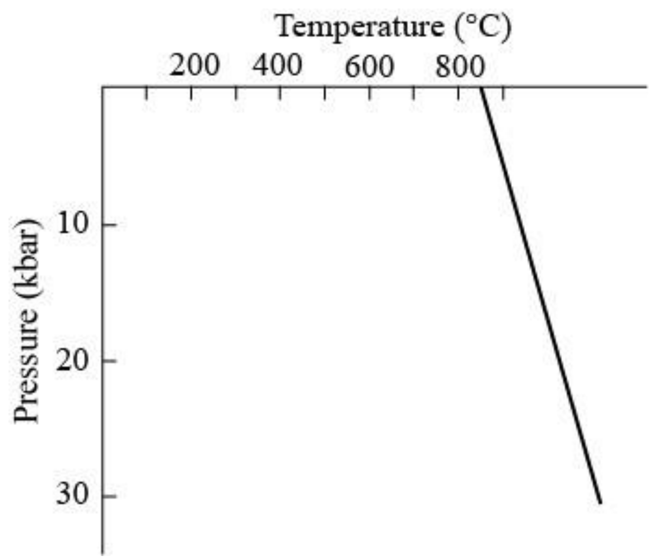
GEOL 241: Igneous Rocks and Processes

Igneous rocks are rocks that crystallized from a magma, or molten rock. In this lab we will learn about the processes that generate magma, the differences between igneous rocks that cool intrusively and extrusively, and how to identify igneous rocks in the field.

Part I: Magma Generation

1. Phase diagrams are graphs in *P–T* space that indicate when a material of a given composition changes phase, for example from liquid to solid. Use the phase diagram for felsic compositions below to answer the following questions.

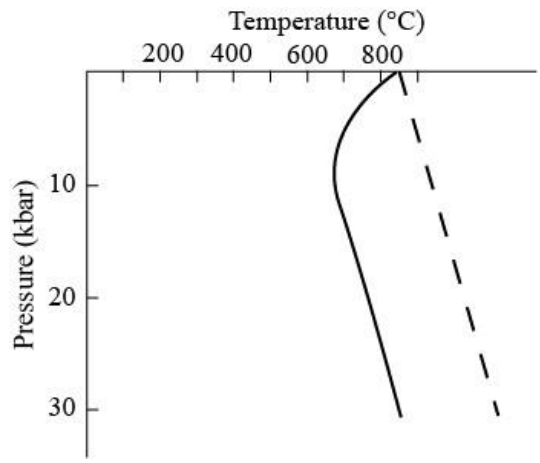


   A) Label liquid and solid stability fields on the phase diagram.

   B) In a laboratory, a felsic rock is exposed to a temperature of 900ºC at 15 kbar (kilobar). Will the rock be liquid or solid? (**Note:** 1 bar ~ atmospheric pressure at sea level. Often pressure is given in Pascals, Pa, where 1 bar = 1 x 10^5 Pa. See chart in Notes at end of this document).

   C) Solid rocks can melt through the *addition of heat energy* while maintaining constant pressure, or by *advecting* (moving) toward the surface of the earth thus reducing pressure while maintaining a contstant temperature. Indicate both of these melting mechanisms on the phase diagrams above by drawing the *P–T* paths that a solid rock might follow during melting associated with the **(1)** addition of heat, and **(2)** advection.

2. When an impurity is added to the rock, the composition of the material changes, and thus you can expect a change in the phase diagram. In the phase diagram below, the dashed line represents the phase diagram of the original composition and the solid line represents a new phase diagram after water has been added to the system.
3.

