

**Exploration Geology On Line - Spring 2002****LAB 1****MINERAL CLASSIFICATION AND IDENTIFICATION**

Exploration geology requires the recognition of the types of ore minerals which are present. This lab evaluates the classification and characteristics of ore minerals. This is done by a systematically testing the physical properties of the ore minerals, and then finding these properties listed in mineral identification references. There are many useful book references and websites with descriptions and close-up photos of ore minerals.

**Classification of Minerals****\*\*\*WEB SITES:**

**Mineral Gallery:** <http://mineral.galleries.com/minerals/property/physical.htm>

There are approximately 3,000 known minerals. New minerals are being discovered at the rate of about 60 per year. A number of mineral classification schemes have been created. About 160 years ago, a geologist named Dana recognized the fact that there are a limited number of mineral groups in nature. He devised a classification system for minerals based on their chemical make up, similar to the one outlined below:

| <u>Mineralogical Group</u> | <u>Description/Examples</u>   | <u>Approx. No.</u> |
|----------------------------|---|--------------------|
| Native Elements            | Native metals: gold, silver, copper, platinum, iron, arsenic, bismuth<br>Native elements: sulfur, diamond and graphite (carbon) | 50                 |
| Sulfides & other "ides"    | Elements complexed with sulfur (sulfides).<br>Others: tellurides, bismuthides, antimonides, arsenides, selenides,               | 300                |
| Sulfosalts                 | Similar to sulfides, sometimes called "double sulfides"   | 100                |
| Oxides                     | Oxygen combined with one or more metals   | 250                |
| Hydroxides                 | Similar to oxides, but Hydrogen takes the place of a metal  |                    |
| Halides                    | Electronegative halogen ions dominate (Cl-, Br-, F-, I-). NaCl (salt)   | 100                |
| Carbonates                 | Contains carbonate radical ( $\text{CO}_3$ )  |                    |
| Nitrates                   | Contains nitrate radical ( $\text{NO}_3$ )  | 200                |
| Borates                    | Contains borate radical ( $\text{BO}_3$ )   |                    |
| Sulfates                   | Contains sulfate radical ( $\text{SO}_4$ )  |                    |
| Chromates                  | Contains chromate radical ( $\text{CrO}_4$ )  | 200                |
| Molybdates                 | Contains molybdate radical ( $\text{MoO}_4$ )   |                    |
| Tungstates                 | Contains tungstate radical ( $\text{WO}_4$ )  |                    |
| Phosphates                 | Contains phosphate radical ( $\text{PO}_4$ )  |                    |
| Arsenates                  | Contains arsenate radical ( $\text{AsO}_4$ )  | 350                |
| Vanadates                  | Contains vanadate radical ( $\text{VO}_4$ )   |                    |
| Silicates                  | Built on $\text{SiO}_4$ tetrahedra or derivative. $\text{SiO}_2$ (quartz)   | 500                |

Ore minerals occur in every one of these groups. However, two of the groups stand out as being abundant in a vast number of deposits of base metal and precious metal deposits. These are the sulfide and oxide minerals. An example of a sulfide mineral mined for copper for example is the mineral chalcopyrite ( $\text{CuFeS}_2$ ). It is a "sulfide" mineral, which means ions are complexed with sulfur. In this case it is Fe (iron) and Cu (copper) ions are involved. Chalcopyrite is an ore mineral which is mined for copper. Some base metal (Cu, Pb, Zn) deposits and precious metal (Au, Ag) deposits have both sulfide and oxide ores present which may form a zoning pattern. Oxide ores are often more easily smelted than sulfide ores.

## **Identification of Minerals**

### **\*\*\*\*WEB SITES:**

<http://mineral.galleries.com/Minerals/content/signific.htm>

<http://un2sg4.unige.ch/athena/mineral/mineral.html>

<http://www.immr.tu-clausthal.de/labs/mincoll.html>

Many different techniques can be used to identify minerals. The best are laboratory methods using specialized equipment and methods, such as X ray diffraction, or thin-section petrography. These methods are conclusive, and relatively inexpensive, but require more time. Field exploration geologists must rely on “field tests”, which can be conducted quickly in the field. They also use these same identification skills to identify rocks in the field.

Field mineral testing methods involve making a series of tests and observations of the physical properties of unknown minerals. Typically, the observations are compiled in a table format. The observations are then compared with the known properties of minerals from various published mineralogy references. The table on page 14 – 15 (Faulkner) is an example of a table containing some of the more common rock-forming and ore minerals. Check the websites for additional descriptive information, and Faulkner pp. 9 – 13 for additional information on selected mineral properties and testing.

## **Mineral Properties Used for Field Identification**

**Color:** As observed on either the fresh or weathered surface or both. Color is caused by the absorption of selected wavelengths of light, due to the crystal structure and composition of the mineral. Often not a good characteristic to judge by, because many silicate and other minerals have multiple colors for the same mineral. For example “fluorite” comes in at least eight colors. There are rare times when color is a useful indicator, for example the color green or blue often indicates the presence of copper in an oxide setting. Fortunately, there is consistency in some metallic sulfide minerals, such as chalcopyrite (copper iron sulfide) has a distinct yellow brassy color, and bornite ( $\text{CuFeS}_2$ ) tarnishes to a distinct iridescent rainbow color (hence the name “peacock ore”). Color for a mineral changes with ionic substitution within a mineral (called solid solution series; for example in the mineral amphibole: “tremolite”, the magnesium endmember, is white, and “hornblende”, the iron endmember, is green. Certain trace element substitutions in some gemstones causes specific colors, as in the case of “beryl”, which has a green endmember we know as “emerald”. Also, the minerals “ruby” and “sapphire” (varieties of “corundum”) are caused by trace amounts of chromium, and chromium, cobalt and titanium (respectively).

