Igneous Rocks

Magma

- molten rock material consisting of liquid rock and crystals.
- A variety exists, but here are the end members:

Types of Magma

Basaltic, Basic or Mafic

- very hot (900-1200°C)
- very fluid
- low SiO_2 (silica) content (~50%)
- mafic (magnesium and iron rich) minerals
- volatile gases are low
- produces “flowing” volcanoes: lava flows

Silicic, Felsic, Acidic or Granitic

- less than 850°C
- highly viscous
- high SiO_2 content (~65-77%)
- felsic (feldspar and silica rich, like quartz) minerals
- volatile gases may reach 15%
- H_20,$C0_2$ – volatile gasses

Magma eventually cools to form igneous rock. It can cool:

1) Intrusively, beneath the surface – also called plutonic rock
   >Most common type: granite
   >Later uplift exposes them
   >One of the most common rocks found in the continental crust

2) Extrusively, on top of the surface – also called volcanic rock
   >Most common type: basalt
   >The most common rock found in the ocean crust

Causes of Melting:

1) Melting Due to Decompression: pressure typically prevents melting, so if there is a decrease in pressure while the rock stays hot, it can melt.
2) Melting Due to Addition of Volatiles, also known as flux melting: adding volatiles decreases a rock’s melting temperature.
3) Melting Due to Heat Transfer: complete melting of rock due to contact with hot magma.

Properties of Igneous Rocks

- Elements you find in igneous rocks:
  - Si, O, Al, Ca, Na, K, Fe, Mg

- ***SiO_2 and water control the physical properties of magma, such as density, viscosity, and the manner in which it is extruded.***

Igneous Rock Textures:

Generally, igneous rock textures are directly related to their rate of cooling. Big crystals indicate that the rock had lots of time to cool. Small crystals indicate a rapid cooling.

Volcanic Textures: These textures form in rocks that crystallize at the surface of the earth.
1) Glassy - This texture develops when molten rock material cools so rapidly that the migration of ions to form crystal grains is inhibited. Glassy texture typically forms on the crust of lava flows and in viscous magma.

Example: Obsidian and Pumice

2) Aphanitic - This texture consists of mineral grains too small to be seen without a microscope, which is a result of rapid cooling. Sometimes tiny crystals can be seen with the naked eye.

Example: Basalt, Rhyolite, Andesite

3) Vesicular - Gas bubbles are trapped in this form of rock. The result is a rock with numerous cavities, which can range in size from almost microscopic (Pumice) to a few millimeters (Scoria).

Examples: Pumice, Scoria

4) Pyroclastic - This texture forms when crystals, fragments of rock, and glass are blown out of a volcano as ash. Generally the particles fall to Earth and accumulate in sediment like layers. Ash flows are very hot, and move close to the ground, and the individual fragments become fused in a dense mass.

Example: Tuffs

Plutonic Textures: These textures form in rocks that crystallize beneath the surface of the Earth. As a result, they crystallize at a much slower rate, resulting in larger crystals.

5) Phaneritic - This texture consists of grains large enough to be seen with the unaided eye. Grains are roughly the same size and interlock to form a tight mass.
The large crystals suggest a relatively slow rate of cooling.
A Plutonic Texture. Example: Granite

6) Pegmatitic - occur when there is an extremely slow rate of cooling, resulting in huge crystals. Many of our gemstones and minerals are produced this way.
A Plutonic Texture. Example: Granite Pegmatite

Special Textures: These textures have a more complicated cooling history.

7) Porphyritic - This texture occurs in conjunction with aphanitic or phaneritic rocks (resulting in porphyritic aphanitic or porphyritic phaneritic texture), and results from two separate rates of cooling. The larger crystals were produced by a slow cooling rate, and the smaller crystals by a faster rate.

Show pretty examples here:

EXTRUSIVE ROCK BODIES

- ***Silicic or Felsic Lava Flows*** (Pyroclastic)
  - 1) Air Fall Tuffs are produced when the ash falls out of the atmosphere to the ground and accumulates. These events can spread out carrying materials thousands of miles away.

  - 2) Ash Flow Tuffs form from particles that move laterally across the surface in a gas-charged flow which moves like a lava flow, but much more rapid. They can reach speeds of over 250 km/hr, and are capable of mass destruction.

