IGNEOUS ROCKS

Teacher Guide

including
Lesson Plans, Student Readers, and More Information

Lesson 1 - Rock Cycle

Lesson 2 - Formation of Igneous Rocks

Lesson 3 - Classification of Igneous Rocks

Lesson 4 - Igneous Rocks - Lab

Lesson 5 - Formation of Granite

designed to be used as an Electronic Textbook
in class or at home

materials can be obtained from the Math/Science Nucleus

EARTH SCIENCES - IGNEOUS ROCKS

Lesson 1 - Rock Cycle

MATERIALS:

reader

Objective: Students explore details of the rock cycle.

Teacher note

The rock cycle is a journey of how three types of rocks recycle themselves throughout Earth's history. Review with students the three types including igneous, metamorphic, and sedimentary. Discuss in detail the rock cycle using the graphics in the reader. As students go through each of these lessons, emphasize how it fits into the rock cycle.

There are several web sites that can assist you in learning more about the different components of the rock cycle. Below are just a few, but we suggest you do a search to find any new or updated sites on the Rock Cycle.

http://www.geocities.com/RainForest/Canopy/1080/
"The Stupid Page of Rocks" - good basic information on rocks, aimed at kids

http://seis.natsci.csulb.edu/basicgeo/IGNEOUS_TOUR.html
California State University, Long Beach, tour of igneous rocks

http://geollab.jmu.edu/Fichter/IgnRx/IgHome.html
James Madison University Geology Department

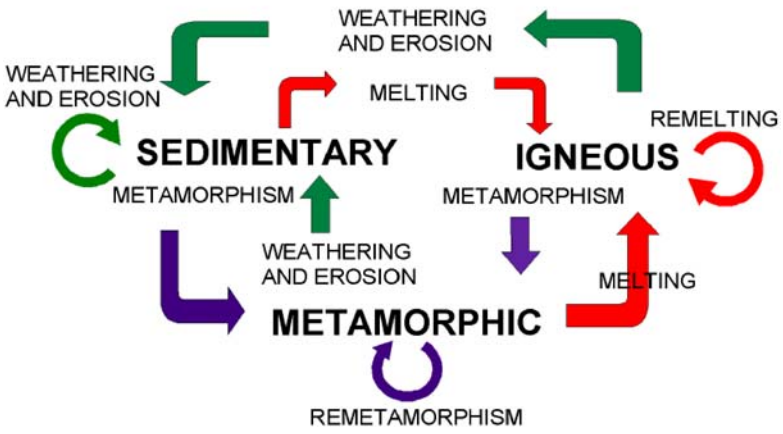
The eruption occurred only a few months ago, but yet the tour buses are bringing people to view the majestic Mt. Etna, on the island of Sicily. The view from the window is obscured by **ash** that still rains down as the wind kicks ash and spins it around the bus. The tires on the bus are specially made to drive over the crumbly, jagged **basaltic** rock. The creation of igneous rocks is an awesome sight, especially when you realize that this is the beginning of the **rock cycle**.


Looking in the caldera of Mt. Etna

Recent snow combines with the ash to make a gray slush that seems out of place, on a mountain where **lava** recently rolled down the **flanks** of the volcano. The bus can only go so far, because another lava flow could erupt at any time. As you walk to the **caldera,** you wonder about what you will see. Weird thoughts of seeing the center of the Earth or even jumping to join the devil, enter your thoughts.


Walking on the top of Mt. Etna

As you look over, the gas looks like it is bubbling, like a witch's brew. The wind from the earthly hole whips your hat, as you jump back and almost wish you hadn't wanted to experience the formation of **igneous** rocks.



Life isn't easy for rocks. They are born from breaking, melting, and extreme pressures. Rocks never die. They are forever forming and changing. We stand on rocks, build with rocks, grow food from rocks, and mine **resources** from rocks.

Look around and you can see that the products of minerals and rocks are a vital part of our everyday life. Concrete is a building material made of cement (calcite and clay), sand, and gravel. Cinder blocks are reformed **cinder** deposits from a volcano. Homes use a variety of **stones** as building and ornamental materials.

The rock cycle is a symbol of an ever-changing Earth. The three types of rocks **igneous**, **metamorphic**, and **sedimentary**, record these changes, and it is up to geologists to decipher the clues and develop a history of the Earth.

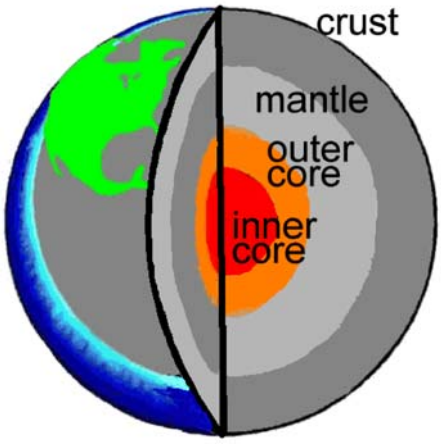
Early humans could not imagine where rocks came from. They could describe the physical features of a rock but it was difficult to determine where rocks came from. Rocks that formed through the action of water were observed early on. Since sedimentary rocks are the most common on the surface of the Earth, it was easy for people to make this connection.

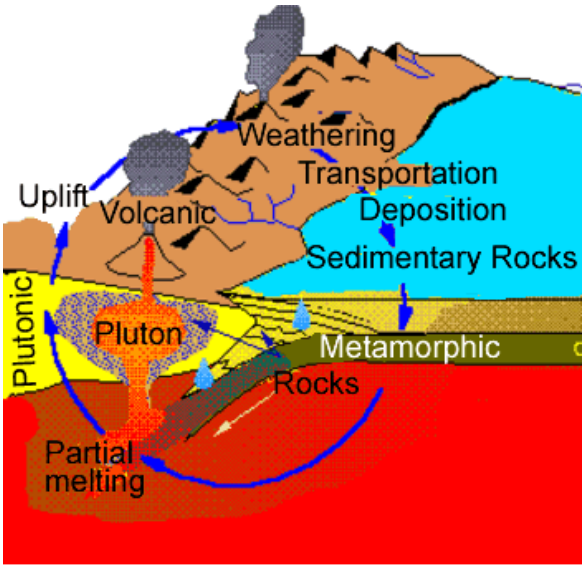

Lava flow from Hawaii

Geologists even up to the early 1800's believed that all rocks crystallized from oceanic water. Even volcanic eruptions were thought to be burning of coal seams beneath a volcanic **vent**. Eventually the "Neptunists" or people who believed that all rocks came from water, were replaced by geologists who witnessed volcanic activity. An expedition around 1730's to Iceland, watched lava flows from **fissures** in the Earth, was the evidence that Plutonists (scientists who believed that volcanic rocks were from within the Earth) needed to dispel the theories of the Neptunists.


Kenya, Africa

It was not until the 1960's that the understanding of the crust of the Earth, through plate tectonic movement, did it become apparent how the rocks actually "recycled" themselves. Slowly through time, the crust of the Earth moves and causes rocks to melt, crystallize, weather, and get squished over and over through time. The understanding of plate tectonics gave geologists an overall picture of rock formation.

