Paleo Lab 1 - Mineral Identification

All rocks are composed of one or more minerals. In order to be able to identify rocks you have to know how to recognize those key minerals that make of the bulk of rocks. By definition, any substance is classified as a mineral if it meets all 5 of the criteria below:

- is naturally occurring (ie. not artificial);
- solid (not liquid or gaseous);
- inorganic (not living and never was alive);
- crystalline (has an orderly, repetitive atomic structure);
- has a definite chemical composition (you can write a discrete chemical formula for any mineral).

Identifying an unknown mineral is like identifying any group of unknowns (leaves, flowers, bugs... etc.) You begin with a box, or a pile, of unknown minerals and try to find any group of features in the samples that will allow you to separate them into smaller and smaller piles, until you are down to a single mineral and a unique name. For minerals, these group features are called physical properties. Physical properties are any features that you can use your 5 senses (see, hear, feel, taste or smell) to aid in identifying an unknown mineral. Mineral physical properties are generally organized in a mineral key and the proper use of this key will allow you to name your unknown mineral sample. The major physical properties will be discussed briefly below *in the order in which they are used to identify an unknown mineral sample*.

Luster

Luster is the way that a mineral reflects light. There are two major types of luster; metallic and non-metallic luster. A mineral with a metallic luster is either shiny, because it reflects light like a polished piece of metal, or is dull- looking, because it reflects light like a metal rust or a metal tarnish. All other minerals that do not reflect light like some form of metal are said to be non-metallic. There are many sub-groupings of non-metallic luster and the terms for these lusters are very descriptive of their appearance; pearly, silky, waxy, dull, earthy, glassy (often called vitreous) are just a few examples.

Streak

A mineral's streak is the color of its powder when the mineral is rubbed on a square of porcelain called a streak plate. Streak is one of the best physical properties for the recognition of metallic minerals because metallic minerals all have a very dark-colored streak that is nearly always consistent for a given metallic mineral. Streak is, however, not a useful property for minerals that have a non-metallic luster. Non-metallic minerals have either a white streak or a very light-colored streak that is not consistent from one sample to the next. Also, some non-metallic minerals are actually harder than the streak plate (which is about 7.5 on the Mohs Hardness Scale) and thus can not be powdered.

Hardness

The hardness of a mineral is determined by scratching the mineral with a material of known hardness. The materials that Geologist's use to test mineral hardness are a set of minerals of known hardness called the Mohs Hardness Scale. There are ten minerals in the Mohs Hardness scale assigned numbers from 1 to 10, where 1 is the softest mineral possible and 10 is the hardest known mineral. The ten minerals and their hardness numbers are listed below:

1 talc
2 gypsum
3 calcite
4 fluorite
5 apatite
6 orthoclase (a common form of potassium feldspar)
7 quartz
8 topaz
9 corundum
10 diamond.

Minerals with a higher hardness number with scratch all minerals with a lower hardness numbers and *two minerals of the same hardness will scratch each other*. This is not a linear scale, that is, a mineral of hardness of 2 is not twice as hard as a mineral of hardness 1. What this means is that to test really hard minerals you have to use a great deal more force than for softer minerals. You must wipe off any mineral powder from the samples and examine them very closely to see which one (or even both if they have equal hardness numbers) was scratched. Also, do **NOT** use your jewelry to test mineral hardness! A diamond may be the hardest known mineral, but it is rather brittle and relatively easy to crush against even a softer mineral. Even if your diamond does survive a hardness test, the precious metal that gemstones are set in is quite soft and very easy to damage.

