Name:_____

Lab 3: Mineral Properties
April 9, 2008

The word "mineral" takes on different meanings in various contexts, such as in the study of nutrition and diet, but as a geologic term it refers to a material that meets the following five-part definition:

A mineral is:

(1) *naturally occurring*. Synthetic materials, while often chemically similar or even identical to minerals, are not naturally occurring and therefore are not minerals.

(2) *solid*. Liquids and gases, while common in nature, are not minerals.

(3) *inorganic*. Minerals are produced by nonbiological means. For example, pearls are not minerals, as they are made by oysters.

(4) an element or compound with a *definite crystal structure*. A crystal structure is a periodic (repeating) three-dimensional arrangement of atoms. The atoms are arranged in specific patterns based on their size and the way that they bond to one another. It is possible for materials of the same composition to have different structures, such as graphite and diamond, both of which contain only carbon. These are, therefore, two <u>different</u> minerals.

(5) a compound with *a composition that varies only slightly within specific limits*. A specific mineral will always contain the same combination of elements in the same proportions. For example, the mineral <u>quartz</u> has the composition SiO_2, indicating that it has one silicon atom (Si) for every two oxygen atoms (O). In many cases, however, it is possible for different elements to substitute for one another, as in the case of the mineral <u>olivine</u>. Its formula is written $(Mg,Fe)_2SiO_4$, indicating that magnesium (Mg) and iron (Fe) may be present in variable amounts ranging from 100% Mg, which would be Mg_2SiO_4, to 100% Fe, or Fe_2SiO_4. Within certain limits, such ranges are grouped together as single minerals; once that range has been exceeded, the material is considered to be a different mineral.

A mineral's physical properties arise from its specific chemical composition and crystalline structure; therefore many of these properties are unique to each mineral and can be used for identification. This lab will introduce some of the more useful properties.

Color and Streak

The color of a mineral is determined by its composition and structure. Chemical composition is responsible for color in two basic ways:

(1) Idiochromatic ("self-colored") color: The color of the mineral is inherent in its bulk chemical composition and physical structure. For example, the mineral <u>malachite</u> has

the formula $Cu_2CO_3(OH)_2$. The copper (Cu) is responsible for its vibrant green color.

(2) Allochromatic ("other-colored") color: The color of the mineral is determined by trace amounts of impurities within the crystal. These impurities are elements that are not part of the mineral's "standard" chemical formula, but are present in small amounts anyway. For example, corundum, or Al_2O_3, is colorless, but if a few percent of the aluminum (Al) atoms are replaced by chromium (Cr), then the mineral takes on a bright red color. This variety of corundum is known as ruby. On the other hand, corundum may also be colored by trace amounts of iron (Fe) or titanium (Ti), which produce a blue color. The result is now known as sapphire.

Color is not a reliable tool for identifying minerals, since (a) many different minerals may show the same color, and (b) different samples of the same mineral may show quite different colors. Furthermore, a single crystal of a mineral may even show different colors from one part to another. Color is often of use in narrowing down the range of possible identities and may serve as an additional confirmation of an identity, but should not be relied upon as a primary means of identification.

The color of the powdered mineral, the streak, is usually much less variable than the color seen in hand specimens. A streak is produced by rubbing the mineral on an unglazed porcelain plate. The powdered mineral can then be observed against a contrasting background. Streak color is particularly useful in distinguishing metallic minerals that look very similar in hand sample, such as hematite, an iron oxide (rust) and an important iron-ore mineral, and galena, an ore of lead and zinc. Nonmetallic minerals generally have a colorless or white streak.

Luster

Luster refers to the way in which a mineral's surface reflects light. The two major categories of luster are metallic and nonmetallic.

Metallic lusters are those which cause the mineral to resemble metals such as steel, iron, gold, or copper (Some of these metals *are* minerals, by the way). The surface may be either very reflective or dull, as long as it resembles the surface of a metal.

Nonmetallic lusters may be broken into a range on the basis of how reflective the sample is. Some of the more common nonmetallic lusters are:

Adamantine-- exceptionally brilliant, such as a cut diamond.
Vitreous-- glassy appearance, such as quartz. This is the most common luster.
Pearly-- self-descriptive; an example is the mineral talc.
Resinous-- resembling tree sap; sphalerite is one example.
Dull or Earthy-- again, self-descriptive.

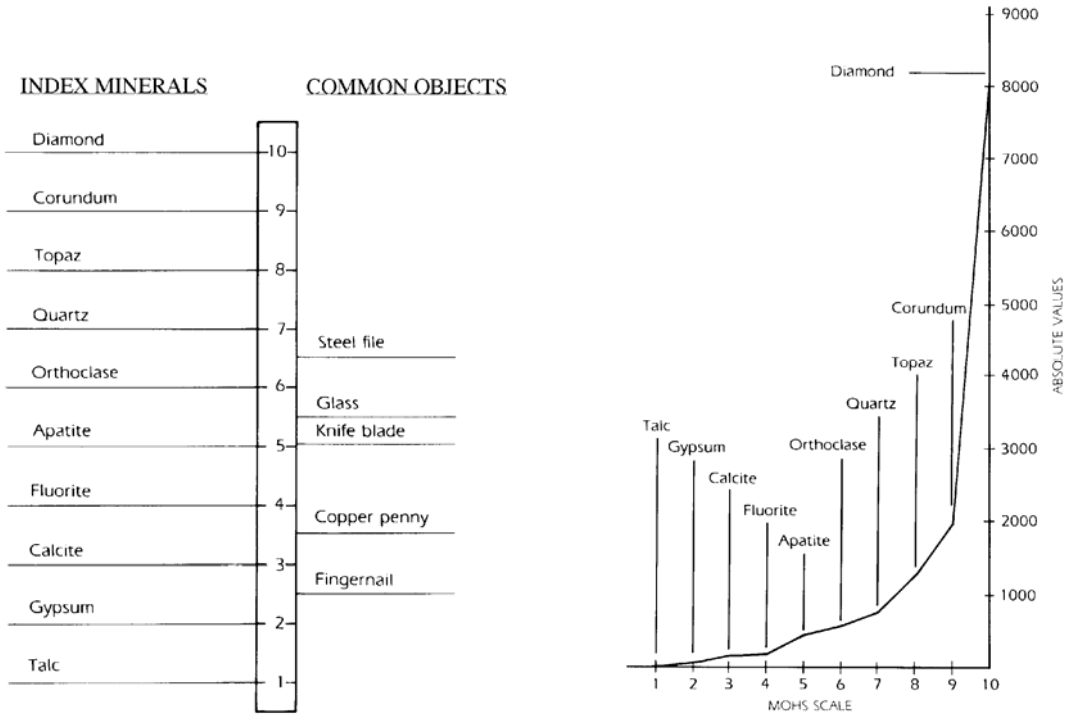
Crystal Form

The six **crystal systems** are cubic (also called isometric), tetragonal, orthorhombic, monoclinic, triclinic, and hexagonal. These refer to the six (the *only* six) fundamentally different ways in which it is possible to build a crystal structure, each of which shows a different type of symmetry in its arrangement. Within each system, however, there are many different **crystal forms**, or external shapes, each of which possesses the same underlying symmetry as the system to which it belongs. A

