Chlorite feels slippery. Crystal system: monoclinic. Chemical formula: $(Mg,Fe)_3(Si,Al)_4 0_{K)}(OH)_2(Mg,Fe)_3(OH)_6$ (magnesium, iron, aluminum silicate).

Corundum—Corundum varies in color (brown, blue, red, etc.), has an adamantine to vitreous luster, a hardness of 9 on the Mohs scale, and a specific gravity of 4. Corundum is found in massive deposits as emery and as hexagonal crystals (see photo) with striations on basal faces and has conchoidal fracture. Gem-quality corundum is commonly known as sapphire and ruby. Crystal system: hexagonal. Chemical formula: $Al_2 0_3$ (aluminum oxide).

Dolomite—Dolomite varies from colorless to white, gray, brown, and pink. Dolomite has perfect rhombohedral cleavage, hexagonal crystal form, and a dull to vitreous to pearly luster. Cleavage and crystal form are not evident in massive pieces. Specific gravity is 2.85, hardness is 3.5 to 4, and dolomite has a white streak. In powdered form, dolomite effervesces in cold, dilute hydrochloric acid. Crystal system: hexagonal. Chemical formula: $CaMg(C0_3)_2$ (calcium, magnesium carbonate).

Fluorite—Fluorite has perfect octahedral cleavage, cubic crystal form, and conchoidal fracture. Fluorite is colorless and transparent when pure but may be blue, green, pink, purple, yellow, or black. Fluorite has a vitreous luster, specific gravity of 3.18, hardness of 4, and a white streak. Crystal system: isometric (cubic). Chemical formula: CaF_2 (calcium fluoride).

Galena—Galena has a perfect cubic cleavage and cubic or octahedral crystal form. Galena is lead gray, has a gray streak, metallic luster, and a hardness of 2.5. Galena has a high specific gravity (7.57). Crystal system: isometric (cubic). Chemical formula: PbS (lead sulfide).

Garnet—Garnet has a splintery or conchoidal fracture, no cleavage, and a resinous to vitreous luster. Color varies with composition but is commonly dark red to reddish brown or yellow. Garnet forms dodecahedral crystals in some metamorphic rocks and is also found in coarse granular masses. Garnet has a specific gravity of 3.5 to 4.3, and **a** hardness of 6.5 to 7.5. Crystal system: isometric (cubic). Chemical formula: Fe, Mg, Mn, Ca, Al silicate (complex iron, magnesium, manganese, calcium, aluminum silicate).

Goethite—Goethite is a variety of iron oxide. Goethite has a prismatic ciystal form and cleaves parallel with the prisms. Goethite is yellow or yellowish-brown to silvery brown in color, has a brownish-yellow streak, a specific gravity of 4.37, and a hardness that ranges from 5 to 5.5. Massive goethite has an adamantine to dull luster. Goethite is also found with rounded (reniform) masses that have a metallic luster. Crystal system: orthorhombic. Chemical formula: FeO(OH) (hydrous iron oxide). Pronounced "guhr-thite."

Graphite—Graphite has perfect cleavage in one direction, although the mineral is usually found as foliated masses. Graphite is dark gray to black in color, has a gray to black streak, a metallic luster, a specific gravity of 2.23 (low), and a hardness of 1 to 2. Graphite feels "greasy." Crystal system: hexagonal. Chemical formula: C (carbon).

Gypsum—Gypsum is translucent and generally white, but may be tinted to various colors. Gypsum has a white streak, pearly to vitreous luster, cleavage a conchoidal, irregular, or fibrous fracture, a specific gravity of 2.32, and a hardness of 2 on the Mohs scale. Crystal system: monoclinic. Chemical formula: $CaSCy2H_20$ (hydrous calcium sulfate). Three varieties are distinctive.

Alabaster gypsum—Alabaster is the fine-grained, massive variety of gypsum. Alabaster, also called rock gypsum, is generally white, but may be slightly tinted with other colors. It has a pearly luster and cleavage is not apparent. Chemical formula: See above.

