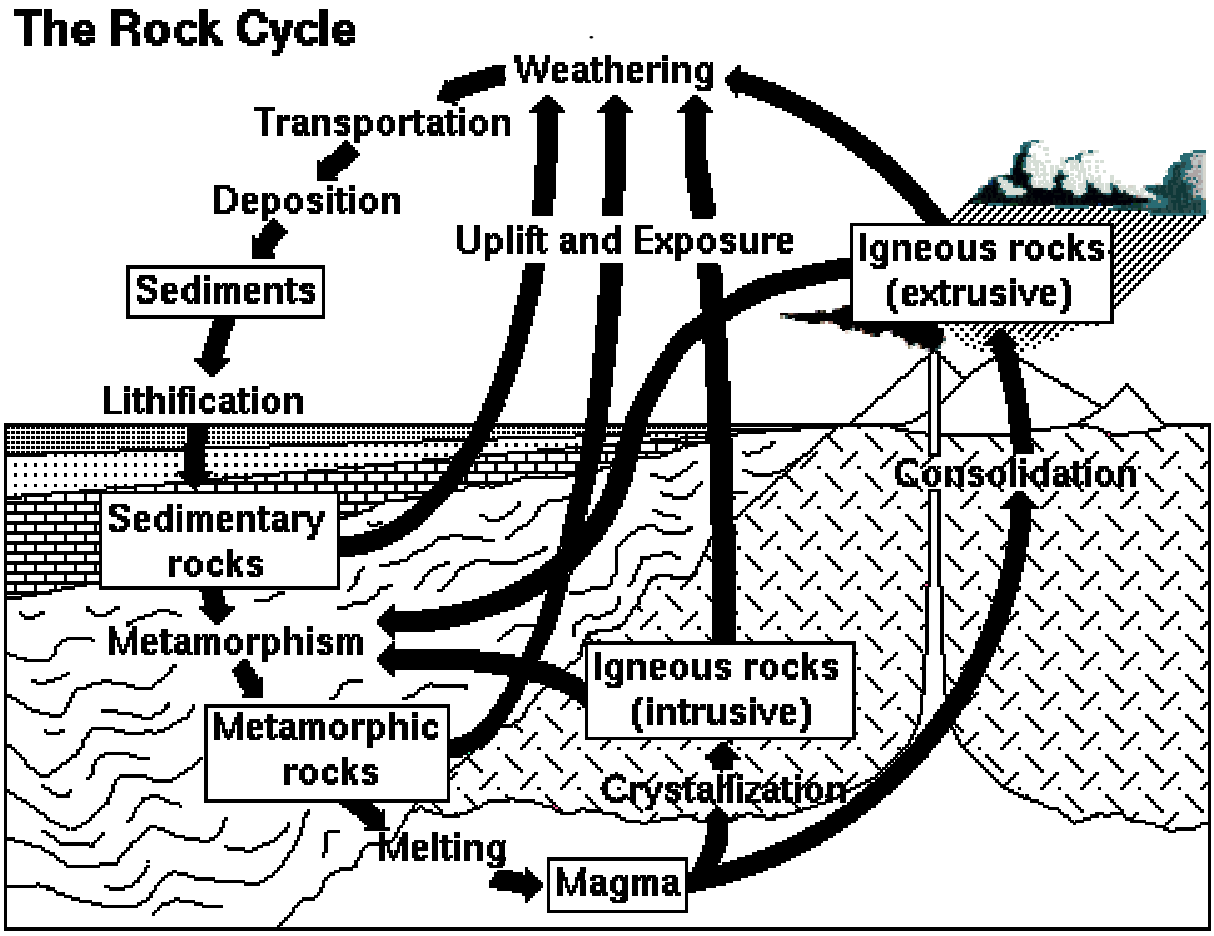

The Rock Cycle
Weathering
Transportation
Deposition
Sediments
Lithification
Uplift and Exposure
Igneous rocks (extrusive)
Consolidation
Sedimentary rocks
Metamorphism
Metamorphic rocks
Igneous rocks (intrusive)
Crystallization
Melting
Magma

ROCKS	Most rocks are any naturally formed aggregates or masses of minerals. Other types are composed by organic matter
IGNEOUS ROCKS	Formed by the crystallization of magma.
MAGMA	Natural hot melt composed by **SILICATE** liquids and solids and gases (mostly $H_20 + CO_2$). Minor amounts of Sulfur, Cl , and F
LAVA?	

IGNEOUS ROCKS can be classified on the basis of their **COMPOSITION** (chemical or mineralogical) and their **TEXTURE**.