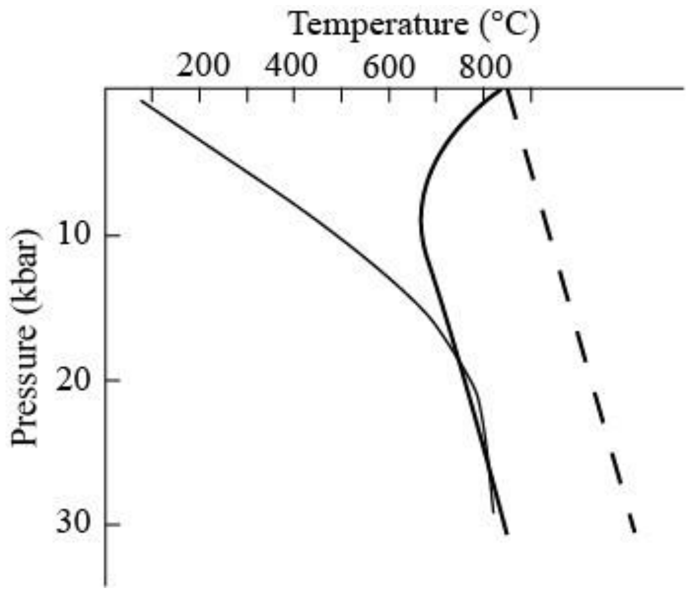


A) Did the addition of water increase or decrease the melting temperature of the rock?

B) In what tectonic setting might you expect water to get infused into high temperature rocks deep in the earth and cause wet melting?

C) In what tectonic setting(s) might you expect to find dry rocks melting through decompression melting?

D) The *geotherm* indicates the temperature at any given pressure within the earth, and it can also be plotted in P–T space. The relationship between the geotherm and the phase diagram can be used to determine if melting will occur. Use the phase diagram below with the geotherm indicated with a thin line to answer the following questions (next page).



E) If the rock is dry, do you expect melting to occur? If so, at what pressures?

F) If the rock is wet, do you expect melting to occur? If so, at what pressures?

<u>Part II: Grain Size</u>

1. Station #1 shows *Sample HTC-1*. This rock shows very large mineral sizes – what minerals are present?

2. Station #2 includes two rocks with similar chemical composition but that cooled at different rates. In general, rocks that cool quickly form fine grained crystals or are completely glassy (aphanitic), while rocks that cooled slowly form coarse crystals (phaneritic).

   A) *Sample 1a and 1b:* Draw a sketch and measure the average grain size in each rock (be sure to include a scale in your sketch).

   B) How would the cooling rate vary in a magma that cooled underground (intrusive) vs. a magma that cooled at or near the Earth's surface (extrusive)?

   C) Based on the observed grain sizes label your sketches as either *intrusive* or *extrusive*.

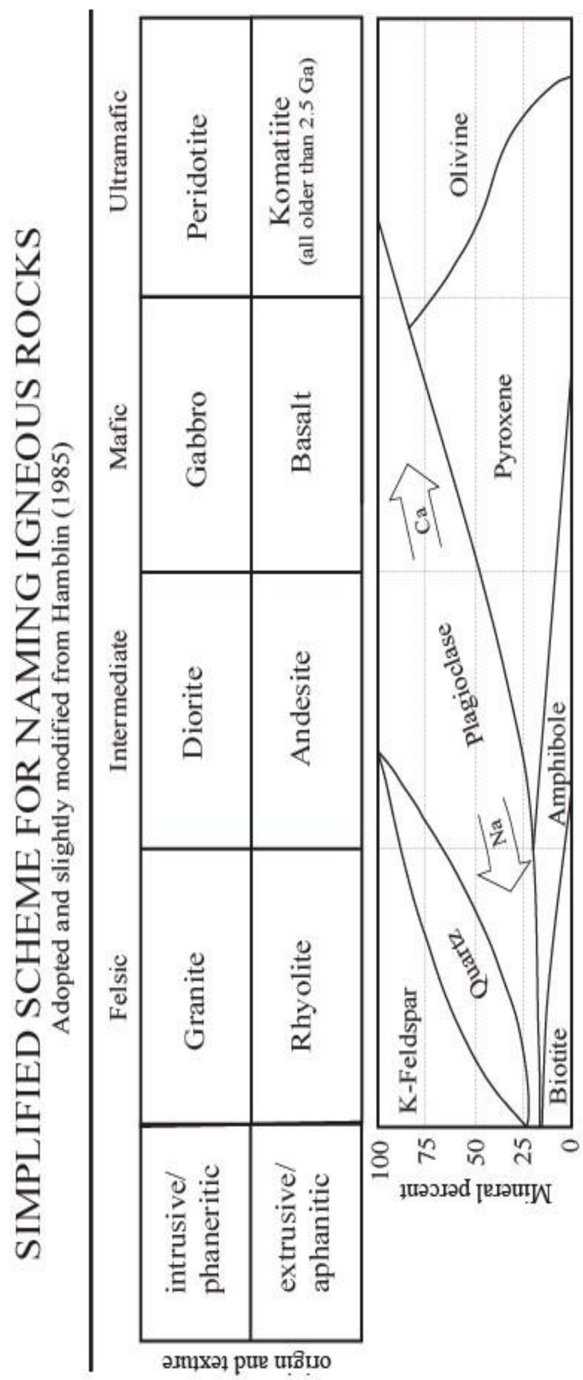
3. Station #3 has a rock with a porphyritic texture with large and small crystals.

