Lab 8: IGNEOUS ROCK IDENTIFICATION 100 pts

Introduction

Igneous rocks are aggregates of minerals that have crystallized from ***magma***. Magma is generated deep within or beneath the earth's crust and usually works its way toward the surface. Some magma reaches the earth's surface where it is extruded as lava producing ***volcanic*** igneous rocks. Other magma may solidify before it reaches the surface, producing ***plutonic*** igneous rocks.

The chemical constituents of magma determine the minerals which will be formed as it cools and solidifies. Individual mineral grains may be large enough to be identifiable by the naked eye or they may be so small that they can be distinguished only under a microscope. The rate of cooling of a magma determines whether its mineral grains will be microscopic or visible (megascopic) or a combination of both. The size, shape, and mutual relationships of the minerals in an igneous rock is called the ***texture***. The kinds of minerals present in an igneous rock determine its ***composition***.

These two properties, texture and composition, provide the means for both the identification and the classification of igneous rocks.

There are only eight silicate minerals which comprise the chief constituents of most igneous rocks. These eight minerals do not crystallize from magma simultaneously. Each will begin to crystallize at a different temperature. The order in which minerals crystallize from magma can be approximated from ***Bowen's Reaction Series***. This sequence of minerals crystallizing from a magma is shown in **table A**, as well as on **Figure 1** as a Temperature vs. Composition diagram.

In general, minerals that crystallize at the same temperature occur together in the same igneous rock. Rocks composed of minerals that crystallize at high temperatures are comparatively rich in magnesium and iron and are called ***mafic*** igneous rocks. Rocks composed of minerals that crystallize later at relatively lower temperatures are relatively rich in silica, sodium or potassium and are termed ***felsic*** or ***silicic*** igneous rocks. Between these two compositional extremes are ***intermediate*** rocks.

<table>
<tr><th></th><th></th><th colspan="3">Rock Physical & Chemical Properties</th></tr>
<tr><th>Temperature</th><th>Order of Crystallization
Bowen's reaction series</th><th>Composition or bulk chemistry</th><th>Most abundant Minerals</th><th>Color tone</th></tr>
<tr><td rowspan="3">1st to crystallize
1300 °C

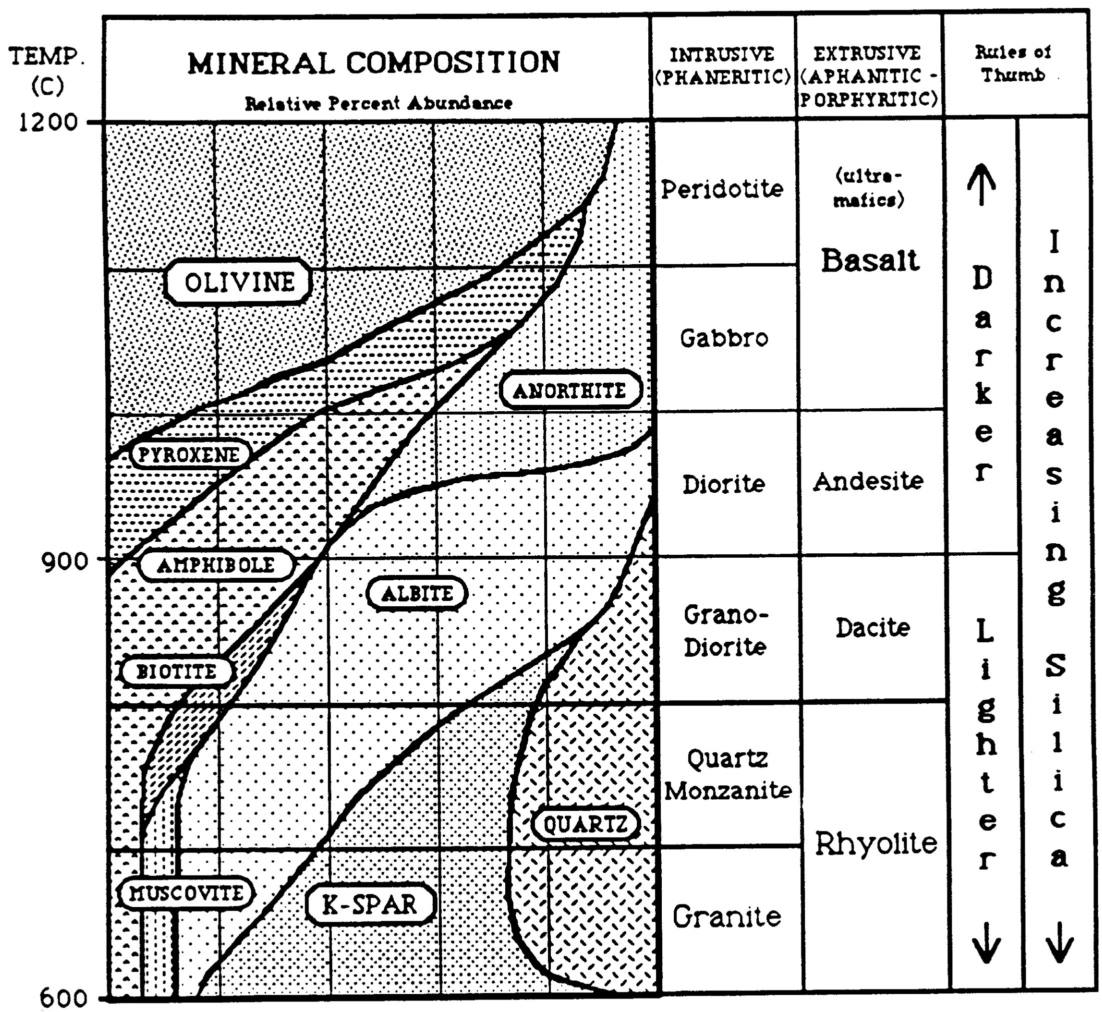
Last to crystallize
600 °C</td><td rowspan="3">(Ferromagnesian)
Olivine
Augite
Hornblende
Biotite

