Student Name: _____ ***Grade:***_____

Physical Geology Laboratory
IGNEOUS ROCKS CLASSIFICATION AND IDENTIFICATION

INTRODUCTION & PURPOSE:

In this lab you will learn about the physical properties of igneous rocks, and you will also learn how to identify igneous rocks in hand samples, from their physical properties. You will become familiar with the most common assemblages of igneous-rock forming minerals and the various igneous rock textures. The nature and origin of magmas, important aspects of mineral crystallization, the major types of intrusive and extrusive igneous rock structures, and the connection between plate tectonics and the rock cycle will also be explored. The purpose of this laboratory experience is to become familiar with both identifying common igneous rocks and understanding their origin. The first part of the lab goes over the classification scheme of igneous rocks. The second part of the lab is a review of the common igneous rock-forming minerals. The third part covers the different textures of igneous rocks, and the fourth part is an unknown rock identification exercise. This lab finishes with a reflection.

LAB PREPARATION SECTION

GENERAL CLASSIFICATION OF IGNEOUS ROCKS

A. Overview: The classification of igneous is based upon two major criteria:

1) **Composition** (mineralogy/geochemistry)
2) **Texture** (crystal grain size and grain size distribution

B. **Igneous Compositions**: Igneous rocks are divided into **four major groups** based upon their mineralogy, which reflects the rocks' geochemical composition:

1. **Silicic or Felsic** = silica, sodium and potassium-rich; lots of quartz and feldspar minerals
2. **Intermediate** = plagioclase and amphibole minerals most abundant;
3. **Mafic** = iron, magnesium, and calcium-rich; plagioclase and pyroxene most abundant;
4. **Ultramafic** = silica-poor; very rich in iron and magnesium; mostly pyroxene and olivine

An igneous rock's composition is controlled primarily by the **1)** *composition of its parent magma,* **2)** *crystallization fractionation of magma, **3)** magma mixing, or* **4)** *assimilation of wall rock into magma***.**

The classification and naming of igneous rocks is based in part on their composition:

1) Igneous rocks with a **felsic-silica-rich** composition are classified as either **granite** (intrusive) or **rhyolite** (extrusive).
2) Igneous rocks with an **intermediate** composition are classified as either **diorite** (intrusive) or **andesite** (extrusive).
3) Igneous rocks with a **mafic-rich** composition are classified as either **gabbro** (intrusive) or **basalt** (extrusive).
4) Igneous rocks with an **ultramafic-rich** composition are classified as either **peridotite** (intrusive) (intrusive) or **komatiite** (extrusive).

C. Igneous Textures: Igneous rocks are divided into **four major textural categories** based on differences in crystal grain size and size distribution:

1) **Pegmatitic** = extremely coarse-grained (plutonic)
2) **Phaneritic** = coarse- to medium-grained (plutonic)
3) **Porphyritic** = mixed-grained = coarse-grained surrounded by fine-grained (volcanic)
4) **Aphanitic** = very fine-grained (volcanic)

There are **three additional extrusive textural** classifications:

1) **Glassy** = the absence of minerals (volcanic)
2) **Vesicular** = the presence of vesicles (volcanic)
3) **Pyroclastic** = composed of volcanic rock fragments (volcanic)

An igneous rock's texture is controlled primarily by the **1)** *rate of cooling of the magma* as it crystallizes into a solid rock, and also its **2)** *dissolved gasses content***:**

- ✓ Igneous rocks that are **pegmatitic** or **phaneritic** have an **intrusive** (plutonic) origin and thereby cooled very slowly into a course-grained rock

- ✓ Igneous rocks that have a **aphanitic**, **glassy**, **vesicular**, or of **fragmental** texture, have an **extrusive** (volcanic) origin and thereby, cooled very quickly into a fine-grained rock.
- ✓ Igneous rocks that are **porphyritic** have a complex cooling history: first cooling slowly underground (partially crystallizing the magma), followed by transport to the surface, where the remaining molten material is cooled very rapidly into a mixed-grain rock.
- ✓ **Glassy** = extremely fast cooling – magma is literally quenched with no crystals forming.
- ✓ **Vesicular** = degassing (effervescing) of lava while it undergoes very rapid cooling.