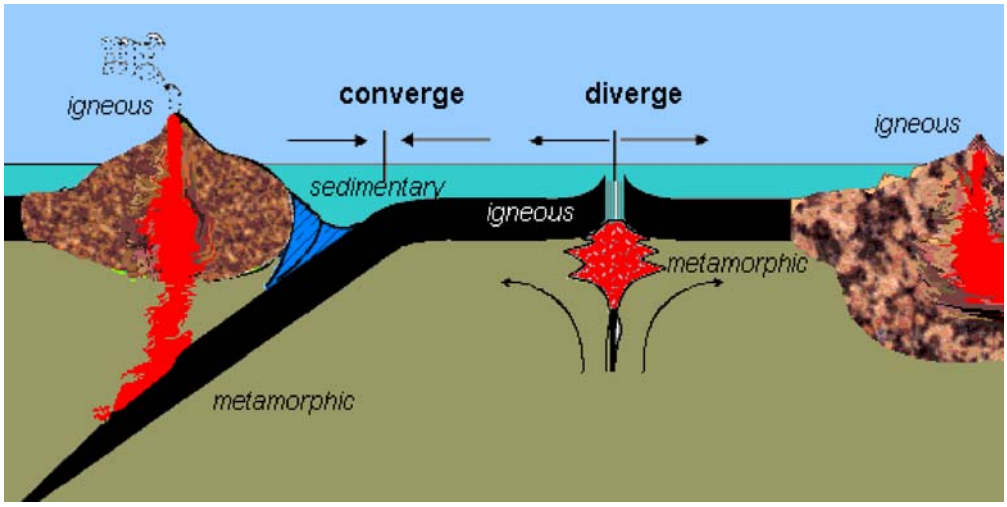




Simplified rock cycle

Today we are still refining how rocks are formed. Even some rocks like granite (igneous) and chert (sedimentary) are still in debate. As we understand more of the dynamics of the crust and its interaction with the **mantle** and **core**, we might unlock the mysteries of how rocks are formed.

As we understand them now, igneous rocks are formed when rocks are melted and then cooled. Magma can cool slowly inside the crust and upper mantle of the Earth, forming rocks like granite. Granite has large minerals that can be seen with the naked eye. These are called **plutonic** rocks. Quick cooling magmas are generally erupted onto the Earth's surface, called **volcanic** rocks.

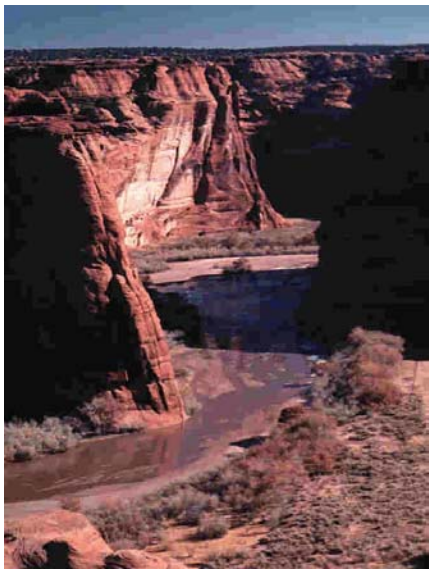


Igneous rocks are found where plates **diverge**, as lava rises and fills the gap between the plates. Igneous rocks also form where plates **converge**. The **subducting** plate melts as it sinks into the crust of the Earth, and the melt rises into the overriding plate forming volcanoes.

Metamorphic rocks from Canadian shield

Metamorphic rocks are formed mainly in the **lithosphere** or crust and upper mantle, wherever there is high pressure and high temperature. If the pressure and temperature are too high, metamorphic rock will melt and become igneous. Metamorphic rocks are most abundant at convergent plate boundaries, but can occur in other areas where there are increased pressures and/or temperatures.

Sedimentary rocks form only on the surface of the Earth. Sedimentary rocks form in two main ways, from **clastic** material (pieces of other rocks or fragments of skeletons) that are cemented together, and by chemical mechanisms including **precipitation** and **evaporation**. There are many environments associated with sedimentary rock formation including oceans, lakes, deserts, rivers, beaches, and glaciers. They may form at all types of plate boundaries, but the thickest sedimentary rock accumulations occur at convergent plate boundaries. Fossils are associated with sedimentary rocks.



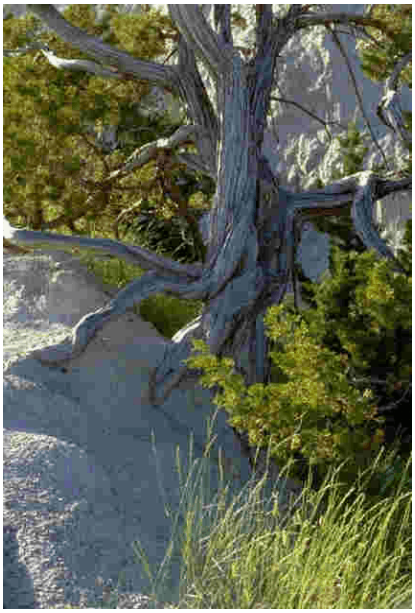
Sedimentary rocks from Canyon de Chelly, Arizonia

Grinding stone

Early humans used stones in their everyday life. They did not know how they formed, but they used tools fashioned from stones. These tools were used as weapons, in agriculture, grinding food, or to build a house. Even the first wheels were made of stones.

Learning about the rock cycle is more than just identifying rocks and minerals. Rocks can hold clues of how the Earth formed and evolved through time, and it is for us to interpret ancient environments. Geology unlike other scientific fields incorporates the fourth dimension, time. As the Earth moves slowly through time, the landscape can change from cold to hot, from rainy to dry. It can melt large spans of the ocean or erode the highest mountains. As these processes of the rock cycle are at work, they are superimposed by living organisms, especially within the last billion years of time.

Stone weapon



Tree growing from granite

The interface of the Earth and life is a unique feature of the Rock Cycle. Plants require the nutrients that minerals from the rocks provide. Rocks are sometimes considered a dead science, but add water and life can come from rocks.

EARTH SCIENCES - IGNEOUS ROCKS

Lesson 2 - Formation of Igneous **Rocks**

MATERIALS:

reader

Objective: Students read about how igneous rocks are formed.

Teacher notes

If your students have completed the Plate Tectonic units on Volcanoes, they should be familiar with different volcanic environments. This reader emphasizes how all igneous rocks are formed and explores how the formation is related to igneous rock classification.

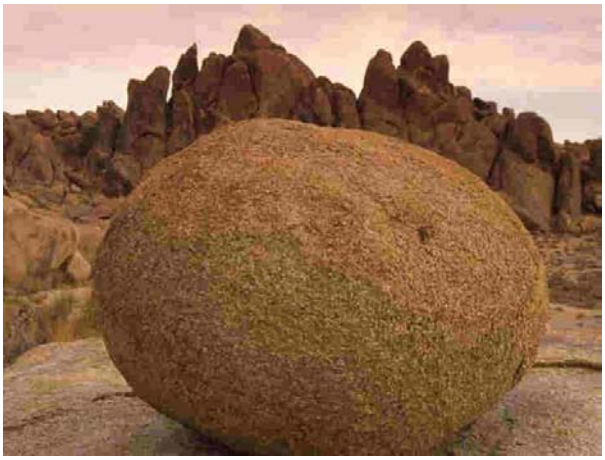
Emphasize the two different environments, volcanic (lava, extrusive) versus plutonic (magma, intrusive). There are many different environments that can create very different rocks. It is not always easy to identify hand samples. Sometimes igneous rocks can look like sedimentary or metamorphic. Geologists sometimes have to take a specimen back into their lab and do further analysis under the microscope to really determine the type of rock.

