Lab 3 - Identification of Igneous Rocks

Introduction

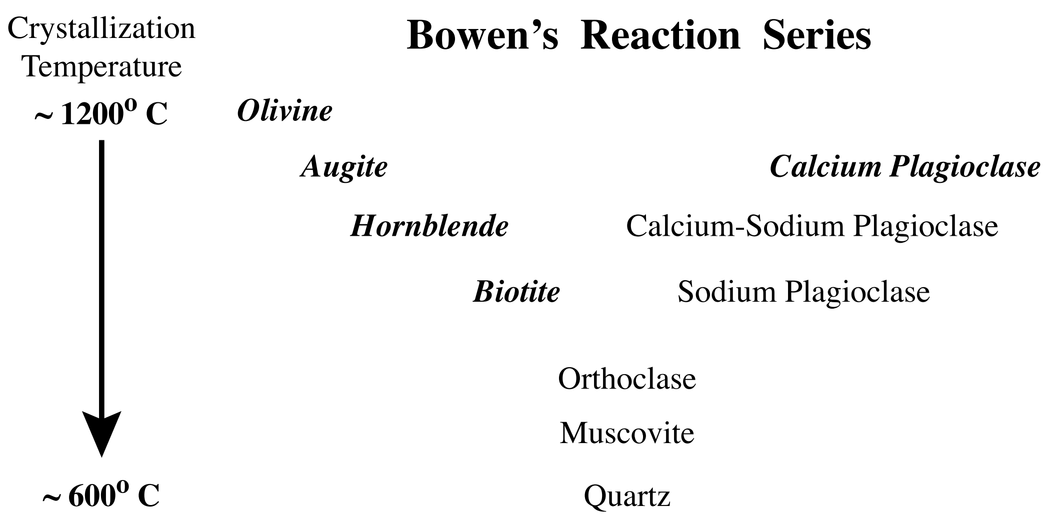
A rock is a substance made up of one or more different minerals. Thus an essential part of rock identification is the ability to correctly recognize the major (or most abundant) minerals within a given rock sample. This is often described as the rock's mineralogy. Another important component in rock identification is to correctly interpret the rock texture. Technically, texture is the size, shape, and grain-to-grain relationships between minerals in a rock. For the purposes of this and the next two labs, texture really implies genesis, or how the rock formed. All rocks can be placed into one of three major rock groups based on their texture; igneous, sedimentary or metamorphic rocks. Recognition of the texture of a rock allows one to properly place the rock into its appropriate rock group.

Igneous rocks form from the cooling and crystallization of molten rock. When minerals grow directly from a liquid the boundaries between adjacent minerals tend to penetrate each other, forming a very strong, interlocking pattern similar to that of pieces in a jigsaw puzzle. Given this and the fact that igneous rocks are composed of relatively hard silicate minerals, igneous rocks are very hard rocks that have been used as important building materials by people for thousands of years.

Mineralogy of Igneous Rocks

All igneous rocks originally form from partial melting of the earth's crust, or even, the earth's upper mantle. Since both crust and upper mantle are composed largely of silicate minerals (minerals that contain both silicon and oxygen) igneous rocks also consist mostly of silicate minerals. In the early 1900's a Canadian Petrologist by the name of N. L. Bowen first published the sequence of silicate minerals and the order in which they crystallize from a magma. This sequence of minerals is now referred to as Bowen's Reaction Series (Figure 1). Bowen also proposed that a single magma body (a single liquid) may be capable of producing different types of igneous rocks through a process called fractional crystallization. As a magma body raises towards the surface minerals that crystallize from the magma may sink to the bottom of the magma chamber (or fractionate) and be left behind by the raising liquid. This would change the chemistry of the raising liquid causing it to crystallize different minerals on its way toward the surface. In this way a very hot, very deep magma body would first crystallize olivine, which would sink to the bottom and be left behind. The raising and cooling magma body would then crystallize augite and calcium-rich plagioclase, which would sink and be left behind. Next would come hornblende and calcium-sodium plagioclase, then biotite and sodium-rich plagioclase and finally, as the magma nears the surface, the last minerals in Bowen's sequence would crystallize out from the, largely cooled and solidified magma body.

In Lab 3 we identified the major silicate minerals by first placing them into subclasses based on the arrangement of Si-O tetrahedra and metals present in the silicate mineral. For the purpose of this lab it is more convenient to classify the various silicate minerals based on their chemical composition. **Ferromagnesian** silicate minerals are those that contain high amounts of the metals iron, magnesium and/or calcium in them. These metals tend to make ferromagnesian silicates dark in color (dark gray to black). So igneous rocks that contain high percentages of ferromagnesian silicates tend to be dark colored. **Nonferromagnesian** silicate minerals are those that contain little or no iron, magnesium or calcium in them. Instead, they tend to have have sodium, potassium and/or aluminum in their chemical make up. These metals produce silicate minerals that have light colors (white, light gray or pink). Igneous rocks that contain high percentages of nonferromagnesian silicates tend to be light colored.



