Student Name: _____ San Diego Mesa College Grade:_____

Physical Geology 101 Laboratory

MINERALS II – Focus on Silicate and Carbonate Rock-Forming Minerals

I. INTRODUCTION: The purpose of this lab is you will improve your mineral identification skills and experience. The focus of today's mineral lab is identifying minerals in rocks. First, you will review silicate and carbonate minerals, with emphasis on mineral physical properties and identification skills; Second, you will identify minerals in igneous, sedimentary and metamorphic rocks, which is fundamental in the classification and identification of the three rock types.

The SILICATE MINERAL GROUP: Silicates make up the vast majority of rock-forming minerals (by volume) in the Earth's crust and mantle. Silicates are among our most important rock forming minerals – they are very common in all three major rock types: igneous, sedimentary and metamorphic. They all contain silica and oxygen, but can also contain various metal ions. Quartz and other forms of pure silica consist only of silica tetrahedron covalently bonded together in a three dimensional framework. However, in most silicates some of the silica covalent bonds are replaced by ionic bonds to metals, such as aluminum, iron, magnesium, sodium, potassium, and calcium. These bonds may create planes of weakness and a noticeable cleavage. You need to become familiar with each of these mineral's **color, hardness,** and **cleavage** to be good at identifying hand samples of these minerals**.**

Quartz, the feldspars (the two potassium feldspars and sodic plagioclase), and muscovite are the light-colored minerals rich in silica, sodium and potassium. The rest of the common igneous minerals are dark-colored, and are rich in iron, magnesium, and calcium (including calcic plagioclase). Note that all the common igneous minerals are hard except for the micas. Most have cleavage except for a few minerals, like quartz. Below is a color image of the 12 most common igneous rock-forming minerals, which includes magnetite, an iron oxide mineral common in mafic to intermediate igneous rocks.

The CARBONATE MINERAL GROUP: The carbonate minerals, which include calcite and dolomite – the two most common varieties - are found in sedimentary rocks such as limestone, and in metamorphic rocks, such as marble. The carbonate minerals and carbonate-rich rocks are generally light-colored, except for rocks that have abundant carbon in them. The carbonate minerals and their associated rocks are fairly easy to identify due to their softness and reaction to acid – two tests easily preformed in either the field or in lab. These minerals and their associated rocks are soft (H = 3 to 3

½) and will react to mild hydrochloric acid. All carbonate minerals have very well-developed rhombic cleavage (three sets of cleavage not at 90) - easy to spot if the crystals are large enough to see.
Calcite is the most common carbonate mineral, with a chemical formula of $CaCO_3$. Dolomite is less common in nature, with a very chemistry except that it also has magnesium $MgCaCO_3$. Most limestones and marbles consist of typically 80% or higher of these minerals, most typically calcite.

Gypsum is actually a sulfate-group mineral and is a exclusively found in sedimentary rocks. Like the carbonate minerals, gypsum is light-colored, soft (H = 2 ½), with 3 sets of cleavage, but it is nonreactive to acid. Halite is another exclusively-sedimentary mineral, and it is also light-colored, soft (H=3) with 3 sets of cleavage, but it's nonreactive to acid and tastes salty. Both gypsum and halite are associated with sedimentary evaporate deposits.

II. COMMON ROCK-FORMING MINERAL PROPERTIES AND THEIR ASSOCIATED ROCK TYPES

Directions: Determine the color, hardness, cleavage, and associated rock types of the following mineral samples found in your reference set box. Carefully read the steps listed below:

1) Note color as either "*Light"* or "*Dark"; AND note actual hue, like "white", "gray", "black", "brown", "green", or "violet".* Check that the first eight minerals are typically light-colored; the last eight minerals are typically light-colored
2) Note hardness as either "*Hard"* (5 1/2 and harder); or "*Soft" (5 or softer).*
3) Note number of sets of cleavage (0, 1, 2 or 3). Also note the angle between two or more sets (at/near 90° or not at 90°).
4) Other includes Acid, Magnetic or Taste tests: Acid fizz = "Fizz"; Magnetic="Mag"; Salty = Salt. If Other test(s) not needed/not done, then mark as "ND"
5) Finally, using your mineral glossary charts, list the names of rock that the mineral is most commonly associated with.

