Key

GS 104: Laboratory # 6
PHYSICAL PROPERTIES OF MINERALS AND MINERAL IDENTIFICATION

Introduction

Minerals are naturally occurring, usually inorganic, solids that possess a definite chemical composition and a specific, orderly arrangement of atoms. This lab will help you to develop the ability to identify common minerals found at the earth's surface. Although there are literally thousands of minerals, the small number of the most common rock forming, ore, and industrial minerals studied here constitute a large part of the earth's crust. Identification is accomplished by testing and observing the physical properties studied in the first of part of this laboratory. The second part of the lab will focus on describing the physical properties of a mineral and on identifying minerals using the physical properties.

Objectives

- Recognize and describe the physical properties of minerals
- Develop and use a mineral identification key to name minerals
- Identify minerals using physical properties

Part A: Activities Focusing on Physical Properties

Minerals exhibit certain diagnostic properties, called physical properties, which can be tested and observed, thereby leading to the correct identification of the mineral. Many (but not all) of these properties are unique to a given mineral. One of the keys to identifying minerals is observing a combination of physical properties displayed by a mineral. Therefore, you must be sure of the meaning of each of the physical properties. On the following pages, you will define and study these properties: luster, color, streak, luster, heft, hardness, cleavage, fracture and crystal form, and others, such as, magnetism, taste, effervescence in HCl.

Important Terminology: Complete prior to arriving at your lab section.

COLOR

STREAK

LUSTER

HEFT

HARDNESS

CRYSTAL FORM

CLEAVAGE

FRACTURE

OTHERS (MAGNETISM, TASTE, EFFERVESCENCE IN HCL)

STATION #1: *Luster and Color*

1. Study the various mineral specimens provided. How many specimens can be grouped into each of the following luster types?

 2 Metallic   5 Nonmetallic-glassy

Describe Luster in your own words.

The way a mineral's surface appears.

2. Study the mineral specimens of quartz (Sample #3) provided. What is the reason for the variety of colors that quartz exhibits? (***Hint***: Think about what a single drop of food coloring does to a glass of water.) Impurities in quartz give it color.

3. Is color a reliable physical property to help identify a given mineral specimen? Explain your answer. No. Two samples of the same mineral can have different colors.

STATION #2: *Other Physical Properties* **(Streak, Magnetism, and Effervescence)**

1. Describe Streak, Magnetism, and Effervescence in your own words.

Streak - the color a mineral has when powdered

Magnetism - attraction to a magnet

Effervescence - reacts with acid to produce bubbles

2. Study the collection of samples provided and complete the data table by recording the following observations for each sample:

Sample Number	**Streak**	**Magnetism**	**Reaction to HCl**
#1	brownish red	no	no
#2	black	yes	no
#13	white	no	yes

STATION #3: Cleavage, Fracture, and Crystal Form

Study the collection of samples of single mineral crystals. The samples are separated into smaller groups: several samples exhibiting cleavage (Samples #5, #6, and #13), a sample showing fracture (Sample #3), and a sample demonstrating crystal form (Sample #4).

Cleavage and **Fracture** are related to how a mineral breaks apart. They are controlled by the internal atomic arrangement of the mineral.

1. Between cleavage and fracture, which is controlled by weak chemical bonding, and which is controlled by strong chemical bonding? Briefly explain.

   Cleavage is controlled by weak bonding because a mineral that exhibits cleavage breaks along planes of weakness. When a mineral fractures, all planes within crystal have strong bonds, so there is no preferred direction to break.

Crystal Form is also controlled by the internal atomic structure but is not related to how a mineral breaks.

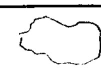
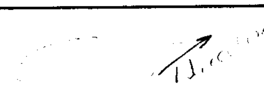
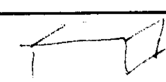
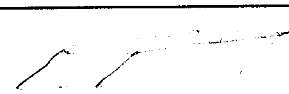
2. What is Crystal Form?

   The shape a crystal takes as it grows.

3. Describe **Cleavage**, **Fracture**, and **Crystal Form** in your own words.

   Cleavage is the tendency of a mineral to break along planes of weakness.
   Fracture is the tendency to break unevenly.
   (see above for crystal form)

Study the group of minerals exhibiting cleavage and complete the data table. For each, describe the cleavage in terms of the number of directions and the angle between them. Also, provide a simple sketch of the sample emphasizing the cleavage.