D. Common Igneous Rock-Forming Minerals: There are eleven common igneous rock-forming minerals that You should be familiar with by now (studied and identified in mineral lab). Each of the four type-pairs of igneous rocks (listed above) have a unique assemblage of these minerals. For example, the **granite-rhyolite** pair is rich in the light-colored potassium feldspar, plagioclase feldspar and quartz, with lesser amounts of one or more possible accessory minerals, such as muscovite, and/or biotite, and/or amphibole, and/or garnet and tourmaline. BUT the **granite-rhyolite** pair is totally lacking pyroxene and olivine. On the other side of the compositional spectrum, the mafic **gabbro-basalt** pair is rich in dark-colored amphibole, pyroxene, olivine, and calcium-rich plagioclase, with lesser amounts of possible accessory minerals such as magnetite.

Directions: Write down the names of the eleven minerals in the appropriate column, either as light-colored or dark-colored. Knowing and understanding the relationship between each igneous rock pair (discussed above) and their respective mineral assemblage will make classifying and identifying igneous rocks much easier. You will identify and carefully (re)examine the eleven igneous mineral samples in lab.

Light-colored Minerals	**Dark-colored Minerals**	
1. _____	1. _____	5. _____
2. _____	2. _____	6. _____
3. _____	3. _____	7. _____
4. _____	4. _____	

E. Igneous Rock Names: Review the four igneous rock intrusive/extrusive pairs (subgroups) and the common minerals associated with each igneous rock sub-group. Thoroughly study the Igneous Rock ID Charts in your lab manual (see page 81). Make sure you understand all the textural and compositional terms before analyzing this lab's rock samples. Carefully examine the color index, mineralogical assemblage, and rock nomenclature charts in Lab Manual. **Note:** *The vertical columns in the rock ID charts indicate the different compositional categories in terms of color index, mineralogy, and rock nomenclature. The horizontal rows in the rock ID charts reflect the textural between*

Directions: List the names of the four paired igneous rock groups and their associated minerals as discussed in sections C. and D. above.

Rock Pair	**Felsic**	**Intermediate**	**Mafic**	**Ultramafic**
Intrusive:	_____	_____	_____	_____
Extrusive:	_____	_____	_____	Not formed in Nature
Major	_____	_____	_____	_____
Minerals	_____	_____	_____	_____
	_____	_____	_____	
Accessory	_____	_____	_____	_____
Minerals	_____	_____	_____	_____
	_____	_____	_____	_____

PART II. REVIEW ID OF IGNEOUS ROCK-FORMING MINERALS:

Directions: Carefully examine each of the following common igneous rock-forming minerals in the clear plastic tub at your table that contains the unknown mineral set that you examined in the previous mineral lab. Write the sample # of each unknown mineral sample next to the correct mineral name.

	Unknown Sample #		**Unknown Sample #**
1. Quartz	____	7. Augite (pyroxene)	____
2. Plagioclase Feldspar	____	8. Olivine	____
3. Potassium Feldspar	____	9. Tourmaline	____
4. Muscovite (mica)	____	10. Garnet	____
5. Biotite (mica)	____	11. Magnetite	____
6. Hornblende (amphibole)	____		

PART II. THE INTRUSIVE (PLUTONIC) IGNEOUS ROCKS:

A. Introduction: Intrusive rocks have crystalline grain textures that you can **clearly see nearly ALL** the crystal grains by eye, termed "**megascopic**" textures. In contrast, most crystals in extrusive rocks are invisible to the eye.

B. Color Index (CI) is a quantitative feature of **phaneritic** igneous rocks that expresses the rock's mineral composition in terms of the **volume percentage of dark minerals** found in the rock. A **numeric** color indexes value is only used for classifying *intrusive* igneous rocks (see page 81 in lab book)

C. Intrusive Textures: The **two** basic **intrusive** rock textures are: **Pegmatitic** (very coarse-grained) and **Phaneritic** (coarse-grained). (see Figure 5.3 and page 80). Both types form by the slow-cooling of magma at depth. As a general rule, the coarser the texture, the slower the cooling.

D. Intrusive Reference Collection Analysis: Eight intrusive (plutonic) igneous rock reference samples are found in the igneous rock reference collection in the blue plastic tub on your lab bench. Carefully study and compare them. Check and record each sample for color index, mineralogy, and texture.

	Rock Name	**CI**	**ID'd Minerals**	**Texture**
Sample# **I0**	Peridotite	____	_____	_____
Sample# **I1**	Gabbro	____	_____	_____
Sample# **I2**	Diorite	____	_____	_____
Sample# **I3**	Granodiorite	____	_____	_____
Sample# **I4**	Granite	____	_____	_____
Sample# **I4A**	Granite Pegmatite	____	_____	_____

Intrusive Reference Rock Questions

1) Question: Which of these samples has the highest amounts of iron and magnesium? How can you tell?