Reference Box #	Color (shade/hue)	Hardness	Cleavage	Other	Associated Rock Types
_____ **Olivine**	____ / _____	____	_____	____	**Mafic/Ultarmafic Igneous**
_____ **Augite**(pyrx)	____ /_____	____	_____		**Intermediate/Mafic/Ultramafic Igneous**
_____**Hornblende**(amph)	____/_____	____	_____		**Intermediate/Mafic Igneous / Amphibolite**
_____ **Biotite** (mica)	____ / _____	____	_____		**Felsic-Intermediate Igneous / Schists**
_____ **Chlorite** (mica)	____ / _____	____	_____	____	**Metamorphic Schist/Hornfels**
_____ **Garnet**	____ / _____	____	_____		**Granite/ Metamorphic Schist/Gneiss**
_____ **Tourmaline**	____ / _____	____	_____	____	**Granite Pegmatite**
_____ **Magnetite**	____ / _____	____	_____		**Intermediate/Mafic Igneous / Sandstone**
_____. **Quartz**	____ / _____	____	_____		**Numerous rocks of all three types**
_____**Potassium Feldspar** (K-spar Includes Orthoclase and Microcline)	____ / _____	____	_____		**Felsic Igneous /Sandstones /Gneiss**
_____ **Plagioclase Feldspar**	____ / _____	____	_____		**Felsic Igneous /Sandstones /Gneiss**
_____ **Muscovite** (mica)	____ / _____	____	_____		**Felsic Igneous /Schist /Gneiss**
_____ **Kaolin** (clay)	____ / _____	____	_____		**Shales, Claystone/ Slate**
_____ **Calcite**	____ / _____	____	_____	____	**Limestone / Marble**
_____ **Gypsum**	____ / _____	____	_____	____	**Rock gypsum**
_____ **Halite**	____ / _____	____	_____	____	**Rock salt**

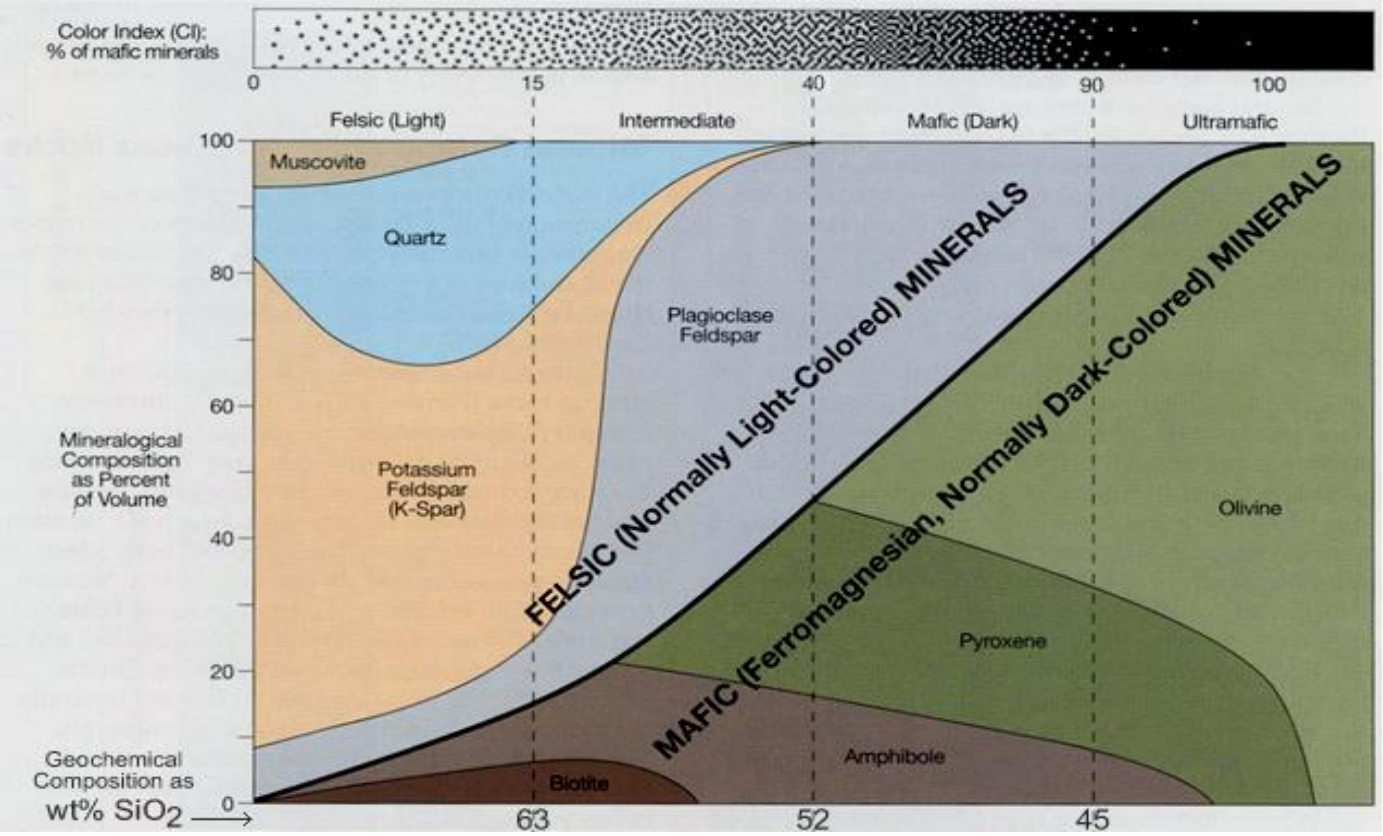
III. UNKNOWN COMMON ROCK-FORMING MINERAL SAMPLE IDENTIFICATION:

Directions: Determine the color, hardness, cleavage, and other characterizing physical properties of the following unknown mineral samples. Finally name the unknown mineral based on the determined properties. Follow the steps listed below:

1) Note luster as either *metallic "M"* or *nonmetallic "NM"*.
2) Note color as either "***Light"*** or "***Dark****"; AND note actual hue, like "white", "gray", "black", "green", or "violet".*
3) Note hardness as either "*Hard"* (5 1/2 and harder); or "*Soft" (5 or softer).*
4) Note number of sets of cleavage: (0, 1, 2@90, 2not@90; 3@90; or 3not@90).
5) If you do the acid test, mark as "Pos" for fizz and "Neg" for no fizz. If test not needed, then mark as "NN"
6) If you did magnet test, mark "M" if magnetic or "NM" for nonmagnetic. If test not needed, then mark "NN".
7) Finally, using your mineral ID chart, List the name of the mineral that best fits your listed physical properties.

Samp#	Color	Hardness	Cleavage	Acid test	Magnetic	Mineral name
A.	_____ / _____	_____	_____	_____	____	_____
B.	_____ / _____	_____	_____	_____	____	_____
C.	_____ / _____	_____	_____	_____	____	_____
D.	_____ / _____	_____	_____	_____	____	_____
E.	_____ / _____	_____	_____	_____	____	_____
F.	_____ / _____	_____	_____	_____	____	_____
G.	_____ / _____	_____	_____	_____	____	_____
H.	_____ / _____	_____	_____	_____	____	_____
I.	_____ / _____	_____	_____	_____	____	_____
J.	_____ / _____	_____	_____	_____	____	_____
K.	_____ / _____	_____	_____	_____	____	_____
L.	_____ / _____	_____	_____	_____	____	_____

IV. IGNEOUS ROCK-FORMING MINERALS ABUNDANCES IN IGNEOUS ROCKS: Each of the common igneous rock-forming minerals varies in occurrence and abundance in the various types of igneous rocks, based on the chemistry of the magma or lava that they crystallized from. You need to become familiar with the igneous mineral abundance chart below, in terms of which specific minerals characterize each igneous rock type and the general proportion that each mineral contributes to the total mineral make-up of the rock. The COLOR INDEX (shown at top of figure below) helps to classify the mineral composition of the unknown igneous rock, but is only useful for course-grained rocks.



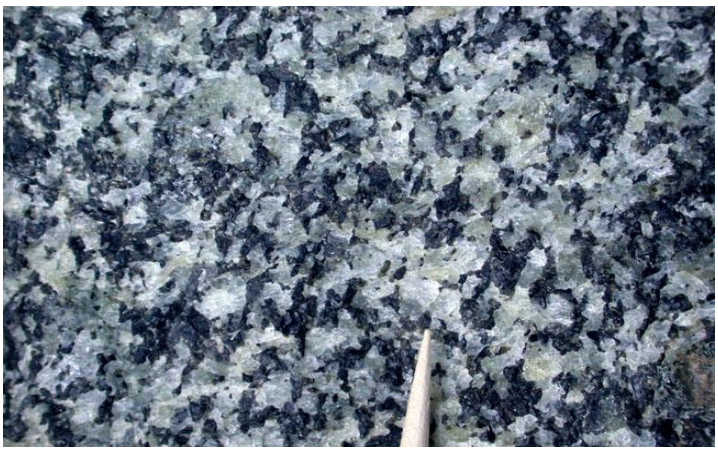
FELSIC IGNEOUS ROCK (Granite): Rich in potassium feldspars, sodic plagioclase and quartz, granites also have accessory minerals, including (but necessarily all present in same rock) biotite, muscovite, garnet, tourmaline and hornblende. Color index is low: between 0 and 20.