   A) *Sample 1c:* make a sketch of this rock and illustrating porphyritic texture (include a scale).

   B) Given the observed variability in grain size in this igneous rock, make a hypothesis which explains a mechanism by which porphyritic textures might form.

Part III: Intrusive Igneous Rocks

Igneous rocks are named according to their grain size (phaneritic vs. aphanitic) and their chemical composition (felsic–ultramafic). While grain size can be determined relatively easily, composition is a bit more difficult. When there are enough visible grains, the mineralic make-up of the rock can be used to approximate the chemical composition, and a name can be assigned according to the chart below.



1. Use the chart on the previous page to name each of the four rocks at this station, and fill out the chart below.

Sample Number	Estimate of diagnostic mineral composition (volume %)	Rock name	Tectonic setting
A-1			
A-2			
A-3			
A-4			

2. Assume that these rocks all originated from the same magma. Based on Bowen's Reaction Series and what you know about the evolution of magma as it cools, place these 4 samples in order according to their timing of crystallization from the melt.

Part IV: Extrusive Igneous Rocks

Although the fine-grained or glassy nature of extrusive igneous rocks makes it difficult to accurately determine compostion, many extrusive igneous rocks contain larger phenocrysts that can be used to determine the approximate composition, and the rocks can be named accordingly. In addition, there are a variety of extrusive igneous textures that are important for classification, and that can also be used to add insight into the eruptive environment.

1. Effusive igneous textures (lava flows).
   A) *Sample A:* This sample a sample of vesicular pahoehoe basalt.
      - Draw a picture of this sample in the space below.
      - What are vesicles and how do they form?
      - What is the color of this rock (dark/light)?
      - Based on the textures observed and composition of this rock, what was the relative viscosity of the melt that produced this rock?

   B) *Sample JDR*: This sample was dredged from the Juan de Fuca mid ocean ridge. It has a glassy appearance because it was quenched (cooled quickly) upon contact with the cold ocean water.
      - What is the texture of this sample (glassy/obsidian, fine-grained, porphyritic)?
      - What is the color of this sample (dark/light)?
      - Investigation of this specimen under a microscopic reveals micro-phenocrysts of ~50% plagioclase feldspar and ~50 clinopyroxene. Use the chart above to name this sample.

C) *Sample WP-1:* This sample is from a lava flow in the of the White Pine Range, NV.
- What is the texture of this sample (glassy/obsidian, fine-grained, porphyritic)?
- What is the color of this sample (dark/light)?
- What are the phenocrysts visible in this sample?
- Name this rock using the phenocrysts names as a modifier in front of the name derived from the table above.