2) Question: Which of these samples has the highest amounts of silica? How can you tell?

3) Question: Which of these samples has the coarsest grain texture?

4) Question: Which of these samples has the finest grain texture?

5) Question: How did all these rock form? Choose one of the following answers.

a. by magma that cooled slowly
b. by fast cooling lava
c. by a very fast cooling of a lava
d. by a very fast cooling magma during a volcanic eruption
e. by magma that was cooling slowly, then as a lava that cooled quickly.

PART III. THE EXTRUSIVE/VOLCANIC IGNEOUS ROCKS:

A. Introduction: Extrusive rocks have crystalline grain textures which you **mostly cannot see** the individual crystals with the naked eye**,** termed "**microscopic**" textures. In contrast, most crystals in intrusive rocks are visible to the eye. Extrusive microscopic rock textures make rock mineral identification very difficult.

B. Composition: As noted above, extrusive or volcanic igneous rocks are distinguished from their intrusive or plutonic compositional twin by their finer-grained textures. This makes mineralogy determination far more difficult and less accurate. The grain sizes of an extrusive igneous rocks are so small (or completely lacking) that you cannot distinguish most, if not all of the crystal grains by eye, or with low-powered microscope – only the phenocrysts that are embedded in the microscopic groundmass. Therefore, the mineral composition of a volcanic rock cannot be determined directly by visual inspection, using the numeric color index method (used with course- grained igneous rocks) to estimate light-dark color mineral percentages. However, the volcanic rock's overall **color shade** of its groundmass (matrix) material can be used as a rough first- guess estimate of the rock's mineral content: e.g. **dark-** -colored = mafic, **medium**-colored = intermediate, and **light**-colored = felsic/silicic.

B. Volcanic Textures: The **five** basic **volcanic** rock textures are **Porphyritic**, **Aphanitic**, **Glassy**, **Vesicular**, and **Volcano-clastic**. Each textural type is based on both grain size and rock "fabric", e.g. vesicles and/or rock fragments. The microscopic fine-grained texture of most extrusive rocks indicate that they cooled fast (**aphanitic**), and some so fast that they failed to form crystals (**glassy**). Other extrusive textures indicate that the rock first started crystallizing slowly deep underground (forming phencrysts), and while it was still partially molten, erupted to the surface to finish crystalizing much faster (aphanitic groundmass) to produce a mixed grained rock texture (**porphyritic**). Any lava that cools quickly tot a solid rock while it is actively degassing (exsolving of dissolved gasses) will produce a volcanic rock with cavities (**vesicular**). Finally, any lava (and previously formed lava rock) shot up into the air by a violent eruption will cool in the air and then fall back down to the surface to eventually pile up and harden together as clastic deposits (**volcanoclastic or fragmental**)

C. Extrusive Reference Collection Analysis: Nine extrusive (volcanic) igneous rock reference samples are found in the igneous rock reference collection in the blue plastic tub on your lab bench. Carefully study and compare them. Check and record each sample for color shade (light, medium or dark), mineralogy (if there are any phenocrysts), and texture.

	Rock Name	Rock Color	Visible ID'ed Minerals	Texture
Sample# **I5**	Basalt	_____	_____	_____
Sample# **I6**	Porphyritic Andesite	_____	_____	_____
Sample# **I7**	Andesite	_____	_____	_____
Sample# **I8**	Rhyolite	_____	_____	_____
Sample# **I9**	Scoria	_____	_____	_____
Sample# **I10**	Pumice	_____	_____	_____
Sample# **I11**	Obsidian	_____	_____	_____
Sample# **I12**	Volcanic Tuff	_____	_____	_____
Sample# **I13**	Tuff Breccia	_____	_____	_____

Extrusive Reference Rock Questions

1) Question: Which sample has the highest amounts of iron and magnesium? How can you tell?

2) Question: Which sample has the highest amounts of silica? How can you tell?

3) Question: Which sample has abundant phenocrysts embedded in a fine-grained groundmass?

4) Question: Which sample has a highly vesicular glassy texture?

5) Question: How did rock sample **I6** form? Choose one of the following answers.

a. by magma that cooled slowly
b. by fast-cooling lava
c. by fast-cooling lava while it was strongly degassing
d. by a super-fast cooling lava
e. by a fast-cooling lava while it got erupted into the air and then deposited on the ground
f. by magma that was cooling slowly, then erupted as a lava that cooled quickly.