Sample Number	# of Directions	Angle (90° or not 90°)	Sketch
#3	0	X	
#5	1	X	
#6	3	90°	
#13	3	not 90°	

STATION #4: Density and Heft

One of the physical properties is called heft. This term is a person's estimation of how heavy a mineral is. Obviously different people have different ideas of what is heavy. Therefore, heft is not very "scientific" if by what we mean exactly. The physical property called density determines exactly how heavy a mineral is. Density can be measured with a high degree of accuracy (although your measurement may not seem so because you are using a relatively primitive method). Perhaps of greater importance, any person doing the determination should get the same answer. In other words, the answer is objective and not subjective. The concept that anyone doing the experiment should get the same answer is fundamental to science. Try to think of any other sphere of knowledge where that is true.

You will be provided a specimen for which the density is to be determined. The density of any substance is the mass per volume, shown by the equation: Density = Mass/Volume.

First step: Weigh your specimen on the scale provided. 20.8 g

Second step: Determine the volume of the specimen by displacement of water in a graduated cylinder. 8 ml

Third step: Use the equation to determine the value of the density. 2.60 g/cc

Show work here

$$D = \frac{20.8\ g}{8\ cc} = 2.60\ \frac{g}{cc}$$

Questions for thought:

1. What volume of quartz (density = 2.65 g/cm3) would weigh 1 gram? 0.38

Show work here

$$V = \frac{1g}{2.65\ g/cc} = 0.38\ cc$$

A term, quite similar to density that is often used is specific gravity (S. G.). It also gives the idea of "heaviness" of a mineral, but it does so by comparison with water, which has a SG of one. Specific gravity can be thought of as the number of times the mineral is heavier than if the piece of mineral were made of water. If a mineral has a specific gravity of 3.47, which means it is 3.47 times heavier than if that same specimen were made of water.

2. What would you guess the specific gravity of oil is? less than 1
3. If a substance had a specific gravity of 2.54, would it float or sink in water? sink
4. What must be the specific gravity of ice? less than 1

STATION #5: Hardness

The following hardness guide is useful to bracket the hardness of an unknown sample.

Hardness Guide:

Hardness	**Description**
less than 2.5	Mineral can be scratched by fingernail (H = 2.5).
2.5 to 3.5	Mineral cannot be scratched by fingernail (H = 2.5) and cannot scratch penny (H = 3.5).
3.5 to 5.5	Mineral cannot scratch penny (H = 3.5) and cannot scratch glass (H = 5.5).
greater than 5.5	Mineral can scratch glass (H = 5.5).

Determine the hardness for the small group of minerals provided and complete the data table.

Sample Number	**Hardness**
#3	> 5.5
#7	> 5.5
#13	2.5 - 3.5
#14	less than 2.5

Part B: Activities focusing on Mineral Description and Mineral Identification

<u>Description</u>

You are now ready to collect a complete set of data on the physical properties useful in mineral identification. Determine the physical properties of each sample and record your observations in the data table provided on the following page. Compare you determinations with the mineral charts. To learn to identify these minerals, you should concentrate on a small number (1-3) of diagnostic properties for each mineral.

<u>Identification</u>

Mineral identification is a process of elimination based on determinations of physical properties. In this activity, you will develop an identification key for the minerals that you described above. An identification key in the form of a flow chart helps in leading you to one or a limited number of possibilities. Construct a flow chart identification key based on the physical properties. Begin with broad divisions and work towards increasingly discriminating properties.

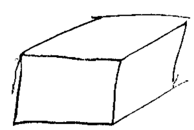
Post-Lab Questions

1. Describe the procedure for identifying a mineral and arriving at its name.

Minerals are identified by noting the sample's physical characteristics (color, cleavage, hardness, etc.).

2. Name the physical property that is described by each of the following statements:
   a. Breaks along smooth planes: cleavage
   b. Scratches glass: hardness
   c. A red-colored powder on unglazed porcelain: streak

3. Describe the shape and sketch a mineral that has three directions of cleavage that intersect at 90°.



it has a rectangular prism shape.

4. How many directions of cleavage do the feldspar minerals, potassium feldspar and plagioclase have? 2 at apprx. 90°

5. How would you tell the difference between a crystal face and a cleavage plane?

Cleavage planes will parallel fractures throughout the sample.

6. Which would tell you more about a mineral's identity: luster or hardness? Why?

Hardness is more informative because it is objective and can be measured. Luster has an aspect of subjectivity to it.