There are different web sites that can help your students visualize volcanic rocks, but plutonic rocks are more difficult. Below are a few sites that may be helpful.

Class notes from Dr. Pamela Gore, of Perimeter College. Good pictures of the different types of igneous rocks.
http://www.dc.peachnet.edu/~pgore/geology/geo101/igneous.htm

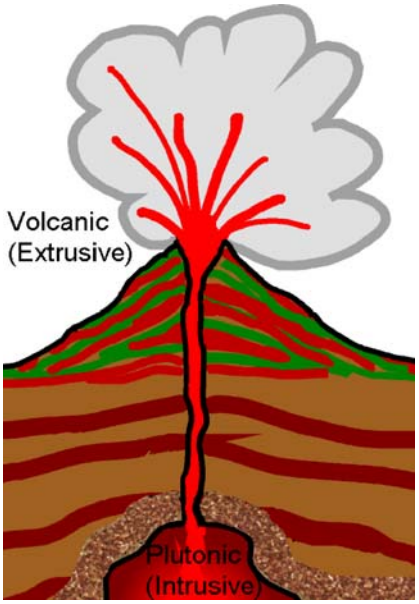
Pictures of igneous rocks from Volcano World.
http://volcano.und.nodak.edu/vwdocs/vwlessons/lessons/Slideshow/Igrocks/Igindex.html

Igneous rocks form from molten rocks, which are thick, **fluid** masses of very hot elements and compounds. There are many different types of igneous rocks. However, they were once melted and have since cooled down. The two major factors that influence the creation of igneous rocks are the original rock that was melted and the cooling history of the molten rocks.

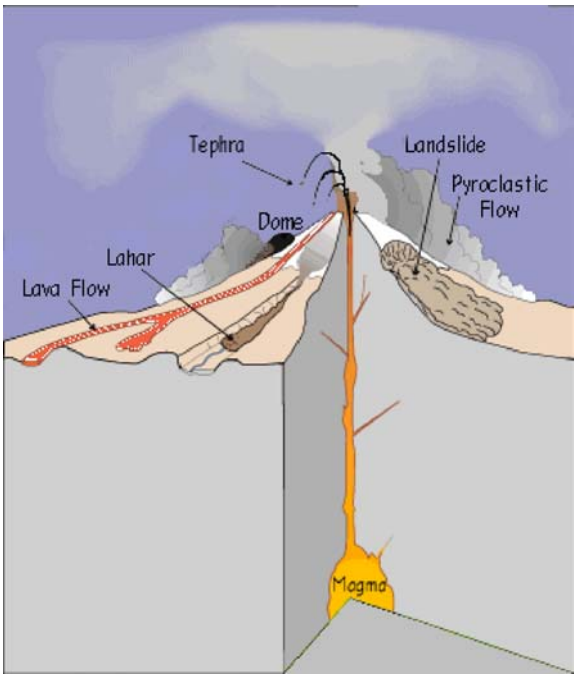


Granite boulder reveals where these rocks were formed

The original rock could be any initial rock. Plate tectonic mechanisms move rocks throughout the crust, so even sedimentary and metamorphic rocks can become melted again in a subduction zone. The different types of rocks melt into different chemical magmas, which then is dependant on how it cools.



Molten rock with different cooling histories and different chemical composition will form different igneous rocks. If **magma** cooled inside the crust of the Earth, the rocks will have larger minerals and referred to as **plutonic** or **intrusive** rocks. Molten rock that flows out onto the surface is called **lava**. These rocks are called **volcanic** or **extrusive** rocks.



Volcanic rock formation


Volcano, Costa Rica

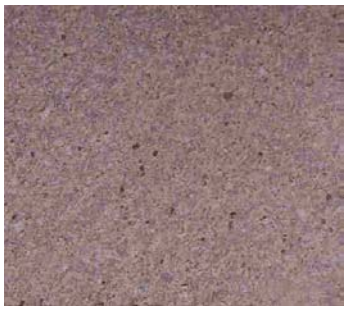
Extrusive igneous rocks have small minerals (fine-grained) because they cooled quickly. The minerals did not have enough time to form larger minerals. The minerals cannot be seen without the aid of a hand lens. Geologists use the term **aphanitic** to describe this texture. The rocks can be whitish to very dark gray, depending on what minerals formed during cooling.

Different types of volcanoes produce a variety of rocks. Sometimes the pressure in a volcano is so great that it explodes violently. These eruptions produce the secondary type of volcanic rock, called **pyroclastic** rock (from the Greek, "pieces of fire.") Pyroclastic rocks may contain crystals, if the molten rock had begun to crystallize before it exploded. Pyroclastic rocks may also contain pieces of pre-existing rock. Another type of volcanic rock is caused by a **lahar**. A lahar is an Indonesian term that describes a hot or cold mixture of water, old rock fragments, and new pyroclastic material. It can flow down the slopes of a volcano and (or) river valleys and create layers of a "mess."


Basalt

Identification of volcanic rocks is dependant on the type of eruption and the original chemistry of the lava. Lavas that are rich in minerals like **quartz** and **feldspar** are usually light in color. They are usually associated with volcanism on land. Rocks that are rich in **hornblende**, **augite**, and **olivine** are darker in color and associated with eruptions under the oceans.

All volcanic rocks will cool much quicker than plutonic rocks and this is reflected in the size of the minerals. In a hand sample, the minerals are difficult to distinguish. But, you can look at the rock and get a basic idea. If it is a dark colored rock and fine grained, it can be basalt. If it is lighter colored, almost a pink-gray, then it is andesite.


Andesite

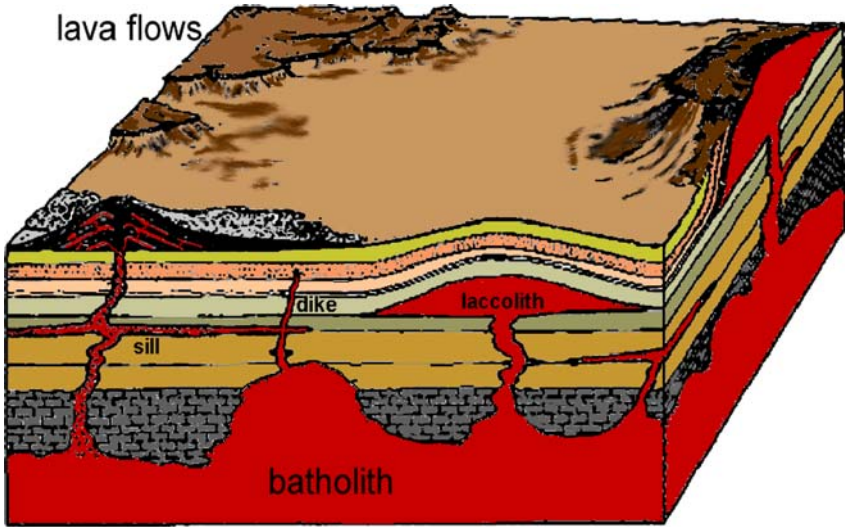
Scoria

Tephra

There are many types of pyroclastic rocks that are produced. **Tephra** is the general term for rocks produced by an explosive volcanic eruption. Tephra includes large dense blocks and bombs, and small light rock **debris** such as scoria, pumice, and ash.

