Identification of Rock forming mineral

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Minerals are the natural material that every inorganic material on planet Earth is composed of. They are the foundation of both our planet and most human industry.

Minerals can be defined as naturally occurring, inorganic substances that have characteristic chemical composition. Because individual minerals must have the same chemical composition, they must also share distinctive physical properties and have a crystalline atomic structure. This means that the atoms or molecules that make up each mineral exist in an orderly three dimensional arrangement. The structure that results from such arrangement is called a **crystal**.

Mineral Properties

Seven properties are commonly used to identify minerals: color, luster, hardness, streak, cleavage, fracture, and crystal form. For many of the minerals you will look at during this lab, these properties will be all that is necessary to identify the samples. However, at times other properties such as reaction to acid, magnetism, **striation**, and the existence of **exsolution lamellae** will be needed to make a correct identification.

Color

Color is one of the most noticeable physical attributes of a mineral. The true color of a mineral is due to the manner in which chemical bonds (or the molecular structure) interact with natural light (absorbing and reflecting different wavelengths). However, as you will see during this lab, often the same mineral can exist in many different colors. For example, calcite, a mineral composed entirely of calcium carbonate, exists in a colorless, white, green, and even blue form.

This variety in color is most often due to impurities within or on the surface of the mineral. Because of this, natural color is not often a reliable property for use in mineral identification. However, if we could limit the effect of impurities, it would be possible to see the mineral’s “true” color, which should be the same in all varieties of one mineral.

Streak

One way to observe the true color of a mineral is to observe very small quantities of the mineral. By doing this the percentage of color-producing impurities is kept to a minimum and the true color of the mineral becomes more obvious. One way to do this is to perform the streak test. This is done by scratching the mineral against a white ceramic streak plate. The resulting color of the streak is the true color of the mineral.

To test this, obtain a piece of specular and oolitic hematite, two varieties of the same mineral. If this test is correct then the streak of these two very different looking minerals should be the same color.

What is the color of the streak produced by both of these minerals?

Specular Hematite ______________ Ooilitic Hematite___________________

The streak test must be performed very carefully because not all minerals will leave a streak. In some cases the mineral will actually scratch the streak plate. This will result in the appearance of a white streak; however, further observation will show a shallow scratch beneath the streak. In this case the mineral is still considered to leave a white streak.

Hardness

The ability of some minerals to scratch the streak plate while others are scratched by the streak plate is a result of another property known as **hardness**. The hardness of a mineral is a measurement of the strength of the chemical bonds between the individual atoms or molecules within the mineral.

The strength of the bonds depends solely on the physical properties of the atoms within the bond. With over 2000 known minerals, each of which has its own definite chemical composition, using hardness as an identifying property could be a daunting task. This process is simplified by using a relative scale such as Mohs Scale of Hardness.

To use this technique, hardness values between 1 and 10 have been assigned to some common minerals. 1, the softest, is a mineral known as talc; the hardest mineral, 10 on Mohs scale, is diamond. Along with assigning hardness values to common minerals, these values have also been assigned to other common objects as illustrated below.

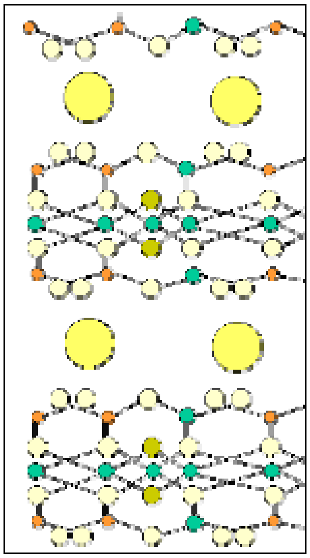
<table>
<tr><th colspan="2">Mohs Hardness</th><th>Common Objects</th></tr>
<tr><td>10</td><td>Diamond</td><td rowspan="10">– 6.5 Streak Plate
– 5.5 Glass or Knife Blade
– 4.5 Iron Nail
– 3.5 Copper penny
– 2.5 Fingernail</td></tr>
<tr><td>9</td><td>Corundum</td></tr>
<tr><td>8</td><td>Topaz</td></tr>
<tr><td>7</td><td>Quartz</td></tr>
<tr><td>6</td><td>Orthoclase Feldspar</td></tr>
<tr><td>5</td><td>Apatite</td></tr>
<tr><td>4</td><td>Fluorite</td></tr>
<tr><td>3</td><td>Calcite</td></tr>
<tr><td>2</td><td>Gypsum</td></tr>
<tr><td>1</td><td>Talc</td></tr>
</table>