The Bowen's Reaction Series with ferromagnesian silicate minerals in ***bold-italic*** text and nonferromagnesian sililicate minerals in normal text.

Igneous Rock Texture

Texture is anything that you can see in a rock that can give you clues as to how that rock formed. All igneous rock began as molten rock formed deep within the earth called magma. If the magma starts to raise toward the surface it will start to cool. This process of raising and cooling may take thousands of yours and, thus, the minerals that form from a magma may have had thousands of years to grow. This allows the minerals to become large enough to be visible, thus, igneous rocks formed from the slow cooling of magma are said to have a coarse-grained or **phaneritic** texture. The word phaneritic literally means 'visible', so a phaneritic texture is one in which all of the minerals in the igneous rock are large enough to be visible.

Magma that flows onto the earth's surface (or onto the sea floor) is called lava. Lava is more than just molten rock. It usually contains a portion of large minerals that formed while the lava was below the surface called **phenocrysts**. If a lava flows onto the surface the liquid portion will cool very quickly, in a matter of hours or days at the most. The resulting igneous rock will have a texture of mixed mineral sizes. It will have a few coarse-grained phenocrysts in it that were formed from slow cooling while it was below the surface. Surrounding the phenocrysts will be a very fine-grained rock composed of microscopic-sized minerals called **groundmass** formed by the quick cooling of the liquid portion of the lava. A lava rock that contains a mixture of large phenocrysts and fine-grained groundmass is said to have a **porphyritic** texture.

Lavas may also contain gases (mostly water vapor) called volatiles dissolved within them. These gases can bubble out of the lava as it is flowing and cooling and leave behind holes or **vesicules** in the solidified lava rock. A lava rock that contains vesicules is said to have a **vesicular** texture. If a lava contains very high amounts of volatiles it may not flow onto the surface, but instead, may explode violently onto the surface. Explosive volcanic events may send a fine mist of lava for miles into the air where it quickly cools as volcanic ash and settles to the ground. Volcanic ash and larger masses of lava that explode out of a volcano are referred to as pyroclasts (pyro = fire; clast = pieces) and a rock made up of pyroclasts is said to have a **pyroclastic** texture.

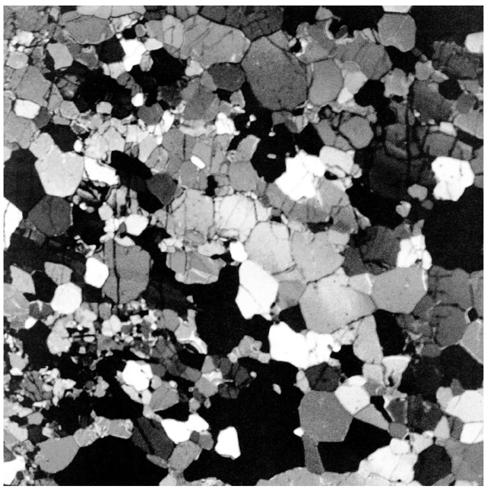
Whenever lava cools extremely fast, minerals may not get a chance to form. By definition, if any liquid cools too fast for minerals to form then what does form is called **natural glass**. Volcanic ash is actually very fine bits of glass formed by the quick cooling of a lava mist. Natural glass may also form as a thin crust on the very top of lava flows when the lava that is in direct contact with cooler air quick chills.

Identification of Igneous Rocks

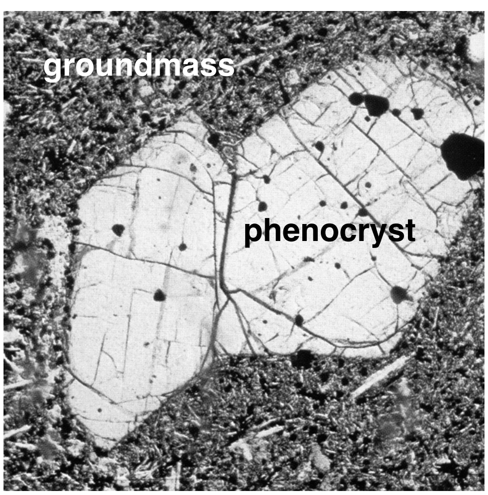
Identification of igneous rocks involves determining the major minerals (mineralogy) of the rocks and their texture. Determination of the mineralogy is aided by the color of the rock. Remember that ferromagnesian silicates are dark colored minerals and nonferromagnesian minerals are light in color. Very dark colored rocks (sometimes called ultramafic igneous rocks) consist primarily of the mineral olivine and are dark green. Dark colored rocks (mafic igneous rocks) are dark gray to nearly black. Both ultramafic and mafic igneous rocks consist entirely of ferromagnesian silicate minerals. Medium colored igneous rocks (or intermediate igneous rocks) contain about half ferromagnesian silicates and about half nonferromagnesian silicates. Coarse-grained intermediate igneous rocks are said to have a “salt and pepper” appearance. Light colored igneous rocks, those dominated by nonferromagnesian silicates silicates are called felsic igneous rocks and are either pink or light gray.

