ES 104: Laboratory # 7
IGNEOUS ROCKS

Introduction

Igneous rocks form from the cooling and crystallization of molten rock material. This can occur below the surface of the earth forming *intrusive rocks* (also called *plutonic rocks*) or on or above the surface as *extrusive rocks* (also called *volcanic rocks*). As a generalization, extrusive igneous rocks cool rapidly when compared with intrusive igneous rocks.

The rate of cooling has a profound influence the size of the crystal grains formed in the igneous rock, so the **textures** of igneous rocks tell us much about the rate of cooling of the rock and thus whether their origin is plutonic or volcanic. If cooling is slow, atoms have plenty of time to migrate to the growing nuclei of growing crystals, thereby enlarging these mineral grains. So, a longer cooling time results in larger crystal grains. Intrusive igneous rocks have *coarse-grained textures*, including *pegmatitic* (crystals larger than 10 mm). Because of their rapid cooling, extrusive igneous rocks generally have fine-grained textures, including *porphyritic*, *glassy*, and *frothy*.

In addition to texture, the mineral **composition** also determines the appropriate classification of an igneous rock. Determining composition of an igneous rock is not always easy, particularly because as the texture gets finer, the individual mineral grains become too small to be seen easily. In these cases, the color of a rock becomes helpful. As a general rule, dark rocks are typically *mafic* and light colored rocks are typically *felsic*. NOTE: be aware that there are a few important exceptions to this general rule.

Be sure to define the terms in italics in your notes.

Objectives

- Learn to recognize the major types of igneous rocks
- Understand the significance of texture and composition in the formation of igneous rocks

Name_____**KEY**_____

Lab day _____Lab Time_____

Pre-lab Questions – Complete these questions before coming to lab.

1. What are the three main classes of rocks and how does each of them form?

IGNEOUS FROM COOLING OF MAGMA
SEDIMENTARY ROCK FROM PARTICLES OR PRECIPITATION OF PRE-EXISTING ROCK
METAMORPHIC FROM CHANGE OF ATOMIC ARRANGEMENT OF MINERALS IN THE SOLID STATE

2. Draw and label a diagram of the rock cycle **on the back** of this sheet. Be sure to show the three classes of rocks and how the relate with one another.

SEE PAGE 53 IN 11TH ED. OF TEXTBOOK

3. What is the difference between an extrusive and intrusive igneous rock?

EXTRUSIVE HAD MAGMA ERUPT ON THE SURFACE—RESULTING ROCK IS FROM RAPID COOLING OF MAGMA, VERY FINE GRAINED.
INTRUSIVE DID NOT ERUPT. COOLED VERY SLOWLY BELOW GROUND AND LARGE CRYSTALS WERE ABLE TO DEVELOP.

4. Define the following igneous rock terms:

   a. Coarse grained—LARGER THAN 1 MM, COMMONLY DISTINGUISHES INTRUSIVE IGNEOUS ROCKS

   b. Fine grained—SMALLER THAN 1 mm, OFTEN MINERAL GRAINS ARE SO SMALL THAT INDIVIDUAL GRAINS CANNOT BE DISTINGUISHED WITH THE NAKED EYE. COMMONLY DISTINGUISHES EXTRUSIVE IGNEOUS ROCKS.
   c. Porphyritic—TWO DISTINCT SIZES OF CRYSTALS, OFTEN ONE IS COARSE-GRAINED, THE OTHER IS SO FINE-GRAINED THAT INDIVIDUAL CRYSTALS CANNOT BE DISTINGUISHED WITH THE NAKED EYE.
   d. Felsic—MAGMA RICH IN SILICA, CRYSTALLIZES INTO (MOSTLY) FELDSPAR AND QUARTZ.
   e. Mafic—MAGMA CONTAINING SIGNIFICANT IRON AND MAGNESIUM, CRYSTALLIZES INTO FERROMAGNESIAN MINERALS, PLAGIOCLASE FELDSPAR, AND no QUARTZ.
   f. Magma—MOLTEN SILICATE MIX OF IONS, GASES AND CRYSTALS
   g. Lava—MAGMA THAT HAS ERUPTED ONTO EARTH'S SURFACE, AND HAS LOST MOST OF ITS DISSOLVED GASES

Part A – Identification of Igneous Rocks

Classification of igneous rocks is based on texture (grain size) and mineral composition (often related to color). Use the classification chart (Table 1) to assign correct names to the lab specimens. Identify the rocks in the study set using the rock identification chart. Begin by describing the texture and color of the rock. You should be able to identify minerals present in the coarse-grained and porphyritic rocks. To identify visible mineral grains, use the same mineral identification procedures that you used in Lab 6. Fill in the identification table (Table 2).