Minerals or objects that have higher hardness values will be able to scratch minerals or objects of lesser hardness values. Therefore fluorite, hardness 4, will be scratched by any mineral with hardness greater than 4 as well as by an iron nail.

To determine the hardness of a mineral, start by scratching it with your fingernail then use progressively harder and harder objects until the mineral scratches. You will then be able to narrow down the hardness of the mineral to a hardness range.

Cleavage and Fracture

Along with determining the hardness, the bonding and molecular structure of a given mineral will also determine the manner in which a mineral breaks. Surfaces held together by relatively weak bonds, such as those between repeated parallel layers of a crystal, will tend to break more easily than those held together by strong bonds. The tendency of a mineral to break along these flat parallel surfaces is known as **cleavage**. This can best be seen in the atomic model of the muscovite mica crystal below.



Notice the lack of bonds (represented by lines drawn between atoms) between the large yellow atoms (representing potassium) and the layers of highly bonded silicate, aluminum, and hydroxide ions.

The number and strength of bonds between the silica, aluminum, and hydroxide ions make those layers much stronger. Therefore, muscovite mica is much more likely to break along the layers that only contain the weakly bonded phosphorous ions. This results in 1 excellent cleavage plane of mica. This cleavage is observed in the ability to peel sheets of mica.

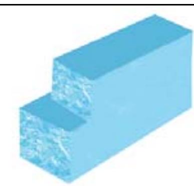
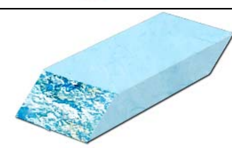
Cleavage can be described as being excellent, good, poor, or absent. Excellent cleavage, such as that of muscovite mica, will result in smooth, flat, parallel surfaces. Good cleavage, as can be seen in the diagram at right, will often result in small, smooth, step-like flat surfaces. In minerals that exhibit poor cleavage, it may be difficult to identify any cleavage surfaces. In poor cleavage, the cleavage surface is often mixed in with fractured surfaces. If a mineral exhibits no cleavage, cleavage is said to be absent; in these cases the mineral is said to have **fracture**.

Fracture can be described as either being **irregular**, as in the diagram at right, or **conchoidal**. Conchoidal fracture will result in the mineral breaking along smooth, curved surfaces. Typically, these surfaces resemble the inside of clam shells.

Describing Cleavage

In order to describe the cleavage of a mineral, you must first count how many planes of cleavage exist. To do this, first rotate the mineral until you find a smooth flat surface. If the surface is a cleavage plane, there will be another smooth flat surface parallel to the first surface on the opposite side of the mineral. Two parallel smooth flat surfaces equal **one** cleavage plane. Therefore, if a mineral is in the shape of a cube, you should be able to count 3 cleavage planes.

When describing cleavage it is also necessary to describe the angle between the cleavage planes. If, for example, a mineral is in the shape of a cube the angle between the cleavage planes should be 90^{o}. If, however, the angle is not 90 degrees the mineral will no longer have a cubic shape. Below is a brief chart describing the shapes associated with certain cleavages.

# Cleavage Planes	Shape	Example
1	Basal Cleavage Splits into flat sheets	
2 at 90^{o}	Rectangular	
2 not at 90^{o}	Elongated Parallelogram	
3 at 90^{o}	Cubic	
3 not at 90^{o}	Rhombohedral	
4	Octahedral	

Crystal Form

The **crystal form** of a mineral is the external feature, or geometric shape, of the mineral crystal. Mineral crystals can take on a number of forms such as cubes, pyramids, or prisms. The characteristic crystal form of a mineral is known as the mineral's **habit.**

In order for a mineral to exhibit perfect crystal form, its growth must be unrestricted. Typically many crystals of a mineral will be growing together, so unrestricted growth is rare and therefore perfect crystal form is also rare.

