Lab 9 - 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 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.

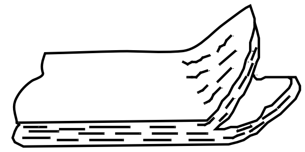
Since even Geologists do not carry a pocket full of minerals in the field with them for testing purposes (and certainly not a large diamond), there are a few relatively common materials that will allow you to get a range of mineral hardnesses without having to purchase a Mohs Hardness scale set. A human 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**

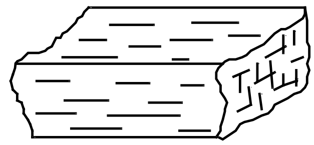
Cleavage and Fracture

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.

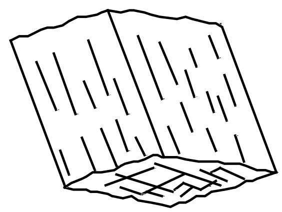
a. Cleavage in one direction
(example: muscovite; **basal** cleavage)



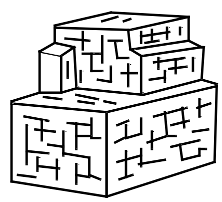
b. Cleavage in two directions at right angles
(example: feldspar; **prismatic** cleavage)



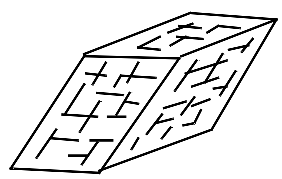
c. Cleavage in two directions not at right angles
(example: hornblende; **prismatic** cleavage)



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)

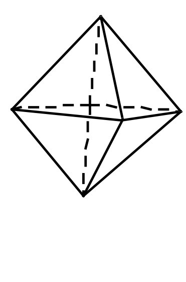


Figure 1. Different types of mineral cleavage create cleavage fragments of different shapes.

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.

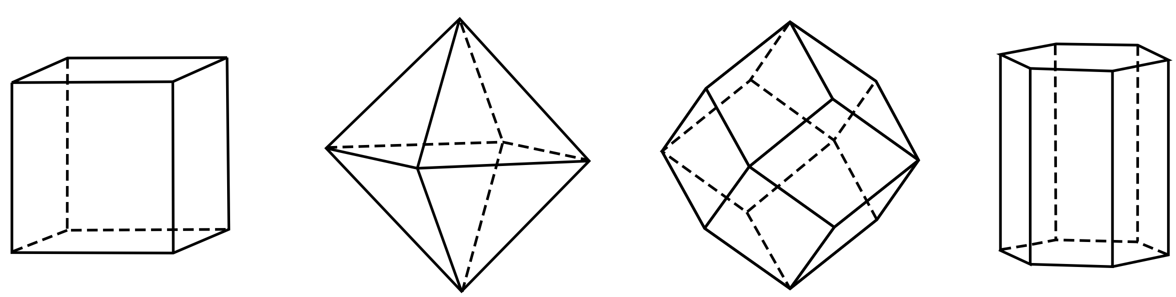


Figure 2. Examples of different types of crystal shapes.

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			brown, gray, blue (rarely red); 6-sided crystals with flat ends; H=9	**corundum**

Luster	Streak	H	Cleavage	Other Properties	NAME

FOLLOW THE INSTRUCTIONS BELOW PRECISELY. DO NOT SKIP AHEAD.

Pull out the minerals from your plastic box. Also place the last three pages from your lab on your table (you only need one set per table).

The most fundamental mineral property is luster. Recall that there are two types of luster (metallic and non-metallic). Find the four minerals that you think have metallic luster in place them on that sheet of paper. Do not worry about naming these minerals now. That will come later. **Your instructor will check to see if you grouped the minerals correctly.**

Recall that minerals that have a metallic luster are shiny like a metal. But they also can look dull like metal rust or tarnish.