Selenite gypsum—Selenite gypsum has perfect cleavage in one direction and a conchoidal fracture. Selenite is colorless to white, transparent to translucent, and has **a** vitreous luster. Chemical formula: See above.

Satin spar gypsum—Satin spar gypsum is fibrous, colorless to white, and has a silky luster. Cleavage is not apparent in this variety. Chemical formula: See above.

Halite—Halite has perfect cubic cleavage and cubic crystal form (see photo). Halite **is** colorless to white but impurities can give it a yellow, red, blue, or purple **tint.** Halite is transparent to translucent, has a vitreous luster, a specific gravity of 2.16, **and a** hardness of 2.5. Halite feels greasy and tastes salty **(tasting of laboratory specimens is not recommended).** Crystal system: isometric (cubic). Chemical formula: NaCl (sodium chloride).

Hematite—Hematite is steel gray, to black, to red, to reddish brown. Hematite has a red to red-brown streak, a specific gravity of 5.26, a hardness that ranges from 5.5 to 6.5, an irregular fracture, and a metallic or a dull luster. Crystal system: hexagonal. Chemical formula: Fe_20_3 (iron oxide). Oolitic and specular are two important varieties.

Oolitic hematite—Oolitic hematite is composed of small spheres (ooliths) of hematite. Oolitic hematite is red to brownish red, has a red streak, and an earthy luster. See hematite above for other properties. Chemical formula: See above.

Specular hematite—Specular hematite has a platy (glitter-like) appearance and may be slightly to strongly magnetic. Specular hematite is steel gray or "silvery" with a metallic luster, and has a red streak. See hematite above for other properties. Chemical formula: See above.

Hornblende—Hornblende is dark green to black, has a vitreous luster, a specific gravity of 3 to 3.5, a white to gray streak, and a hardness of 5 to 6. Hornblende is an amphibole with two cleavage angles (56° and 124°) and an uneven fracture opposite of the cleavage directions. Crystal system: monoclinic. Chemical formula: Ca, Na, Mg, Fe, Al silicate (calcium, sodium, magnesium, iron, aluminum silicate).

Kaolinite—Kaolinite has perfect cleavage (not apparent in massive pieces). Kaolinite is white, has a dull to earthy luster, a white streak, a specific gravity of 2.6, and a hardness of 2. Kaolinite looks and feels like chalk, a kind of limestone, but does not react with hydrochloric acid. Kaolinite fractures irregularly. Crystal system: tridinic. Chemical formula: $Al_4Si_4O_{10}(OH)_8$ (hydrous aluminum silicate).

Limonite—Limonite, a variety of iron oxide, is dark brown to brownish yellow, has a yellow to brown streak, an earthy to dull luster, a specific gravity of 2.9 to 4.3, and a hardness of 4 to 5.5. Limonite fractures irregularly. Chemical formula: FeO(OH) (hydrous iron oxide).

Magnetite—Magnetite is a black mineral with a gray to black streak, a specific gravity of 5, a hardness of 5.5 to 6, a dull luster, is strongly magnetic, and fractures irregularly. Crystal system: isometric (cubic). Chemical formula: Fe_30_4 (iron oxide).

Muscovite—Muscovite is colorless to brown, gray, or green. Muscovite has a vitreous to silky to pearly luster, perfect cleavage in one direction allowing it to be separated into thin flexible sheets, a white streak (if sample is thick enough), a specific gravity of 2.8, and a hardness of 2 to 2.5. Fracture is uneven perpendicular to the cleavage direction. Crystal system: monoclinic. Chemical formula: $KAl2(AlSi_3)O_{]0}(OH)_2$ (hydrous potassium, aluminum silicate).

Olivine—Olivine is an olive-green to light gray mineral with a vitreous luster, conchoidal fracture, a specific gravity of 3, and a hardness of 6.5 to 7. Cleavage, when visible, is poor. Crystal system: orthorhombic. Chemical formula: $(Mg,Fe)_2Si0_4$ (magnesium, iron silicate).