Since it is more common for mineral crystals to crowd together, we often find minerals formed in a network of intergrown crystals that do not resemble the true crystal form.

Most samples that you will observe in the following exercise will not exhibit their crystal form because they are broken fragment from larger samples. However, identifying those that do exhibit their crystal form can help in identification. Most importantly, do not confuse the flat crystal faces with cleavage planes. The flat surfaces of crystals are simply areas where the crystal stopped growing.

Luster

The **luster** of a mineral is a description of how a mineral reflects light. This can be described by either a **metallic** luster or a **nonmetallic** luster. If a mineral has a metallic luster, it will appear to have a silvery, gold, brassy, or iron look it. Nonmetallic minerals will appear more earthy or glassy.

When observing luster, it is important to observe a freshly broken surface of the mineral since oxidation can occur on exposed surfaces and the mineral will become tarnished.

Other Properties

Reaction to Acid

How a mineral reacts to acid depends on the components of the mineral. Minerals that contain the CO_3^{2-} ion (all of the carbonate minerals, such as calcite) will effervesce (bubble) when HCl is applied to their surface. The strength of this reaction depends upon the strength of the bonds between the atoms. In some cases the bubbling will be immediately evident, while in other cases the surface of the mineral may need to be scratched to induce the reaction.

Striations and Exsolution Lamellae

Striations are thin-hairline grooves that appear of the cleavage surface of some minerals. Often the mineral must be tilted in the light to see the striations. The existence of striations is a good distinguisher between plagioclase and potassium feldspar.

In addition to the lack of striations, potassium feldspar also exhibits exsolution lamellae. Exsolution lamellae will appear to be striations but on further observation, you will notice that the lines are actually thin, discontinuous, subparallel layers or alternating color.

Name ______________________________

Questions:

1. Indicate the luster of each of the following materials

   a. Penny ________________
   b. Brick ________________
   c. Pencil Lead ________________
   d. A mirror ________________
   e. The table top ________________

2. Describe the cleavage exhibited by the following

   a. Muscovite Mica ________________
   b. Calcite ________________
   c. Plagioclase Feldspar ________________
   d. Quartz ________________
   e. Hornblende ________________

3. A mineral can scratch fluorite but can be scratched by a knife

   a. What is the hardness of the mineral? _____________
   b. What mineral on Mohs Scale has this hardness _____________

4. A nonmetallic mineral with a hardness of 6 exhibits excellent cleavage in two planes at nearly right angles. What other information would you require to determine the name of this mineral?

5. How can the hardness of a mineral hinder your ability to observe cleavage?

Identification of Rock Forming Minerals

Use the tables on the following pages to complete this table and identify the selected minerals

Sample #	Luster	Hardness	Cleavage	Streak	Other	Name
1						
2						
3						
4						
5						
7						
10						
11						
12						
15						
17						
18						
21						

Metallic			
	Streak	**Physical Properties**	**Name**
Hardness > 5	Dark Gray	Brass yellow	**Pyrite**
		Dark gray-black, attracted to magnet	**Magnetite**
	Brown	Silvery black to black tarnishes gray	**Chromite**
Harness < 5	Red-Red/Brown	Silvery gray, black, or brick red	**Hematite**
	Dark Gray	Brass yellow, tarnishes dark brown or purple	**Chalcopyrite**
		Iridescent blue, purple or copper red, tarnishes dark purple	**Bornite**
		Silvery gray, tarnishes dull gray Cleavage good to excellent	**Galena**
		Dark gray to black, can be scratched with fingernail	**Graphite**

