Name: ________________________

Lab 6: Igneous Rock Identification

Review of Igneous Composition

Igneous rock composition can be described with varying levels of detail. Generally, composition is based on the relative abundance of felsic and mafic minerals. Mafic minerals include olivine, pyroxene, and Ca-rich plagioclase, which are typically dark in color. Thus, igneous rocks which contain mainly of dark-colored minerals will probably be mafic in composition. Light-colored minerals, including quartz, potassium feldspar (orthoclase), and Na-rich plagioclase, are felsic and the igneous rocks made mainly of these light-colored minerals are called felsic rocks. Igneous rocks that contain a mixture of light- and dark-colored minerals are called intermediate. Greater detail comes from estimating or measuring the percentage of different minerals found in a rock specimen. For example, one type of granite (a felsic igneous rock) would be more fully described by saying it is composed of 40% quartz, 35% potassium feldspar, and 25% plagioclase.

Review of Igneous Texture

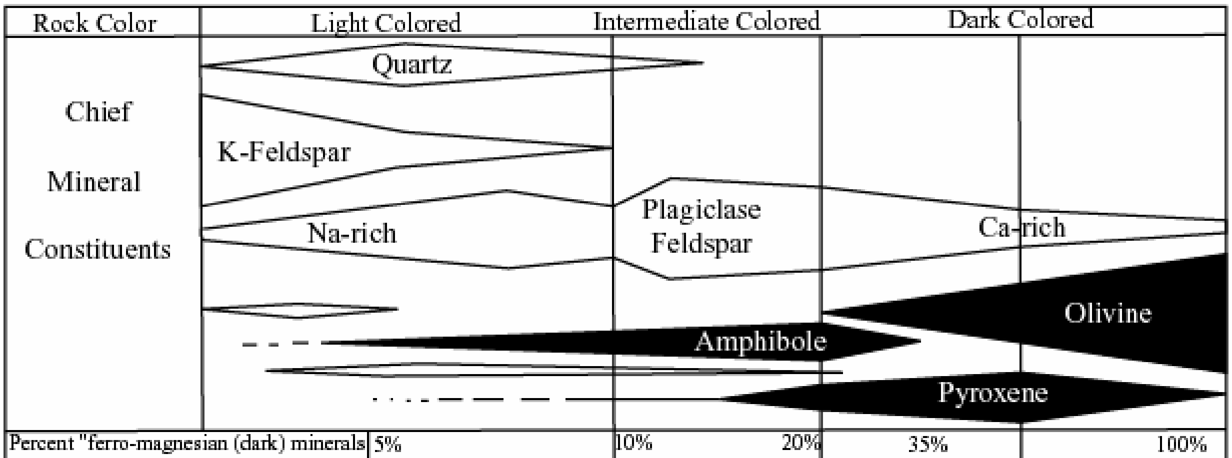
Igneous rock texture describes the size and arrangement of the crystals that comprise the rock, and is largely a function of the cooling rate. The texture of igneous rocks with large, visible crystals is called phaneritic. If the crystals are small and difficult to see with the unaided eye, the texture is termed aphanitic. Some igneous rocks contain large crystals within a groundmass of smaller crystals; this texture is called porphyritic. If an igneous rock cools so quickly that crystals do not have time to form at all, a glassy texture is produced. Finally, if an igneous rock cools relatively quickly, thereby trapping gas bubbles (vesicles) in its structure, it is called vesicular.

Igneous Rock Classification

Igneous rocks are classified based on their composition and texture. One basic classification is a binary classification which treats each property as a single variable when assigning a rock name. One modification arises in the case of rocks with a porphyritic texture, wherein the rock name is based on the texture and composition of the groundmass with the modifier “porphyry.” For example, a mafic rock with large olivine crystals in an aphanitic groundmass would be classified as a basalt porphyry (alternatively, a porphyritic basalt). Likewise, a felsic rock with extremely large potassium feldspar crystals in a phaneritic groundmass would be classified as a granite porphyry. Rocks with vesicular texture are similarly classified based on the texture and composition of their groundmass.