  - When the flow comes to rest, the particles of hot, crystal fragments, glass and ash may fuse to form a rock called a welded tuff. Some of these flows form rock units over 100 meters thick and cover thousands of square kilometers. As the mass of rock cools, ***columnar joints*** may form.

Volcano Type: Stratovolcano or Composite Cone

- Explosive eruptions of silicic volcanoes can blow out large volumes of ash and magma. As a result, the summit area sometimes collapses, forming a large basin-shaped depression known as a caldera.

Caldera Formation (insert your pretty drawings here)

In general, composite cones tend to erupt materials of felsic to intermediate composition, since the magma is influenced by the continental crust, which tends to be felsic. Generally, if a magma becomes more felsic during its time in the continental crust, it will become more viscous as well. The resultant eruptions of extremely viscous lavas are not flows, but more typically are explosive.

Basaltic or Mafic Lava Flows

Basaltic Flows

- These are the most common on Earth. The lava is generally extruded from fractures and fissures in the crust. These lavas can flow at speeds as high as 30-40 km/hr down steep slopes, but rates of 20 km/hr are unusually rapid.

Types of basaltic flows:
(Time for you to learn some Hawaiian)

- AA - slow moving and 3-10 m thick. As it moves slowly, the crust is broken into a jumbled mass of angular blocks and clinkers.
- Pahoehoe flows – faster moving and thinner, more a roapy look

Volcano Types:
1) Shield Volcano

2) Cinder Cone

Comparative Scale of all three major types of volcanoes:

Other extrusive features (most of these occur as basalt):

- Columnar Jointing - a system of fractures that splits a rock body into long prisms, or columns that results from contraction of the lava.
- Lava Tubes - these are created when lava breaks through an already solidified area and empties a flow space (conduit).
- Pressure Ridge - the crust of the flow arches and cracks, releasing gas and lava.
- Fissure - a crack or vent opening where lava can escape.
- Spatter Cones - result from the splashing of lava around a fountain or vent where lava escapes.
- Tephra - volcanic ash, dust and debris thrown into the air.
  - Bombs - big stuff
  - Ash and Dust - little stuff

Eruptive Characteristics of Volcanoes

1) Hawaiian fountain explosions are caused by escaping gas.
2) Vulcanian Eruptions occur when a buildup of gas and magma explodes.
3) Strombolian crater explosions occur through thinly crusted lava.
4) Plinean Eruptions shoot huge volumes of ash and pumice up to 50 km into the atmosphere. Pyroclastic flows are frequently associated with these.

Where do volcanoes form?

1) Mid-Ocean Ridges
2) Convergent Boundaries
3) Continental Rifts
4) Hot Spots

Flood Basalts (aka LIPS):

Hazards Associated with Volcanism:

1) Lava Flows
2) Falling Ash and Lapilli
3) The Blast Itself
4) Landslides and Lahars
5) Earthquakes and Tsunamis
6) Expelled Gas

Volcanoes Elsewhere:

1) Moon
2) Venus
3) Olympus Mons
4) Io

INTRUSIVE ROCK BODIES

Intrusive rocks are plutonic, which indicates that they formed beneath the surface, and therefore, crystallized slowly. These rocks are common building materials, utilized for countertops, floors and sinks for they commonly show large crystals. Many can be euhedral, or perfectly shaped.

Batholiths: Masses of coarsely crystalline rock, generally of granitic composition

>**Largest intrusive bodies** of the Earth's crust.
>It is difficult to determine their exact depth, but they do not extend into the mantle (in other words, their maximum depth is 60 km).

Examples: Sierra Nevada, Coast Ranges, Much of the rockies

Stocks: Medium sized intrusions.

Dikes and Sills: Dikes cut across the pre-existing rock layers, Sills are parallel to pre-existing rock layers

Laccolith - larger lens shaped intrusion parallel to pre-existing rock layers.

Xenoliths often are captured as part of the intrusive process. As the magma rises, it moves through other rock, and part of the other rock can be captured and included. This is most easily done when the "country rock" (original rock) is of a higher melting temperature than the intruding rock.

Differentiation of Magma

What governs composition of magma?

1) Assimilation: chunks of material that fall into the magma chamber and become dissolved into the magma . . .

2) Magma mixing

3) Fractional crystallization

- olivine, pyroxene, Ca- Plag, crystallization first.
- *left over melted stuff increases in SiO2 content*
- *Partial Melting*

Bowens Reaction Series governs what crystallizes or melts first and last.