GEOL 333 - Lab 7 (Silicic Igneous Rocks in Hand Sample and Thin Section)

Introduction

To review key points from last week, igneous rocks form from *cooling of molten rock* at or below Earth's surface and are classified based on their **composition** and **grain size**, which is controlled by the cooling rate of the molten rock (fast cooling = small grains and slow cooling = large grains). Most igneous rocks have randomly oriented grains with an interlocking texture, i.e., no space between grains. Silicic (also called felsic), intermediate, and mafic refer to an igneous rock's composition. Last week, you studied hand samples and thin sections of mafic igneous rocks.

This week, you will study hand samples and thin sections of silicic igneous rocks, which contain abundant silica (>~65% SiO_2), relatively high amounts of K and Na, as well as relatively low amounts of Fe and Mg compared to mafic igneous rocks. Silicic igneous rocks are rich in light-colored minerals, making them light in color. The major silicic minerals are quartz, Na-rich plagioclase feldspar (albite), and K-feldspar (also called alkali feldspar). Alkali feldspar sometimes shows exsolution lamellae (separation of K-rich and Na-rich feldspar within a single grain). Perthite is alkali feldspar dominated by the K-rich feldspar with small linear zones of Na-rich feldspar. Minor minerals include muscovite, biotite, and amphibole. Two end-members of silicic igneous rocks are Rhyolite (fine-grained) and Granite (coarse-grained). Volcanic eruptions of silicic lava commonly are explosive, which causes very rapid cooling to produce amorphous volcanic glass. Tuff forms from explosive volcanic eruptions and can include pumice (coarse-grained volcanic glass with abundant vesicles), volcanic ash (medium-grained volcanic glass with smooth, curved surfaces) and phenocrysts (crystals of feldspars, quartz or other minerals). Vitric tuff has abundant volcanic glass; crystal tuff has abundant mineral grains; welded tuff is compacted when hot and soft and it may contain fiamme (flattened pumice); unwelded tuff is uncompacted. Obsidian is massive volcanic glass formed from a lava flow that cooled very quickly.

To summarize, the most important minerals in silicic igneous rocks are quartz, plagioclase feldspar, and K-feldspar. The optical characteristics of these minerals as well as volcanic glass and vesicles are listed later in this document just before the Unknown Rock Identification Sheets.

Lab Exercise

1. Define the following terms. You will need to use them later in your rock descriptions.

   a) Pumice:

   b) Fiamme:

   c) Volcanic Ash:

   d) Tuff:

   e) Perthite:

Thin section examination of sample 56-7-8 will be done together as a group.

2) a) Examine the hand sample of **56-7-8b**. Describe the hand sample.

b) Examine the thin section of sample **56-7-8**. Pore space is represented by the blue stained regions seen in plane-polarized light. Briefly describe the thin section and also try to interpret the origin of this rock, e.g., slow or fast cooling, explosive eruption, etc. Make sure to examine the thin section in both medium and low power magnification.

3) Complete an Unknown Rock Identification Sheet (found at the very end of this document) for each of the following four silicic igneous rock samples. **NOTE: The letter S at the end of the sample label indicates a stained version of the sample. For the stained thin section, K-feldspar is green in PPL, plagioclase feldspar is orange in PPL and quartz is clear/white in PPL.**

a) Settlement Quarry or Settlement Quarry S
b) 955-55-26B or 955-55-26B S
c) GT
d) 215C-100 or 215C-100 S

Unknown Rock Identification Sheets - Explanation of Terms

For the 4 silicic igneous rocks assigned today, you will fill out an identification sheet that includes your observations on both the hand sample and associated thin section. These observations are key to naming the sample, however the most important part is an accurate description of the mineral content and texture. Normally, the more information you collect and record about the sample, the better.

- **Hand Sample Description**

Complete the hand sample description first by observing the sample with and without a binocular microscope. Describe the color (e.g., "medium gray", or "grayish-green rock with white veins"), mineral content (names and approximate abundance of each mineral, especially K-feldspar, plagioclase feldspar, and quartz vs. mafic silicate minerals) and texture, which includes grain size (e.g., fine, medium, or coarse-grained), grain shape, and grain arrangement (see below for specific textural terms). Finally, name the rock based on your hand sample description (e.g., "porphyritic rhyolite").