6) Question: How did rock samples **I9**, and **I10** form? Choose one of the following answers.

a. by magma that cooled slowly
b. by fast-cooling lava
c. by fast-cooling lava while it was strongly degassing
d. by a super-fast cooling lava
e. by a fast-cooling lava while it got erupted into the air and then deposited on the ground
f. by magma that was cooling slowly, then erupted as a lava that cooled quickly.

7) Question: How did rock sample **I11** form? Choose one of the following answers.

a. by magma that cooled slowly
b. by fast-cooling lava
c. by fast-cooling lava while it was strongly degassing
d. by a super-fast cooling lava
e. by a fast-cooling lava while it got erupted into the air and then deposited on the ground
f. by magma that was cooling slowly, then erupted as a lava that cooled quickly.

8) Question: How did rock samples **I12**, and **I13** form? Choose one of the following answers.

a. by magma that cooled slowly
b. by fast-cooling lava
c. by fast-cooling lava while it was strongly degassing
d. by a super-fast cooling lava
e. by a fast-cooling lava that got erupted into the air and then deposited on the ground
f. by magma that was cooling slowly, then erupted as a lava that cooled quickly.

PART IV. IDENTIFYING UNKOWN IGNEOUS ROCKS –DESCRIPTION & IDENTIFICATION

A. Identifying Unknown Igneous Rock Types: Identification of unknown igneous rock samples are done utilizing a simple step-by-step procedure that is outlined in your Lab Manual.

Igneous Rock Identification Procedure:

Step 1: Estimate the rock's **Color Index** (if coarse-grained) or **Overall Rock Color** (if fine-grained)
Note that **color index** is applicable for **phaneritic rocks ONLY**! IF **APHANITIC** or **PORPHYRITIC** where there is little to no observable minerals, then estimate the composition by the **Overall Rock Color** ("light-colored" = felsic/silicic, "medium-colored" = intermediate, or "dark-colored" = mafic).

Step 2: Identify all visibly discernable minerals. Estimate relative abundances of each mineral type.

Step 3: Observe and record the rock's **TEXTURE** (Use seven texture terms in part III.B. above)

Step 4: Use the igneous rock flowchart in your lab manual to **NAME the ROCK**

Directions: Identify the ten (10) unknown igneous rock samples found in **"IU" Sample Collection**
Circle all the appropriate attributes for each unknown sample and then list the rock's name.

a) Color Index (plutonic) ***OR*** the Overall **Rock Color** (volcanic);
b) Identifiable minerals; if none observable than write "None Observed"
c) Texture (pegmatitic, phaneritic; porphyritic, aphanitic, aphanitic vesicular, glassy, volcano-clastic)
d) Cooling Origin: 1) Solidified deep underground = (***Slow***); 2) Partially crystallized deep underground followed by eruption (***Slow-then-Fast***); 3) Crystallized almost entirely at or near surface (**Fast**): 4) Crystallized almost entirely at surface while degassing (**Fast/Effervescing**); 5) Solidified at the surface without crystallizing (**Super Rapid**); or 6) Previously-solidified airborne volcanic material falling and collecting on the ground (Airfall-deposited)
e) Write down the **Name** of the rock.

UNKNOWN IGNEOUS ROCK WORKSHEET

Sample# UNI1

a) ***Color Index*** # ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nill

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI2

a) ***Color Index*** # ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nill

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI3

a) ***Color Index*** # ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI4

a) ***Color Index*** # ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI5

a) ***Color Index*** # ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI6

a) ***Color Index*** **#** ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI 7

a) ***Color Index*** **#** ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI 8

a) ***Color Index*** **#** ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI 9

a) ***Color Index*** **#** ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

Sample# UNI 10

a) ***Color Index*** **#** ____% (if pegmatitic or phaneritic); **OR** ***Rock Color*** **Shade** (if aphanitic or porphyritic) _____

b) **Observed Minerals:** Quartz; K-spar; Plag; Muscovite; Biotite; Tourmaline; Hornblende; Pyroxene; Olivine; Nil

c) **Texture:** Pegmatitic; Phaneritic; Porphyritic; Aphanitic; Aphanitic vesicular; Glassy; Volcano-clastic

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Fast w/ Effervescing; Super-Rapid; Airfall-Deposited

e) **Rock Name** _____

GO TO NEXT PAGE FOR LAB REFLECTION

V. IGNEOUS ROCK LABORATORY REFLECTION

Directions: Write a reflection of the 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.*

_____

_____

_____

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