Scoria is a vesicular (bubbly) glassy lava rock with a chemical composition similar to basalt with more iron. Pumice is a frothy obsidian rock. Volcanic bombs can be larger chunks of lava that are basically spitted from the volcano. They are dense and look like a bomb. Particles of volcanic ash are extremely small, but they are very hard. If you breathe ash during an eruption, it can puncture your lungs and cause damage

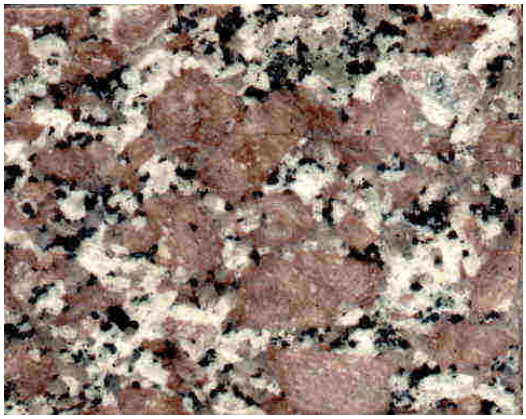
Volcanic bomb



Plutonic rocks can form in large or small **magma chambers** inside the crust and upper mantle of the Earth. These chambers never reach the surface, unless they have cooled and the surface rocks are eroded away. The term **pluton** refers to large and small chambers. A **batholith** is the largest chamber, while a **laccolith** is a smaller pluton. Magma cuts into what is called the **country rock**. It can intrude either in the same direction (a **sill**) or across the beds (**dike**).

Sometimes the molten rock inside the chambers may be chemically different. This would create different types of minerals as the rock cools. For example, molten rock rich in silica (SiO_2), aluminum (Al), potassium (K), and calcium (Ca) tends to make light-colored minerals. This would be similar to granite. In contrast, gabbro is a rock from magma rich in iron (Fe) and magnesium (Mg), with green to black minerals.

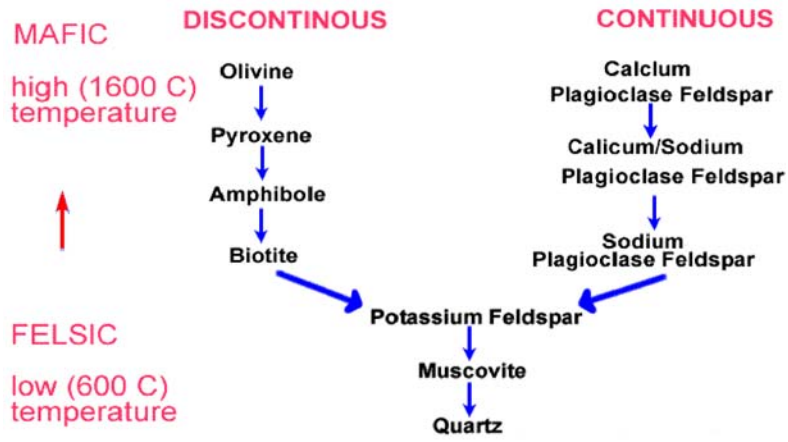
Plutonic rocks are composed of large minerals because they cooled slowly within the crust and upper mantle of the Earth. This gives the minerals time to grow larger. Large minerals are referred to having a **phaneritic** texture. For example, magma that cools slowly creates rocks like granite, which have large minerals that can be seen with the naked eye.


Granite

Plutonic rocks have other textures that can help identify them. Because the magma chamber is a fluid there can be movement of the liquid. As the minerals start to **precipitate** out of the melt, they can form patterns as the fluid moves. Sometimes the magma cools into rock with this pattern. For example, a schlieren structure is due to this movement. It is a concentration of darker minerals in a wavy pattern.


Schlieren structure

Minerals form from the magma through different processes. One process starts with magma and first formed minerals remove hornblende, augite and plagioclase from the brew. The remaining melt will have the ingredients to form lighter colored minerals like orthoclase and quartz. Dr. N.L. Bowen in the early 1900's of the Geophysical Labs in Washington, D.C. discovered this order of **crystallization**. This chemical explanation is called the Bowen reaction series.



Bowen Reaction Series

Another process that forms minerals is the melting of different rocks. In areas where magma is formed in **a subduction** zone, the original melt has a higher concentration of sedimentary rocks and water. This mixing of other continental rock can influence how the minerals are created.

EARTH SCIENCES - IGNEOUS ROCKS

Lesson 3 - Classification of Igneous Rock

MATERIALS:

reader

Objective: Students learn to identify igneous rocks by using an identification chart.

Teacher notes

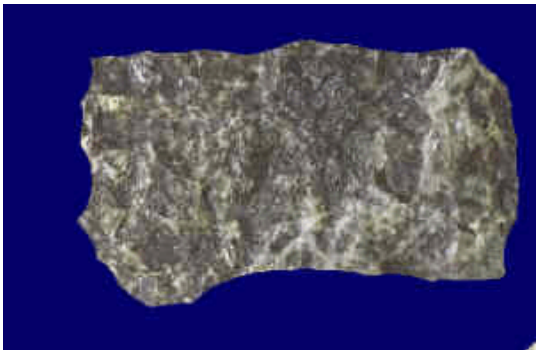
Igneous rocks are easy to identify if students learn how to identify dark and light colored minerals within a sample. This exercise has students learn to read an igneous classification chart, which can help students with identification.

There are two key elements to the chart. The size of the minerals within the rock (texture) and the percentage of different dark and light minerals. Students should complete the worksheet, which has them use the chart. Notice that light colored minerals (quartz, plagioclase, orthoclase) dominate the left side of the chart. Dark minerals like hornblende, augite, and olivine are on the right side.

This exercise will prepare them for lab, when they will actually see the rock samples.

Geologists classify igneous rocks based on both their texture (appearance) and mineral composition. The **texture** of the igneous rock helps to identify a sample and describe a specimen, but also provides clues to determine where it was formed. Geologists will first look at the size of the minerals in a sample. If they can see the minerals with their naked eye then it was formed inside the Earth's crust. This texture is called **phaneritic** (coarse grained) when the minerals are large and visible. Rocks like granite or gabbro have a phaneritic texture. They cooled slowly, from magma taking up to tens of years for small **plutons** and hundreds of thousands to millions of years for large **batholiths**.

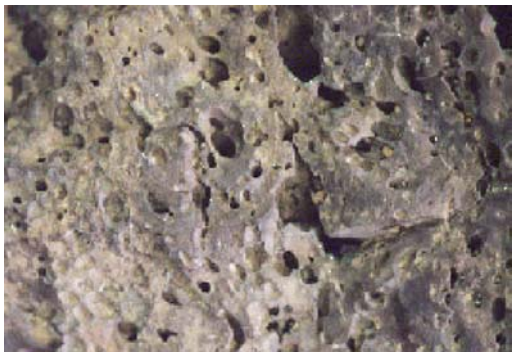
Phaneritic texture in a granite



Phaneritic texture in gabbro

Aphanitic texture in a basalt

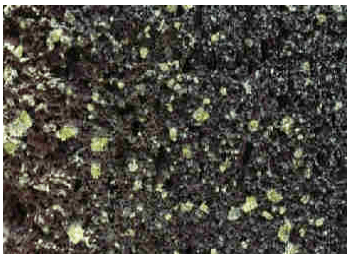
Some igneous rocks are composed of small minerals that are only visible with a hand lens or microscope. This texture is referred to as **aphanitic** (fine grained) texture. These rocks, like basalt (dark in color) or rhyolite (pink in color), cooled quicker. Basalt or rhyolite are examples of lava that cooled within weeks to months.