More detailed igneous rock classifications focus on the abundance (by percentage) of particular minerals in the rock, using ternary analysis. These classifications are based on the relative proportion of three mineral components. These classifications require more detailed knowlege of mineral composition, but provide greater insight into its history. They are most often used when chemical analyses of the rocks are available, so that compositional data are more quantitative.

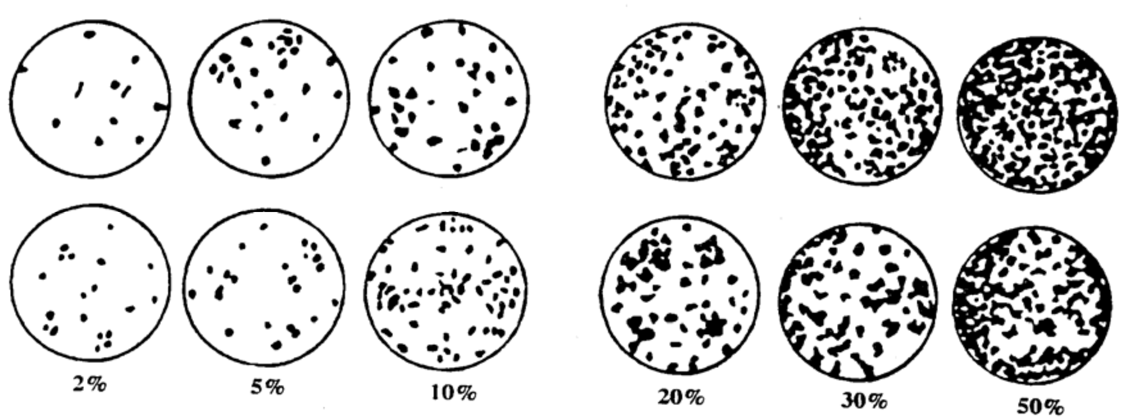
Classification and Identification Chart for Hand Specimens of Common Igneous Rocks



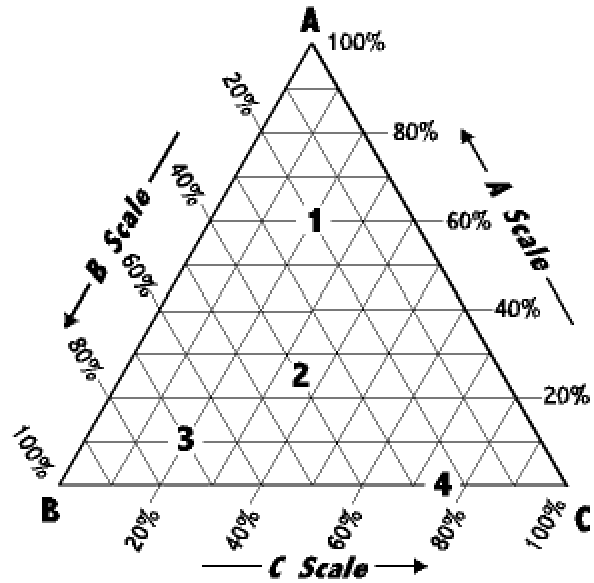
Texture				
Phaneritic	Granite	Diorite	Gabbro	Dunite and Peridotite
Aphanitic	Rhyolite	Andesite	Basalt	Komatiite
Porphyritic	Rhyolite Porphyry	Andesite Porphyry	Basalt Porphyry	
Vesicular	Pumice	Scoria		
Glassy	Obsidian			
Pyroclastic	Rhyolite Tuff, Andesite Tuff, Basalt Tuff, Volcanic Breccia, Agglomerate			

Muscovite and biotite are accessory minerals and are not essential to the classes of rocks containing them. Amphibole and pyroxene are accessory minerals where shown as thin dashed line in the granite group

Binary classification of igneous rocks, indicating approximate ratios of major minerals.