(Felsic)
Anorthite
(Ca Plagioclase)
Albite
(Na-Plagioclase)
Orthoclase

Muscovite
Quartz</td><td>Mafic</td><td>Olivine &/or augite, Ca-plagioclase</td><td>Dark</td></tr>
<tr><td>Intermediate</td><td>Na-Ca plagioclase, augite, &/or hornblende
Ferromagnesian minerals approx. equal to felsic minerals</td><td>Half dark & half light (salt and pepper)</td></tr>
<tr><td>Felsic or silicic</td><td>Biotite &/or hornblende, orthoclase & quartz</td><td>Light (white to pinkish with specs of black)</td></tr>
</table>

Table A

Figure 1: Temperature-composition Diagram



Classification of Igneous Rocks

Igneous rocks are classified according to their mineral composition and texture.

Mineral Composition

Essential minerals are those that must be present in order for the rock to be assigned a specific name on the classification chart. *Accessory minerals* may or may not be present in a given rock, but the presence of an accessory mineral in a rock may affect the name of that rock. For example, the essential minerals in *granite* are *quartz* and *orthoclase*, but if a particular granite contains an accessory mineral such as biotite or hornblende, the rock may be call a *biotite granite* or a *hornblende granite*, respectively.

The essential minerals in common igneous rocks are quartz, orthoclase, plagioclase, augite (pyroxene), and olivine.

The key to igneous rock identification is the ability to recognize the presence or absence of quartz in the rock and to distinguish between orthoclase and plagioclase. Color is of limited help in identifying minerals because quartz, orthoclase, and plagioclase can occur in various shades of gray. The distinction between quartz and the feldspars can be made because quartz has no cleavage and the feldspars have 2 cleavages at right angles (orthorhombic cleavage).

The distinction between orthoclase and plagioclase is more difficult because both have cleavage planes which show up as bright reflected surfaces in phaneritic igneous rocks. A pink feldspar is usually orthoclase, but a white feldspar could be either orthoclase or plagioclase. Plagioclase has characteristic minute striations (like straight record grooves) that may be visible on some cleavage faces, especially if the grains are relatively large. Striations on smaller plagioclase crystals may be difficult to see and require the careful use of a hand lens. Gray to dark feldspar is usually Ca-plagioclase.

Texture

Texture refers to mineral size and shape and the boundary relationships between adjacent minerals in a rock. In most igneous rocks, the texture has an overall appearance of a mass of interlocking crystals. This is especially obvious in a rock containing large crystals.

Textures of igneous rocks develop primarily in response to the composition and rate of cooling of the magma. Magmas deep beneath the earth's surface cool very slowly. Individual crystals are more or less uniform in size and may grow to 1 cm or more in diameter. Magmas extruded out upon the earth's surface cool rapidly and their crystals have only a short time to grow. Crystals from such a magma are typically so small that they cannot be seen without a microscope and the rock appears ***massive***. If extremely rapid cooling takes place, the magma is quenched before crystals can form. The rock resulting from such a process would be a ***natural glass*** called obsidian. An additional textural type may develop when the cooling history is more complex, involving a period of slow cooling followed by a later period of more rapid cooling. Two distinct crystal sizes would develop in this situation, producing a ***porphyritic*** texture. The large crystals (***phenocrysts***) developed during the slower period of cooling are surrounded by smaller crystals (collectively called ***groundmass***) that formed during the period of rapid cooling.

