Igneous Rocks

- Formed by crystallization (or solidification) of melted material
- Molten material within the earth, MAGMA, cools to form PLUTONIC, or INTRUSIVE igneous rock.
- Molten material that emerges at the earth's surface, LAVA, cools to form VOLCANIC, or EXTRUSIVE igneous rock.

Some Definitions

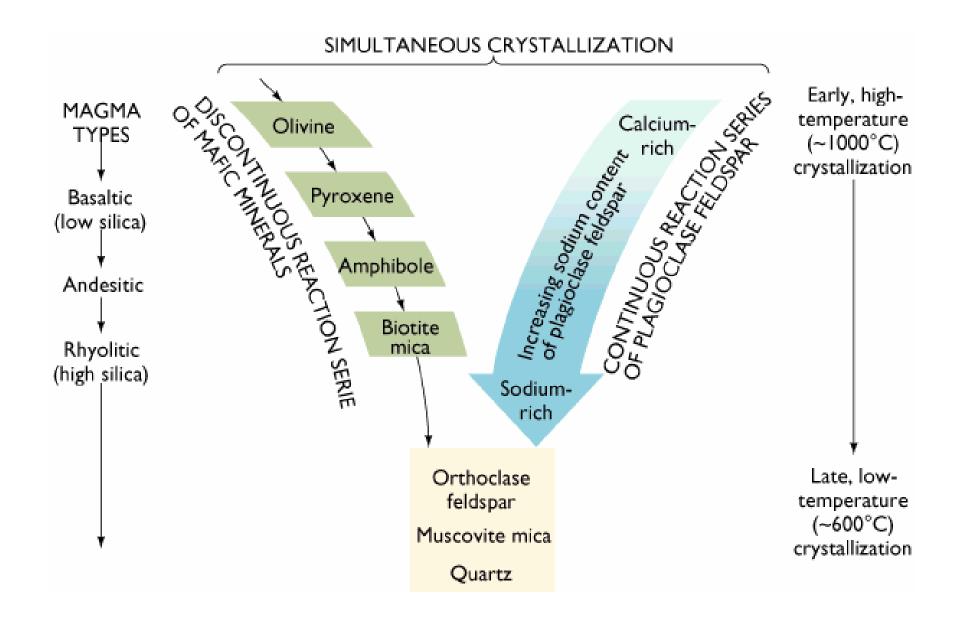
- MAGMA: a combination of melted silicate material, volatiles, and possibly already solidified crystals
- VOLATILES: substances that are gases at low temperature, chiefly H_2O

Viscosity

- VISCOSITY: resistance of a substance to flow. Examples: pine sap (higher viscosity) *vs*. water (lower viscosity)
- Viscosity increases as the lava starts to cool.
- The more complex the silicates melted in the magma, the higher the viscosity (examples of complex mineral structures: quartz, orthoclase).

Classification of Igneous Rocks

- Classified by MINERAL COMPOSITION and TEXTURE
- BOWEN'S REACTION SERIES: (N. L. Bowen, 1911)



Bowen's Reaction Series

- Generalization about magma behavior and sequence of crystallization
- Silica tetrahedron: one silicon bound to 4 oxygens
- Continuous and Discontinuous Series
- Minerals crystallizing along the discontinuous series have distinctly different mineral structures (isolated, chain, double chain, sheet, framework).
- Olivine contains isolated SiO_4 tetrahedrons.
- Quartz is a <u>framework</u> silicate in which every tetrahedron is linked at its corners to four other tetrahedrons (every oxygen atom is shared).

Significance of Bowen's Series

- Minerals that crystallize first have higher melting points than minerals down the series.
- Complexity of silicate structures increases down the series.
- Viscosity of the magma increases down the series.
- Minerals lower down the series are more resistant to chemical weathering.
- Mineral densities decrease down the series.

Terms Related to Mineral Composition

- Felsic: igneous rocks rich in light-colored minerals such as orthoclase and quartz
- Intermediate: igneous rocks rich in minerals such as Na-Ca plagioclase and hornblende
- Mafic: igneous rocks rich in dark-colored ferromagnesian minerals (augite, hornblende) but with abundant plagioclase feldspar
- Ultramafic: igneous rocks composed chiefly of dark-colored ferromagnesian minerals, especially olivine and augite, with no plagioclase

Terms Related to Texture

• Crystal Size:

Fine-grained: less than 1mm

Medium-grained: 1-2 mm

Coarse-grained: larger than 2 mm

Pegmatitic: very coarse-grained, approx. 5cm to as large as a house

• Porphyry: igneous rock with large crystals (PHENOCRYSTS) set in a matrix of fine-grained crystals (GROUNDMASS)

Cooling History

- Absence of crystals (glassy) indicates extremely rapid cooling (quenching).
- Absence of crystals (frothy) indicates extremely rapid cooling with high dissolved gas content.
- Small crystals indicate rapid cooling.
- Large crystals indicate slow cooling.
- Pegmatitic texture indicates slow cooling in the presence of H_2O .
- Porphyritic texture indicates two distinct cooling histories: slowly at depth, then rapidly at the surface.

Igneous Landforms

- Plutonic rock body: sill, dike, batholith
- Volcanic landform: fissure flow, shield volcano, composite volcano
- Crater (constructional feature) (example: Mt. Rainier, Washington State)
- Caldera (destructional feature) (example: Crater Lake, Oregon)

Mafic Magma

- Mafic magma typically has a higher temperature than felsic magma.
- Higher-temperature magmas commonly have:
 - lower viscosity
 - lower volatile content
 - less explosive tendency (lava rather than pyroclastic material)

Volcanic Terms

- Pyroclastic rock: explosively erupted as hot but nevertheless solid particles
- Tuff: explosively erupted, fine-grained volcanic rock whose grains are commonly welded together
- Vesicles: cavities in a volcanic rock, once occupied by gas bubbles