Orthoclase **Feldspar**—Orthoclase feldspar is white to pink, has a vitreous luster, a specific gravity of 2.57, and hardness of 6 on the Mohs scale. Orthoclase has two directions of cleavage at 90° angles and an uneven fracture opposite the cleavage directions. Crystal system: monoclinic. Chemical formula: $KAlSi_30_8$ (potassium, aluminum silicate).

Plagioclase Feldspar—Plagioclase feldspar includes a group of feldspars that occupy gradational positions within a single series (see Bowen's Reaction Series, Chapter 2). Plagioclases are white to gray, to dark gray, have a vitreous luster, a specific gravity of 2.62 to 2.76, and a hardness of 6 on the Mohs scale. The minerals in this group have cleavage planes at or almost at 90° angles and striations may be noticeable on some cleavage planes. Crystal system: triclinic. Chemical formula: $(Ca,Na)(Al,Si)AlSi_20_8$ (calcium, and/or calcium-sodium, and/or sodium, aluminum silicate). Albite and labradorite are low- and medium-temperature varieties.

Albite—Albite is a low-temperature, light-colored, plagioclase feldspar with two directions of cleavage. Fracture is uneven perpendicular to the cleavage direction. Striations may be present. Chemical formula: $NaAlSi_30_6$ (sodium aluminum silicate).

Labradorite—Labradorite is gray-blue, medium-temperature, plagioclase feldspar with two directions of cleavage, and two opposing sides with uneven fracture. Some samples exhibit a flash ("play") of different colors on cleavage surfaces. Striations may be present. Chemical formula: $(Ca,Na)AlSi_3O_s$ (calcium-sodium aluminum silicate).

Pyrite—Pyrite is a brassy-yellow mineral with a greenish to brownish-black streak, has **a** metallic luster, a specific gravity of 5.02 (high), and a hardness of 6 to 6.5. Pyrite has cubic or octahedral crystals and striations may be seen on some crystal faces. Crystal system: isometric (cubic). Chemical formula: FeS_2 (iron sulfide).

Quartz—Quartz is colorless to white but is often tinted. Quartz has a vitreous luster, conchoidal fracture, a specific gravity of 2.65, and a hardness of 7 on the Mohs scale. Crystal system: hexagonal. Chemical formula: $Si0_2$ (silicon dioxide). Quartz has many varieties.

Amethyst—Amethyst is the purple-tinted hexagonal crystal variety of quartz. See quartz (above) for other properties and chemical formula.

Chalcedony/Agate—Chalcedony is a milky colored cryptocrystalline variety of quartz. Chalcedony is frequently banded, and more transparent varieties with darker mineral inclusions ("growths") are usually called agate. Chalcedony/agate has a waxy to vitreous luster, and an obvious conchoidal fracture. See quartz (above) for other properties and chemical formula.

Chert/Flint—Chert/flint is an opaque, cryptocrystalline, and darker variety of quartz. Chert is generally lighter in color than flint. The dark gray to black variety is usually called flint. Chert/Flint has waxy to vitreous luster, and an obvious conchoidal fracture. See quartz (above) for other properties and chemical formula.

Jasper—Jasper is a red to reddish-brown cryptocrystalline quartz with an obvious conchoidal fracture. See quartz (above) for other properties and chemical formula.

Milky quartz—Milky quartz is the translucent to white, crystalline variety of quartz with microscopic conchoidal fracture. See quartz (above) for other properties and chemical formula.

Rock crystal—Quartz crystals are bipyramidal hexagonal, and usually show striations. See quartz (above) for other properties and chemical formula.

Rose quartz—Rose quartz is the pink-tinted crystalline variety of quartz. See quartz (above) for other properties and chemical formula.

Smoky quartz—Smokey quartz is the smoky-yellow, to brown, to black variety of crystalline quartz. See quartz (above) for other properties and chemical formula.