BASIC IGNEOUS ROCK TEXTURES

1. *Phaneritic*: This term applies to an igneous rock in which the constituent minerals are megascopic (visible) in size. Dimensions of individual crystals range from less than 1 mnm to more than 10 mm.

    - *phaneritic equigranular* most of the mineral grains in the rock are about the same size.

- *phaneritic seriate* if there is a complete range of sizes, from smallest to largest, represented in the rock.

2. *Aphanitic*: This term is used to describe the texture of an igneous rock composed entirely of microscopic crystals (too small to identify with the naked eye).

    - *Microcrystalline*: mineral grains which are too small to be seen with the aid of a hand lens

    - *Glassy*: few or no mineral grains are present and the main material present is volcanic glass.

3. *Porphyritic* - This term applies to an igneous rock in which larger grains (*phenocrysts*) are embedded in a matrix of distinctly smaller grains (*groundmass*) which are either phaneritic or aphanitic.

    - *prophyro-phaneritic* both the large phenocrysts as well as the smaller crystals in the groundmass are large enough to see without magnification.

    - *porphyro-aphanitic* if the phenocrysts are large enough to see but the groundmass is microcrystalline.

4. *Pyroclastic*: This term applies to igneous rocks composed of fragments of volcanic material ejected during an eruption. This material may include dust, ash, lapilli, bombs, and blocks, as well as individual mineral grains.

SPECIAL IGNEOUS ROCK TEXTURES

Vesicles are spherical or subspherical cavities in igneous rock produced by gas which was present in the original magma. Igneous rocks containing vesicles are termed *vesicular* igneous rocks.

Amygdules are vesicles which have been filled with mineral grains after the initial cooling of the igneous rock. Rocks containing amygdules are referred to as *amygdaloidal.*

Pegmatitic texture is applied to rocks consisting of exceptionally large mineral grains (larger than 2cm).

Aplitic texture applies to granitic dike rocks consisting of fine-grained, sugar-sized crystals.

A **flow chart** for determining the texture of an igneous rock appears on **Figure 2**. This flow chart serves as a reminder of what questions to ask, and observations to make, about the igneous rock sample you are trying to identify. Eventually, you will learn to make these observations without having to rely on the chart.

Method for Identification of Igneous Rocks

Table B is a chart that shows the names of about thirty common igneous rocks. The texture categories are given along the left-hand side of the chart, and the essential minerals are shown along the top of the chart. You should use the following method in order to make use of this rock chart. Make notes of your observations on the *work sheet for igneous rock determination* found at the end of this exercise.

1. Determine the texture (using the flow chart) and locate the proper row for the texture on the left-hand side of the rock chart.

2. Determine the mineral composition of the rock and list <u>all</u> the minerals present, both essential and accessory.

    - Is there a feldspar present?

    - If so, is plagioclase or orthoclase predominant?

    - Is quartz present or is it absent?

    - If you can't see any crystals (the sample is aphanitic), what color is it? (light, grey, dark)

3. Locate the proper column along the top of the chart according to the mineral composition

4. Locate the proper column along the top of the chart according to the mineral composition. The composition of the feldspars in the rock is the first step to determining the proper column, and usually the column can be determined secondly by the presence absence of quartz in the rock.

5. Project the row for texture and the column for composition to where they intersect, and read the name of the rock listed in that box. This is the root name of the igneous rock.

6. You should now list in *front* of the name any accessory minerals which were observed in the particular rock.

Note that the classification of microcrystalline and glassy rocks by hand lens methods depends on color alone. However, more detailed distinctions can be made between those rocks which are phaneritic in texture.

On the right-hand column there are two special types of rocks that are usually found in dikes:

- ***Pegmatite*** is a rock of granitic composition with extremely large mineral grains

- ***aplite*** is a dike rock of granitic composition consisting of small interlocking, sugar-sized grains.

Materials Required & Lab Procedure

You should read and understand the introductory material below, as well as the chapter on igneous rocks in your textbook. Be familiar with the common igneous rock forming minerals and know HOW to identify them both as large specimens and as small grains. Pay particular attention to look-alike minerals such as biotite and muscovite, orthoclase and plagioclase etc. Have Bowen's reaction series committed to memory as this will help greatly with mineral associations.