4. What is your estimated color index for the granite pictured above? _____

5. Light-colored minerals in above rock are most likely: _____, _____and _____

6. Dark-colored minerals in the above rock are most likely: _____and/or _____

INTERMEDIATE IGNEOUS ROCK (Diorite): Rich in intermediate plagioclase and hornblende, diorites can also have accessory minerals including(but necessarily all present in same rock) quartz, pyroxene, biotite, and magnetite. Color index is mid range: between 20 and 40



4. What is your estimated color index for the diorite pictured above? _____

5. Light-colored minerals in above rock are most likely: _____, _____and _____

6. Dark-colored minerals in above rock are most likely: _____, _____&/or _____

MAFIC IGNEOUS ROCK (Gabbro): Rich in calcic plagioclase, pyroxenes, olivine, and hornblende, gabbros can also have accessory minerals, like magnetite. Color index is high: between 40 and 90.

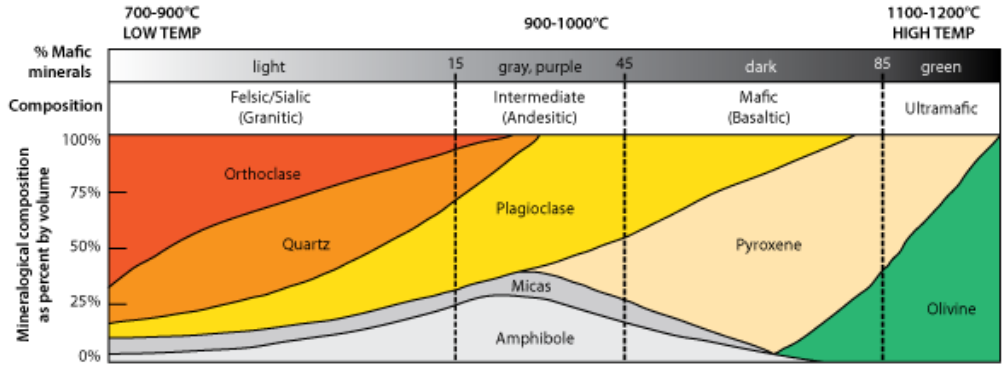
4. What is your estimated color index for the gabbro pictured above? _____

5. The light-colored mineral in the above rock is most likely: _____

6. Dark-colored minerals in above rock are most likely: _____, _____&/or _____

V. MINERAL IDENTIFICATION OF MINERALS IN UNKNOWN IGNEOUS ROCK SAMPLES

Directions: Do the following for each of the FIVE unknown coarse-grained igneous rock samples (1– 5) provided by your instructor: **1)** Determine the color index (0 to 100); **2)** Make your best determination as to what the light and dark minerals are in the hand sample; And **3**) List the igneous rock type, based on the color index (Felsic/Silicic, Intermediate, or Mafic). Note to use your igneous rock chart to help you answer both 1), 2) and 3). Use the microscope and the igneous rock chart on next page to help in the determination of the minerals.



Texture	Rock names			
Coarse-grained	Granite	Diorite	Gabbro	Peridotite
Fine-grained	Rhyolite	Andesite	Basalt	Uncommon (rarely encountered)
Pyroclastic	Rhyolite Tuff	Andesite Tuff	Basalt Tuff	
Glassy	Obsidian			
Vesicular	Pumice (like meringue)		Scoria	

Sample	Color Index	Observable minerals present in Rock Sample	Igneous Rock Type
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____

VI. MINERAL IDENTIFICATION OF MINERALS IN UNKNOWN SEDIMENTARY ROCK SAMPLES

Directions: Do the following for each of the FOUR unknown sedimentary rock samples (6 – 9) provided by your instructor: **1)** Determine the rock hardness (Hard or Soft); 2**)** Make your best determination as to what the most abundant mineral is the hand sample (Quartz, Clay, Mica or Calcite); And **3**) List the sedimentary rock type, based on the dominant mineral present. Note to use your sedimentary and metamorphic rock charts in the lab manual to help you . Use the acid test, microscope, and the sedimentary rock chart (including the one below) to help in the determination of the minerals and rock name.