Sphalerite—Sphalerite is brown, yellow or black, has a brown to yellow streak (strong sulfur smell), a resinous to submetallic luster, a specific gravity of 4, and a hardness of 3.5 to 4. Sphalerite has a perfect dodecahedral cleavage. Crystal system: isometric (cubic). Chemical formula: ZnS (zinc sulfide).

Sulfur—Sulfur is usually bright yellow but may vary with impurities to green, gray, or red. Sulfur has a white to pale yellow streak, a resinous to greasy luster, no cleavage, a conchoidal to uneven fracture, a specific gravity of 2, and a hardness of 1.5 to 2.5. Sulfur has a "rotten egg" odor. Crystal system: orthorhombic. Chemical formula: S (sulfur).

Talc—Talc is white, brownish, gray, or greenish-white, has a white streak, a pearly to dull luster, a specific gravity of 2.7 to 2.8, and a hardness of 1 on the Mohs scale of hardness. Talc has perfect basal cleavage (not apparent in massive specimens), and a smooth or soapy feel. Crystal system: monoclinic. Chemical formula: $Mg{\wedge}Si_4Oi_0(OH)_2$ (hydrous magnesium silicate).

MINERAL USES

Augite—Most augite is only of interest to mineral collectors. Clear varieties are occasionally used as gemstones. Name derivation: from Greek *augities,* meaning "brightness" or "luster."

Bauxite—Bauxite is a mineraloid, not a true mineral. It is important as an aluminum ore, the source material for aluminum as metal. Bauxite forms by the concentration of hydrated aluminum oxides in the soils of humid tropical regions. Bauxite is a heterogeneous mixture of the minerals gibbsite [$AlO(OH)_3$], boehmite, and diaspore [both $AlO(OH)$]. Hematite and/or limonite may be present in small amounts. Name derivation: for occurrence near Baux, France.

Biotite—Biotite has no economic use but is of interest to collectors. Name derivation: for French physicist, J. B. Biot.

Calcite—Calcite has many uses: lime (Ca oxide) is a fertilizer, the raw material from which Portland cement (for making concrete) is made, and is used as a building stone (limestone and marble). Name derivation: from Latin *calx,* meaning "burnt lime."

Chlorite—Chlorite has no commercial value, but is a natural green pigment often found in marbles, etc. Name derivation: from Greek *chloros,* meaning "green."

Corundum—Because of its great hardness (9), corundum is used as an abrasive ("black" sandpaper), or for emery wheels for the grinding of metal. Rubies (if red) and sapphires (if blue, pink or yellow) are transparent varieties. Name derivation: *kauruntak*—Indian (Hindu) name for corundum.

Dolomite—Because dolomite contains magnesium, it is a source of this element for magnesium-deficient diets. It is also used as a building stone or as road gravel. Name derivation: after French scientist D. de Dolomieu.

Fluorite—Fluorite is a source of fluorine, used to fluoridate drinking water or added to toothpaste to increase the hardness of dental enamel; is used in the manufacture of hydrofluoric acid (the only acid that will dissolve glass); as a flux in steel making, etc. Name derivation: Latin *fluere,* meaning "to flow." Refers to the ease at which fluorite melts when heated, compared to other minerals.

Galena—Galena is a source of lead as metal when refined, is used in glass making (leaded crystal), and is used in radiation-shielding material. Name derivation: Latin *galena*—original name for lead ore.

Garnet—Garnet is slightly harder than quartz and thus is a good abrasive ("red" sandpaper). It is used as a sandblasting medium and as a grit and powder for optical grinding and polishing. When transparent and without internal fractures, garnet is also a semiprecious gem. Name derivation: Latin *granatus,* meaning "like a grain."

Goethite—Goethite is an ore of iron. Name derivation: after J. W. Goethe, a German poet and scientist.

Graphite—Graphite is the "lead" in pencils, a dry lubricant, and is used in the steel industry. Name derivation: Greek *graphein,* meaning "to write."