Vesicular texture in basalt

Many volcanic lava flows are charged with gas that gets trapped as the rocks are cooling. They create a rock that has a **vesicular** texture, which is a rock that has visible holes.

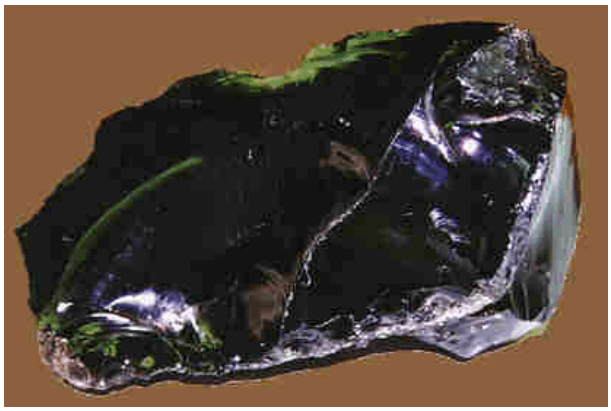
Sometimes magma starts crystalizing minerals and then they cooled quickly. The **matrix** (the background material) can be aphanitic, but the minerals are visible. Olivine starts to crystallize from a melt first, then as cooling increasing the other minerals produce an aphanitic matrix.



Olivine in basalt

Pumice

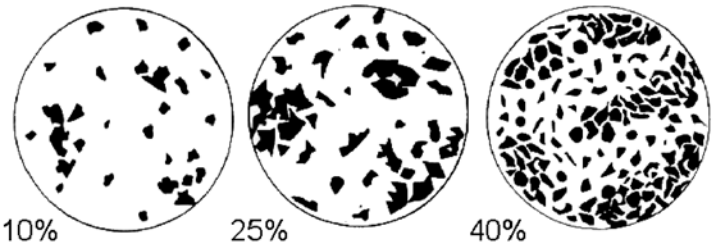
A **glassy texture** is when the rock looks like glass. Rocks like obsidian are formed when lava cools within minutes to hours. This usually occurs as thin layers as the lava flows over the land. The lava contains silica dioxide which has not had time to form crystals. This amorphous fluid hardens without forming any true minerals. Obsidian is actually composed of SiO_2, but has no crystalline structure.



Obsidian

Pumice, which has a frothy look is also considered glassy, because if you look at it closely, the dividing walls between the cells are actually glassy.

A **pyroclastic** texture is composed of fragments, like **tephra**, which includes bombs and ash. These rocks take on an irregular shapes created during volcanic eruptions. Hardened ash flows with other pyroclastic material are grouped as "**tuffs**."

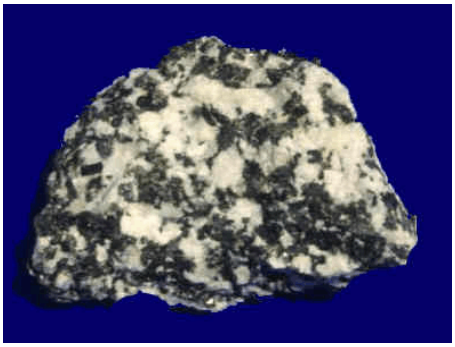


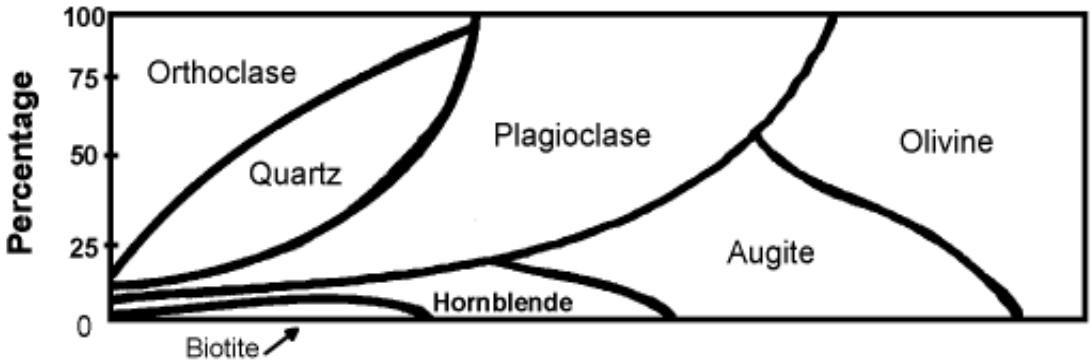
Percentage of same minerals in a sample

Just identifying the texture is not enough to name a rock. The mineral composition is important especially for phaneritic and aphanitic rocks.

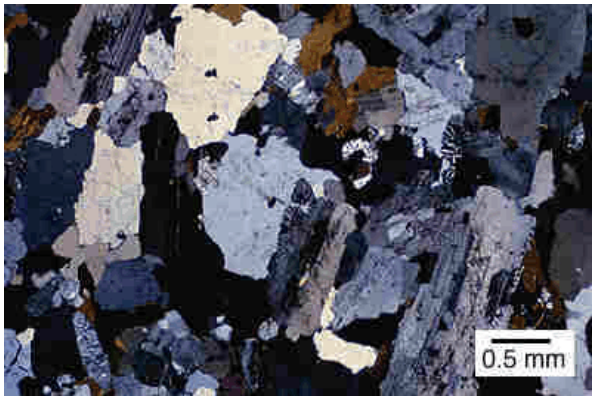
Percentage of minerals is key to identifying igneous rocks. There are two basic ways to determine the percentage. One is a rough estimate using a visual inspection of a piece of rock. We will use this method.

If a specimen is phaneritic, you can further classify it using the percentages of certain key minerals. For example, look at the chart and find the phaneritic rock diorite. Read vertically upward onto the mineral composition part of the chart. Here you can see that a diorite is composed of 0-5% biotite, 5-20% hornblende, 0-15% augite, and 20-70% plagioclase. These percentages are ranges. Different diorites have different amounts of these minerals. This may seem confusing at first, but if you look at the chart you will see that the other types of igneous rocks have different minerals.


Diorite



Aphanitic	Rhyolite	Andesite	Basalt	
Phaneritic	Granite	Diorite	Gabbro	Peridotite
Other	Obsidian Pumice		Scoria	



Thin section of granite

However, what do you do if the rock is aphanitic and you can't see the minerals? In this case, you can use color as a guide. Rhyolites are usually light colored, ranging from white to pink to light gray. In contrast, basalts are dark colored, usually dark green to black. Andesites are in between, for example gray as opposed to white or black.