All igneous rocks that form from the slow cooling of magma are collectively called **Plutonic** igneous rocks. Because of the slow cooling, all Plutonic igneous rocks have a coarse-grained or phaneritic texture.

All igneous rocks that form from the quick cooling of lava are collectively called **Volcanic** igneous rocks. Volcanic igneous rocks that form from lava flows generally have a porphyritic or a mixed coarse-grained (phenocrysts) and fine-grained (groundmass). In addition, basalt lavas tend to be rather gassy and so some basalt rocks may have a vesicular texture. Any time lava cools so quickly that no minerals get a chance to form then glass can be created. Some glasses are nonvesicular (obsidian) and some glasses may have been very gassy (scoria or pumice). Compacted volcanic ash or very hot volcanic ash that wields itself together due to extreme heat has a pyroclastic texture and is called tuff. All glasses, whether nonvesicular, vesicular or ash, contain NO minerals.



A coarse-grained **phaneritic** texture in a Plutonic igneous rock formed from the very slow cooling of magma. Note the interlocking pattern at the mineral grain boundaries as this is diagnostic of all rocks that form from a liquid.



A mixed, coarse-grained (pheoncrysts) and fine-grained (groundmass) **porphyritic** texture typical of a Volcanic igneous rock formed form the fast cooling of lava. Note that this photo has been magnified roughly 50 times to make the tiny minerals in the groundmass visible.

<table>
<tr><th></th><th></th><th>Plutonic Igneous Rocks
(cooled from magma)</th><th colspan="3">Volcanic Igneous Rocks
(cooled from lava)</th></tr>
<tr><th>Rock Color</th><th>Major Mineralogy</th><th>Phaneritic Texture</th><th>Porphyritic Texture</th><th>Vesicular & Glassy Texture</th><th>Pyroclastic Texture</th></tr>
<tr><td>very dark colored (Ultramafic)</td><td>Olivine</td><td>DUNITE</td><td>KIMBERLITE
(rare)</td><td>R A R E</td><td>R A R E</td></tr>
<tr><td>dark colored (Mafic)</td><td>Pyroxene
Calcium Plagioclase</td><td>GABBRO</td><td>BASALT
or
VESICULAR BASALT</td><td rowspan="3">OBSIDIAN
(dense glass, no vesicules)

SCORIA
(~ 50% vesicules)

PUMICE
(~ 90% vesicules)</td><td rowspan="3">TUFF
(compacted or wielded volcanic ash)</td></tr>
<tr><td>medium colored (Intermediate)</td><td>Hornblende
Ca-Na Plagioclase</td><td>DIORITE</td><td>ANDESITE</td></tr>
<tr><td>light colored (Felsic)</td><td>Biotite
Sodium Plagioclase
Orthoclase
Muscovite
Quartz</td><td>GRAY GRANITE
(no orthoclase)
PINK GRANITE
(with orthoclase)</td><td>RHYOLITE</td></tr>
</table>

Rock Texture	Rock Composition	Characteristic Features	NAME

Lab 3 - Igneous Rocks

1. Five of your samples have a coarse-grained ‘phaneritic’ texture from the slow cooling of a magma. What are the names of these 5 samples ?

2. Compare the 5 phaneritic igneous rocks and give me one good characteristic that could be used to easily distinguish each one.

3. What mineral is present in the pink granite to give it the pink color (hint: it is absent in the gray granite) ?

4. What visible evidence is present in all of the phaneritic samples that indicates slow cooling of a magma ?

5. Four of your hamples have a fine-grained ‘porphyritic’ texture from the fast cooling of a lava. What are the names of these 4 samples ?

6. What evidence can you see in the andesite that tells you that part of it formed from the slow cooling of a magma ?

7. Texturally, how can you tell the difference between the 2 samples of basalt ?

8. Compare the density of the rhyolite and the non-vesicular basalt. How can you tell which part of the Bowen’s Reaction Series (top, middle or bottom) each of these samples crystallized at ?

9. List the 3 samples that have a glassy texture.

10. Do the glassy samples contain minerals ? Why or why not ?

11. Compare the 3 glassy textured igneous rocks and give me one good characteristic that could be used to easily distinguish each one.

12. Examine the tuff sample carefully. How can you tell that this sample has a pyroclastic texture ?