Table 1: Igneous Rock Classification Table.

See footnotes below for abbreviations	**Composition** /(Mineral content)			
	Felsic (light colored)	**Intermediate**	**Mafic (dark colored)**	**Ultramafic (green)** (the exception)
Texture	10-20%QUARTZ K-SPAR>PLAG <15% FERRO-MAGS†	NO QUARTZ PLAG> K-SPAR >20% FERROMAGS	NO QUARTZ NO K-SPAR SOME PLAG +>40% FERRO-MAGS	NO QUARTZ NO K-SPAR NO PLAG 100% FERROMAGS
Very coarse grained rock with most grains > 10 mm in diameter	PEGMATITE	DIORITE	GABBRO	PERIDOTITE
Medium and coarse grained rocks (average grain size 1 – 10 mm in diameter)	GRANITE	DIORITE	GABBRO	PERIDOTITE
Fine grained rocks (average grain size < 1 mm in diameter)	RHYOLITE	ANDESITE	BASALT	--
Porphyritic (larger grains surrounded by a finer grained matrix)	PORPHYRITIC RHYOLITE	PORHYRITIC ANDESITE	PORPHYRITIC BASALT	--
Glassy	OBSIDIAN		--	--
Frothy or foamy‡	PUMICE		SCORIA	

†**FERROMAGS** = Ferromagnesian silicate minerals (biotite, hornblend, augite, and olivine)
PLAG = Plagioclase Feldspar; **K-SPAR** = Potassium Feldspar

‡**FROTHY or FOAMY** rocks are mostly made of void space. They will have very low densities and there will be no visible mineral crystals.

Table 2: Igneous Rock Description Table.

SAMPLE NUMBER	TEXTURE	COMPOSITION **Chemical** based on color (usually), **and minerals** *if you can see them*	ROCK NAME
1	COARSE TO VERY COARSE	MAFIC—PLAGIOCLASE AND AUGITE	GABBRO
2	GLASSY	FELSIC	OBSIDIAN
3	PORPHYRITIC	FELSIC—Ph-CRYSTS ARE QUARTZ	PORPHYRITIC RHYOLITE
4	MEDIUM TO COARSE	INTERMEDIATE—PLAGIOCLASE, HORNBLENDE	DIORITE
5	PORPHYRITIC	INTERMEDIATE—Ph-CRYSTS ARE HORNBLENDE	PORPHYRITIC ANDESITE
6	PORPHYRITIC, VESICULAR	MAFIC—Ph-CRYSTS ARE PLAGIOCLASE	PORPHYRITIC VESICULAR BASALT
7	FROTHY	FELSIC	PUMICE
8	COARSE	FELSIC—K-SPAR, PLAGIOCLASE, QUARTZ, HORNBLENDE	GRANITE
9	FROTHY	MAFIC	SCORIA
10	MEDIUM	ULTRAMAFIC—OLIVINE	PERIDOTITE

Part B – Igneous Rocks Supplemental Questions

Sample A: Observe the textural characteristics in **an igneous rock with larger crystals in a fine-grained matrix**. Examine Sample A and answer the following questions.

1. Describe and identify the mineral that forms the larger crystals.

BLACK ELONGATE PHENOCRYSTS ABOUT ½ mm BY 2-3 mm--HORNBLENDE

2. Identify the rock (use correct name from Table 1 on page 7-3).

_____PORPHYRITIC ANDESITE_____

3. Interpret the cooling history of this rock. Support your interpretation with observations of the textural features in the sample.

THE PHENOCRYSTS FORMED AS THE MAGMA WAS COOLING SLOWLY, AT GREAT DEPTH. SOME EVENT CAUSED THIS MAGMA TO ERUPT AS LAVA, AND THE GRAY GROUNDMASS COOLED SO QUICKLY THAT THE CRYSTALS THERE ARE TOO SMALL TO SEE. SEE PAGE 57 IN 11TH ED. OF TEXTBOOK FOR FURTHER DISCUSSION.

Sample B: Observe the textural characteristics in a **fine-grained igneous rock**.

Examine Sample B and answer the following questions.

1. Can you identify any of the minerals present in this sample? What problem do you encounter when trying to identify minerals in a fine-grained rock?