few are illustrated on the following pages for each system. A given mineral will always crystallize in the same *system*, but different specimens of that mineral may show different *forms* from one another, as long as the forms are all members of that same system. Thus, it is necessary to recognize both the individual form and determine to which system it belongs.

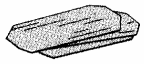
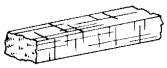
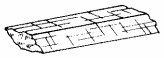
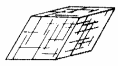
Hardness

Hardness is defined as a mineral's ability to resist scratching or abrasion. For example, diamond is the hardest natural substance known and will scratch all other minerals. A mineral can be scratched by all minerals harder than itself and will scratch all minerals softer than itself. Samples are tested for hardness against a set of index minerals that are scaled from 1 (softest) to 10 (hardest), called Mohs Hardness Scale (below). Mineral hardness is determined by comparing the relative hardness of an unknown specimen with an index mineral or other material with known hardness. Glass is often used because: (1) it is easy to see a scratch on glass, and (2) the hardness of glass is about midway on Mohs Scale. A set of probes of known hardness is available, as well.



Cleavage and Fracture

Cleavage is the tendency of a mineral to split, or cleave, along closely spaced parallel planes. The planes along which a mineral cleaves (when hit with a hammer, for example) are the planes along which the bonds between atoms in the mineral are the weakest. Minerals that break easily and cleanly along one or more planes are said to have good cleavage. If the break is less clean the cleavage is referred to as poor. The number of cleavage planes and the angles between cleavage planes are commonly used to distinguish minerals. The following table includes examples of cleavage in common minerals.

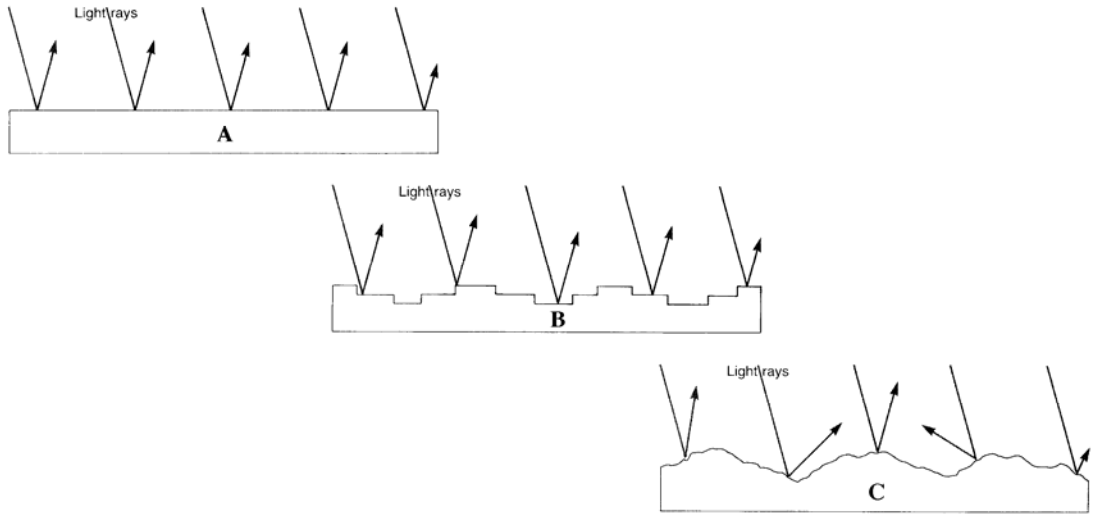
# of Cleavage Planes	Angle Between Planes	Shape	Sketch	Number of Flat Surfaces
0 No cleavage, only fracture	NA	Irregular masses		0
1	NA	Flat sheets		2
2	90°	Elongate form with rectangular cross-section, rough ends		4
2	not at 90°	Elongate form with parallelogram cross-section, rough ends		4
3	90°	Cube		6
3	not at 90°	Rhombohedron		6
4	not at 90°	Octahedron		8
6	not at 90°	Dodecahedron		12

Mica minerals have only one cleavage plane, producing a series of sheets. Halite has cleavage in three directions, with all planes at right angles (90°). *Note that even though a cube has six sides, opposite sides are parallel to each other and therefore represent the same cleavage plane. A cubic shape represents three cleavage planes, not six.*

Cleavage planes are flat and will reflect light at a uniform angle. Slowly turn a mineral under light and watch for these reflections. Hold transparent samples up to a light and look for cleavage planes running through the interior, too. Also note that some minerals have corners or "steps" along their edges, indicating at least two different planes of cleavage.

Minerals that don't readily split along planes will instead break, or fracture, along uneven surfaces. Many minerals fracture smoothly along curved, shell-like surfaces, sometimes forming sharp edges (like broken glass). This is called conchoidal fracture. Other types of fracture include fibrous (like asbestos), rough (like pyrite), and earthy (like kaolinite).

Cleavage surfaces may be confused with crystal growth faces; in fact cleavage planes are sometimes parallel to growth faces. They can be distinguished as follows. (1) Growth faces are normally smooth, whereas cleavage planes, though also smooth, commonly are broken in a step-like fashion. (2) Some growth faces have fine grooves or ridges on their surfaces, whereas cleavage planes generally do not. (Plagioclase is an exception — it has striations on its cleavage planes.) (3) Finally, unless growth faces happen to coincide with cleavage planes, the mineral will not break parallel to growth faces.