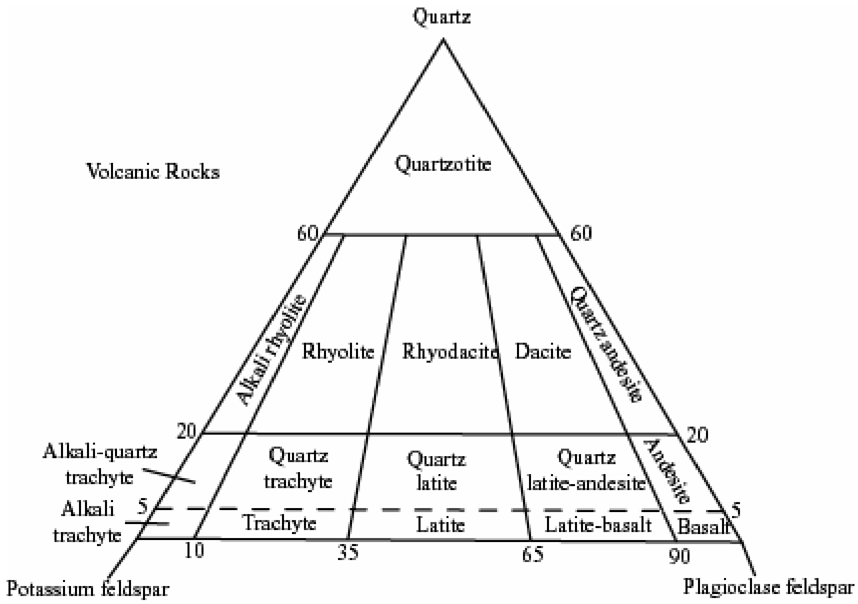
Guide to estimating percentages of ferro-magnesian (dark) minerals

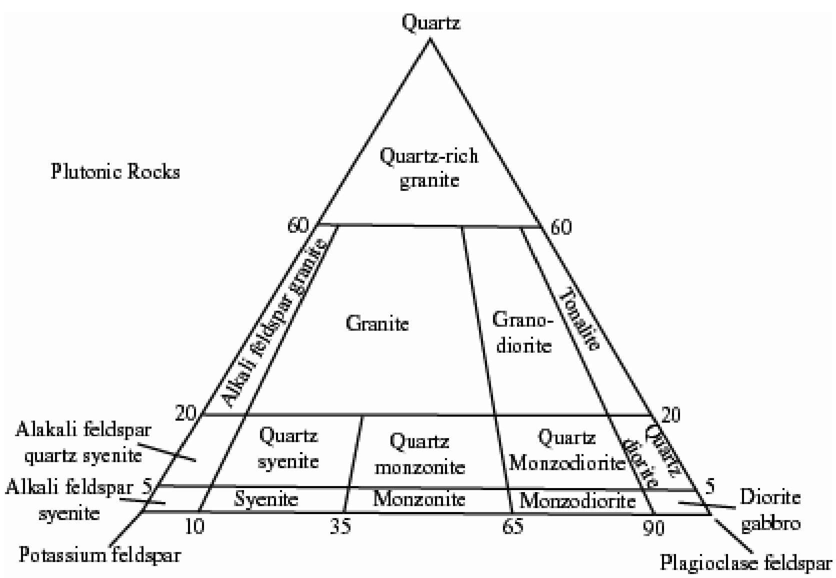


The above illustration is of a ternary diagram, which is a useful way of displaying abundances of three components which are constrained to add to 100%. Each of the three corners represents a particular component mineral (for example, A = quartz, B = plagioclase feldspar, and C = potassium feldspar). If a rock is composed of 100% of a certain mineral, its composition will plot on that mineral's apex. If a rock contains 0% of a certain mineral, it will plot on the side of the triangle opposite that mineral's apex. Most rocks will plot in the interior of the triangle, which may then be divided into named regions. The percentages of each mineral for a sample must sum to 100%. Minor components are disregarded in this approach, though some classification schemes will incorporate additional phases by projecting additional dimensions onto the plane of the termary diagram. Three components are usually sufficient, however, provided they have been selected appropriately for the type of interpretation required.