THE GRAINS ARE TOO SMALL TO IDENTIFY ANY MINERALS

2. Identify the rock (use correct name from Table 1 on page 7-3).

____BASALT_____

3. Compare this Sample B with Sample A. List two features that would help you distinguish these two rocks.

COLOR SHOWS THAT THEY HAVE DIFFERENT CHEMICAL COMPOSITIONS. THE PHENOCRYSTS IN SAMPLE A ALLOW YOU TO DETERMINE IT IS ANDESITE, NOT RHYOLITE OR BASALT.

Sample C: Observe the textural characteristics in a **coarse-grained igneous rock**.

Examine Sample C and answer the following questions.

1. Briefly describe (i.e. give color, shape, and relative size) and identify the different mineral grains present in this rock.

PINK—LARGE, BLOCKY, HARD, WITH CLEAVAGE: POTASSIUM FELDSPAR
BLACK—LARGE, ELONGATE, HARD, WITH CLEAVAGE: HORNBLENDE
CLEAR—MEDIUM, IRREGULAR, HARD, NO CLEAVAGE: QUARTZ

2. Identify the rock (use correct name from Table 1 on page 7-3).
____GRANITE PEGMATITE_____

3. Describe the shape and relative size of the quartz grains. Can you see crystal faces? Is it larger or smaller than the other minerals?

(SEE 'CLEAR' ABOVE) YOU CANNOT SEE CRYSTAL FACES

4. Describe the shape and relative size of the pink mineral grains. It may be difficult to determine the extent of a single pink mineral grain. Since cleavage is consistent throughout a single mineral grain, you can use the extent of a flat, shiny cleavage surface to determine the boundaries and shape of the mineral grains.

(SEE 'PINK' ABOVE)

5. Based on your observations, do you think the quartz crystallized before or after the pink mineral? Explain. Where do the dark minerals fit into the crystallization sequence?

THE IRREGULAR SHAPE OF THE QUARTZ CRYSTALS INDICATES IT COOLED LATER, FILLING IN THE SPACES REMAINING BETWEEN EXISTING, EARLIER-FORMED CRYSTALS. THE DARK MINERALS MUST HAVE CRYSTALLIZED FIRST, BECAUSE THE FELDSPAR ENGULFS THEM…THEY COULD NOT HAVE PENTRATED EXISTING CRYSTALS OF FELDSPAR.

6. Using Bowen's Reaction Series, predict the first two minerals to be consumed upon melting of this rock.

QUARTZ, THEN THE POTASSIUM FELDSPAR, THE MELTING ORDER IS OPPOSITE THEIR CRYSTALLIZATION-UPON-COOLING ORDER.

Name_____KEY_____

Lab day _____Lab Time_____

Post-Lab Assessment

1. Describe the procedure you would follow to determine the name of a specific igneous rock.

DETERMINE THE TEXTURE OF THE ROCK BY LOOKING AT THE SIZE AND INTER-RELATIONSHIP OF THE MINERAL GRAINS.

DETERMINE THE CHEMICAL COMPOSITION OF THE ROCK BY IDENTIFYING THE MINERAL GRAINS (IF POSSIBLE) AND THEIR RELATIVE PERCENT OF THE ROCK…OR BY THE COLOR IF THE MINERAL GRAINS ARE TOO SMALL TO IDENTIFY.

2. What factor determines the size of the crystals in igneous rocks?

RATE OF COOLING—LONG TIME: LARGE, SHORT TIME: SMALL

3. What general principles can be used to determine the **order** in which mineral crystals form in a cooling magma? Consider the crystallization histories of rocks A and C (in part B) of this lab, and include some of your observations of these rocks in your answer.

LOOK AT THE INTER-RELATIONSHIP OF THE MINERAL GRAINS: DO THEY FILL IN SPACES BETWEEN CRYSTALS WITH WELL-FORMED CRYSTAL FACES? THEY MUST HAVE CRYSTALLIZED LATER. DO THEY PENETRATE OTHER CRYSTALS? THEY MUST HAVE CRYSTALLIZED FIRST, AND THE OTHER CRYSTAL SURROUNDED THEM. IF THERE ARE TWO SIZES, AN ABRUPT CHANGE IN THE RATE OF COOLING IS INDICATED, WITH THE LARGER CRYSTALS FORMING IN THE SLOW-COOLING STAGE, AND THE SMALLER ONES FORMING IN THE RAPID-COOLING PHASE LATER.