- **Thin Section Description**
    - **Rock Texture**

Rock texture refers to the size, shape and arrangement of the mineral grains. In your rock descriptions use the appropriate mineralogical terms for texture given in several lists below. Examples of questions to address include: What is the average grain shape? Are the grains similar in shape or is there a wide range? What is the average grain size? Are most of the minerals the same size or two groups of sizes or a wide range of sizes? Is the shape similar for all mineral grains?

Field of View Size for our Petrographic Microscopes (used for grain size determination)

Power	**Width of field**	**Radius**
2.5x (low)	4.5 mm	2.25mm
10x (med.)	1.8mm	0.9mm
40x (high)	0.45mm	0.225mm

- **Grain Size Terms** (Note: Use these for both hand samples and thin sections)

1. Phaneritic - Coarse Grained: most grains are distinguishable as individual entities by naked eye or with a magnifying glass.
2. Aphanitic - Fine Grained: may be glassy or crystalline. Individual grains below resolution of naked eye or hand lens.
3. Porphyritic - contains both large and small grains
4. Fine-grained - between 0.1 – 1 mm
5. Medium-grained - between 1 – 5 mm
6. Coarse-grained - between 5 – 10 mm
7. Very coarse-grained - between 10 – 20 mm
8. Pegmatitic - >20 mm
9. Microcrystalline - microscopically crystalline (between 0.01 - 0.1 mm)
10. Glassy - volcanic glass (amorphous)

- **Grain Shape Terms**

1. Euhedral - has good crystal outline (flat crystal surfaces on all sides)
2. Subhedral - has incomplete or poor crystal outline
3. Anhedral - no crystal outline

- **Grain Arrangement Terms**

Describe how the minerals grains are situated in relation to each other, as well as any disruptions of the normal pattern. Some relevant terms are **interlocking texture** (no space between mineral grains, i.e., jigsaw puzzle-like fit) **with random grain arrangements** (a typical igneous texture), **welded texture** (contains abundant fiamme and no space between mineral grains) **with aligned grains** (many grains oriented in specific direction), and **vesicular** (contains abundant holes, usually involves volcanic glass).

- **Major Minerals**

Identify each major mineral (*>5%*) and for each mineral, give the % abundance, grain shape and grain size. **Be as detailed and as descriptive as you can.** Refer to your thin section sketch to show the grain shape and size, but do not substitute the sketch for a verbal description.

- **Minor Minerals and Alteration**

Do not worry about identifying minor (<5% abundance) minerals, unless they are relatively easy to identify (e.g., biotite, hornblende, or muscovite), but try to describe them. Alteration means a primary mineral grain that has been altered to another mineral usually caused by reactions with water. All of the major minerals in silicic igneous rocks, **except for quartz**, can alter to fine-grained clay minerals, which are difficult to identify specifically.

- **Interpretations and Environment of Formation**

Describe briefly the environment of formation, e.g., coarse-grained texture = cooling deep within Earth and fine-grained or glassy texture = cooling at Earth's surface from a volcanic eruption (explosive or non-explosive). Also, explain any unusual features in the rocks.

- **Rock Name**

Classify the rock based on your observations in hand sample and thin section. You can include the most abundant or especially distinctive lesser abundant minerals before the rock name, such as "biotite granite" for a granite containing abundant biotite, or "olivine basalt" for an olivine-rich basalt.

Optical Characteristics of Minerals and Other Components of Silicic Igneous Rocks