Examples of how a mineral surface reflects light for minerals with (A) good cleavage, (B) poor cleavage, and (C) fracture.

Other Properties

Magnetism - Some minerals, such as magnetite, are attracted to magnets.
Taste - Some minerals have a characteristic taste. For example, halite tastes like salt.
Acid reaction - Some minerals that contain carbonate (CO_3) will react with diluted hydrochloric acid (HCl), forming carbon dioxide (CO_2) gas bubbles. Calcite ($CaCO_3$) will react with HCl.
Feel - Some minerals, such as talc, feel soapy or greasy.
Presence of striations - Some minerals, such as pyrite, have closely spaced fine grooves on their crystal faces.

To identify a mineral, one should characterize as many properties as can be determined with the tools available. Then, use the attached mineral identification tables (A-1, A-2, and A-3). Use the following procedure:

Step 1 Determine whether the mineral has a metallic (go to step 2) or nonmetallic (go to step 3) luster. If you are uncertain about a mineral's luster, then it is probably nonmetallic.

Step 2 If the mineral is metallic, determine the mineral's characteristics in the following order and use Table A-1 to identify the mineral:

i. streak
ii. hardness
iii. other properties as needed

Step 3 If the mineral is nonmetallic, determine the mineral's characteristics in the following order and use Table A-2 (light-colored minerals) or Table A-3 (dark-colored minerals) to identify the mineral:

i. hardness
ii. number of cleavage planes and angles between cleavage planes
iii. other properties as needed

Part 1. Crystal System and Crystal Form

Determine the crystal system and crystal form for the wooden blocks.

Block Number	Crystal System	Crystal Form
24		
31		
53		
58		
64		
65		
66		
83		
89		
90		
105		
151		
171		
183		
187		

Part 2. Mineral Characteristics

Determine the characteristics of the specimens below, then use Tables A-1, A-2, and A-3 to identify them.

Specimen Number	Luster	Streak (metallic minerals)	Hardness (relative to glass)	Cleavage/ Fracture	Other Diagnostic Properties	Mineral Name
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

Distinguishing similar-looking minerals.

1. Name three different physical characteristics for distinguishing quartz from calcite.

2. What single diagnostic property is most useful for distinguishing between amphibole and biotite?

Table A-1
Metallic Mineral Identification Chart

Luster	Streak	Hardness	Cleavage	Color	Specific Gravity	Other Properties	Name
Metallic	Dark Gray to Black	6.0-6.5	No	brass yellow	5.0	cubic crystals (with striations) common	**PYRITE**
		6.0	No	dark gray to black	5.2	strongly magnetic	**MAGNETITE**
		3.5-4.0	No	golden yellow	4.2	may tarnish to bronze or purple; massive	**CHALCOPYRITE**
		2.5	Yes	silvery gray	7.5	perfect cubic cleavage (3 planes at 90^{o})	**GALENA**
		1.0	Yes-d	gray to black	2.5	marks paper and fingers; greasy feel	**GRAPHITE**
	Red to Red-Brown	5.0-6.5	No	silver to gray to red	5.0	may be tiny glittering flakes	**HEMATITE**
	Yellow-Brown	3.5-4.0	Yes-d	yellow-brown to dark brown	4.0	submetallic to resinous luster; 6 cleavage planes	**SPHALERITE**
	Copper	2.5-3.0	No	copper to dark brown	8.9	malleable	**NATIVE COPPER**

Note: Yes-d means cleavage is present but may be difficult to see

Table A-2. Light Colored Non-metallic Mineral Identification Chart

Luster & Color	Relative Hardness	Hardness	Cleavage	Color	Specific Gravity	Other Properties	Name
	Harder than Glass	7.0	Yes-d	pistachio green	3.3-3.6	surface coatings, or massive	**EPIDOTE**
	Harder than Glass	7.0	No	variable	2.7	vitreous luster; conchoidal fracture; massive but also occurs as 6-sided crystals	**QUARTZ**
	Similar to Glass	6.0	Yes	pinkish-orange (variable)	2.5	vitreous luster; banding; 2 cleavages at 90^{o}	**ORTHOCLASE** (Potassium Feldspar)
	Similar to Glass	6.0	Yes	white to gray	2.6-2.8	vitreous luster; 2 cleavages at 90^{o}; striations common on cleavage faces	**PLAGIOCLASE** (Na & Ca Feldspar)
	Similar to Glass	5.0-7.0	Yes-d	bluish-gray	3.5	vitreous luster; blade shaped crystals	**KYANITE**
	Softer than Glass	4.0	Yes	clear, purple, yellow (variable)	3.2	vitreous luster; 4 perfect cleavages forming octahedrons	**FLUORITE**
	Softer than Glass	3.0	Yes	white to clear (variable)	2.7	reacts with HCl; rhombic cleavage; 3 perfect cleavages not at 90^{o}	**CALCITE**
	Softer than Glass	2.5	Yes	clear to milky white	2.2	3 perfect cleavages at 90^{o} (cubes); salty taste	**HALITE**
	Softer than Glass	2.0-2.5	Yes-d	white to tan	2.6	dull luster, powdery; earthy odor; white streak	**KAOLINITE**
	Softer than Glass	2.0-2.5	Yes	clear to light yellow	2.5-3.0	vitreous luster; perfect cleavage in 1 dir.;forms flexible, transparent, thin sheets	**MUSCOVITE**
	Softer than Glass	2.0	Yes	clear, white, yellow (variable)	2.3	vitreous to pearly luster; brittle flakes; perfect cleavage in 1 direction	**GYPSUM**
	Softer than Glass	1.5-2.5	No	yellow	2.0	yellow streak; distinctive sulfurous odor	**SULFUR**
	Softer than Glass	1.0	Yes-d	apple green to silvery white	2.7	pearly luster; greasy feel	**TALC**

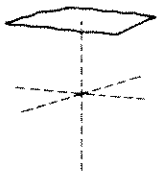
Note: Yes-d means cleavage is present but may be difficult to see.

