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
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 they 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.

<table>
<thead>
<tr>
<th>Texture</th>
<th>Felsic (light colored)</th>
<th>Intermediate</th>
<th>Mafic (dark colored)</th>
<th>Ultramafic (green)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very coarse grained rock with most grains &gt; 10 mm in diameter</td>
<td>PEGMATITE</td>
<td>DIORITE</td>
<td>GABBRO</td>
<td>PERIDOTITE</td>
</tr>
<tr>
<td>Medium and coarse grained rocks (average grain size 1 – 10 mm in diameter)</td>
<td>GRANITE</td>
<td>DIORITE</td>
<td>GABBRO</td>
<td>PERIDOTITE</td>
</tr>
<tr>
<td>Fine grained rocks (average grain size &lt; 1 mm in diameter)</td>
<td>RHYOLITE</td>
<td>ANDESITE</td>
<td>BASALT</td>
<td>--</td>
</tr>
<tr>
<td>Porphyritic (larger grains surrounded by a finer grained matrix)</td>
<td>PORPHYRITIC RHYOLITE</td>
<td>PORPHYRITIC ANDESITE</td>
<td>PORPHYRITIC BASALT</td>
<td>--</td>
</tr>
<tr>
<td>Glassy</td>
<td>OBSIDIAN</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Frothy or foamy‡</td>
<td>PUMICE</td>
<td>SCORIA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

†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>
<thead>
<tr>
<th>SAMPLE NUMBER</th>
<th>TEXTURE</th>
<th>COMPOSITION</th>
<th>ROCK NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Chemical (usually), and minerals if you can see them</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>COARSE TO VERY COARSE</td>
<td>MAFIC—PLAGIOCLASE AND AUGITE</td>
<td>GABBRO</td>
</tr>
<tr>
<td>2</td>
<td>GLASSY</td>
<td>FELSIC</td>
<td>OBSIDIAN</td>
</tr>
<tr>
<td>3</td>
<td>PORPHYRITIC</td>
<td>FELSIC—Ph-CRSTS ARE QUARTZ</td>
<td>PORPHYRITIC RHYOLITE</td>
</tr>
<tr>
<td>4</td>
<td>MEDIUM TO COARSE</td>
<td>INTERMEDIATE—PLAGIOCLASE, HORNBLENDE</td>
<td>DIORITE</td>
</tr>
<tr>
<td>5</td>
<td>PORPHYRITIC</td>
<td>INTERMEDIATE—Ph-CRSTS ARE HORNBLENDE</td>
<td>PORPHYRITIC ANDESITE</td>
</tr>
<tr>
<td>6</td>
<td>PORPHYRITIC, VESICULAR</td>
<td>MAFIC—Ph-CRSTS ARE PLAGIOCLASE</td>
<td>PORPHYRITIC VESICULAR BASALT</td>
</tr>
<tr>
<td>7</td>
<td>FROTHY</td>
<td>FELSIC</td>
<td>PUMICE</td>
</tr>
<tr>
<td>8</td>
<td>COARSE</td>
<td>FELSIC—K-SPAR, PLAGIOCLASE, QUARTZ, HORNBLENDE</td>
<td>GRANITE</td>
</tr>
<tr>
<td>9</td>
<td>FROTHY</td>
<td>MAFIC</td>
<td>SCORIA</td>
</tr>
<tr>
<td>10</td>
<td>MEDIUM</td>
<td>ULTRAMAFIC—OLIVINE</td>
<td>PERIDOTITE</td>
</tr>
</tbody>
</table>
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 PHENOCRYSTST 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 PENETRATED 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.
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.