Lab 1 - Physical Properties of Minerals

All rocks are composed of one or more minerals. In order to be able to identify rocks you have to be able 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 following criteria:

- is naturally occurring (ie. not man-made);
- solid (not liquid or gaseous);
- inorganic (not living and never was alive);
- crystalline (has an orderly, repetitive atomic structure);
- 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 has a very high metal content and 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 (i.e., that have a low metal content) are said to be nonmetallic. There are many sub groupings of nonmetallic luster and the terms for these lusters are very descriptive of their overall appearance; pearly, silky, waxy, dull, earthy, glassy (often called vitreous), resinous (like dried pine sap) 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 nonmetallic luster. Nonmetallic minerals have either a white streak or a very light-colored streak that is not consistent from one sample to the next. Also, some nonmetallic minerals are actually harder than the streak plate 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. Table X.X lists the Mohs Hardness Scale along with the hardness of several common mineral substitutes.

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 good 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 diamonds are set in is quite soft and very easy to damage.

Hardness (H)	Mohs Mineral	Common Materials
1	Talc	
2	Gypsum	
2.5		Untreated Fingernail
3	Calcite	US Copper Penny (pre - 1982)
3.5		US Zinc Penny (after 1982)
4	Fluorite	
5	Apatite	Steel Nail
5 - 5.5		Pocket Knife
5.5		Glass Plate
6	Orthoclase	
6.5		Steel File
7	Quartz	
7.5		Streak Plate
8	Topaz	
9	Corundum	
10	Diamond	

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 rubbed. 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	$H \leq 2.5$	Hardness is **Soft**
between a fingernail and a steel nail	$H > 2.5 \leq 5$	Hardness is **Medium**
can scratch a steel nail	$H > 5$	Hardness is **Hard**

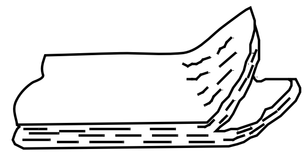
Cleavage and Fracture

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.) A mineral which displays all of its surfaces of cleavage is called a cleavage fragment.

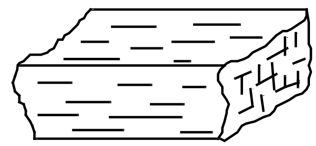
Some minerals lack cleavage and are said to have fracture instead. A fracture surface may appear either grainy and irregular like a piece of broken rock (an irregular fracture) or have very sharp and curved breaks like a piece of broken glass (i.e., a conchoidal fracture). Also note that there are different 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 cleavage fragment (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.

Types of mineral cleavage fragments and their proper names.

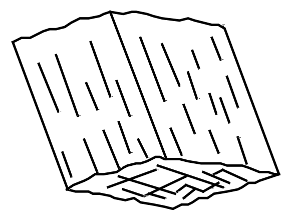
a. Cleavage in one direction
(example: muscovite; **basal** cleavage)



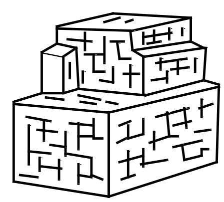
b. Cleavage in two directions at right angles
(example: feldspar; **prismatic** cleavage)



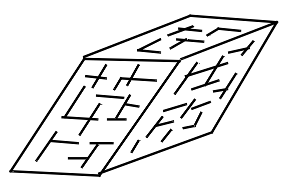
c. Cleavage in two directions not at right angles
(example: hornblende; **prismatic** cleavage)



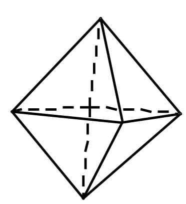
d. Cleavage in three directions at right angles
(example: galena; **cubic** cleavage)



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

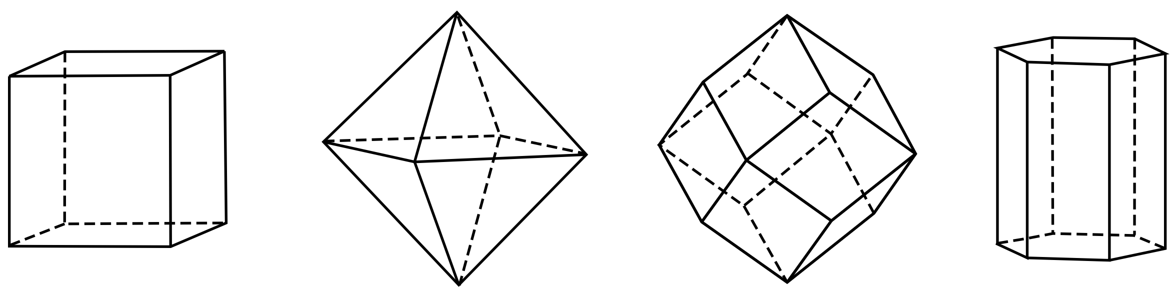


f. Cleavage in four directions
(example: fluorite; **octahedral** cleavage)



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 XX shows several possible crystal forms. Be warned that is very common to confuse a mineral crystal for a cleavage fragment. Mineral cleavage is reproducible when a mineral is broken, but if you break the smooth faces of a crystal then you destroy the crystal. The smooth faces of a crystal are not reproducible when the crystal is broken.



Several crystal shapes that can be found in some minerals.