Table A-3. Dark Colored Non-metallic Mineral Identification Chart

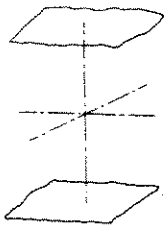
Luster & Color	Relative Hardness	Hardness	Cleavage	Color	Specific Gravity	Other Properties	Name
Non-Metallic Dark Colored	Harder than Glass	9.0	No	brown (variable)	4.0	six-sided prismatic crystals	**CORUNDUM**
		7.0	Yes-d	brown	3.8	vitreous to dull luster; prismatic to cross-shaped crystals	**STAUROLITE**
		7.0	No	red or brown	3.5-4.3	twelve-sided crystals common; vitreous luster	**GARNET**
		7.0	No	variable	2.7	vitreous luster; conchoidal fracture; massive but also occurs as 6-sided crystals	**QUARTZ**
		6.5-7.0	No	olive green	3.3-4.4	vitreous luster; granular	**OLIVINE**
	Similar to Glass	6.0	Yes	gray to white	2.6-2.8	vitreous luster; 2 cleavages at 90°; striations common on cleavage faces	**PLAGIOCLASE**
		5.0-6.0	Yes-d	dark green to black	3.3	vitreous to dull luster; 2 poor cleavages at 90°	**PYROXENE**
		5.0-6.0	Yes	dark green to black	3.3	vitreous luster; splintery appearance; 2 perfect cleavages at 120° and 60°	**AMPHIBOLE**
		5.0-6.0	No	reddish-brown to black	5.0	red-brown streak; dull luster; massive	**HEMATITE**
		5.0	Yes-d	green, brown, blue, black	3.2	vitreous luster; six-sided crystals common	**APATITE**
	Softer than Glass	3.5-4.0	Yes-d	grass green	4.0	occurs as surface coatings, masses, or tiny crystals; green streak	**MALACHITE**
		2.5-3.0	Yes	brown to black	2.8-3.0	vitreous luster; perfect cleavage in 1 direction; forms flexible thin sheets	**BIOTITE**
		2.0-2.5	Yes-d	dark or light green	2.6-2.9	flexible crystal flakes; crystal aggregates common	**CHLORITE**

Note: Yes-d means cleavage is present but may be difficult to see.

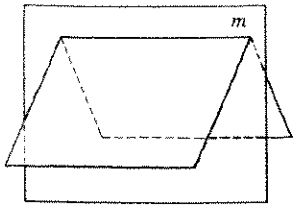
Non-isometric forms



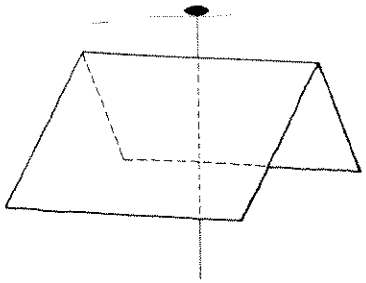
(1) Pedion
(Monohedron)



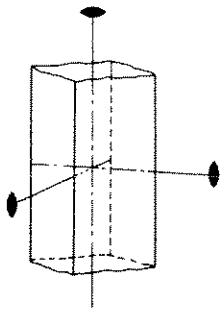
(2) Pinacoid
(Parallelohedron)



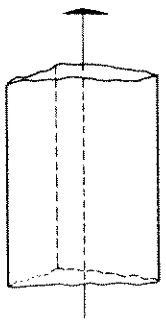
(3) Dome
(Dihedron)



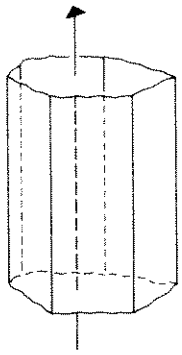
(4) Sphenoid
(Dihedron)



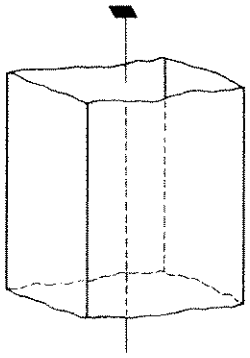
(5) Rhombic prism



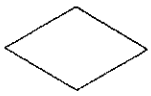
(6) Trigonal prism

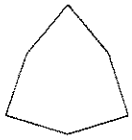


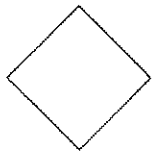
(7) Ditrigonal
prism

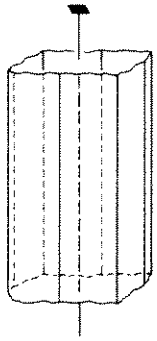


(8) Tetragonal
prism

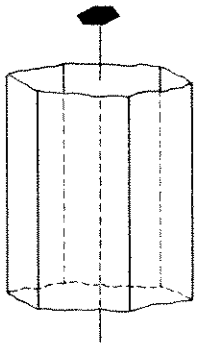




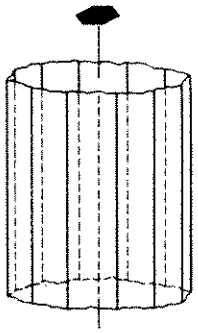




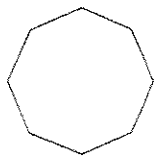
(9) Ditetragonal
prism

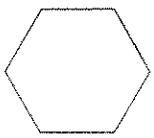


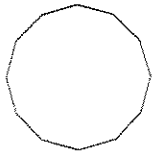
(10) Hexagonal prism

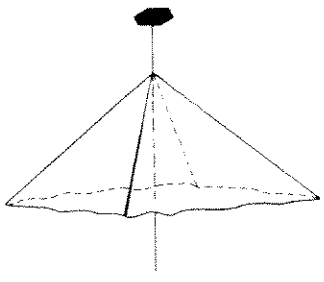


(11) Dihexagonal prism

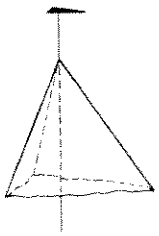






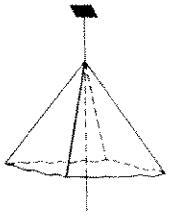


(12) Rhombic pyramid

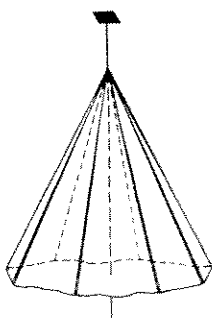


(13) Trigonal pyramid

(14) Ditrigonal pyramid

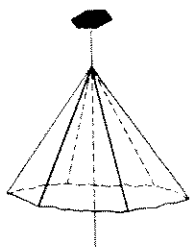


(15) Tetragonal pyramid

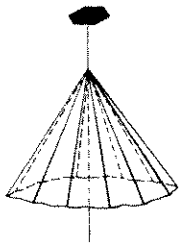


(16) Ditetragonal dipyramid

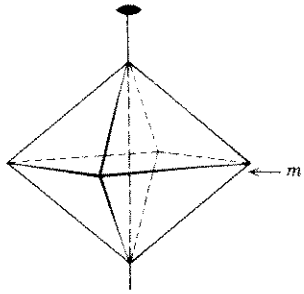
Non-isometric forms (cont'd)