Since even Geologists do not carry a pocket full of minerals in the field with them for testing purposes (and certainly not a large diamond), there are a few relatively common materials that will allow you to get a range of mineral hardnesses without having to purchase a Mohs Hardness scale set. A human fingernail has a very consistent hardness of 2.5. Any mineral that you can scratch with your fingernail is 2.5 or less in hardness. It must be emphasized that you should use an untreated fingernail, as some fingernail polishes and hardeners can be considerably harder than 2.5. In addition, any mineral of hardness of 1 will feel almost soapy when scratched. Another common material used in hardness tests is a steel nail. Steel nails have a hardness of about 5. So, if you can not scratch a mineral with your untreated fingernail, but can scratch it with a steel nail than your mineral has a hardness range of greater then 2.5 but less than or equal to 5. (Note that many Geologists carry a pocket knife with them in the field since the blade of most pocket knives have a hardness that is close to a steel nail, i.e. 5 to 5.5). Finally, any mineral that will scratch a steel nail must have a hardness that is greater than 5. These three hardness categories have been simplified in a table below:

Can scratch with a fingernail	H ≤ 2.5	Hardness is **Soft**
between a fingernail and a steel nail	H > 2.5 ≤ 5	Hardness is **Medium**
can scratch a steel nail	H > 5	Hardness is **Hard**

Cleavage and Fracture

Minerals are chemical compounds, which means that on an atomic level they are made up of atoms that are chemically bonded to each other. There are several possible types of chemical bonds that can be present in minerals. Some bonds may be weaker and others stronger. If a mineral contains weaker chemical bonds that are aligned, then these minerals will break along the planes of weakness created by these weaker chemical bonds. The ability of a mineral to break along smooth planes of weakness is a physical property called mineral cleavage (or just cleavage). Cleavage is a reproducible property, that is, if you see a smooth surface on a mineral and are able to reproduce that smooth surface by striking the mineral, then that smooth surface is known as a direction of cleavage. Minerals may have 1, 2, 3 or even 4 directions of cleavage (Figure 1). Note that a mineral actually has two smooth, parallel planes for each direction of mineral cleavage it contains (1 direction of cleavage yields 1 pair of parallel planes, 2 directions of cleavage yields 2 pairs of parallel planes,... etc.) Some minerals lack cleavage and are said to have fracture instead. A fracture surface may appear either grainy and irregular like a piece of broken rock or sharp and irregular like a piece of broken glass. Also note that there are different degrees (good, fair or poor) of cleavage possible in different mineral samples. Good cleavage means that a mineral has readily visible, smooth cleavage surfaces upon breaking. Fair cleavage means that some samples may show all of their cleavage surfaces while others may not show their cleavage well. Poor cleavage means that smooth surfaces are rarly seen and that you must use the overall shape of the broken sample to determine the cleavage (or examine the broken surfaces with a magnifying glass to see the cleavage). Finally each type of cleavage is given an abbreviated name based on the shape of the mineral after it has been cleaved (Figure 1); 1 direction of cleavage is called basal cleavage, 2 directions is called prismatic, three directions may be called either cubic or rhombic and 4 directions of cleavage is known as octahedral cleavage.

a. Cleavage in one direction
(example: muscovite; **basal** cleavage)

b. Cleavage in two directions at right angles
(example: feldspar; **prismatic** cleavage)

c. Cleavage in two directions not at right angles
(example: hornblende; **prismatic** cleavage)

d. Cleavage in three directions at right angles
(example: galena; **cubic** cleavage)

e. Cleavage in three directions not at right angles
(example: calcite; **rhombic** cleavage)

f. Cleavage in four directions
(example: fluorite; **octahedral** cleavage)