You will need access to the Igneous Rock Samples available in the classroom or study room. Your hand lens is ESSENTIAL equipment for this exercise. Access to a microscope is also very important, especially when first starting out. However, the ultimate goal is for you to be able to identify igneous rocks using only your handlens. Small vials containing sand-sized grains of the common igneous rock forming minerals are also very useful when first learning to look at hand samples - these are also available in the classroom or geology study room

Part 1 (50 pts): Study the unknown igneous rocks provided in the classroom or study room. Begin by identifying one rock at a time following the method described above. Fill in the appropriate texture and composition columns in the Igneous Rock Identification Chart provided with this lab. With this information you can refer to the Igneous Rock Identification chart and determine a name for the rock. Note that you may have more than one specimen of a given rock type. Once you have identified two or three of your specimens, let your instructor check your identification.

Part 2 (50 pts): Identify all of the rocks assigned before continuing on to answer the following questions.

Questions

1. Take samples of basalt, andesite, and porphyritic granite from the igneous rock set. List the first minerals to crystallize in the magmas which produced each of these three rocks. ***(10 pts)***

ROCK	1ST MINERAL	2ND MINERAL	3RD MINERAL
Basalt			
Andesite			
Granite			

On what basis did you draw your conclusions?________________________________

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2. Compare the andesite to the quartz diorite specimen. List the minerals which you think are probably present in the groundmass of the andesite ***(6 pts):***

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Why did you pick the minerals you listed above?

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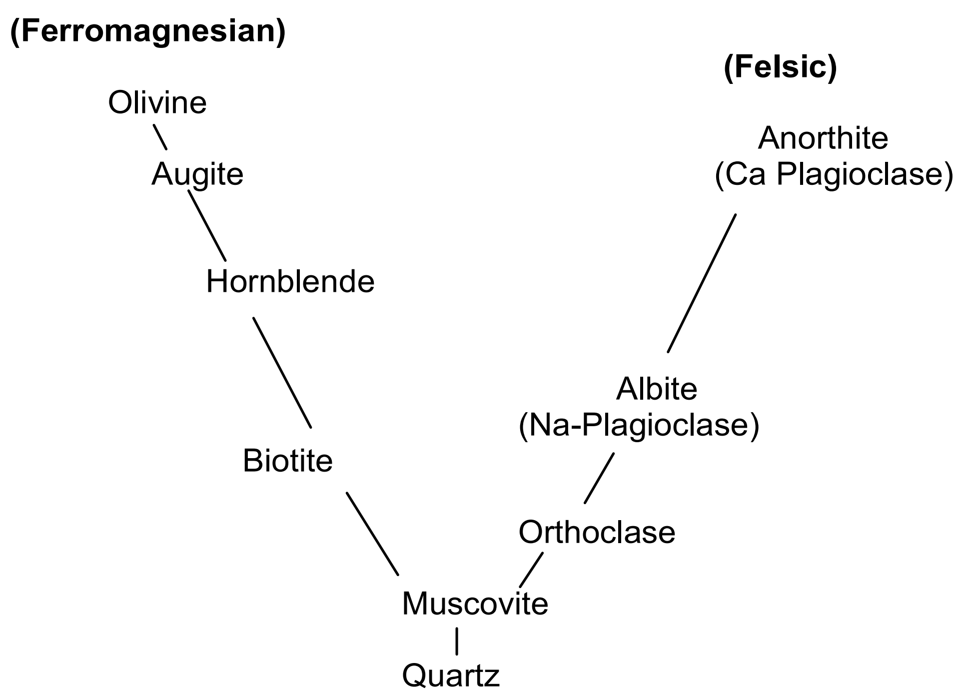
3. A sketch of Bowen's Reaction Series is shown below. Along the side of this sketch, please write in the names of each of the rocks in Question 1 according to their probable position in the series. For example, those at the top would be rocks that formed at relatively high temperatures early in Bowen's Reaction Series, etc ***(6 pts).***



4. Look at the sample of basalt and compare it to the sample of pumice. Besides the difference in chemistry of the two rocks, there is clearly a major difference in the number of vesicles in the two rocks. The basalt magma had just as much dissolved gas as the magma which produced the pumice. Why is the pumice so much more vesicular than the basalt? ***(4 pts)***

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5. The sketch below shows one feldspar overgrown (*mantled*) by a second feldspar. This is a common relationship between feldspars in some igneous rocks. Please name which feldspar occurs in the center and which one occurs in the rim & explain how you know ***(4 pts).***

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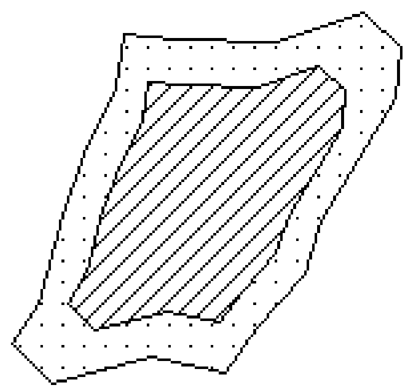

How did you know which feldspar occurred at each site?

