Reflecting on the Activity and the Challenge

You have seen evidence that rocks formed by volcanic eruptions look different from those formed in other ways. They also vary greatly in their chemical composition. You can try to use what you have learned about the ages of the rocks in your area to decide on the probability of a volcano erupting in your community. Consider how you can share this knowledge with your audience.

Digging Deeper

IGNEOUS ROCKS

Introduction

Igneous rocks crystallize from cooling magma and lavas. Some igneous rocks form from magma that has cooled slowly beneath Earth's surface. The slow cooling allows crystals to form and grow, yielding coarse-grained igneous rocks such as granite. We know from laboratory work on melted rock that it takes extremely long times for large crystals to grow from a cooling magma. Such slow cooling can happen only deep within the Earth. These **intrusive igneous rocks**, also called **plutonic igneous rocks**, are made of crystals large enough to be seen with the naked eye. The sizes and shapes of bodies of intrusive igneous rocks vary greatly, from human scale to whole mountain ranges. Because intrusive igneous rocks form underground, they can only be seen where uplift and erosion have removed the overlying rocks.

Other igneous rocks, called **extrusive igneous rocks**, form from magma that is brought to the Earth's surface. Magma at or near the Earth's surface cools more rapidly, and crystals do not have time to grow to a large size. Sometimes, lava cools so fast that no crystals have a chance to form. Instead, the lava forms a kind of glass, called obsidian, as shown in *Figure 3*. Extrusive rocks are only one kind of volcanic rock. Remember from an earlier activity that pyroclastic volcanic rocks are also important.

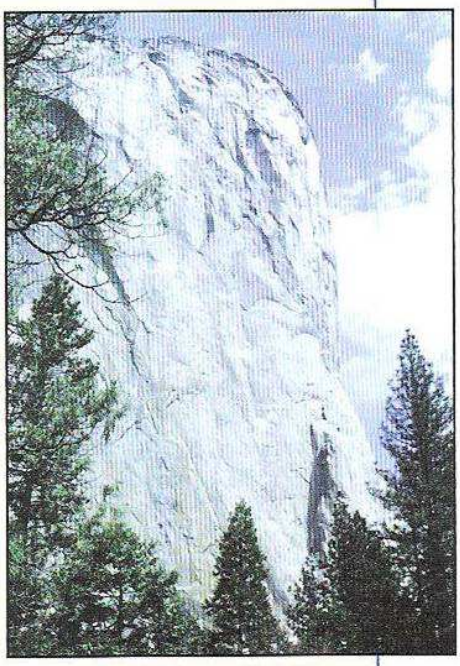

Figure 1 Granite is one kind of intrusive igneous rock formed by slow cooling of magma below Earth's surface.

Geo Words

intrusive igneous rock (plutonic igneous rock): igneous rock formed at considerable depth by the crystallization of magma

extrusive igneous rock: an igneous rock that has formed by eruption of lava onto the surface of the Earth

Usually, the color of igneous rocks reflects the composition of the magma from which they form. Rocks from magmas high in silica (rhyolite and granite) tend to be lighter in color because their minerals are lighter in color, such as quartz, muscovite, and feldspar. These minerals are relatively poor in magnesium and iron, which are chemical elements that tend to make minerals dark.

Igneous rocks from magmas low in silica (basalt and gabbro) are darker in color, because they contain a large percentage of dark-colored minerals like pyroxenes, amphiboles, and dark micas. These minerals are relatively rich in magnesium and iron.

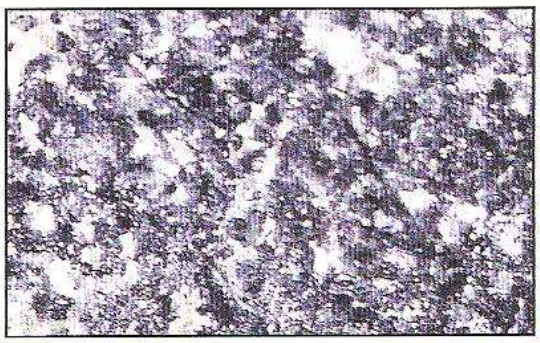

Figure 2 Scoria is an extrusive igneous rock with a frothy texture.

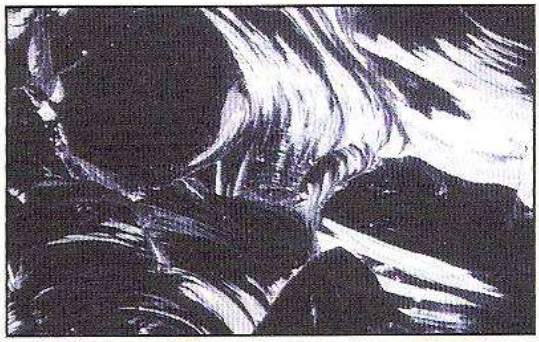

Figure 3 Obsidian is an extrusive igneous rock with a glassy texture.

Volcanic rocks of intermediate composition are mixtures of light and dark minerals that give the rock an intermediate color. A good example is andesite. It is named after the Andes Mountains, a mountain chain in South America that has many volcanoes.