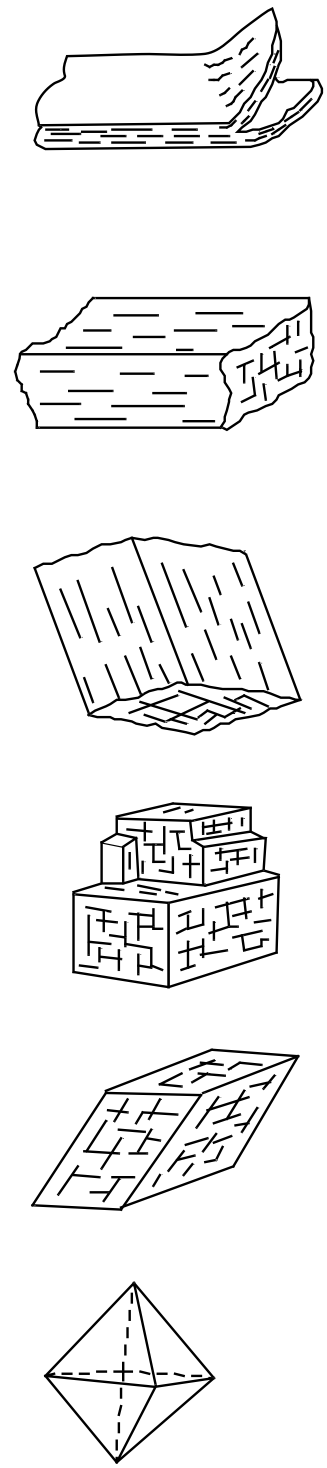

Figure 1. Different types of mineral cleavage create cleavage fragments of different shapes.

Other Physical Properties

There are several physical properties that are useful for recognizing either individual minerals or small groups of minerals. An example of this is the soft, soapy feel of all minerals with a hardness number of 1. Several of these ‘limited utility’ physical properties are briefly explained below.

Color

Color is generally considered a poor criteria for mineral identification. Most minerals, when absolutely pure, are either clear or white. But absolutely pure minerals are a rare find in nature. Many minerals are colored by trace amounts of impurities present in the environment in which they formed. Some relatively common minerals, such as quartz and calcite, may exist in any color. The only way to know if the color of a mineral is a useful property for identification is to look at as many samples as is possible and to note any color variations.

Crystal Form

A crystal is a near-perfect geometric shape that is the outward expression of the orderly internal atomic structure of a mineral. All minerals are crystalline, but not all minerals display the outward geometric shape of a crystal. Crystals need time to grow large enough to be visible and room in which to grow in. Without the time or the space, a mineral will have crystals that are too small to be seen without the aid of a microscope. If they are visible, the shape of a crystal, or its crystal form, is an excellent physical property for the recognition of a mineral because every mineral has a particular crystal form. Figure 2 shows several possible crystal forms. Be warned that is very common to confuse a crystal for a cleaved mineral. Mineral cleavage is reproducible when a mineral is broken, but if you break the smooth faces of a crystal then you permanently destroy the crystal. The smooth faces of a crystal are not reproducible when the crystal is broken.

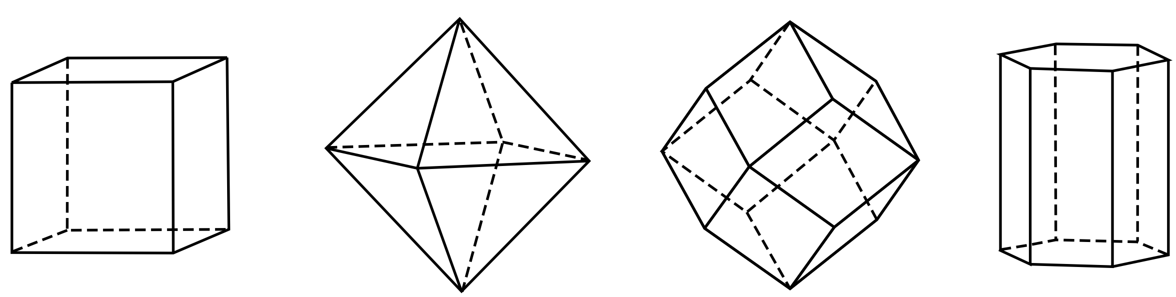

Figure 2. Examples of different types of crystal shapes.

Specific Gravity

Specific Gravity (often abbreviated SG) is the weight of a mineral compared to the weight of an equal volume of water. It is literally how dense or heavy a mineral feels for its size. Minerals that have a low metal content tend to have low specific gravities (3 to 5) and feel very light when held. Minerals with a high metal content tend to have high specific gravities (>5) and may feel very heavy, especially when compared to lower SG samples of equal size.

Specific Properties

Certain minerals called carbonates will effervesce or bubble when acid is applied to them. One relatively common mineral has so much iron in it that it will stick to a magnet. A few minerals have a property known as elasticity, that is, if you bend thin sheets of these minerals they will snap back like a rubber band. Some minerals have a high sulfur content and literally stink if you rub them. These are additional physical properties that you may encounter in a few of your lab samples.