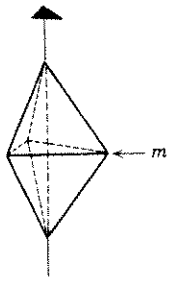
(17) Hexagonal pyramid



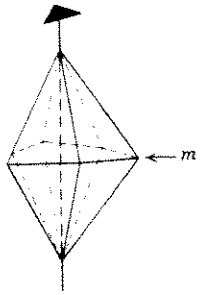
(18) Dihexagonal pyramid



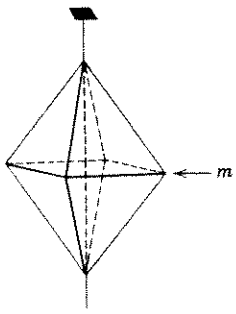
(19) Rhombic dipyramid



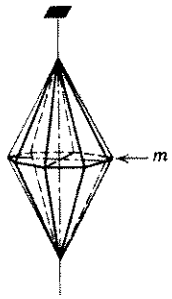
(20) Trigonal dipyramid



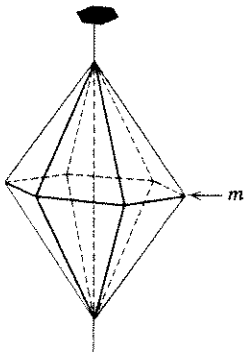
(21) Ditrigonal dipyramid



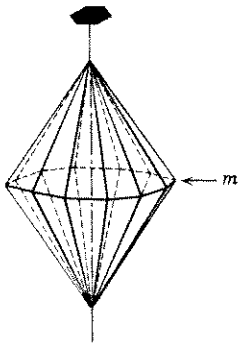
(22) Tetragonal dipyramid



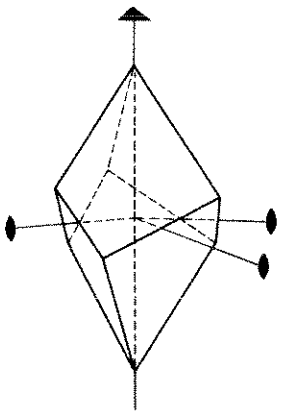
(23) Ditetragonal dipyramid



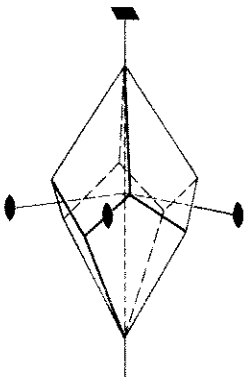
(24) Hexagonal dipyramid



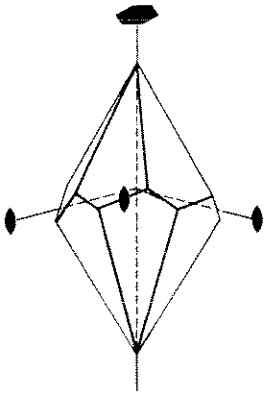
(25) Dihexagonal dipyramid



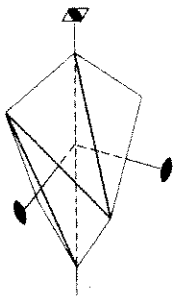
(26) Trigonal trapezohedron



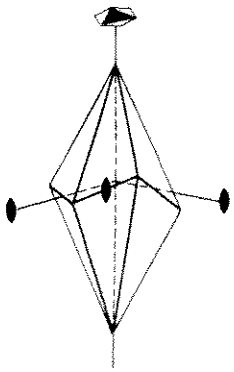
(27) Tetragonal trapezohedron



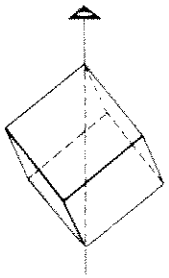
(28) Hexagonal trapezohedron



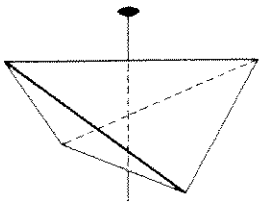
(29) Tetragonal scalenohedron (Rhombic scalenohedron)



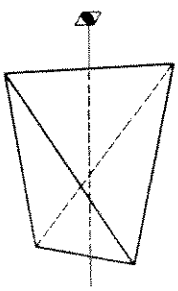
(30) Hexagonal scalenohedron (Ditrigonal scalenohedron)



(31) Rhombohedron

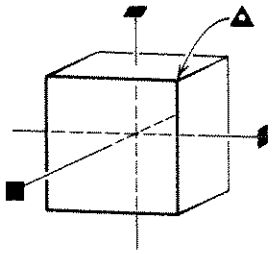


(32) Rhombic disphenoid (Rhombic tetrahedron)

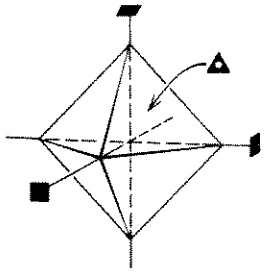


(33) Tetragonal disphenoid (Tetragonal tetrahedron)

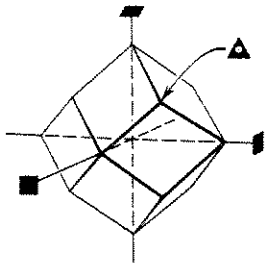
Isometric forms



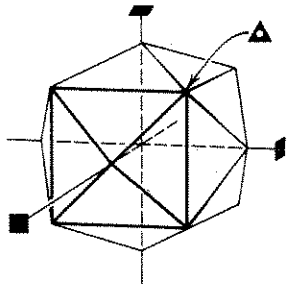
(34) Cube (Hexahedron)