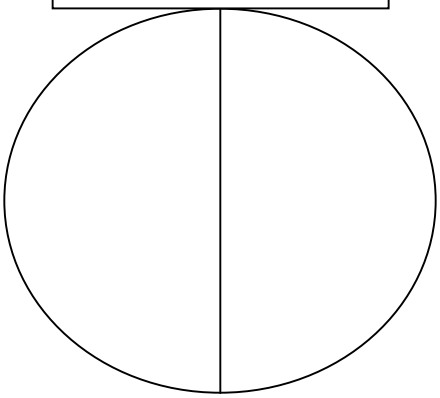
Mineral Name	Plane Polarized Light	Cross Polarized Light
Plagioclase Feldspar	Low relief, can be partly altered to clay (cloudy appearance)	Polysynthetic twinning (black and white stripes), Low (1st order) birefringence (white or gray), clay alteration involves small, highly birefringent grains
K-feldspar (characteristics in bold are most useful in distinguishing K-feldspar from quartz)	Low relief, **2 directions of cleavage (parallel lines) at 90° (moderately developed), can be partly altered to clay (cloudy appearance)**	May show cross-hatch twinning (black and white criss-cross pattern) and exsolution lamellae (thin, parallel lines), Low (1st order) birefringence (white or gray), clay alteration involves small, highly birefringent grains
Quartz	Low Relief, **No cleavage, no alteration to clay (clear appearance)**	Low (1st order) birefringence (white or gray)
Glass	Low relief	Completely black (isotropic)
Vesicles	Clear holes (may see epoxy glue)	Completely black (isotropic)

Common minerals in low abundance include muscovite (1 cleavage, clear in PPL, high birefringence), biotite (1 cleavage, brown and pleochroic in PPL, high birefringence), and amphibole (2 directions of cleavage at 60° or 120°, green and pleochroic in PPL, high birefringence).

Unknown Rock Identification Sheet - Silicic Igneous Rocks

Sample #:_____

Thin Section Sketch
PPL/XPL
Color and Label Grains



TEXTURE

Grain Size (circle one): **Phaneritic (coarse)** **Aphanitic (fine)** **Porphyritic (both)**

If the sample is porphyritic, then identify the phenocrysts and groundmass:

Phenocrysts: _____

Groundmass: _____

Grain Arrangement (circle one): **Interlocking** **Vesicular** **Random** **Aligned**

Additional features and observations? (e.g., color, flow banding, welding, fiamme)

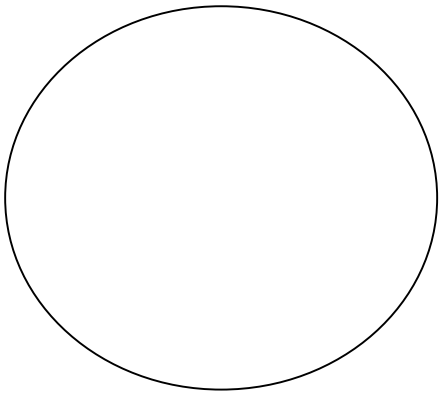
COMPOSITION

Complete the following table. You should look at the rocks using both the Petrographic Microscope and Binocular Microscope to identify the mineral composition. Identify Major and Minor minerals, and classify groundmass (unidentifiable fine grains), glass (including volcanic ash and pumice), vesicles, or alteration products (i.e., clay) in the **'Other'** column. The Abundance of mineral/other row should add up to %100 for all listed species.

	Mineral	**Mineral**	**Mineral**	**Mineral**	**Mineral**	**Other** (glass, ash, pumice, vesicles, rock fragments)
Name						
Size (**coarse, medium, or fine**)						----------
Grain Shape (**euhedral, subhedral, or anhedral**)						----------
Color of grains in Hand Sample						
Abundance of mineral/other (0 - 100%)						

INTERPRETATION

Hand Sample Sketch
Color and Label Grains



Cooling rate (circle one): **Slow** **Fast** **Both**

Environment of formation (circle one): **Intrusive** **Extrusive** **Both**

Location of Cooling (circle one): **Deep in Earth** **Earth's Surface** **Both**

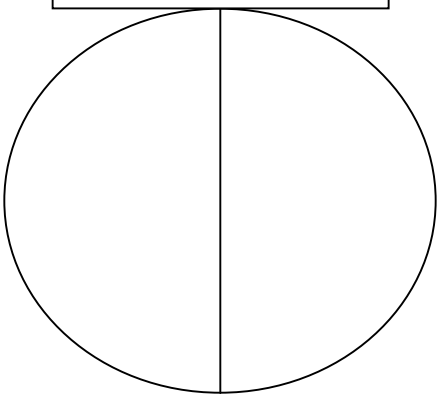
Any other processes (e.g., explosive eruption, lava flow):