Questions:

1. A very useful property of metallic luster mineral is streak color. By conducting a streak test you will get a unique color for each metallic luster mineral. Determine the streak color for each of your specimens. Write the color and mineral name here and place your minerals on the appropriate sheet of paper. **Your instructor will check to see if you identified the minerals correctly.**

2. Hardness can also be a useful property. Check the hardness of your four metallic luster minerals. Write the hardness and mineral name here.

3. Only one of your metallic luster minerals has cleavage and the other three have fracture. Identity the mineral with cleavage and indicate the type of cleavage.

4. The mineral pyrite has cubic crystals and galena has cubic cleavage. Superficially they look similar but are different. Describe the difference between cleavage and crystal form.

5. Metallic luster minerals tend to have a relatively low or high specific gravity or density.

6. From the table on pg. 7 pick **one** other unique property for your minerals with metallic luster. NOTE THAT YOU CAN NOT CHOOSE COLOR.

Now you can fill out the table on page 8 for the minerals that have metallic luster.

The remaining minerals in your set have non-metallic luster. For non-metallic minerals streak color is not a useful property because all non-metallics either do not leave a streak or have a white streak. For non-metallic luster minerals hardness is a much more useful property. Select the four soft non-metallic minerals. **Your instructor will check to see if you grouped the minerals correctly.** These minerals you should be able to scratch with your fingernail. Do not worry about naming these minerals now. That will come later.

Questions:

7. What type of cleavage do all of your soft non-metallic minerals have ___________________

8. One of your soft non-metallic minerals has a soapy feel.
   Identify this mineral. ___________________

Find the two soft non-metallic minerals that consist of thin elastic sheets. Show these to your instructor.

Identify your four soft non-metallic minerals by placing them on the appropiate sheet. **Your instructor will check to see if you identified the minerals correctly.** Once checked then you can fill out the table on page 8. Be sure to select **one** other property from page 7. NOTE THAT YOU CAN NOT CHOOSE COLOR.

You have three minerals that are medium and non-metallic. These minerals you should be able to scratch with your steel nail. Group these minerals together. Do not worry about naming these minerals now. That will come later. **Your instructor will check to see if you grouped the minerals correctly.**

Questions:

9. Identify the type of cleavage / fracture in your three medium non-metallic minerals. When you have done this you have essentially identified the specimen. Place your mineral on the appropiate sheet. **Your instructor will check to see if you identified the minerals correctly.**

10. Select **one** other property from page 7 for your medium non-metallic minerals. You can also fill out the table on page 8. NOTE THAT YOU CAN NOT CHOOSE COLOR.

The remaining minerals in your set are hard and have non-metallic luster. To confirm the hardness check the mineral see if it can scratch the steel nail.

Questions:

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

Group these minerals into two piles. One with only fracture and the other with prismatic cleavage surfaces. Y**our instructor will check to see if you grouped the minerals correctly.**

12. Select **one** other property for your hard non-metallic minerals. You can also fill out the table on page 8. NOTE THAT YOU CAN NOT CHOOSE COLOR.

13. Note that you have two quartz specimens in your set. Sometimes quartz can exhibit nice crystal form. However, not all quartz forms large crystals. Think about the conditions that are needed to favor the growth of large crystals and discuss.

Identify your hard non-metallic minerals by placing them on the appropiate sheet. **Your instructor will check to see if you identified the minerals correctly.** Once checked then you can fill out the table on page 8.

14.. Many of the hard non-metallic minerals have both cleavage and fracture surfaces. Name three hard non-metallic minerals that have both cleavage and fracture. **Make sure you are able to show your instructor that you know the difference between a cleavage and fracture surface.**

Metallic Luster

hematite	***galena***	***magnetite***	***pyrite***

Non-Metallic Luster - soft

talc	***gypsum***	***muscovite***	***biotite***

Non-Metallic Luster - medium

calcite ***fluorite*** ***apatite***

Non-Metallic Luster - hard - prismatic cleavage

orthoclase ***plagioclase*** ***augite*** ***hornblende***

Non-Metallic Luster - hard - fracture

quartz (crystal)

quartz (fractured)

corundum