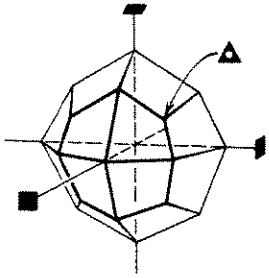
(35) Octahedron



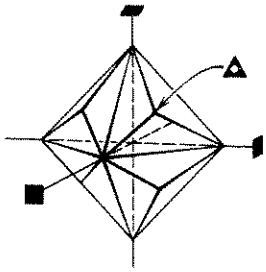
(36) Dodecahedron
(Rhomb-dodecahedron)



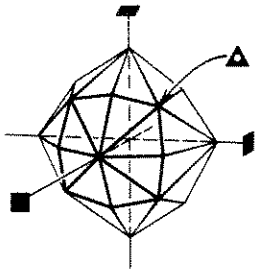
(37) Tetrahexahedron



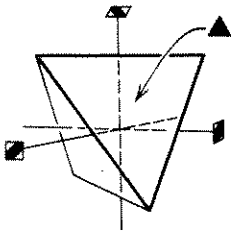
(38) Trapezohedron
(Tetragon-trioctahedron)



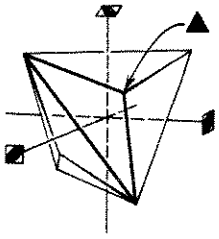
(39) Trisoctahedron
(Trigon-trioctahedron)



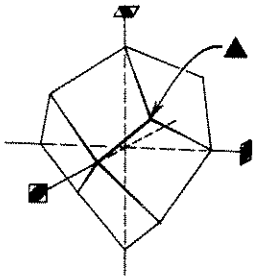
(40) Hexoctahedron
(Hexaoctahedron)



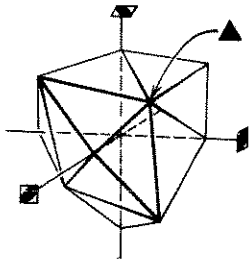
(41) Tetrahedron



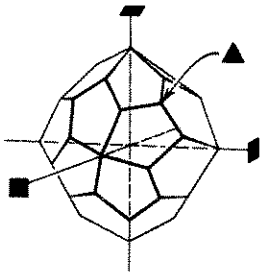
(42) Tristetrahedron
(Trigon-tritetrahedron)



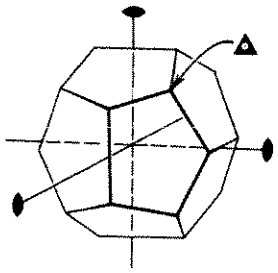
(43) Deltoid dodecahedron
(Tetragon-tritetrahedron)



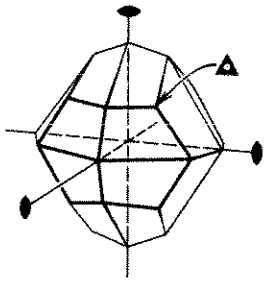
(44) Hextetrahedron
(Hexatetrahedron)



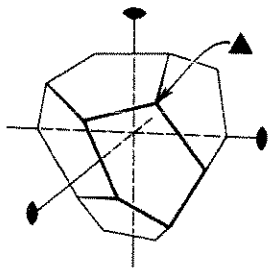
(45) Gyroid
(Pentagon-trioctahedron)



(46) Pyritohedron
(Dihexahedron)



(47) Diploid
(Didodecahedron)



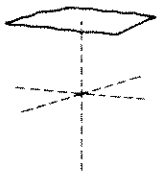
(48) Tetartoid
(Pentagon-tritetrahedron)

Table A-1
Metallic Mineral Identification Chart

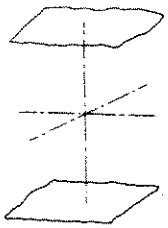
Luster	Streak	Hardness	Cleavage	Color	Specific Gravity	Other Properties	Name
Metallic	Dark Gray to Black	6.0-6.5	No	brass yellow	5.0	cubic crystals (with striations) common	**PYRITE**
		6.0	No	dark gray to black	5.2	strongly magnetic	**MAGNETITE**
		3.5-4.0	No	golden yellow	4.2	may tarnish to bronze or purple; massive	**CHALCOPYRITE**
		2.5	Yes	silvery gray	7.5	perfect cubic cleavage (3 planes at 90^{o})	**GALENA**
		1.0	Yes-d	gray to black	2.5	marks paper and fingers; greasy feel	**GRAPHITE**
	Red to Red-Brown	5.0-6.5	No	silver to gray to red	5.0	may be tiny glittering flakes	**HEMATITE**
	Yellow-Brown	3.5-4.0	Yes-d	yellow-brown to dark brown	4.0	submetallic to resinous luster; 6 cleavage planes	**SPHALERITE**
	Copper	2.5-3.0	No	copper to dark brown	8.9	malleable	**NATIVE COPPER**

Note: Yes-d means cleavage is present but may be difficult to see

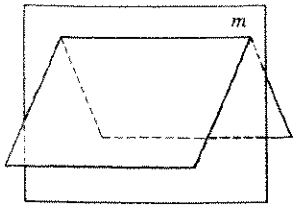
Non-isometric forms



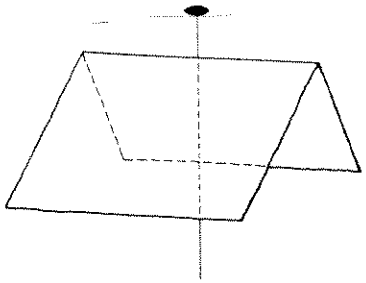
(1) Pedion
(Monohedron)



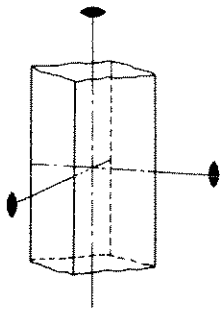
(2) Pinacoid
(Parallelohedron)



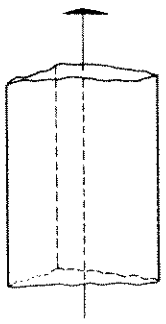
(3) Dome
(Dihedron)



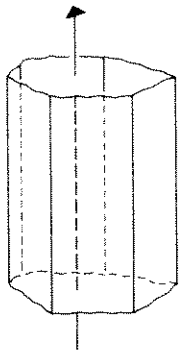
(4) Sphenoid
(Dihedron)