Rock Name: _____

Unknown Rock Identification Sheet - Silicic Igneous Rocks

Sample #:_____

Thin Section Sketch
PPL/XPL
Color and Label Grains



TEXTURE

Grain Size (circle one): **Phaneritic (coarse)** **Aphanitic (fine)** **Porphyritic (both)**

If the sample is porphyritic, then identify the phenocrysts and groundmass:

Phenocrysts: _____

Groundmass: _____

Grain Arrangement (circle one): **Interlocking** **Vesicular** **Random** **Aligned**

Additional features and observations? (e.g., color, flow banding, welding, fiamme)

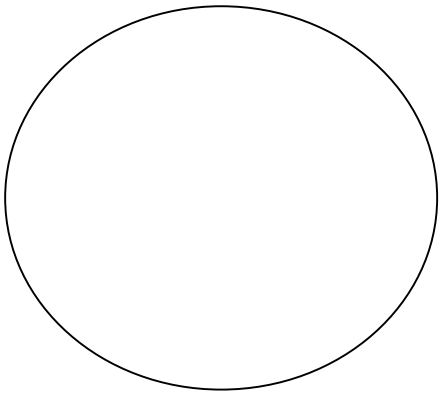
COMPOSITION

Complete the following table. You should look at the rocks using both the Petrographic Microscope and Binocular Microscope to identify the mineral composition. Identify Major and Minor minerals, and classify groundmass (unidentifiable fine grains), glass (including volcanic ash and pumice), vesicles, or alteration products (i.e., clay) in the **'Other'** column. The Abundance of mineral/other row should add up to %100 for all listed species.

	Mineral	**Mineral**	**Mineral**	**Mineral**	**Mineral**	**Other** (glass, ash, pumice, vesicles, rock fragments)
Name						
Size (**coarse, medium, or fine**)						----------
Grain Shape (**euhedral, subhedral, or anhedral**)						----------
Color of grains in Hand Sample						
Abundance of mineral/other (0 - 100%)						

INTERPRETATION

Hand Sample Sketch
Color and Label Grains



Cooling rate (circle one): **Slow** **Fast** **Both**

Environment of formation (circle one): **Intrusive** **Extrusive** **Both**

Location of Cooling (circle one): **Deep in Earth** **Earth's Surface** **Both**

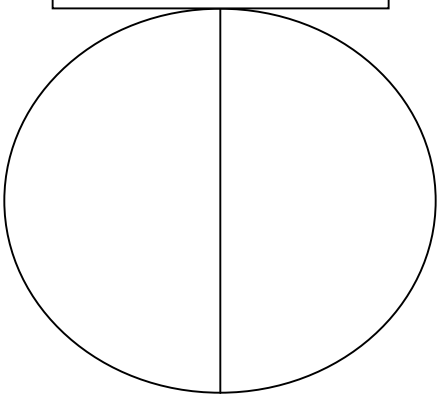
Any other processes (e.g., explosive eruption, lava flow):

Rock Name: _____

Unknown Rock Identification Sheet - Silicic Igneous Rocks

Sample #:_____

Thin Section Sketch
PPL/XPL
Color and Label Grains



TEXTURE

Grain Size (circle one): **Phaneritic (coarse)** **Aphanitic (fine)** **Porphyritic (both)**

If the sample is porphyritic, then identify the phenocrysts and groundmass:

Phenocrysts: _____

Groundmass: _____

Grain Arrangement (circle one): **Interlocking** **Vesicular** **Random** **Aligned**

Additional features and observations? (e.g., color, flow banding, welding, fiamme)

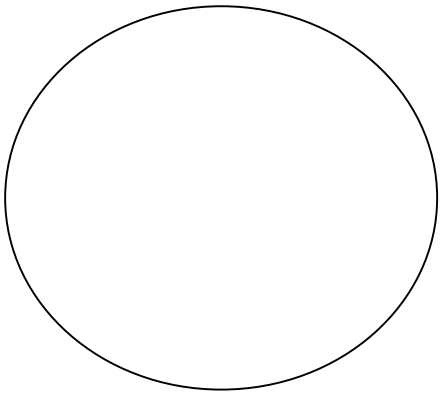
COMPOSITION

Complete the following table. You should look at the rocks using both the Petrographic Microscope and Binocular Microscope to identify the mineral composition. Identify Major and Minor minerals, and classify groundmass (unidentifiable fine grains), glass (including volcanic ash and pumice), vesicles, or alteration products (i.e., clay) in the **'Other'** column. The Abundance of mineral/other row should add up to %100 for all listed species.