L	Streak	H	Cleavage	Other Properties	NAME
Metallic Luster	reddish-brown	soft	fracture	reddish-brown color; earthy texture; specific gravity=5; silver form is harder	**hematite**
	gray	med.	cubic	silver-gray color; specific gravity=7.6; good cleavage	**galena**
	black	hard	fracture	black color; specific gravity=5.2; high Fe content will attract a magnet	**magnetite**
	greenish-black			brass-yellow color; specific gravity=5.2; often in small cube crystals	**pyrite**
Non-metallic Luster	**NOT USEFUL**	soft	basal	white, gray, greenish; soft soapy feel; fair cleavage in thin plates; H=1	**talc**
	NOT USEFUL			clear to white; H=2; common form has good cleavage in flexible sheets	**gypsum**
	NOT USEFUL			clear to silvery color; H=2-2.5; very good cleavage in thin elastic sheets	**muscovite**
	NOT USEFUL			dark brown to black; opaque; H=2.5; good cleavage in thin elastic sheets	**biotite**
	NOT USEFUL	med.	rhombic	clear to white (can be any color); H=3; very good cleavage; effervesces in acid	**calcite**
	NOT USEFUL		octahedral	clear, green, yellow, purple; H=4; good cleavage with triangular breaks	**fluorite**
	NOT USEFUL		fracture	light green to reddish brown; H=5; often in 6-sided crystals	**apatite**
	NOT USEFUL	hard	prismatic (at 90°)	flesh pink color; H=6; fair cleavage; a common form of potassium feldspar	**orthoclase**
	NOT USEFUL			white to gray (dirty white); H=6; fair cleavage with striated surfaces	**plagioclase feldspar**
	NOT USEFUL			dark green; fair to poor cleavage with blocky breaks; H=6	**augite (pyroxene)**
	NOT USEFUL		prismatic (not at 90°)	black color, poor cleavage with long breaks; H=6	**hornblende (amphibole)**
	NOT USEFUL		fracture	clear to any color; breaks like glass; may form 6-sided crystals; H=7	**quartz**
	NOT USEFUL			light green to brownish, granular ‘sugary’ crystals; H=7.5	**olivine**
	NOT USEFUL			brown, gray, blue (rarely red); 6-sided crystals with flat ends; H=9	**corundum**

Luster	Streak	H	Cleavage	Other Properties	NAME

Study the Mineral Identification Keys (page 7) in the lab manual. There are 18 minerals to identify (2 are the same) during this lab period. First you should answer questions 1 to 14 below, which are designed to help you get started with your mineral identification. The ultimate goal is for you of to fill out the data table on page 8 as completely as possible and in the process of filling out this table you should learn how to identify some of the more common minerals that exist in nature.

Luster:

1. List the minerals in your box that have metallic luster. Have non-metallic luster?

2. Which sample, while appearing non-metallic by definition, has a metallic luster?

Hardness:

3. An unknown mineral is scratched by a piece of orthoclase and, in turn, scratches a piece of fluorite. What is its hardness or possible range of hardnesses?

4. Which of your minerals is harder than a steel nail?

5. Which of your minerals is softer than your fingernail?

Color:

6. Why is color a poor criterion to use (in most cases) for mineral identification?

7. Name two of the mineral specimens in your box that can exhibit different colors. List these minerals and the colors that they can exhibit using the mineral key on page 7.

Streak Color:

8. What is the streak color of your metallic luster minerals. Again list your metallic lustered minerals and the streak colors they exhibit.

9. Corundum is 9 on Mohs hardness scale. Comment on the possible reasons why corundum does not leave a streak powder on the streak plate.

[Think about the hardness of the streak plate vs. corundum]

Cleavage and Fracture:

10. Of your mineral specimens indicate the mineral(s) that exhibit one, two, three and four good direction of cleavage.

11. In general, how can you tell the difference between a cleavage and fracture surface?

Crystal Form:

12. Quartz can exhibit nice crystal form. However, not all quartz forms large crystals. Discuss!

Specific Gravity:

13. Which minerals have relatively high specific gravities? What type of luster do these mineral possess?

Other Properties:

14. Which mineral in your box have a distinctive “feel.” Describe this feel!