Earth's crust is 4/5 igneous rock. Every igneous rock begins as magma. As magma migrates toward the surface, some of it hardens underground into various types of igneous rocks. Magma that reaches the surface erupts in either flowing or explosive volcanoes, generating two pyroclastic rocks.

Igneous rock is formed when molten, or partially molten, rock solidifies.

Igneous Rock-forming environments
- Extrusive
- Intrusive

Igneous Rocks (two categories)
- Intrusive
  - Magma crystallized slowly within the crust. No exposure to the cold atmosphere.
  - Phaneritic - intrusive igneous rock at great depth within crust or outside.
- Extrusive
  - Lava and pyroclastic debris extruded at surface or at any shallow levels.

Igneous Rocks
- Igneous Rocks are named on the basis of their texture and composition.
  - Texture of a rock is the size and arrangement of the minerals it contains.
  - Composition of a rock is the assemblage of minerals it contains.

As magma crystallizes a network of interlocking minerals develops. The composition and texture of the resulting rock is determined by these minerals.

Phaneritic texture - with large crystals therefore, this is an intrusive rock
Texture
Aphanitic texture - mineral grains too small to see with the unaided eye (Basalt)

Small crystals had a short time to crystallize. Therefore, this is an extrusive rock.

Texture
Vesicular texture - many pits from gas escape (Basalt)

Extrusive rock.

What is the cooling history?

Texture
Porphyritic texture - with 2 distinct grain sizes, large and small (Andesite Porphyry)

Texture
Glassy texture - without obvious minerals (Obsidian)

No crystals. This is an extrusive rock.

Texture is estimated using visual grain size (depends on crystallization history)

Composition
Igneous color (gray scale) is used to estimate chemical composition

Felsic – oxygen, silicon, sodium enriched
Iron, magnesium, calcium depleted
Source – partial melting, continental crust

Intermediate
Granite

Orthoclase
Feldspar

Plagioclase
Feldspar
(Ca/Na)

Muscovite
Mica

Quartz

Mafic – iron, magnesium, calcium enriched
Oxygen, silicon, sodium depleted
Source – mantle, oceanic crust

Ultramafic
Peridotite

Melting

Crystallizing

How do igneous rocks form in a cooling magma chamber?
Remember partial melting?

When the components melt first – therefore in a cooling magma chamber for many crystal layers

Iron-rich (felsic) compounds melt last – therefore in a cooling magma chamber they will crystallize first

Therefore cooling magma will become enriched in Si/O as crystallization proceeds.

Composition
Felsic: igneous rocks enriched in oxygen, silicon, sodium

Mafic: iron, magnesium, calcium enriched

Source: partial melting, continental crust

Intermediate: granite

Melting and crystallizing

Igneous Rock-Forming Minerals

Quartz

Plagioclase

Orthoclase
Feldspar

Biotite
Mica

Muscovite
Mica

Granite

Basalt

Diorite

Pyroxene

Mafic Minerals

Felsic Minerals

Amphibole

Quartz
How do igneous rocks form?

Bowen's Reaction Series

Mafic

Hot Olivine

Pyroxene

Amphibole

Ca‐plagioclase

Plagioclase feldspar

Intermediate

Ultramafic

Basalt

Gabbro

Andesite

Diorite

Types of Rocks formed

Cool

Felsic

Orthoclase feldspar

Muscovite

Quartz

Na‐plagioclase

Intermediate

Felsic

Rhyolite

Granite

Intrusive

Extrusive

The Igneous Rocks

Igneous rock is a ubiquitous component of Earth's crust because it evolves as a product of tectonic processes.