	Mineral	**Mineral**	**Mineral**	**Mineral**	**Mineral**	**Other** (glass, ash, pumice, vesicles, rock fragments)
Name						
Size (**coarse, medium, or fine**)						----------
Grain Shape (**euhedral, subhedral, or anhedral**)						----------
Color of grains in Hand Sample						
Abundance of mineral/other (0 - 100%)						

INTERPRETATION

Hand Sample Sketch
Color and Label Grains



Cooling rate (circle one): **Slow** **Fast** **Both**

Environment of formation (circle one): **Intrusive** **Extrusive** **Both**

Location of Cooling (circle one): **Deep in Earth** **Earth's Surface** **Both**

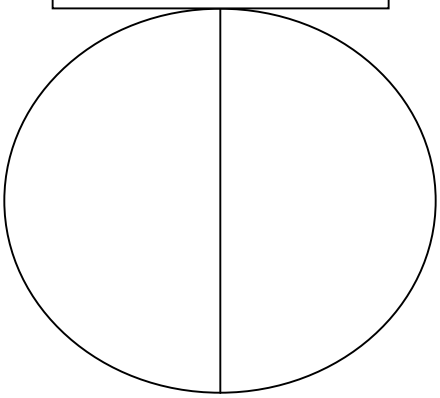
Any other processes (e.g., explosive eruption, lava flow):

Rock Name: _____

Unknown Rock Identification Sheet - Silicic Igneous Rocks

Sample #:_____

Thin Section Sketch
PPL/XPL
Color and Label Grains



TEXTURE

Grain Size (circle one): **Phaneritic (coarse)** **Aphanitic (fine)** **Porphyritic (both)**

If the sample is porphyritic, then identify the phenocrysts and groundmass:

Phenocrysts: _____

Groundmass: _____

Grain Arrangement (circle one): **Interlocking** **Vesicular** **Random** **Aligned**

Additional features and observations? (e.g., color, flow banding, welding, fiamme)

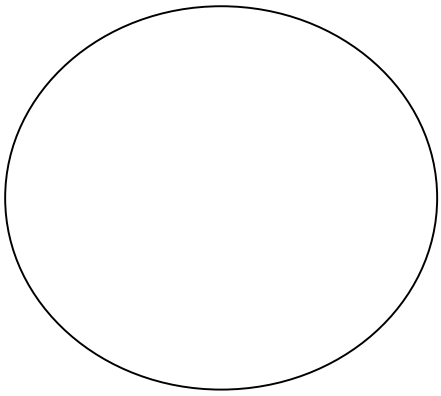
COMPOSITION

Complete the following table. You should look at the rocks using both the Petrographic Microscope and Binocular Microscope to identify the mineral composition. Identify Major and Minor minerals, and classify groundmass (unidentifiable fine grains), glass (including volcanic ash and pumice), vesicles, or alteration products (i.e., clay) in the **'Other'** column. The Abundance of mineral/other row should add up to %100 for all listed species.

	Mineral	**Mineral**	**Mineral**	**Mineral**	**Mineral**	**Other** (glass, ash, pumice, vesicles, rock fragments)
Name						
Size (**coarse, medium, or fine**)						----------
Grain Shape (**euhedral, subhedral, or anhedral**)						----------
Color of grains in Hand Sample						
Abundance of mineral/other (0 - 100%)						

INTERPRETATION

Hand Sample Sketch
Color and Label Grains



Cooling rate (circle one): **Slow** **Fast** **Both**

Environment of formation (circle one): **Intrusive** **Extrusive** **Both**

Location of Cooling (circle one): **Deep in Earth** **Earth's Surface** **Both**

Any other processes (e.g., explosive eruption, lava flow):

Rock Name: _____