Gypsum—When the H_20 is driven off by heat, gypsum becomes anhydrite, and when ground to a powder, it becomes plaster of Paris. Gypsum is used in the manufacture of sheet rock, plaster, plaster casts, as a fertilizer, etc. The alabaster variety is used to make statuary, and satin spar is used as ornamental decoration. Name derivation: Arabic *jibs,* meaning "plaster."

Halite—Used as table salt, a food preservative, for tanning leather, and as a source of sodium and chlorine, etc. Name derivation: Greek *halos,* meaning "salt."

Hematite—Hematite is an ore of iron, the material from which, through the smelting process, iron is extracted as pure metal. Hematite ores can run up to about 70 percent (by weight) iron. It is also used as a red pigment in paint. Name derivation: Greek *haimatos,* meaning "blood" for the "blood" red streak color.

Hornblende—Hornblende has no commercial value, but is of interest to collectors. Name derivation: from German *horn* and *blenden,* meaning "horn" and "blind" in reference to its luster and lack of value.

Kaolinite—Kaolinite is pure china clay and is used for clay for ceramics, filler in paper, rubber, candy, medicines, etc. Name derivation: Chinese name *Kao-ling,* meaning "high ridge," refers to the area in China where it was first obtained for export.

Limonite—Limonite is **a** hydrous, powdery variety of hematite that comes in many shades of yellow, orange, red, and brown. Limonite is the primary pigment in many such colored paints. It is also a natural pigment responsible for soil color. A darker brown limonite rock formed in the red soils of East Texas (Jefferson City) sometimes is used as iron ore.

Magnetite—Magnetite is the most superior iron ore because of its high iron content. Name derivation: for Magnesia, an area near Macedonia, near Greece, where it was originally found.

Muscovite—Because muscovite is a transparent heat-resistant mineral, it is used as the "windows" in high temperature ovens. It is also used as an electrical insulator, and was earlier used as decorative "snow" for Christmas ornaments. Name derivation: from the Muscovy area in Russia where it was used as window glass and from Latin *micare,* meaning "to shine."

Olivine—Olivine, because it is heat resistant, is used as "brick" liners for high temperature ovens or furnaces. It is, when transparent, the gem peridot. Name derivation: from its olive-green color.

Orthoclase—When ground to a powder and mixed with water, orthoclase forms the coating on ceramics that, when fired in a kiln, turns to glaze, glass. Name derivation: Greek *orlhos,* meaning "right angle," and *klasis,* meaning "to break."

Plagioclase Feldspar—Labradorite is used as an ornamental stone when it displays labradoresence (play of colors). Albite, when opalesent, is cut and polished and known as the gem *moonstone.* Name derivation: Greek *plagio,* meaning oblique (cleavage angle).

Pyrite—Pyrite, because of its high sulfur content, is used in the manufacture of sulfuric acid. Name derivation: Greek word *pyx,* meaning fire.

Quartz—Varieties include citrine (yellow), rose (pink), amethyst (purple), smoky (brown-black), milky (white), chalcedony-agate (banded), jasper (red), chert (light gray), flint (dark, dull color), rock crystal (crystal form), etc. Quartz crystals are often used as semiprecious gems or for display in mineral collections. Agate, if partially transparent or translucent, is often polished and used as a semiprecious gem, etc. Chert and flint are the raw material from which stone tools were once made. Pure quartz sand is used to make glass. Name derivation: German *quartz.*

Sphalerite—Sphalerite is zinc ore, the material that, when refined, gives us zinc as metal. A thin coating of zinc on iron or steel offers considerable protection from oxidation (rusting). Originally the zinc was applied by electrolysis, which gave rise to the name "galvanized iron," but it is cheaper to dip the material in a bath of molten zinc. Zinc is used to galvanize corrugated iron roofing, iron buckets, or nails, etc. Name derivation: Greek *sphaleros,* meaning "treacherous."