Mineral Description Table

Sample	Luster	Hardness	Streak	Cleavage/ XL Form	Color/ Others	NAME
1	Metallic	>5.5	reddish brown	—	grey/ reddish brown	Hematite
2	Metallic	> 5.5	dark grey	—	black magnetic	Magnetite
3	Non-met	> 5.5	—	fracture —	clear, brown pink	Quartz
4	Metallic	> 5.5	grey	Xl form	brassy	Pyrite
5	Non-met	2.5-3.5	—	1 direction	brown-black	Biotite
6	Non-met.	2.5	white	3 at 90°	clear	Halite
7	Non met.	> 5.5	—	2 at 120° & 58°	black to dark green	Horneblende
8	Non-met	> 5.5	—	2 at 90°	White to blue	Plagioclase
9	Non-met.	> 5.5	—	—	olive green	Olivine
10	Non-met	> 5.5	—	2 at 90°	White to pinkish orange	Orthoclase
11	Non-met.	> 5.5	—	2 at appr. 90°	black to dark green	Augite
12	Metallic	2.5-3.5	grey	3 at 90°	grey	Galena
13	Non-met.	2.5-3.5	white	3 not at 90°	clear to white/ yellow	Calcite
14	Non-met.	< 2.5	White	3, 1 good	White to pink	Gypsum
15	Non-met.	2.5-3.5	—	1 direction	white or clear or brownish	Muscovite

Table 2a: Mineral Identification

Luster	Hardness	Cleavage	Diagnostic Physical Properties	Mineral Name
Metallic	Harder than glass	Absent	Brass yellow color, tarnishes brown to green; dark gray streak; small cubic crystals common; H = 6 - 6.5	Pyrite FeS_2
			Pale brass yellow to whitish gold color; dark gray streak; radiating masses and "cockscombs" common; H = 6 - 6.5	Marcasite * FeS_2
			Dark gray to black color; dark gray streak; magnetic; massive or "grainy"; H = 6	Magnetite Fe_3O_4
			Silver to gray color, red to red-brown streak; often composed of glittery flakes; H = 5 - 6.5	Hematite Fe_2O_3
			Grayish or dark brown to yellow-brown color; yellow-brown streak; amorphous; H = 5 - 5.5	Limonite $Fe_2O_3 \cdot nH_2O$
	Softer than glass	Present	Silver gray color, tarnishes to dull-gray; dark gray streak; cubic cleavage (three directions at 90°); H = 2.5 (not scratched by fingernail); S.G. = 7.4 - 7.6	Galena PbS
		Absent	Golden yellow color, tarnishes to purple; Greenish black to dark gray streak; H = 3.5 - 4	Chalcopyrite $CuFeS_2$
			Copper to dark brown color, tarnishes to green; copper streak; H = 2.5 - 3; S.G. = 8.8 - 8.9	Copper * Cu
			Dark gray color; dark gray streak; marks paper easily; greasy feel; H = 1; S.G. = 2.1 - 2.3	Graphite C

* These minerals are not included with the GS 104 lab specimens.

These minerals are important to the formation of igneous rocks; study them carefully because they will be used to help identify igneous rocks in next week's lab.

Table 2b: Mineral Identification (continued)

Luster	Hardness	Cleavage	Diagnostic Physical Properties	Mineral Name
Nonmetallic (Light)	Harder than glass	Present	White to pink color; two directions of cleavage at 90°; H = 6; exsolution lamellae (subparallel banding) present on cleavage faces; no striations (parallel grooves) present	Orthoclase Feldspar # $KAlSi_3O_4$
			White to blue-gray color; two directions of cleavage at nearly 90°;H = 6; striations (parallel grooves) present on cleavage faces	Plagioclase Feldspar # $NaAlSi_3O_8$ to $CaAl_2Si_2O_8$
		Absent	White, gray, or pink color; usually massive; transparent to translucent; glassy luster; conchoidal fractures; H = 7	Quartz # SiO_2
			Olive green to yellow-green color; granular masses; single grains are glassy with conchoidal fractures; H = 7	Olivine # $(Fe,Mg)SiO_4$
	Softer than glass	Present	Colorless to yellow, blue, green, or purple; four directions of cleavage (dioctahedral); transparent to translucent; H = 4	Fluorite CaF_2
			White, gray, or pink color; three directions of cleavage not at 90° (rhombohedral); fizzes in dilute HCl only if powdered; H = 3.5 - 4	Dolomite * $CaMg(CO_3)_2$
			Colorless to white, yellow, or gray; three directions of cleavage not at 90° (rhombohedral); fizzes in dilute HCl; H = 3	Calcite $CaCO_3$
			Colorless to white or gray; cubic cleavage (three directions at 90°); salty taste; dissolves in water; H = 2.5	Halite NaCl
			Colorless to clear brownish or yellowish color; one direction of cleavage; usually in thin, elastic, transparent to translucent sheets; H = 2.5	Muscovite (Mica) # $KAl_2(AlSi_3O_{10})(OH)_2$
			Colorless to white; three directions of cleavage (one good direction) forming thick, nonelastic, translucent sheets; H = 2	Gypsum $CaSO_4 \cdot 2H_2O$
		Absent	White color; earthy masses resembling chalk; plastic and sticky when wet; H = 1 - 1.5	Kaolinite $Al_4Si_4O_{10}(OH)_8$