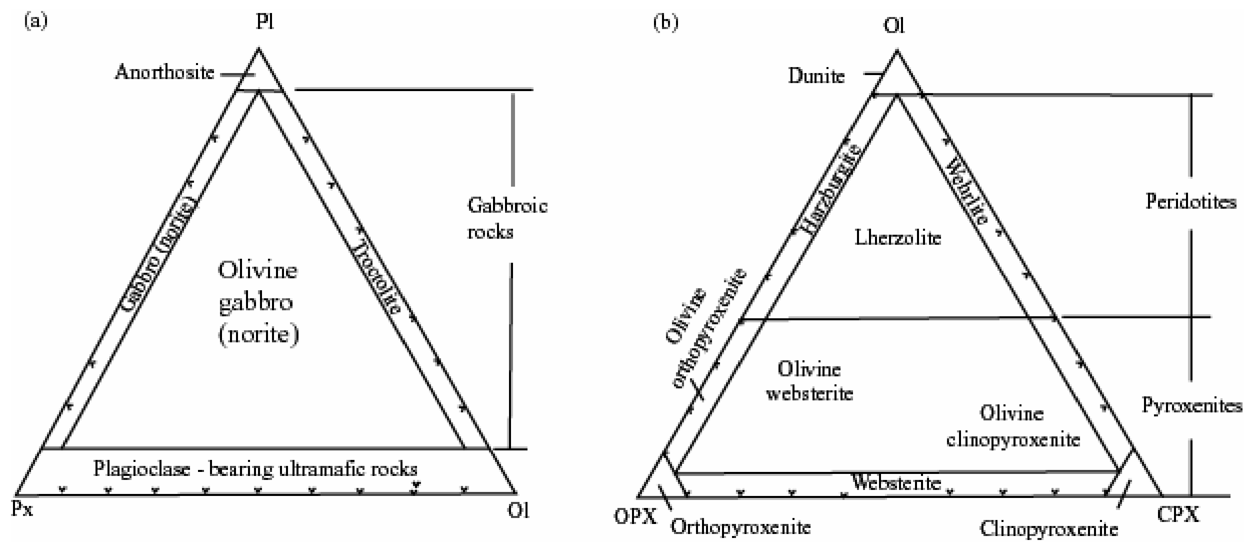
As an example of plotting and reading positions on a ternary diagram, the percentages for the points labeled 1, 2, 3 and 4 on the graph are shown below:

1. 60% A + 20% B + 20% C = 100%
2. 25% A + 40% B + 35% C = 100%
3. 10% A + 70% B + 20% C = 100%
4. 0 % A + 25% B + 75% C = 100%





Ternary classification of **felsic to mafic** igneous rocks. The top diagram is for extrusive rocks and the lower is for intrusive rocks. Note that rocks with glassy or pyroclastic textures may be described by the above compositions, but that for these specimens the final rock name must still include reference to their textures, such as "pumice" or "tuff."



Ternary classification of **intrusive mafic to ultramafic** igneous rocks. The diagram on the left is for rocks containing olivine (Ol), pyroxene (Px), and plagioclase (Pl) (mafic rocks). The diagram on the right is for rocks containing only olivine and/or pyroxene (ultramafic rocks), in which case a distinction must be made between orthopyroxene (OPX) and clinopyroxene (CPX).

Part 1. Igneous Rock Identification

Describe and identify ten igneous rock specimens by completing the tables on the following pages using the **binary** classification scheme *and* the appropriate **ternary** scheme. Note that without quantitative analysis it may be difficult to use the ternary diagrams without a great deal of ambiguity for some specimens.