Sulfur—Sulfur has many uses. It is used in the manufacture of sulfuric acid. Also, when added to rubber (vulcanized rubber) it makes the rubber able to withstand high temperatures as for tires, rubber hoses, etc. It is also used in the production of sulfa drugs. Name derivation: From *sulphur,* meaning "brimstone."

Talc—Talc, when ground to a powder and scented, is used as body powder (talcum, baby powder), and as an ingredient in paint, paper, etc. Name derivation: Arabic word *talq,* meaning "pure."

EXERCISE 1: IDENTIFICATION OF MINERAL UNKNOWNS AND THEIR PROPERTIES

Identify the mineral specimens supplied using the properties discussed in the lecture. You will be supplied with the following materials:

Glass plate	Paper towels	Steel nail	Penny
Streak plates	Magnet	Dilute hydrochloric acid	

SAFETY INFORMATION

The identification of minerals utilizes materials that may cause minor injury if used improperly. The following instructions are intended to familiarize the student with proper laboratory procedures.

Glass Plate

The purpose of the glass plate is to determine whether or not a mineral is harder than the glass plate *(>5.5)* or softer than the glass plate (<5.5). The correct and *safe way to use* the glass plate is to press it firmly against the table while you scratch the mineral across it.

Do no hold the glass plate in your hand while pressing the mineral against it The glass may break and cause injury.

Streak Plate

The purpose of the streak plate is to determine the color of a mineral's powder. If the mineral has a hardness less than that of the streak plate (5.75) then a powder will be left behind. The correct and *safe way to use* the streak plate is to press it firmly against the table while you scratch the mineral against it.

Don't hold the streak plate in your hand while pressing a mineral against it
The porcelain may break and cause injury.

Hydrochloric Acid

The purpose of the hydrochloric acid (HC1) is to determine to what extent a mineral or its powder effervesces (fizzes). When applying acid to mineral samples, use common sense. DO NOT squirt acid on the samples. It may splash and get on clothing, bare skin, or in the eye. One drop will suffice.

Hydrochloric acid can irritate the skin on contact If this happens, immediately wash the area with plenty of water. If you get acid in your eyes call for help immediately and the lab instructor will assist you to the closest rinse station.

All students must wear safety glasses when using HC1 acid.

^~^-^^^ Mineral
Properties^^la

Chemical Formula

Hardness Range
Exact if on Mohs' Scale

Luster
? if Metallic
Describe if nonmetallic

Streak (color)

Diaphanaeity
Transparent,
Translucent or Opaque

Magnetism
? if Magnetic
X if Nonmagnetic

Crystal Form
Describe if Visible
X if Not Visible

Specific Gravity
? if Heavy,
N if Normal, X if Light

Cleavage
# of Planes if Visible,
X if None Visible

Fracture
Yes, No,
? if Conchoidal

Reaction to HCI Acid
Describe Reaction

Color of Mineral

Striations
? if Present, X if Not

List one Use

I >U-' w *&> iL ~a) K^Jt

^""---^^^ Mineral Properties '""^me					
Chemical Formula					
Hardness Range Exact if on Mohs' Scale					
Luster ? if Metallic Describe if nonmetallic					
Streak (color)					
Diaphanaeity Transparent, Translucent or Opaque					
Magnetism ? if Magnetic X if Nonmagnetic					
Crystal Form Describe if Visible X if Not Visible					
Specific Gravity ? **if** Heavy, N if Normal, X if Light					
Cleavage # of Planes if Visible, X if None Visible					
Fracture Yes, No, ? if Conchoidal					
Reaction to HC1 Acid Describe Reaction					
Color of Mineral					
Striations ? if Present, X if Not					
List one Use					