**Luster:** Three main types are *metallic*, *submetallic* and *nonmetallic*:

Metallic means it is bright and shiny like a metal, and opaque (non translucent), and may yield a black streak on a streak plate.

Submetallic means it looks shiny from a distance, but on close examination one can see into the mineral, especially along a thin edge. This type of luster is not near as common as others (the ore mineral “sphalerite”, which is zinc sulfide, is usually has submetallic luster).

Nonmetallic: this applies to all other minerals, from glassy (or “vitreous”, like many silicate minerals) to dull. Examples include resinous (resin like), pearly (pearl like), greasy, silky, or adamantine (brilliant, diamond like).

### **Other Optical Properties:**

Streak Color: this is the color of the powdered mineral observed on a streak plate, which has a hardness of 7).

Opalescence: this is a reflectance habit in opal caused by layers of differing refractive index in layers. Chatoyancy: this is the appearance of silky fibers with a band of light at right angles to them, caused by parallel inclusions (such as in the mineral “tigers eye”).

Asterism: this is the six pointed star effect seen in ruby and sapphire, caused by Inclusions oriented at right angles to the three crystallographic directions.

Luminescence: behavior in ultraviolet light, caused by “activators” (foreign ions) in the crystal structure, which become excited by certain wavelengths of light.

Fluorescence: emits light when exposed to UV light or X-rays (for example “scheelite”).

Phosphorescence: emits light on its own for a short time after the UV light is cut off (for example “carnotite”).

**Magnetism**: indication of the minerals magnetic susceptibility, or strength of its own magnetic field. The mineral “magnetite” is strongly magnetic; the mineral “pyrrhotite” is weakly magnetic.

**Specific gravity:** this is the ratio of the weight of a substance to the weight of an equal volume of water. For most minerals the specific gravity ranges from 2 to 5. Some minerals, like gold (specific gravity 15 to 19), are extremely heavy.

**Cleavage:** tendency to along flat surfaces. three aspects are: 1) total number of planar directions, 2) angular relationships between directions, and 3) the quality of the breakage.

Examples: Basal cleavage (on flat plane): Mica  
 Rhombohedral (three directions not at right angles): Calcite  
 Octahedral (four directions): Fluorite  
 Pinacoidal (two directions nearly at right angles): Feldspar  
 Cubic (three directions all at right angles): Galena  
 Prismatic (two directions with angles of about 124 and 56 degrees): Amphibole

**Fracture:** this is similar to cleavage, but is the character of breakage along non-planar surfaces.

Examples: Conchoidal (curved, fan-shaped surfaces): Obsidian  
 Splintery (as name implies): Tremolite  
 Hackly (irregular, rough and with sharp points): Copper  
 Even (surfaces nearly flat):  
 Uneven (surfaces irregular): Rhodonite

**Crystal Habit:** this is the crystal system the mineral follows by nature.

Examples: Acicular (needlelike):  
 Capillary (hairlike): Boulangerite  
 Bladey (single or aggregates of flat blades): Calcite  
 Dendritic (plantlike branches): Mn-oxides  
 Reticulated (lattice like groups of slender crystals):  
 Radiating (growth outward from central point): Tourmaline  
 Drusy (tiny crystals on a surface): Quartz  
 Columnar (elongated or column like): Tourmaline  
 Fibrous (fibrous aggregates):  
 Botryoidal (like a bunch of grapes):  
 Mammillary (rounded masses):  
 Colloform (general term for rounded masses):  
 Foliated (Separating into plates or leaves):  
 Micaceous (splits into extremely thin sheets): Mica  
 Lamellar or tabular (flat plates superimposed on each other):  
 Granular (an aggregate of grains):  
 Stalactitic (pendant cones):  
 Concentric (concentric spherical layers):  
 Pisolitic (rounded masses about the size of peas):  
 Oolitic (like fish roe):  
 Banded (in narrow bands):  
 Amygduloidal (containing small nodules):  
 Massive (compact, irregular, formless):

**Hardness:** this is the toughness on a scale of 1 to 10, having key minerals as indices, named after Moh:

|                | Softest |                  |           |          | Hard                       |          |                  |       | Hardest           |         |
|----------------|---------|------------------|-----------|----------|----------------------------|----------|------------------|-------|-------------------|---------|
| Hardness Scale | 1       | 2                | 3         | 4        | 5                          | 6        | 7                | 8     | 9                 | 10      |
| Index Mineral  | Talc    | Gypsum           | Calcite   | Fluorite | Apatite                    | Feldspar | Quartz           | Topaz | Corundum          | Diamond |
| Other Objects  |         | Fingernail (2.5) | Penny (3) |          | Steel (5.5)<br>Glass (5.5) |          | Streak Plate (7) |       | Carbide Tip (9.5) |         |

TABLE T2: Moh's Hardness Scale

**Effervescence:** this is the bubbling behavior of a mineral when exposed to hydrochloric acid. Only place one drop at a time, and only as little as necessary to observe a reaction. Some minerals fizz easily (strong effervescence), while others may fizz slightly (weak effervescence), and others may only fizz when crushed.