In summary, igneous rocks crystallize from melted rock. They are divided into two types:

- Intrusive (plutonic) rocks are coarse-grained (>1 mm) and composed of crystals large enough to be seen with the naked eye. This implies slow cooling at depth.
- Extrusive (volcanic) rocks are fine-grained (<1 mm) and are composed mainly of crystals that are too small to be seen without a magnifying glass. This implies rapid cooling at or near the surface. Some may even be glassy, and many are filled with bubble holes, called vesicles.

Classification of Igneous Rocks					
Color		Light	Intermediate	Dark	Dark
Mineral composition		quartz (≥5%) plagioclase feldspar potassium feldspar iron-magnesium rich minerals (≤15%)	quartz (<5%) plagioclase feldspar potassium feldspar iron-magnesium rich minerals (15-40%)	no quartz plagioclase feldspar (~50%) no potassium feldspar iron-magnesium rich minerals (~40%)	nearly 100% iron magnesium rich minerals
Texture	Crystals >10 mm	granite pegmatite	diorite pegmatite	gabbro pegmatite	
	Crystals 1–10 mm	granite	diorite	gabbro	peridotite
	Crystals <1 mm	rhyolite	andesite	basalt	
	Glassy	obsidian		obsidian	
	Frothy	pumice		scoria	

Figure 4

Rocks with Interesting Textures

Pumice, shown in *Figure 5*, feels like sandpaper. It is often light enough to float in water. Pumice forms when the gases inside the lava effervesce (bubble off) as pressure is released, just the way bubbles form when a can of soda, under pressure, is opened. The lava cools into a rock that is mostly tiny holes, with only very thin walls of rock between the holes. Much of the material blown out at first around Mt. St. Helens was pumice.

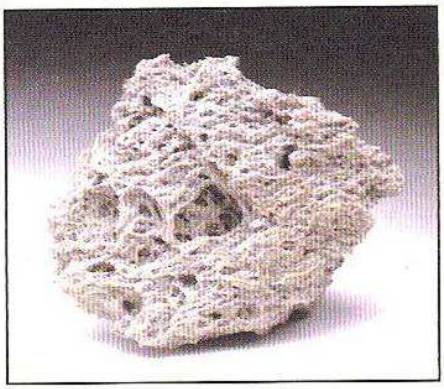

Figure 5 Pumice sample from Mt. St. Helens.

Obsidian is a glassy rock that was cooled so quickly from lava that crystals did not form. A broken surface of obsidian is usually smooth and shiny, just like a broken piece of glass (which it is!).

Tuff is a rock composed of pyroclastic material deposited from explosive eruptions. Some tuffs consist of ash that was put into the atmosphere by the eruption and then fell back to the surface downwind of the volcano. These tuffs may be lightweight, soft, and fragile, if they have not been buried deeply by later deposits. Other tuffs form from pyroclastic flows. These tuffs are often welded tightly together by the heat of the pyroclastic flow.

Scoria is a crusty-looking rock filled with holes made by gas bubbles trying to escape from the lava as it solidified. It is usually red or black, depending on the degree of oxidation of iron. Scoria is heavier to lift than pumice, because it doesn't have as great an abundance of holes. If you get to visit a cinder cone that is being mined, look at the cinders in the center and compare them to the cinders on the flank. The central cinders will be more oxidized and red and the outer samples darker and more like the basalt associated with the cone.

Types of Volcanic Rocks (based on silica content)

Basalt is dark and fine-grained. It is a low-silica rock. It is the most common rock on Earth and makes up the floors of all the oceans. Basalt covers about 70 percent of the surface of Earth. Basalt underlies the sediments on the floors of all the deep oceans of the Earth. Because the deep oceans occupy about 60 percent of the Earth's surface, basalt is the most common rock near the Earth's surface. On the continents, however, sediments and sedimentary rocks are much more common than basalt near the Earth's surface.

Andesite is a rock that is intermediate in silica content. It is also intermediate in color, typically gray, green, or brown. Andesite is typical of volcanic rocks from around the "Ring of Fire" in the Pacific Ocean. The ash from Mt. St. Helens was andesitic.

Dacite is a silica-rich rock that is between a rhyolite and an andesite in composition, somewhat like the difference between blue and violet in the color spectrum. It is lighter in color but not quite as silica rich as a rhyolite. It, too, is fine-grained but may have some visible crystals.

Rhyolite is usually light in color and has a fine-grained background. It forms from viscous lava that is high in silica. One of the identifying aspects of rhyolite is that it has visible quartz crystals that are not often seen in other volcanic rocks. These quartz crystals form because of (and are evidence of) rhyolite's high silica content. Perhaps the most famous rhyolite is the rock found in Yellowstone National Park. It came from one of the most massive volcanic eruptions known in Earth history.

Check Your Understanding

1. How can you distinguish intrusive igneous rock from extrusive igneous rock?
2. What is the difference between the way intrusive and extrusive igneous rock is formed?
3. Which chemical elements tend to make minerals dark?