Name: **Grade:**

Physical Geology Laboratory
IGNEOUS ROCKS CLASSSIFICATION and IDENTIFICATION

INTRODUCTION & PURPOSE:

In this lab you will learn 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. 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.

PRELAB SECTION – To be completed before the lab meeting (due at start of lab #4)

I. GENERAL CLASSIFICATION OF IGNEOUS ROCKS

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

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

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

C. **Igneous Compositions**: Igneous rocks are divided into **four major groups** based upon their mineralogy, which reflects the rocks' geochemical make-up:

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) or **komatiite** (extrusive).

D. Common Igneous Rock-Forming Minerals: There are nine 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) has a unique assemblage of these minerals. For example, the granite-rhyolite pair is rich in the light-colored feldspars and quartz, poor in the dark-colored biotite and amphibole, and 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, and olivine, including calcium-rich plagioclase, but totally lacks light-colored minerals such as potassium feldspar and quartz. The reason for the unique mineral assemblage for each igneous rock pair is explained by **Bowen's Reaction Series**, which involves the systematic crystallization of specific minerals in a given composition of magma as the temperature falls during cooling.

Directions: Write down the names of the nine 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 nine igneous mineral samples in lab.

Light-colored minerals	**Dark-colored minerals**
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
	5. _____

E. Igneous Rock Names: Review the four igneous rock intrusive/extrusive pairs (subgroups) and the common minerals associated with each igneous rock sub-group. Intensely study Figure 5.3 in your lab manual. 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 of Figure 5.3. **Note:** These three charts are lined up vertically to illustrate the compositional relationship between color index, mineralogy, and rock nomenclature.

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:	_____	_____	_____	_____
Mineral Assemblage	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____

Question 1: How does the ***felsic*** *igneous rock pair* compare and contrast with the ***mafic*** *igneous rock pair,* in terms of compositions and textures?

IN-LAB SECTION –To be completed during lab

I. REVIEW ID OF IGNEOUS ROCK-FORMING MINERALS:

Directions: Carefully examine each of the following unknown igneous mineral samples. Write the sample number next to the correct mineral name.

	Sample Number		Sample Number
1. Quartz	____	6. Hornblende (amphibole)	____
2. Plagioclase Feldspar	____	7. Augite (pyroxene)	____
3. Orthoclase Feldspar	____	8. Olivine	____
4. Muscovite (mica)	____	9. Tourmaline	____
5. Biotite (mica)	____	10. Garnet	____

II. THE INTRUSIVE/PLUTONIC IGNEOUS ROCKS:

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

B. Plutonic Textures: The **two** basic **plutonic** rock textures are: **Pegmatitic** (very coarse-grained) and **Phaneritic** (coarse-grained). (see Figure 5.3 and page 80). Both types form by very slow cooling of magma at depth.

C. 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. **Color index** is used exclusively for classifying **only** *intrusive* igneous rocks (see page 81 in lab book)

D. Intrusive Sample Collection Analysis: Eight samples are found in **Collection A** for close study and comparison. Texture, mineralogy and color index of each sample will be discussed in class.

	Rock Name	CI	ID'd Minerals	Texture
Sample# **A1**	Granite	___	_____	_____
Sample# **A2**	Granite	___	_____	_____
Sample# **A3**	Granite	___	_____	_____
Sample# **A4**	Diorite	___	_____	_____
Sample# **A5**	Diorite	___	_____	_____
Sample# **A6**	Gabbro	___	_____	_____
Sample# **A7**	Gabbro	___	_____	_____
Sample# **A8**	Dunite	___	_____	_____

III. THE EXTRUSIVE/VOLCANIC IGNEOUS ROCKS:

A. Introduction: Extrusive or volcanic igneous rocks are distinguished from their intrusive or plutonic compositional twin by their texture: extrusive rocks have textures where by you **cannot distinguish most, or all, of the crystal grains by eye** (microscopic); the grain size is so small, that you need a microscope to view the minerals. Color index **does not** apply to the naming of volcanic rocks. However, the ***groundmass color*** of a volcanic rock can be used as a rough first guess for identifying the rock's composition, e.g. dark = basalt; light = rhyolite.

B. Volcanic Textures: The **five** basic **volcanic** rock textures are **Porphyritic**, **Aphanitic**, **Glassy**, **Vesicular**, and **Volcanoclastic** (see Figure 5.3 and page 80). Each textural type is based on both grain size and rock "fabric", e.g. vesicles and/or rock fragments. These rocks cooled very fast.

C. Volcanic Sample Collection Analysis: Eight samples are found in **Collection B** for study and comparison. Texture, mineralogy and color index of each sample will be discussed in class.

	Rock Name	Rock Color	Visible Minerals	Texture
Sample# **B1**	Rhyolite	_____	_____	_____
Sample# **B2**	Rhyolite	_____	_____	_____
Sample# **B3**	Andesite	_____	_____	_____
Sample# **B4**	Andesite	_____	_____	_____
Sample# **B5**	Basalt	_____	_____	_____
Sample# **B6**	Basalt	_____	_____	_____
Sample# **B7**	Obsidian	_____	_____	_____
Sample# **B8**	Volcanic Tuff	_____	_____	_____

IV. IDENTIFYING IGNEOUS ROCKS – DETAILED DESCRIPTION AND IDENTIFICATION

A. Identifying the Various Igneous Rock Types: Identification of unknown igneous rock samples are done utilizing a simple step-by-step procedure that is outlined in **Figure 5.2** 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/silisic, "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**

B. Identifying Unknown Igneous Rock Samples

Directions: Identify the twelve (12) unknown igneous rock samples found in sample **Collection C**. Circle all the appropriate attributes for each unknown sample and then list the rock's name.

a) Color Index (plutonic) ***OR*** 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**); or 4) crystallized in the air after eruption (**Super Rapid / Air-Cooled**)
e) Write down the **Name** of the rock.

UNKNOWN IGNEOUS ROCK WORKSHEET

Sample# C1

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C2

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C3

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C4

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C5

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C6

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C7

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C8

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C9

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C10

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C11

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

Sample# C12

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

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

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

d) **Rock Cooling History**: Slow; Slow-then-Fast; Fast; Super-Rapid / Air-cooled

e) **Rock Name** _____

V. Post Lab Exercise: Laboratory Reflection

Directions: Write a 120 word minimum 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 on a separate sheet of paper:

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.*