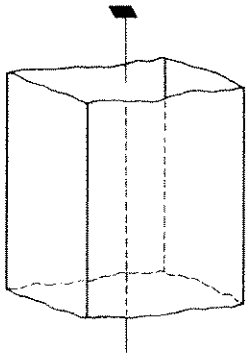
(5) Rhombic prism



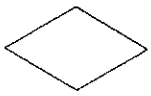
(6) Trigonal prism

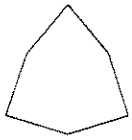


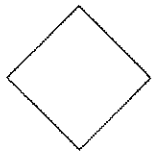
(7) Ditrigonal
prism

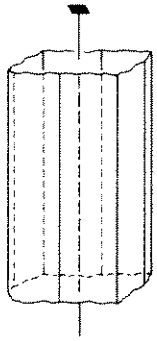


(8) Tetragonal
prism

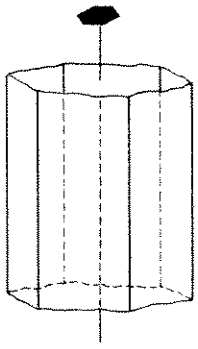




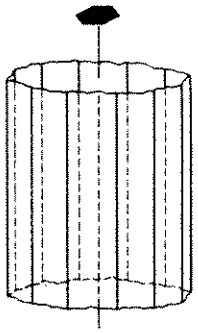




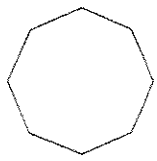
(9) Ditetragonal
prism

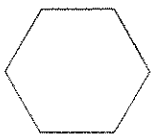


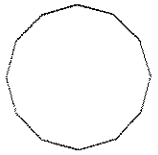
(10) Hexagonal prism

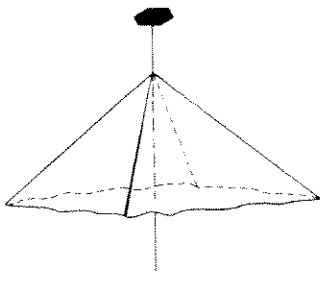


(11) Dihexagonal prism

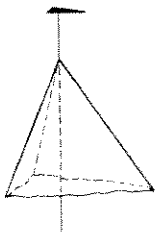






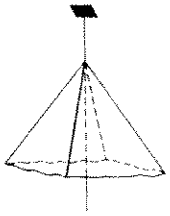


(12) Rhombic pyramid

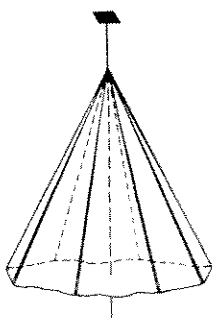


(13) Trigonal pyramid

(14) Ditrigonal pyramid

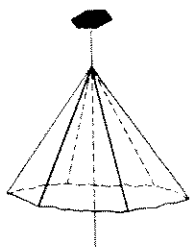


(15) Tetragonal pyramid

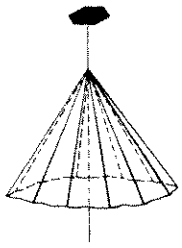


(16) Ditetragonal dipyramid

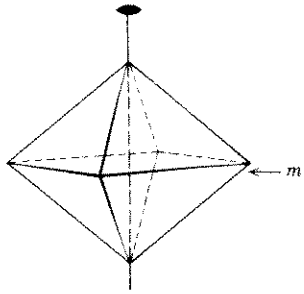
Non-isometric forms (cont'd)