Table 2c: Mineral Identification (continued)

Luster	Hardness	Cleavage	Diagnostic Physical Properties	Mineral Name
Nonmetallic (Dark)	Harder than glass	Present	Black to blue-gray color; two directions of cleavage at nearly 90°;H = 6; striations (parallel grooves) present on cleavage faces	Plagioclase Feldspar # $NaAlSi_3O_8$ to $CaAl_2Si_2O_8$
			Black to dark green color; two directions of cleavage intersecting at 87° and 93°; often massive in appearance; H = 5.5	Augite (Pyroxene) # Ca, Mg, Fe, Al silicate
			Black to dark green color; two directions of cleavage intersecting at 60° and 120°; often massive or splintery in appearance; H = 5.5	Hornblende (Amphibole) # Na, Ca, Mg, Fe, Al silicate
		Absent	Dark gray to smokey brown color; usually massive; transparent to translucent; glassy luster; conchoidal fractures; H = 7	Quartz # SiO_2
			Black to dark green or olive green color; granular masses; single grains are glassy with conchoidal fractures; H = 7	Olivine # $(Fe,Mg)SiO_4$
			Dark red to brownish-red color; translucent; often has smooth, parallel fractures resembling cleavage; H = 7	Garnet Fe, Mg, Ca, Al silicate
			Dull red color; reddish-brown streak; opaque, earthy appearance; H = 1.5 - 5.5	Hematite Fe_2O_3
			Grayish or dark brown to yellow-brown color; yellow-brown streak; amorphous; opaque, earthy appearance; H = 1.5 - 5.5	Limonite $Fe_2O_3 \cdot nH_2O$
	Softer than glass	Present	Dark green to dark brown color; one direction of cleavage; usually in thin, elastic, transparent to translucent sheets; H = 2.5 - 3	Biotite (Mica) # $K(MgFe)_3AlSi_3O_{10}(OH)_2$
			Dark green to green color; one direction of cleavage; usually in thin, opaque, curved sheets; often massive with a greasy feel; H = 2.5	Chlorite Mg, Fe, Al hydrous silcate
		Absent	Dull red color; reddish-brown streak; opaque, earthy appearance; H = 1.5 - 5.5	Hematite Fe_2O_3
			Grayish or dark brown to yellow-brown color; yellow-brown streak; amorphous; opaque, earthy appearance; H = 1.5 - 5.5	Limonite $Fe_2O_3 \cdot nH_2O$

*For your information...***Mineral uses and some mineral facts:**

Hematite	most important ore for steel making; used in pigments, some use as gemstone
Magnetite	minor ore of iron
Galena	most important ore of lead; lead is used in batteries, and in metal products as an alloy, in glass making; used to be the principal ingredient in paints. The Romans used lead for indoor plumbing, which may have resulted in lead poisoning of the higher, classes and contributed to the downfall of the Roman Empire.
Chalcopyrite	important ore of copper; oxidized surfaces show iridescence.
Graphite	this is the "lead" of pencils, also used in protective paints in foundries, batteries, and electrodes; in fine powder form, it is used as a lubricant
Gypsum	plaster (wall board, sheet rock); used in Portland cement; soil conditioner for fertilizer
Fluorite	flux in making steel; used in chemical industry for hydrochloric acid; high-grade ore is used in making optical equipment
Halite	table salt; source of Na and Cl for the chemical industry
Calcite	used for manufacture of cement and lime for mortars, used as soil conditioner, used as flux for smelting metallic ores, building industry
Garnet	semi-precious gemstone, used in abrasive products (sand paper)
Quartz	some use as gemstone; in sand form, used in mortar, concrete, as flux, and for abrasive products. Artificial quartz is now used in radios and for optical instruments (quartz permits both the transmission and reception on a fixed frequency).
Kaolinite	used for brick, paving brick, drain tile, ceramic products, and as filler in glossy paper
Olivine	some used as gem (peridot); used in casting industry because of refractory properties (means high melting temperature)
Sphalerite	most important ore of zinc; galvanized metals are covered with zinc to prevent rusting.
Feldspars	used in manufacture of porcelain; source of aluminum in glass industry
Talc	used in manufacture of paint, paper, roofing materials, rubber, cosmetic powders, and talcum powder; used as insulators in electrical industry
Barite	principle source of barium and sulfate for chemical industry; used in petroleum industry as drilling mud