^ - - ^ ^ ^ **Mineral** **Properties** ~-~^[ame					
Chemical Formula					
Hardness Range **Exact if on Mohs' Scale**					
Luster ? if Metallic Describe if nonmetallic					
Streak (color)					
Diaphanaeity Transparent, Translucent or Opaque					
Magnetism ? **if** Magnetic X if Nonmagnetic					
Crystal Form Describe if Visible X if Not Visible					
Specific Gravity ? if Heavy, N if Normal, X if Light					
Cleavage # of Planes if Visible, X if None Visible					
Fracture Yes, No, ? if Conchoidal					
Reaction to HCI Acid Describe Reaction					
Color of Mineral					
Striations ? if Present, X if Not					
List one Use					

^^^Jr

Mineral Properties Name					
Chemical Formula					
Hardness Range Exact if on Mohs' Scale					
Luster ? if Metallic Describe if nonmetallic					
Streak (color)					
Diaphanaeity Transparent, Translucent or Opaque					
Magnetism ? if Magnetic X if Nonmagnetic					
Crystal Form Describe if Visible X if Not Visible					
Specific Gravity ? if Heavy, N if Normal, X if Light					
Cleavage # of Planes if Visible, X if None Visible					
Fracture Yes, No, ? if Conchoidal					
Reaction to HC1 Acid Describe Reaction					
Color of Mineral					
Striations ? if Present, X if Not					
List one Use					

Mineral Properties					
Chemical Formula					
Hardness Range **Exact if on Mohs' Scale**					
Luster ? if Metallic Describe if nonmetallic					
Streak (color)					
Diaphanaeity Transparent, Translucent or Opaque					
Magnetism ? **if** Magnetic X if Nonmagnetic					
Crystal Form Describe if Visible X if Not Visible					
Specific **Gravity** ? if Heavy, N if Normal, X if Light					
Cleavage # of Planes if Visible, X if None Visible					
Fracture Yes, No, ? if Conchoidal					
Reaction to HCI Acid Describe Reaction					
Color of Mineral					
Striations ? if Present, X if Not					
List one Use					

‖L^ s L^ <^J %^T

^^-~~-~^^^ Mineral Properties >~^Iarne					
Chemical Formula					
Hardness Range **Exact if on Mohs' Scale**					
Luster ? if Metallic Describe if nonmetallic					
Streak (color)					
Diaphanaeity Transparent, Translucent or Opaque					
Magnetism ? if Magnetic X if Nonmagnetic					
Crystal Form Describe if Visible X if Not Visible					
Specific Gravity ? **if** Heavy, N if Normal, X if Light					
Cleavage # of Planes if Visible, X if None Visible					
Fracture **Yes, No,** **? if** Conchoidal					
Reaction to HC1 Acid Describe Reaction					
Color of Mineral					
Striations **? if** Present, **X if** Not					
List one Use					

~^^^^^ Mineral Properties^^^^-^l[3]TM[6]					
Chemical Formula					
Hardness Range **Exact if on Mohs' Scale**					
Luster ? if Metallic Describe if nonmetallic					
Streak (color)					
Diaphanaeity Transparent, Translucent or Opaque					
Magnetism ? if Magnetic X if Nonmagnetic					
Crystal Form Describe if Visible X if Not Visible					
Specific Gravity ? **if** Heavy, N if Normal, X if Light					
Cleavage # of Planes if Visible, X if None Visible					
Fracture Yes, No, ? if Conchoidal					
Reaction to HCI Acid Describe Reaction					
Color of Mineral					
Striations ? if Present, X if Not					
List one Use					

[

r

Mineral Properties / Name					
Chemical Formula					
Hardness Range Exact if on Mohs' Scale					
Luster ? if Metallic Describe if nonmetallic					
Streak (color)					
Diaphanaeity Transparent, Translucent or Opaque					
Magnetism ? if Magnetic X if Nonmagnetic					
Crystal Form Describe if Visible X if Not Visible					
Specific Gravity ? if Heavy, N if Normal, X if Light					
Cleavage # of Planes if Visible, X if None Visible					
Fracture Yes, No, ? if Conchoidal					
Reaction to HCI Acid Describe Reaction					
Color of Mineral					
Striations ?ifPresent,XifNot					
List one Use					