D) *Sample C:* This is sample is from an obsidian dome in the Mammoth Lakes area.
- What is the texture of this sample (glassy/obsidian, fine-grained, porphyritic)?
- What is the color of this sample (dark/light)?
- Can you identify any of the phenocrysts?
- Chemical analysis indicates that this rock is composed of ~70% silica. Name this rock.

E) Can color be used to distinguish chemical composition of fine-grained igneous rocks?

2. Explosive igneous textures.

A) Are explosive igneous eruptions more associated with felsic or mafic magmas?

B) Identify the two primary reasons that explain your answer to question 2A.

C) *Sample 12:* This is a sample of pumice.
- What are the holes in this rock, and how does pumice form?

D) Samples *Sh-1*, *BT-1*, and *Tsc-2*, are from a tuff. Based on your answers to questions 2A and B, what is the composition of these rocks (mafic or felsic)?

E) *Sample BT-1*.

- Describe the texture of this rock (welded/unwelded)?
- What are the inclusions in this rock?

F) *Sample Tsc-2.*

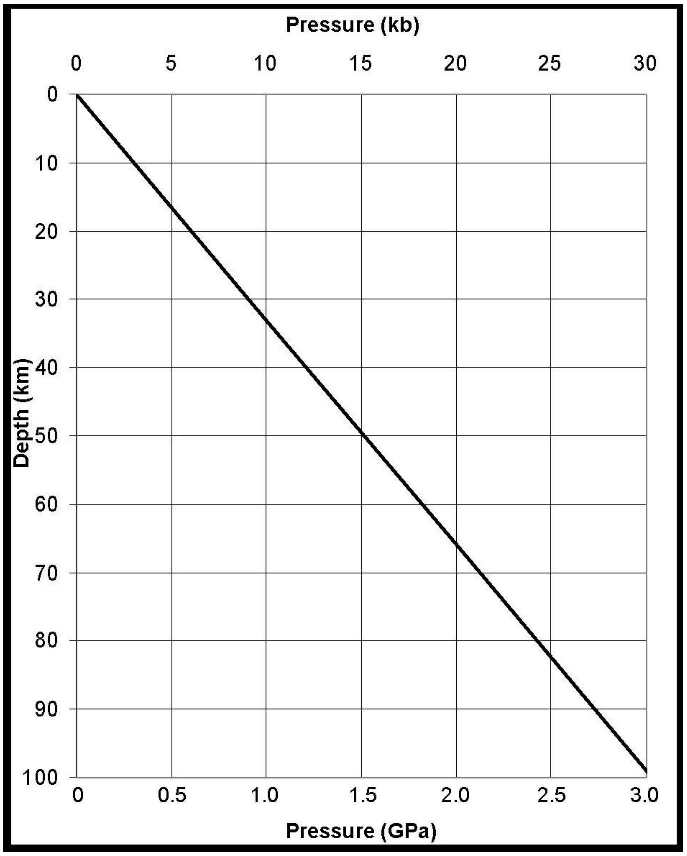
- Describe the texture of this rock (welded/unwelded)?
- What are the more pale colored objects in this rock?
- What are the phenocrysts in this sample?
- Name this rock based using the phenocrysts and texture to modify the compositional name from the chart above.

G) *Sample Sh-1*.

- Describe the texture of this rock (welded/unwelded)?
- What are the lighter and darker inclusions in this rock?
- What patterns do you notice in the lighter and darker inclusions in this rock, and how did they form this way?
- Name this rock.

H) Assuming that samples *Sh-1*, *BT-1*, and *Tsc-2* are part of the same tuff and represent the same eruptive event, place these rocks in stratigraphic order from the bottom to the top of the deposit.

Notes


Pressure (kb)
0
5
10
15
20
25
30
Depth (km)
0
10
20
30
40
50
60
70
80
90
100
0
0.5
1.0
1.5
2.0
2.5
3.0
Pressure (GPa)