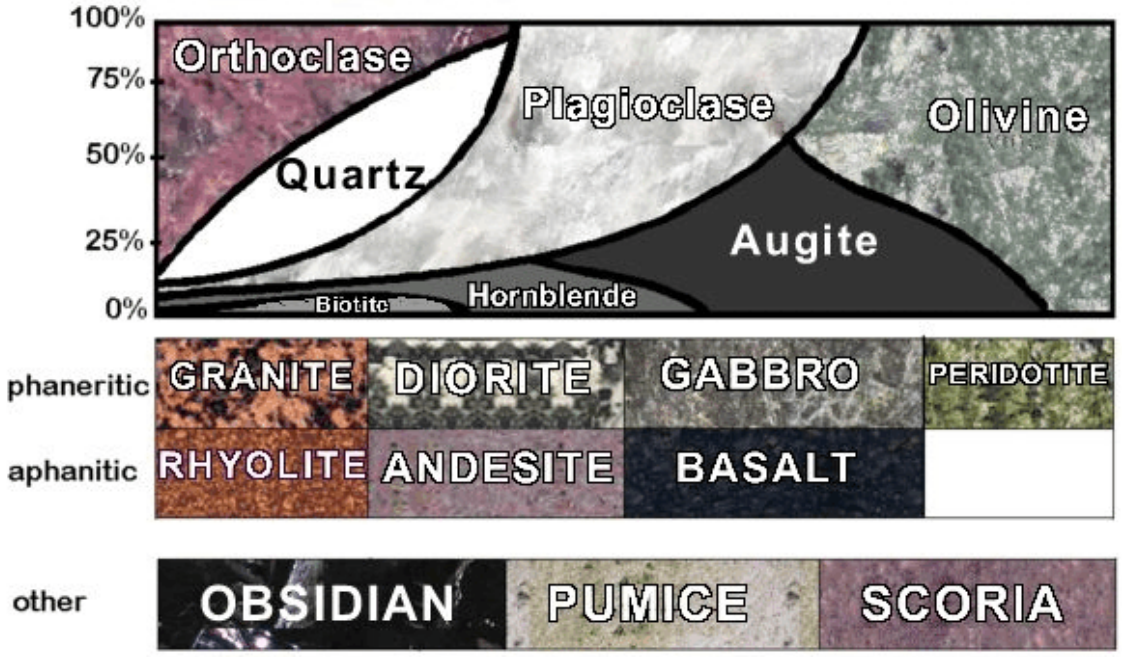
A more precise method is to make a thin section of rock and count the minerals in a given space and then calculate percentages. You can use this method for both aphanitic and phaneritic rocks.


Porphyritic andesite

There are many other types of igneous rocks caused by many different situations. The cooling rate can create bizarre looking rocks. Some rocks start cooling inside and then are "coughed" up. The rock will have a background (matrix) of fine grained volcanic rocks with larger crystals that were cooling slowly. This texture is called **porphyritic**.

Worksheet

READING IGNEOUS CLASSIFICATION CHART



ROCK	TEXTURE	MINERALS	PERCENTAGE RANGE
GRANITE			
DIORITE			

GABBRO			
PERIDOTITE			
RHYOLITE			
ANDESITE			
BASALT			

EARTH SCIENCES - IGNEOUS ROCKS

Lesson 4 - Igneous Rock Lab

MATERIALS:

reader
Igneous Rock Kit

Objective: Students describe and compare igneous rocks.

Teacher notes

Students should read the paragraph and then answer the questions on each sample. If you only have one specimen you can have the students rotate from sample to sample. You may want to time how long they spend at each specimen.

The samples should be labeled, unless you think your students are advanced enough to try and identify them using the classification chart. Remember, these are hand samples and sometimes the percentage of the minerals may be a little distorted.

Students should have a hand lens or a reflecting type microscope to few the samples. If you want to extend the lab, you could have the students draw a picture of their sample, especially the plutonic samples with large minerals.

Answers:

A. Plutonic, because they are not exposed; they are insulated by surrounding rock
B. Volcanoes, undersea volcanoes (i.e. mid-Atlantic ridge)
C. Yes, these plutons will be uplifted, then the rocks above will be eroded away
D. Dependant on your samples.

Answers to rest of questions are dependant on samples that you use.

EARTH SCIENCES-IGNEOUS ROCKS LAB

PROBLEM: How can you tell the difference between plutonic and volcanic rocks?

HYPOTHESIS:

PROCEDURE: General Questions - Answer the following questions.

A. What type of igneous rocks take the longest to cool? Why?

B. Volcanic rocks cool more quickly than plutonic rocks. Name some environments where volcanic rocks are likely to form. (Hint: can volcanoes form underwater?)

C. If plutonic rocks are formed deep inside the crust of the Earth, will we ever see them on the surface of the Earth? Explain your answer.

D. Examine each of the igneous rock samples. Complete the chart below. It is more important to visualize the environment where each rock formed than to memorize the names of each rock.

ROCK NAME	TEXTURE	COLOR	PLUTONIC or VOLCANIC
diorite			
granodiorite (Sierra Nevada)			
basalt			
andesite			
rhyolite tuff			
obsidian			
granite (Texas)			
granite (S. Carolina)			
scoria			
pumice			

Answer the following questions using specimens provided by your instructor. Be sure to examine each specimen, and use the classification charts to help you.

1. PUMICE

Pumice is a type of pyroclastic material. It has a vesicular texture (it is full of holes). These formed because the magma cooled when it was full of gas bubbles. The gas escaped, leaving the holes behind. Pumice is composed of volcanic glass rich in silica (SiO_2).

A. Why is pumice very light?

B. How did pumice form? Was it cooled quickly or slowly?

How can you tell?

C. Does pumice float on water? Why?

2. SCORIA

This volcanic rock may look similar to pumice. In fact, it formed the same way as pumice. It is a volcanic rock that solidified when it was full of gas bubbles. The main difference between the two rocks is composition. Scoria contains much more iron (Fe) and magnesium (Mg) and much less silica (SiO_2) than pumice.

A. Describe scoria.

B. What is the difference between pumice and scoria?

3. OBSIDIAN

Obsidian is volcanic glass. It is magma that became solid so quickly that there was no time for minerals to form. Obsidian is easy to break and shape. For this reason, native peoples often used obsidian to make arrowheads, knives, and other cutting tools. Be careful, your obsidian specimens might be sharp!

A. What common material does obsidian resemble?

B. Can you see any crystals in obsidian?

C. This obsidian was used by the Clear Lake Indians of California. What do you think they used it for? (Hint: is obsidian sharp?)

D. Clear Lake was a _____ area at one time.

4. BASALT
Basalt is the most abundant igneous rock in the Earth's crust. Most of the ocean floor is underlain by basalt. It is a volcanic igneous rock, and is typically dark in color because it contains large amounts of iron (Fe) and magnesium (Mg) compared to other igneous rocks. Basalt is also very common on islands like Hawaii.
A. Describe this specimen of basalt.

B. Can you see any minerals in the sample?

C. Why is basalt always a dark color? (Hint: Has something to do with minerals.)

5. ANDESITE
Andesite is a volcanic igneous rock. It is named after the Andes Mountains of South America, which contain many active volcanoes. Most volcanoes on land are composed of andesite, in the form of either lava or pyroclastic material.
A. Is andesite lighter in color than basalt?

B. Basalt contains a lot of "dark" elements like iron and magnesium. Notice that andesite is not as dark as basalt. Does andesite thus have more or less "dark" minerals?

C. Are any minerals visible in this andesite?

6. RHYOLITE TUFF
Tuff is a name for a pyroclastic rock where the magma fragments are small. A rock with big magma fragments is called a breccia. Tuffs sometimes contain mineral crystals that were blown out of the volcano along with the magma. Tuff is very common in the Western United States, especially in Washington and Oregon, where there are many volcanoes.
A. Describe this rock.