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 specific gravity samples of equal size.

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. Variations in color of a given mineral is known as mineral varieties. If we take quartz as an example:

COLOR	VARIETY
- clear crystals	Rock Crystal
- purple	Amethyst
- red	Rose Quartz
- white	Milky Quartz
- gray to black	Smoky Quartz
- yellow	Citrine
- green	Adventurine
- fine-grained red	Jasper
- fine-grained white to light gray	Chert
- fine-grained dark gray to black	Flint
- fine-grained banded	Agate
- and so on for about 120 known varieties	

Some minerals are more abundant in particular varieties and so color is a more useful for those particular minerals. The only way to know if the color of a mineral is a useful physical property for identification is to look at as many samples as is possible and to note any color variations and whether one color seems to appear more often than others.

Special Properties

There are numerous physical properties that are useful for recognizing either individual minerals or small groups of minerals. These are known as “special properties” and a few are listed below:

Magnetism - Because of their extremely high metal content (notably cobalt, iron or nickle) a very few of the over 4000 known minerals can stick to a magnet.

Elasticity / Flexibility - Elasticity is the ability for a mineral to snap back when bent, like a rubber band. Flexibility means that it will bend slightly but will not snap back like a rubber band.

Striations - Small parallel lines on the surfaces of some crystals and on some cleavage fragments as a result of the way the mineral formed.

Opacity - Minerals that will let light travel through them and you can see an image through them are known as transparent minerals. Those which will allow light to pass through, but you can not see an image through are called translucent minerals. Those that will not let light to pass through them are called opaque minerals.

Smell - Minerals with a high sulfur content will give off the odor of rotten eges when rubbed. Many clay minerals have a very earthy or clay-like smell when warmed by your breath.

Taste - A small group of minerats known as ‘salts’ have a salty taste (table salt is a mineral ‘salt’).

Feel - Minerals with a Mohs hardness of 1 have either a soapy or greasy feel when rubbed because of their extreme softness.

Physical Geology Lab 1 - The Physical Properties of Minerals

Name ________________________________ Date __________

Circle the correct answer for each question below.
Note: the question number corresponds to the station number in each box

1.	A. Which sample has a metallic luster?	(yellow, pink)
	B. Which sample has a nonmetallic luster?	(yellow, pink)
2.	A. Which sample has a metallic luster?	(black, green)
	B. Which sample has a nonmetallic luster?	(black, green)
3.	A. Which sample has a metallic luster?	(red, green)
	B. Which sample has a nonmetallic luster?	(red, green)
4.	How many directions of cleavage does this sample have?	(0, 1, 2, 3, 4)
5.	How many directions of cleavage does this sample have?	(0, 1, 2, 3, 4)
6.	How many directions of cleavage does this sample have?	(0, 1, 2, 3, 4)
7.	How many directions of cleavage does this sample have?	(0, 1, 2, 3, 4)
8.	How many directions of cleavage does this sample have?	(0, 1, 2, 3, 4)
9.	How many directions of cleavage does this sample have?	(0, 1, 2, 3, 4)
10.	A. Which sample is harder?	(white, silver)
	B. What is the hardness range of the white sample?	(soft, medium, hard)
	C. What is the hardness range of the silver sample?	(soft, medium, hard)
11.	A. Which sample is harder?	(clear, pink)
	B. What is the hardness range of the clear sample?	(soft, medium, hard)
	C. What is the hardness range of the pink sample?	(soft, medium, hard)
12.	A. Which sample is harder?	(white, clear)
	B. What is the hardness range of the white sample?	(soft, medium, hard)
	C. What is the hardness range of the clear sample?	(soft, medium, hard)
13.	Which sample has the higher specific gravity?	(silver, clear)
14.	Which sample displays cleavage?	(clear, pink)

15 What ‘special’ physical property do you think might be used to identify this sample?

16. What ‘special’ physical property do you think might be used to identify this sample?

Lab 1 - Physical Properties

1. Is glass is a mineral? Frame your answer in terms of the criteria used to define a mineral.

2. Do all minerals with metallic luster look like shiny metal? Comment in detail.

3. Streak is a physical property that is useful in the identification of minerals with what general type of luster?

4. Would streak be a useful physical property in the identification of hard minerals such as diamond? Explain your answer in detail!

5. What Moh's minerals are softer than a natural fingernail?

6. What Moh's minerals could be used to scratch a steel nail?

7. Describe the difference in the physical appearance of a cleavage versus a fracture surface.

8. The presence of cleavage in a mineral indicates what about the nature of chemical bonding at the atomic scale within a mineral?

9. Comment on the validity of the following statement “Hard minerals that lack significant cleavage planes lack significant planes of weakness.”

10. Describe the difference between cleavage and crystal form as a physical property that can be used identify a mineral.

11. Comment on the validity of the following statement “When breaking a crystal with a hammer the resulting fragments will have the same shape as the original crystal.”

12. Comment on the validity of the following statement “Crystal form is an expression of the internal symmetry of atoms within the mineral.”

13. Minerals with what type of luster will tend to have a higher specific gravity?

14. Why is color a poor criteria for the recognition of most minerals?

15. Quartz has a very simple chemical formula (SiO_2) and yet has about 120 known varieties. Why?