IGNEOUS ROCKS COMPOSITION
MINERALS: SILICATES (SiO_4)

The most important silicate minerals are:

MINERALS	CHEMICAL FORMULAE	ELEMENTS
FELDSPAR **1. PLAGIOCLASE** **2. K-FELDSPAR (ORTHOCLASE)**	($NaAlSi_3O_8$ - $CaAl2Si2O_8$) ($KAlSi_3O_8$)	**[Ca, Na, Al]** **[K, Al]**
3. OLIVINE	($(Fe, Mg)_2$ SiO_4)	**[Fe, Mg]**
4. PYROXENE AUGITE	((Ca, Na) (Mg, Fe^{2+} Al) $(Si,Al)_2O_8$	**[Fe, Mg with Ca, Na and Al]**
5. AMPHIBOLE (HORNBLENDE)		**[hydrous Ca, Fe, Mg, Al]**
6. QUARTZ	(SiO_2)	**[Si]**
MICA **7. BIOTITE** **8. MUSCOVITE**	(K $(Mg, Fe)_3$ $AlSiO_3O_{10}(OH)_2$ ($KAl_3AlSi_3O_{10}$ $(OH)_2$)	**[hydrous K, Fe, Mg, Al]** **[hydrous K, Al]**

These minerals make up to 95% of the volume of common igneous rocks and thus are important for purposes of classification as well as in studies about their origins.

MAGMA / ROCK TYPE

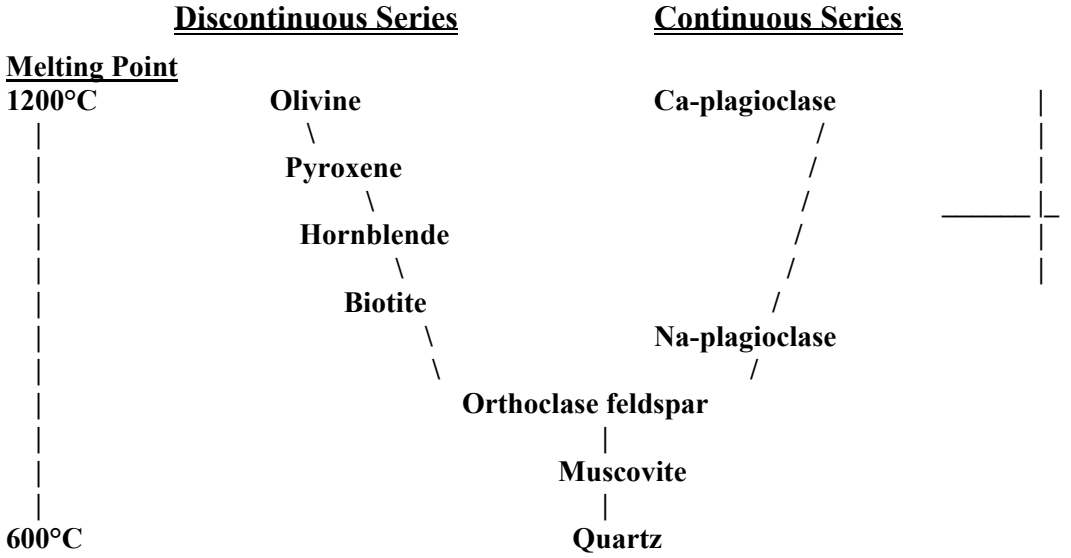
MAGMA TYPE	**CHEMICAL COMPOSITION**	**MINERALS PRESENT**	**GENERAL ROCK COLOR**
SIALIC GRANITIC OR FELSIC	MAGMA RICH IN **Si and Al Na, K**	**Quartz** **K-F. (Orthoclase)** **Na-Feldspar** **Na-Plagioclase** +/- Muscovite **(Felsic minerals)** **[LIGHT-COLORED MINERALS]**	LIGHT-COLORED (light gray, creamy brown, pink)
MAFIC, BASALTIC OR BASIC	MAGMA RICH IN **Fe, Mg, Ca (low in Si)**	**Olivine** **Pyroxene** **Ca-Plagioclase** +/- Biotite +/- Hornblende **(Ferromagnesian minerals)** **DARK-COLORED MINERALS**	DARK-COLORED (dark-gray, black)

MAGMA / ROCK TYPE

MAGMA TYPE	**CHEMICAL COMPOSITION**	**MINERALS PRESENT**	**GENERAL ROCK COLOR**
SIALIC GRANITIC OR FELSIC	MAGMA RICH IN **Si and Al Na, K**	**Quartz** **K-F. (Orthoclase)** **Na-Feldspar** **Na-Plagioclase** +/- Muscovite **(Felsic minerals)** **[LIGHT-COLORED MINERALS]**	**LIGHT-COLORED** (light gray, creamy brown, pink)
INTERMEDIATE			**INTERMEDIATE-COLORED** ("medium gray")
MAFIC, BASALTIC OR BASIC	MAGMA RICH IN **Fe, Mg, Ca (low in Si)**	**Olivine** **Pyroxene** **Ca-Plagioclase** +/- Biotite +/- Hornblende **(Ferromagnesian minerals)** **DARK-COLORED MINERALS**	**DARK-COLORED** (dark-gray, black)
ULTRAMAFIC	MAGMA RICH IN **Fe, Mg, Ca (extremely low in Si)**	Usually composed by one mineral species **Olivine** **Pyroxene** **Ca-Plagioclase**	**DARK-COLORED** (green, dark gray, black)