B. Why is rhyolite light in color?

7. GRANITE (South Carolina)
This granite is a plutonic igneous rock. It formed from a magma that cooled slowly underground. Granites are rich in silica (SiO_2), which makes them light in color.

A. Are the minerals that make up this granite visible to the naked eye?

B. What is the general percentage of light minerals compared to dark minerals? (Hint: greater or less than 50%)

C. What is the difference between basalt and granite?

D. What can you attribute this to?

8. GRANITE (Texas)
This is another granite, from a different part of the United States. It looks different from the specimen in Question 7, because it formed from a slightly different magma. Both rocks are called granite because they have the same general texture and composition. It is important to remember that most rock names are not very specific.
A. What is the general percentage of light minerals compared to dark minerals in your sample?

B. Can you see distinct minerals in this specimen?

C. Does it look the same as #7? Why are they both called “granite?”

9. DIORITE
Diorite is another phaneritic igneous rock. Like granite, it formed by slow cooling inside the crust of the Earth. If the magma which cooled to make a diorite was instead erupted on the Earth’s surface, it would make andesite. This means that diorite and andesite have the same composition, but have very different textures.
A. What is the percentage of dark minerals in this specimen?

What percentage are lighter minerals?

B. Describe the dark minerals

C. What is the difference between diorite and the two granites in questions 7 and 8?

10. GRANODIORITE (Sierra Nevada)
Granodiorite is not on your identification chart. It is an igneous rock which is between granite and diorite in composition. Granodiorites can form directly by melting inside the Earth, or by the mixing of other kinds of magma. The formation of magma inside the Earth can be very complex.

A. Estimate the percentages of dark and light minerals in this specimen.

B. Describe the size of the minerals. Why do you think the minerals are smaller than the granites or diorite?

11. GABBRO
Gabbro is another phaneritic igneous rock. Its dark color indicates that it contains lots of iron (Fe) and magnesium (Mg). Gabbro forms from the same kind of magma that creates basalt and scoria. However, to make gabbro, the magma cooled slowly inside the Earth.

A. Estimate the percentages of dark and light minerals in this specimen.

B. Describe the size of the minerals.

C. What is the difference between gabbro and granodiorite, diorite, and the granites?

EARTH SCIENCES - IGNEOUS ROCKS

Lesson 5 - Formation of Granite

MATERIALS:

reader

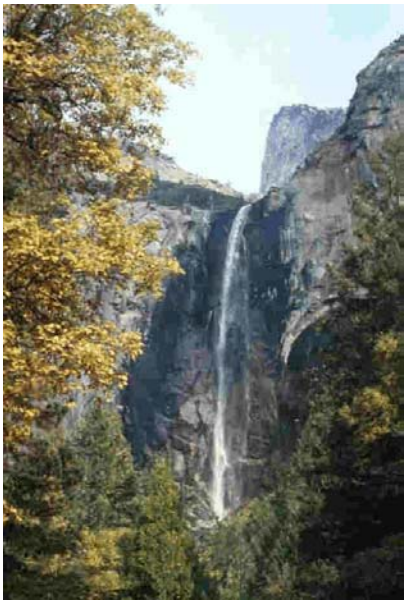
Objective: Students read about how granite forms and some of its uses.

Teacher notes

Many continental igneous rocks range from granites to diorites. These phaneritic rocks are composed of less dense minerals than gabbro (a dark phaneritic igneous rock). As the plates have moved over eons of time, they have kept the less dense rocks on the continents, because they are less likely to be subducted.

Many people associate granite as a symbol of majestic mountain ranges. Yosemite National Park and the entire stretch of the Sierra Nevada are famous for its phaneritic rocks that range from granites to diorites. Texas is noted for its red granites and South Carolina is noted for its pink granites. Granite is mined from all three of these places and noted for tombstones and kitchen counters.

For more information on Yosemite consult the following website.
Yosemite National Park
http://www.nps.gov/yose/home.htm



Yosemite

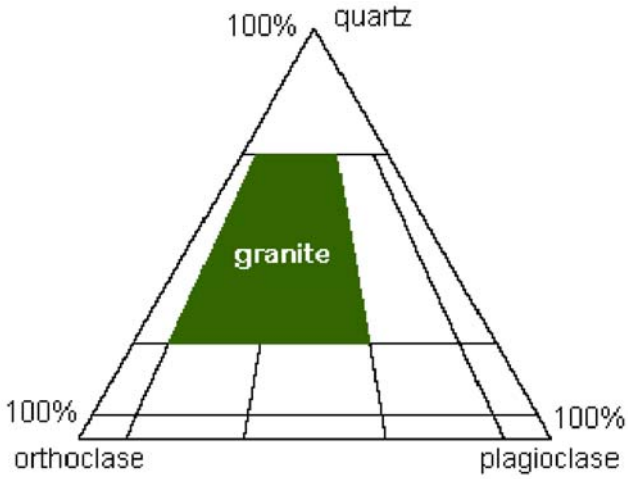
If you were to go hiking in the Sierra Nevada Mountains, California or the Adirondack Mountains, New York, you would spend a lot of time walking on rounded hills. You would notice that the rocks are composed of minerals that you can see. It has a **phaneritic** texture associated with plutonic (intrusive) igneous rocks. If you examined the rock, you would see it is a mixture of light and dark minerals. The rock might also be colored reddish brown where it has been **weathered**.

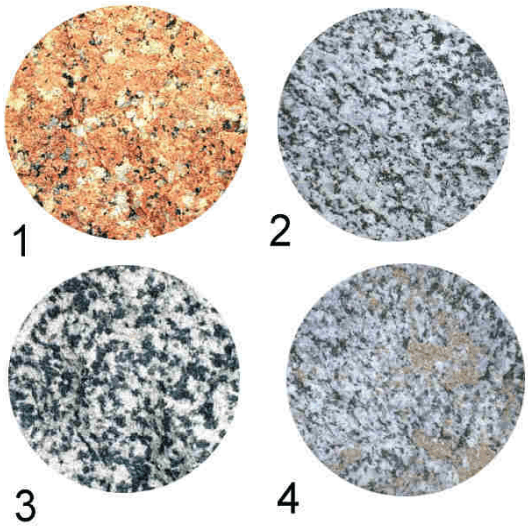
The phaneritic texture reveals that the rock was cooled slowly, within the crust of the Earth. This texture and the light color of the rock tell you that these rocks are probably granite.
.

Half dome

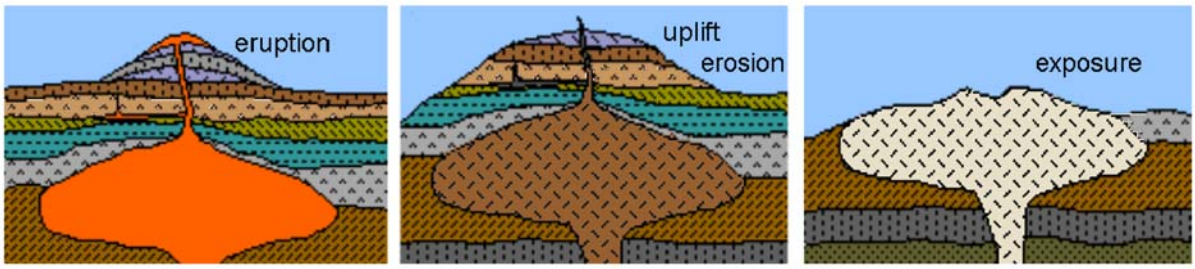
Granite is light in color because it is composed largely of minerals that are rich in silica. These include quartz, feldspar (orthoclase and plagioclase), and muscovite (a mica). Quartz is clear like glass, feldspars are pink, white, or gray, and muscovite is silvery. The dark color of granite comes from dark colored minerals, including hornblende, augite, and biotite (another mica). These minerals are green, brown, and black in color.