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6. Examine the xenolith specimen provided in the lab. When magma is injected it can tear off rock fragments from the surrounding walls of country rock (such as this xenolith). How would you expect these foreign fragments to alter the rate of crystallization of the magma? Do you see any evidence of this in your specimen? ***(4 pts)***

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7. Examine the specimen of a dike provided in the lab. This feature forms when magma is injected into surrounding igneous rock. Please describe the variation in grain size from the center to the edge of this dike. Also note the orientation of the mineral grains in the dike. ***(6 pts)***

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Can you explain the pattern of grain sizes that you see in this rock?

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8. Drawing from the rocks you have already identified, select an example of a rock which could have formed (solidified) in the following settings. In each case, explain why you have selected that particular rock and give an example of where you might go today to find that particular kind of rock. ***(10 pts)***

Setting	**Why?**	**Where?**
Lava flow at an ocean ridge		
Part of the upper mantle		
Lava flow from a composite volcano (stratovolcano)		
An explosive volcanic eruption		
Pluton deep within the crust		

Table B: Igneous Rock Naming Chart

Mineral Composition		Essential Minerals		Orthoclase > Plagioclase		Orthoclase = Plagioclase		Plagioclase > Orthoclase			Augite &/or Olivine
				Quartz Present	Quartz Absent	Quartz Present	Quartz Absent	Quartz Present	Quartz Absent	Augite	
		Characterizing accessory minerals		Biotite, hornblende, muscovite		Hornblende, Biotite		Hornblende, Biotite, Augite		Olivine	
Occurrence		Texture		General increase in the percent of mafic (dark) minerals ----------->							
Intrusive	Plutonic; batholiths, stocks, deep dikes & sills	Phaneritic texture	Equigranular or seriate	Granite	Syenite	Quartz Monzonite	Monzonite	Quartz Diorite (grano-diorite)	Diorite	Gabbro Anorthosite (plagioclase only)	Pyroxenite (augite only) Peridotite (augite & olivine) Dunite (olivine only)
			Porphyro-phaneritic	Porphyritic granite	Porphyritic syenite	Porphyritic quartz monzonite	Porphyritic monzonite	Porphyr-itic quartz diorite	Porphyritic diorite	Porphyritic gabbro	
Extrusive	Volcanic; lava flows, shallow dikes & sills	Aphanitic	Porphyro-aphanitic	Porphyritic rhyolite	Porphyritic trachyte	Porphyritic Quartz Latite	Porphyritic Latite	Porphyr-itic Dacite	Porphyritic Andesite	Porphyritic Basalt	
			Micro-crystalline	Felsite (light colored aphanitic rock)					Basalt (dark colored aphanitic rock)		
	Chiefly surface flows & ejecta	Glassy	Glassy	Obsidian-volcanic class, usually black Pumice-volcanic glass with gas cavities					Scoria Coarsely vesicular, usually dark colored volcanic glass		
	Bedded or massive fragmental ejecta	Pyroclastic	Pyroclastic	Tuff-consolidated dust, ash & cinders to 4 mm Lapilli Tuff-tuff with small volcanic rock fragments Welded tuff-compacted, fused tuff							

Special Dike Rocks: Pegmatite-very course grainded greater than 2 cm
Aplite-Light colored, sugar-sized crystals

#	Texture	Mineral Composition			Notes: vesicles, amygdules, inclusions, etc	Rock Name
		Seriate or Equigranular	Porphyritic			
			Phenocrysts	Groundmass		

#	Texture	Mineral Composition			Notes: vesicles, amygdules, inclusions, etc	Rock Name
		Seriate or Equigranular	Porphyritic			
			Phenocrysts	Groundmass		

#	Texture	Mineral Composition			Notes: vesicles, amygdules, inclusions, etc	Rock Name
		Seriate or Equigranular	Porphyritic			
			Phenocrysts	Groundmass		