

4. Igneous Rocks

Classification of Igneous Rocks

Classified according to *texture* and *mineral composition*.

1) **Texture** - size and arrangement of crystals.

Mode of origin (environment)

fine grained - small crystals - rapid cooling - surface.

coarse grained - large crystals - slow cooling - deep.

Classified using two main textures:

a) Aphanitic - fine-grained

formed at/or near earth's surface.

vesicles - voids left by trapped gas bubbles.

b) Phaneritic - coarse-grained.

formed deep in earth's crust

Also can have: Porphyritic - two sizes:

large crystals embedded in matrix of smaller crystals.

Two different environments

1) deeper slow cooling for phenocrysts - large crystals;

2) shallow, rapid cooling for groundmass.

2) **Mineral composition**.

nonferromagnesian minerals - light (felsic) ferromagnesian - minerals - dark (mafic)

Felsics - plagioclase feldspar (Ca, Na),
potassium feldspar, muscovite, quartz.

Mafics - olivine, pyroxene, amphibole, biotite.

Bowen's Reaction Series

Controls mineral associations.

As magma cools, minerals with higher melting points crystallize out before those with lower melting points.

First minerals to crystallize:

olivine, **Ca plagioclase**, and **pyroxene**, -
high in Fe, Mg, Ca; low in Si, Al.

These minerals compose basaltic rocks:

mafic (Mg and Fe) minerals,
darker and denser.

During crystallization process, composition of melt continually changes. After 50% of melt is used, it is *depleted* in Fe, Mg and Ca, and *enriched* in Al, Na, K and Si.

Last minerals to crystallize:

K feldspar, Na plagioclase and quartz
high in Si, Al and K

These minerals compose granitic rocks:
felsic - feldspar and quartz.

Lighter in *color* and *density*

Magmatic Differentiation - process of developing more than one rock type from a common magma.

1) crystal settling - separation of solid and liquid phases of a magma.

Earliest formed dense crystals (olivine and pyroxene) settle to bottom of magma chamber.

When remaining melt solidifies, it forms rocks with different chemistry.

2) Assimilation:

Magma migrating upward may incorporate surrounding country rock.

3) Magma mixing - intermingling of two magma bodies.

Mafic Rocks

Basaltic Rocks

Dark green to black, fine grained volcanic rock. Pyroxene and calcium-rich feldspars, with lesser olivine and amphibole.

Most common extrusive igneous rock.

Oceanic crust - composed of basalt.

Gabbro

Intrusive equivalent of basalt; same minerals, but coarse grained.

Intermediate Rocks

Andesitic Rocks

Medium gray, fine-grained rock
mainly amphibole and plagioclase feldspars. Often porphyritic.

Felsic Rocks

Granitic Rocks

Phaneritic
25-35% quartz, >50% K and Na - feldspar.
Some muscovite and amphibole or biotite.
Continental crust is granitic.

Obsidian

Dark colored, glassy rock.
Rapidly cooled silica-rich lava.

Occurrence of Igneous Rocks

Most magma is emplaced at depth in plutons:

Intrusive igneous bodies
classified according to their:

- 1) shape: tabular (sheet like) or massive;
- 2) orientation to country (host) rock.
discordant - cut across existing structures
concordant - form parallel to strata

Dikes - discordant sheet-like structures formed when magma is injected into fractures.

Thickness - centimeter to >km.

Most dikes - few meters thick and extend laterally for a few kms.

Sills - tabular plutons formed when magma is injected along sedimentary bedding surfaces.

Horizontal sills most common.

Formed at relatively shallow depth;

Require lifting host rock during emplacement.

e.g. 300 m thick Palisades sill.

Batholiths

largest intrusive igneous bodies. Linear structures several hundred kms long and nearly one hundred kms wide.

thick - possibly several kilometers.

granitic in composition.

intruded over a period of millions of years.

e.g. Sierra Nevadas - Cretaceous subduction zones