Granites actually come in many different colors. This variety in granites is caused by differences in mineral composition, especially in the feldspars. If feldspars are potassium-rich (orthoclase) the granites may be tan to reddish in color. If feldspars are calcium-rich (plagioclase) light to dark gray colored. Looking at the picture sample #1 has more orthoclase, while sample #3 has more minerals like hornblende and plagioclase. The difference between 2 and 3 is the size of the minerals, while sample #4 has a few large orthoclase minerals unevenly arranged.





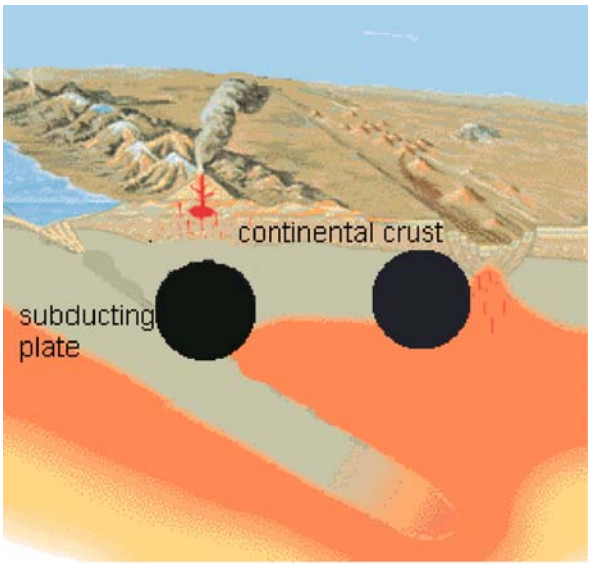
The phaneritic appearance of granite is a clue to where granite forms. It takes hundreds of thousands of years for silicate minerals to grow to the sizes they are in granite. This means that the minerals cooled slowly. This can only take place deep inside the crust of the Earth. Here, the rocks surrounding the magma act like a blanket, keeping it warm and keeping the magma chamber hot, allowing the magma to cool slowly. This means that if you see granite exposed on the Earth's surface, a lot of erosion must have taken place. All of the rock which once covered the granite has been removed.



The minerals in granite can be many different sizes. Some crystals can be quite large. This variety is caused by differences in how fast crystals grow, and in the availability of the elements to make certain minerals. For example, if the magma contains very little iron, then few iron-rich minerals will form.

The formation of granite is a complex process. It can be explained by plate tectonics. Almost all granite forms at convergent plate boundaries where subduction is taking place. Subduction is the downward plunging of one plate under another. Granite forms in two steps. In the first step, the subducting plate dives into the Earth's mantle, heats up and begins to melt. This creates magma. Magma rises, and causes melting in the rock above it, making more magma. When this magma cools, it makes igneous rocks like diorite, not granite.

In the second step, subduction, melting, and magma formation continue. However, when the magmas formed in this step rise upward, they cause part of the diorite formed in the first step to begin to melt. This, combined with melting of surrounding sedimentary and igneous rocks, makes magma which cools to become granite.

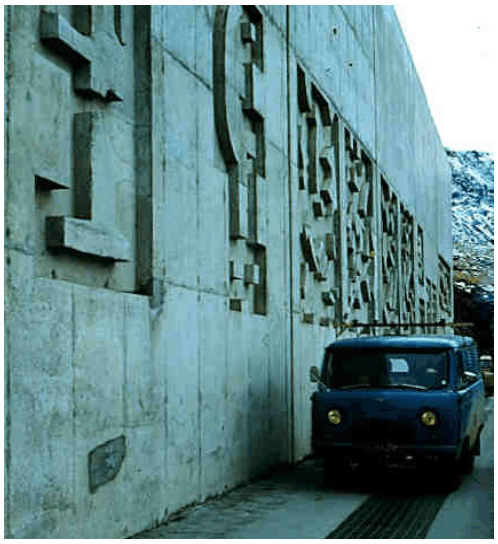


Areas of granite formation

Granite Quarry

Granite is quarried in large blocks and then sent to a location where it can be cut and polished. The surface of granite can be polished just by "sanding" the surface with very fine sand paper. This would be equivalent to tumbling a rock until it is smooth.

Granite is used in many building and **ornamental** places. It is useful for statutes as well as counter tops in kitchens. Many gravestones are made of granite because it is resistant to erosion. So the next time you sit at a counter or walk by a building of granite, you can say that this was formed in large plutons within the crust of the Earth.



Granite building

Fisherman Memorial,
Ensenada,Mexico

Earth Science- Igneous Rocks - Unit Test

Part 1. Definitions Match the number of the term or concept in Column 1 with the letter of the correct definition in Column 2.

Column 1	Column 2
1. magma	a. drives the formation of 3 types of rocks
2. volcanic rock	b. a dangerous volcano in Sicily, Italy
3. plate tectonics	c. an igneous rock composed of very small crystals
4. aphanitic	d. a rock composed of volcanic glass
5. granite	e. molten rock inside the Earth
6. obsidian	f. a flow of molten rock on Earth's surface
7.Mt Etna	g. an igneous rock full of gas bubble holes
8. vesicular	h. molten rock erupted and cooled on the Earth's surface
9. tuff	i. a pyroclastic igneous rock
10. lava	j. a plutonic igneous rock

Part 2. Multiple Choice Choose the best answer to complete each statement.

1. Lava flows:
    a. on the Earth's surface
    b. inside the Earth
    c. on the surface and inside the Earth
    d. none of these

2. Plutonic igneous rocks cool:
    a. slowly
    b. quickly
    c. on the Earth's surface
    d. on the flanks of a volcano

3. Crystals form in a molten rock as it:
    a. cools
    b. loses water
    c. gains water
    d. gains heat

4. Pyroclastic igneous rocks are composed of:
    a. lava
    b. crystals only
    c. fragments of magma and pre-existing rocks
    d. rocks only

5. An igneous rock with a phaneritic texture is composed of:
    a. granite
    b. visible crystals
    c. obsidian
    d. pyroclastic material

6. Rhyolite is to granite, as basalt is to:
    a. volcanic ash
    b. peridotite
    c. gabbro
    d. diorite

7. Lava is composed of _____ igneous rock because it cools on the Earth's surface.

    a. phaneritic
    b. glassy
    c. pyroclastic
    d. aphanitic

8. Granodiorite resembles granite and diorite because it is:
    a. light colored
    b. between them in composition
    c. rich in quartz
    d. all of the above

9. Pumice floats in water because it:
    a. is rich in silica
    b. is full of gas
    c. is full of gas bubble holes
    d. is composed of crystals

10. Dark igneous rocks contains high concentration of
    a. silica
    b. sodium
    c. iron
    d. iron and magnesium

ANSWERS:

Part 1.

1. E
2. F
3. A
4. C
5. J
6. D
7. B
8. G
9. I
10. H

Part 2.

1. A
2. A
3. A
4. C
5. A
6. C
7. D
8. D
9. C
10. D