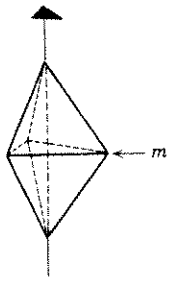
(17) Hexagonal pyramid



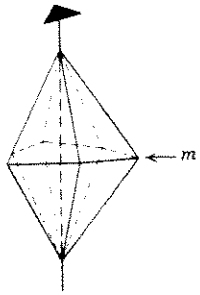
(18) Dihexagonal pyramid



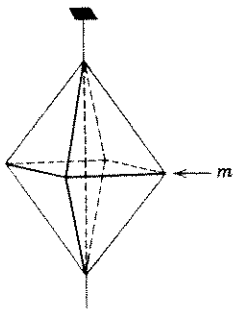
(19) Rhombic dipyramid



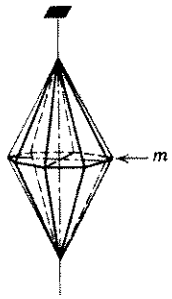
(20) Trigonal dipyramid



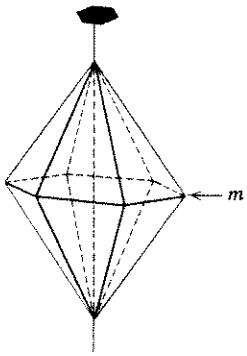
(21) Ditrigonal dipyramid



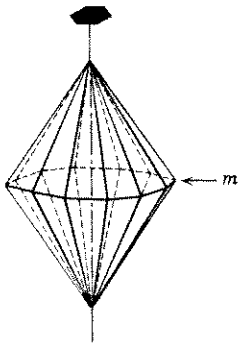
(22) Tetragonal dipyramid



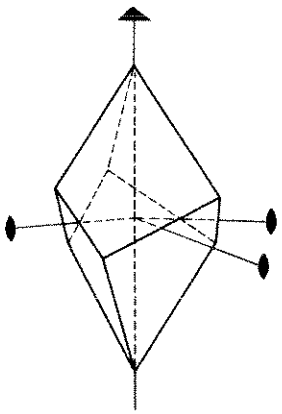
(23) Ditetragonal dipyramid



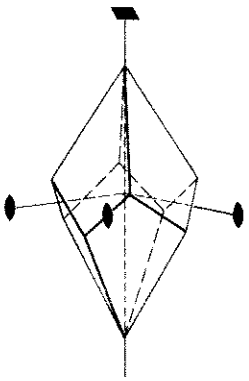
(24) Hexagonal dipyramid



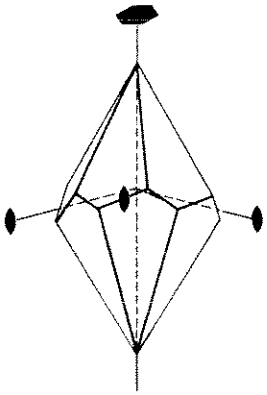
(25) Dihexagonal dipyramid



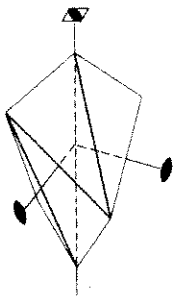
(26) Trigonal trapezohedron



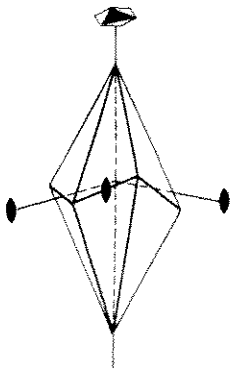
(27) Tetragonal trapezohedron



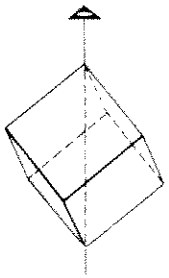
(28) Hexagonal trapezohedron



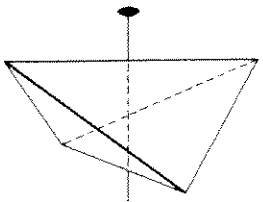
(29) Tetragonal scalenohedron (Rhombic scalenohedron)



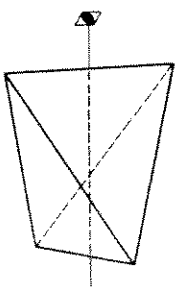
(30) Hexagonal scalenohedron (Ditrigonal scalenohedron)



(31) Rhombohedron

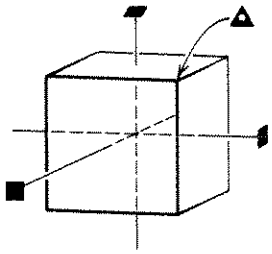


(32) Rhombic disphenoid (Rhombic tetrahedron)

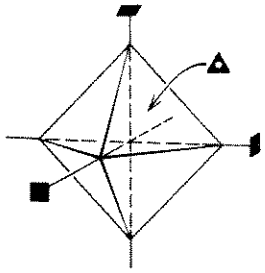


(33) Tetragonal disphenoid (Tetragonal tetrahedron)

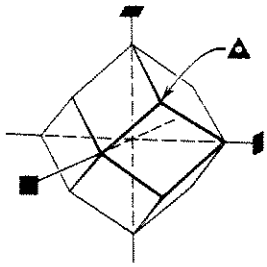
Isometric forms



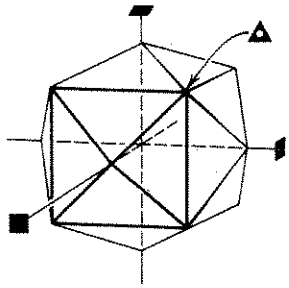
(34) Cube (Hexahedron)



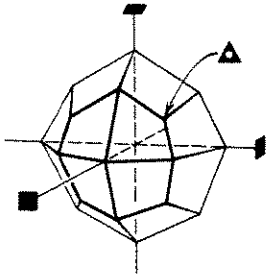
(35) Octahedron



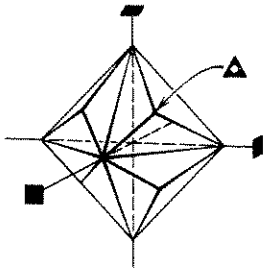
(36) Dodecahedron
(Rhomb-dodecahedron)



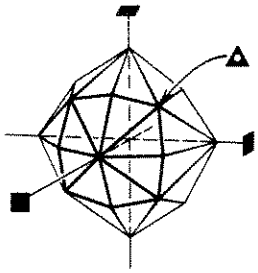
(37) Tetrahexahedron



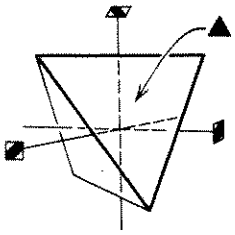
(38) Trapezohedron
(Tetragon-trioctahedron)



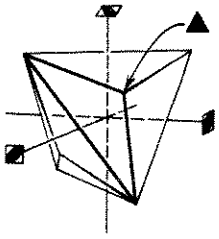
(39) Trisoctahedron
(Trigon-trioctahedron)



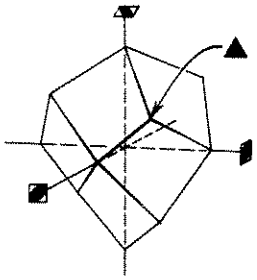
(40) Hexoctahedron
(Hexaoctahedron)



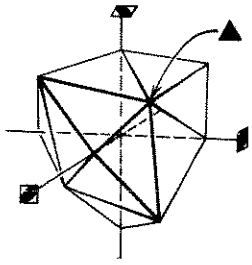
(41) Tetrahedron



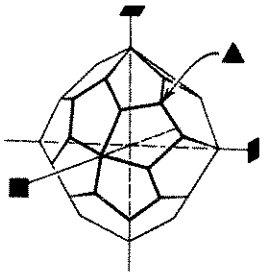
(42) Tristetrahedron
(Trigon-tritetrahedron)



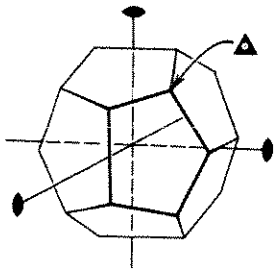
(43) Deltoid dodecahedron
(Tetragon-tritetrahedron)



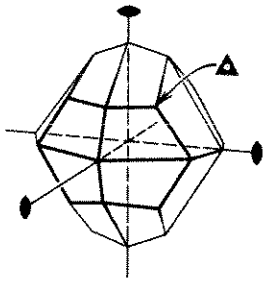
(44) Hextetrahedron
(Hexatetrahedron)



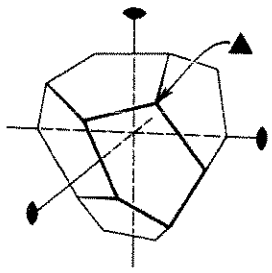
(45) Gyroid
(Pentagon-trioctahedron)



(46) Pyritohedron
(Dihexahedron)



(47) Diploid
(Didodecahedron)



(48) Tetartoid
(Pentagon-tritetrahedron)