Sedimentary Rock Classification

Clastic & Bioclastic textures

Texture	Size		Clast Composition	Rounding	Sorting	Rock Name	Comments	Depositional Environment
Clastic	>2 mm	gravel	variable	angular	poor	**sedimentary breccia**	large angular clasts - less transport	alluvial fan
	>2 mm	gravel	variable	rounded	poor	**conglomerate**	large rounded clasts - more transport	alluvial fan, stream, beach
	2-1/16 mm	sand	quartz	rounded	well	**quartz sandstone**	"clean" sandstone - more transport	dunes, stream
	2-1/16 mm	sand	feldspar, quartz, etc.	angular	mod-poor	**arkose**	"dirty" sandstone - less transport	alluvial fan, stream
	<1/16 mm	mud	-	-	well	**mudstone**	may split apart along bedding; may or may not "fizz"; easily scratched	floodplain, delta, shallow & deep marine
Bioclastic	>2 mm	gravel	shells	poor	poor	**coquina**	poorly-cemented shell fragments	beach
	<1/16 mm	mud	shells	-	well	**chalk**	microscopic shells; "earthy"	shallow-deep marine

Chemical & Biochemical textures

Texture	Composition	Hardness	Color	Rock Name	Comments	Depositional Environment
Chemical	calcite / $CaCO_3$	H=3	variable	**limestone**	will "fizz"; can be scratched by a nail	shallow marine, lake
	dolomite / $CaMg(CO_3)_2$	H=3	variable	**dolomite**	will not "fizz" unless scratched; can be scratched by a nail	nearshore marine
	silica / SiO_2	H=7	variable	**chert**	will not "fizz"; not scratched by a nail	deep sea
	halite / NaCl gypsum / CaSO4*2H2O	H=2.5 H=2	clear-variable white-variable	**evaporites**	soft, non-metallic minerals; halite is "salty"	playa
Bio	altered organic remains	soft	brown-black	**coal**	light in weight	swamp

Sample	Hardness	Dominant Sed Mineral(s) Type in Rock Sample	Most-Likely Rock Name
6.	_____	_____	_____
7.	_____	_____	_____
8.	_____	_____	_____
9.	_____	_____	_____

VII. MINERAL IDENTIFICATION OF MINERALS IN UNKNOWN METAMORPHIC ROCK SAMPLES

Directions: Do the following for each of the THREE unknown metamorphic rock samples (10-12) provided by your instructor: **1)** Determine the rock hardness (H or S); **2)** Make your best determination as to what the most abundant mineral is the hand sample. Common minerals include quartz, mica, feldspar, calcite, amphibole and garnet); And **3**) List the sedimentary rock type, based on the dominant mineral present. Note to use your metamorphic rock charts in the lab manual to help you. Use the acid test, microscope, and the metamorphic rock chart (including one below) to help in the determination of the minerals and rock name.

Sample	Hardness	Dominant Meta Mineral(s) Type in Rock Sample	Most-Likely Rock Name
10.	_____	_____	_____
11.	_____	_____	_____
12.	_____	_____	_____

Scheme for Metamorphic Rock Identification

TEXTURE		GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED	MINERAL ALIGNMENT	Fine	MICA, QUARTZ, FELDSPAR, AMPHIBOLE, GARNET, PYROXENE	Regional (Heat and pressure increases)	Low-grade metamorphism of shale	Slate	
		Fine to medium			Foliation surfaces shiny from microscopic mica crystals	Phyllite	
					Platy mica crystals visible from metamorphism of clay or feldspars	Schist	
	BAND-ING	Medium to coarse			High-grade metamorphism; mineral types segregated into bands	Gneiss	
NONFOLIATED		Fine	Carbon	Regional	Metamorphism of bituminous coal	Anthracite coal	
		Fine	Various minerals	Contact (heat)	Various rocks changed by heat from nearby magma/lava	Hornfels	
		Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	Quartzite	
			Calcite and/or dolomite		Metamorphism of limestone or dolostone	Marble	
		Coarse	Various minerals		Pebbles may be distorted or stretched	Metaconglomerate	

VIII. Written Laboratory Reflection

Directions: Write a reflection of this second mineral lab activity, explaining its purpose, the methods used, the results obtained, and a brief personal reflection of what you enjoyed and learned about doing this lab (*3 points possible*). Answer the following 3-point question reflection set (fill in all the lines for full credit.)

1) *What was the purpose of this lab? What did you actually discover and learn during this lab?*

_____

_____

2) *What did you enjoy most about this lab? Also, what was challenging or thought-provoking?*

_____

_____

3) *What are your constructive comments about the design and execution of this lab? What's good? What's bad? Offer suggestions for making the lab better*

_____

_____