Light-colored minerals			
Hardness	**Cleavage**	**Physical Properties**	**Name**
Hardness >5	Excellent or good	White or gray, Cleavage in 2 planes at nearly right angles, Striations. Hardness-6	**Plagioclase Feldspar**
		Orange, brown, white, gray, green or pink. Cleavage in 2 planes at nearly right angles. Exsolution Lamellae. Hardness-6	**Potassium Feldspar**
		Pale brown, white or gray. Long slender prisms. Cleavage in 1 plane. Hardness- 6-7	**Sillimanite**
	Poor or absent	Opaque red, gray, white hexagonal prisms with striated flat ends. Hardness- 9	**Corrundum**
		Colorless, white, gray or other colors. Greasy luster. Massive or hexagonal prisms and pyramids. Transparent or translucent. Hardness- 7	**Quartz White-Milky, Yellow-Citrine, Pink- Rose**
		Opaque gray or white. Waxy luster. Hardness-7. Conchoidal Fracture	**Chert**
		Colorless, white, yellow, light brown. Translucent opaque. Laminated or massive. Cryptocrystalline. Hardness- 7	**Chalcedony**
		Pale olive green. Conchoidal fracture. Transparent or translucent. Hardness- 7	**Olivine**
Hardness < 5	Excellent or good	Colorless, white, yellow, blue, green. Excellent cleavage in 3 planes. Breaks into rhombohedrons. Effervesces in HCl. Hardness- 3	**Calcite**
		Colorless, white, yellow, blue, green. Excellent cleavage in 3 planes. Breaks into rhombohedrons. Effervesces in HCl only if powdered. Hardness- 3.5-4	**Dolomite**
		White with tints of brown. Short tabular crystals or roses. Very heavy. Hardness- 3-3.5	**Barite**
		Colorless, white or gray. Massive or tabular crystals, blades or needles. Can be scratched by fingernail. Hardness- 2	**Gypsum**
		Colorless, white. Cubic crystals. Salty taste. Hardness- 2.5	**Halite**
		Colorless, purple, green, yellow, blue. Octahedral cleavage. Hardness- 4	**Flourite**
		Colorless, yellow, brown. Splits along 1 excellent cleavage plane. Hardness- 2-2.5	**Muscovite mica**
	Poor or absent	Yellow crystals or earthy masses. Hardness 1.5-2.5	**Sulfur**
		Opaque green, yellow or gray. Silky or greasy luster. Hardness- 2-5	**Sepentine**
		Opaque white, gray or green. Can be scratched with fingernail. Soapy feel. Hardness- 1	**Talc**
		Opaque earthy white to light brown. Hardness- 1-2	**Kaolinite**

Dark-Colored minerals			
Hardness	**Cleavage**	**Physical Properties**	**Name**
Hardness >5	Excellent or good	Dark gray, Blue-gray or black. May be iridescent. Cleavage in 2 planes at nearly right angles, Striations. Hardness-6	**Plagioclase Feldspar**
		Brown, gray, green or red. Cleavage in 2 planes at nearly right angles. Exsolution Lamellae. Hardness-6	**Potassium Feldspar**
		Opaque black. 2 cleavage planes at $60^{o}$and 120^{o}. Hardness- 5.5	**Hornblende (Amphibole)**
	Poor or absent	Opaque red, gray, hexagonal prisms with striated flat ends. Hardness- 9	**Corrundum**
		Gray, brown or purple. Greasy luster. Massive or hexagonal prisms and pyramids. Transparent or translucent. Hardness- 7	**Quartz Black or brown- Smoky , Purple- Amethyst**
		Opaque red or brown. Waxy luster. Hardness- 7. Conchoidal Fracture	**Jasper**
		Opaque black. Waxy luster. Hardness- 7	**Flint**
		Transparent- translucent dark red to black. Hardness- 7	**Garnet**
Hardness < 5	Excellent or good	Colorless, purple, green, yellow, blue. Octahedral cleavage. Hardness- 4	**Flourite**
		Green. Splits along 1 excellent cleavage plane. Hardness- 2-3	**Chlorite**
		Black to dark brown. Splits along 1 excellent cleavage plane. Hardness- 2.5-3	**Biotite mica**
	Poor or absent	Opaque green, yellow or gray. Silky or greasy luster. Hardness- 2-5	**Serpentine**
		Opaque white, gray or green. Can be scratched with fingernail. Soapy feel. Hardness- 1	**Talc**
		Opaque earthy red to light brown. Hardness- 1.5-6	**Hematite**