BOWEN'S REACTION SERIES

Prediction of the mineral composition of a rock formed by solidification of magma. Based on experimental data, an order of crystallization (or nucleation) has been established ***(p. 44 Fig. 3.17)***



Continuous Reaction Series (Plagioclase Feldspars)

Ca is preferentially taken up in plagioclase crystallizing at a high temperature (~ 1200 °C). Thus, as the melt cools, the composition of the melt changes. Ca is being removed and incorporated into early-forming, high-temperature plagioclase crystals, leaving the melt depleted in Ca but relatively enriched in Na. Plagioclase crystallized at lower temperatures is consequently richer in Na.

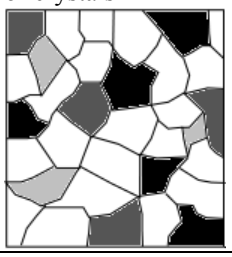
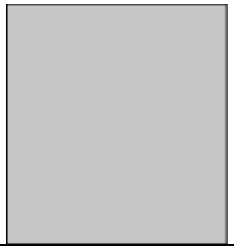
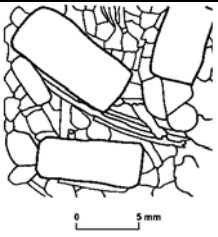
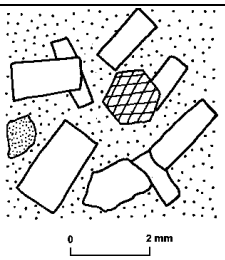
Discontinuous Reaction Series

Minerals crystallize from the melt but subsequently react with the remaining melt as the temperature changes to form new minerals e.g. Olivine crystallizes at high temperature (~ 1200 °C), but as the remaining melt cools, the olivine crystals become unstable and react with the melt to form a new mineral group (pyroxenes).

Both the continuous and discontinuous series occur simultaneously as a melt cools (or as a rock heats up), giving rise to different mineral assemblages in rocks formed at different temperatures.

Exactly which minerals form depends on the starting composition of the magma and the rate of cooling.

TEXTURE **Refers** to the geometrical aspects of the component particles (minerals) of a rocks. These include **SIZE**, **SHAPE**, and **ARRANGEMENT** or **CONTACT RELATIONSHIPS** among particles.

TYPE OF TEXTURE	DESCRIPTION	SIZE OF THE CRYSTALS		RATE OF COOLING	ROCK TYPE / ENVIRONMENT
PHANERITIC (equigranular)	Individual crystals can be seen be the naked eye **Macroscopic**	Barely visible to more than one inch in length	Interlocking mosaic of crystals 	Magmas cooling **slowly.** *Crystallize at one position within the earth's crust*	**Plutonic or Intrusive**
APHANITIC (equigranular)	Individual crystals **very small**. They cannot be detected without the aid of a microscope **Microscopic**	In thin sections under the microscope you can see crystals and sometimes glass	Massive or structure less 	Magmas cooling **rapidly**	**Volcanic or Extrusive**
PORPHYRITIC	Has two distinct crystal sizes				
PORPHYRITIC-PHANERITIC	Has two distinct crystal sizes, both seen with the naked eye	**Groundmass** (smaller crystals) **Phenocrystals** (larger crystals)		If a magma moves upward during its crystallization the rates of cooling will change, producing different crystal sizes	**Intrusive or Plutonic**
PORPHYRITIC -APHANITIC	Has two distinct crystal sizes	**Aphanitc** Groundmass **Phaneritic** Phenocrystals		Two rates of cooling. Slow then fast	**Volcanic or Extrusive** *When phenocrystals are abundant the rock may look with a phaneritic texture*

TYPE OF TEXTURE	DESCRIPTION	SIZE OF THE CRYSTALS		WHERE THEY DEVELOP	ROCK TYPES
GLASSY	Similar to ordinary glass	Very few microscopic crystals. Mostly glass		Reflects extreme rapid rate of cooling in absence of gases	**Volcanic or Extrusive** Massive units or threadlike mesh similar to spun glass
VESICULAR AMIGDULAR	Presents vesicles Filled vesicles			Formed by the expansion of a bubble of gas or steam during the crystallization of the rock	**Volcanic or Extrusive** Small cavities in an aphanitic or glassy rock. Formed
PYROCLASTIC	Broken angular fragments of rock material	Pumice, glass, broken crystals <4 mm tuff >4 mm volcanic breccia			**Volcanic or Extrusive**