Sample Number	Composition	Minerals Present (%)	Texture	Name (Binary)	Name (Ternary)
1					
2					
3					
4					
5					

Sample Number	**Composition**	**Minerals Present (%)**	**Texture**	**Name (Binary)**	**Name (Ternary)**
6					
7					
8					
9					
10					

Part 2. Two Granites

Sometimes identification of minerals in a hand sample can be particularly difficult. One side of Sample A has been stained so that one can easily distinguish between the potassium feldspars and the plagioclase feldspars, both of which can be white. The staining involves etching a surface with hydrofluoric acid (HF), preparing it with amaranth ($C_{20}H_{11}N_2Na_3O_{10}S_3$), and applying a stain of sodium cobaltnitrite ($Na_3Co(NO_2)_6$). Potassium feldspars will stain yellow and plagioclase will stain pink. Quartz is unaffected.

1. Estimate the percentages of the following three minerals in sample A:

Potassium feldspar ______% Plagioclase feldspar ______% Quartz ______%

2. Using the binary classification chart, what is this rock?

3. Using the appropriate ternary classification chart, what is this rock?

"Granites" are exceedingly common in continental crust, but many of the details of their varied origins are obscured by lumping them together under one name. Sample B displays a rather distinct texture and is known as "graphic granite" in that the surfaces appear to be covered with writing. It arises from the concurrent growth of the two minerals involved and is tied more closely to the kinetics of reaction (rates) than the thermodynamics.

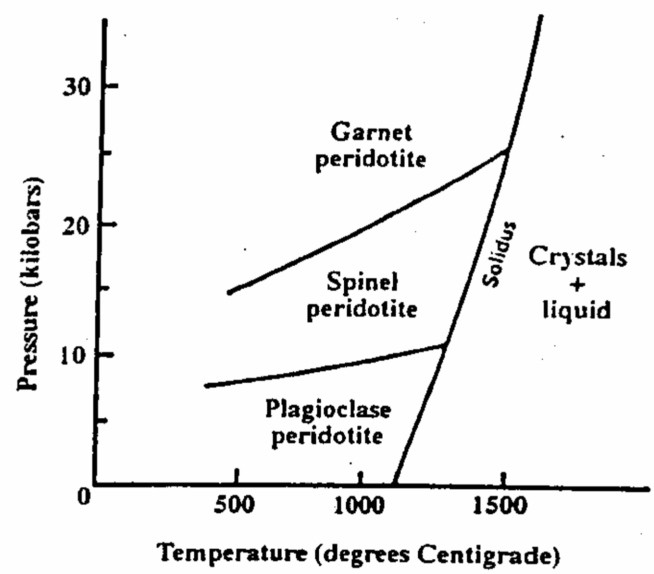
4. What two minerals are responsible for the texture of sample B?

5. Is sample B, strictly speaking, a granite? What is it, using the ternary classification?

Part 3: Mantle Materials

The upper mantle is composed primarily of peridotite, a type of ultramafic rock. The major minerals of peridotite are olivine, two pyroxenes (OPX and CPX), and an aluminum-rich mineral phase that varies depending on the pressure at which the rock forms. This aluminum-rich mineral can be plagioclase, spinel, or garnet, and the mineral present indicates the pressure at which the rock crystallized: it acts as a geobarometer.

1. Experimentally determined pressure-temperature (P-T) diagrams like the one shown below are used to determine the stability fields of minerals and mineral assemblages. Consider a peridotite that crystallized at 45 km depth at 1000°C. For shallow depths, pressure increases approximately linearly at 1 kbar for every 3 km. Since 1 bar is approximately 1 atmosphere, the pressure at the surface is effectively 0 kbar. Mark the corresponding temperature and pressure for this hypothetical sample on the plot below and indicate which aluminous mineral formed.



2. Using the appropriate ternary diagram, name the expected rock for these conditions. Assume that the ratio of olivine:OPX:CPX is 75:15:10. Use the aluminous phase as a modifier (e.g., “garnet lherzolite” or “plagioclase pyroxenite”).

3. Using the above diagram and the appropriate ternary diagram, what is sample C?