Magma Diversification

1) **Magmatic Differentiation**:
The process of evolution of different types of igneous rocks from a single originally uniform magma is called as magmatic differentiation. When a magma of uniform composition starts cooling and crystallization, the early formed crystals can be separated by many means from the magma. The remaining liquid, depleted of the crystallized minerals, has a composition different from that of the original or parent magma and is called as daughter magma. Various processes can bring about differentiation as follows;

(a) Fractional Crystallization: the early crystallized minerals in a magma chamber usually have densities different from that of the corresponding liquid phase. Therefore, they either sink or float in the magma under the influence of gravity and are physically removed from the melt. They are of two types; gravitational differentiation and crystal floatation. Thus their separation affects the composition of the residual magma. This phenomenon is well exhibited by layered igneous intrusions where early formed minerals like olivine, chromite, pyroxene, etc. undergo gravity settling in an originally basaltic magma resulting in formation of various rock types like dunites, pyroxenites, gabbro, etc. gravity differentiation is the most effective mechanism in bringing about magmatic differentiation. Other factors which control gravity differentiation are viscosity of the magma and convection currents within the magma chamber.

(b) Flowage differentiation: when a magma moves along a pipe or a narrow channel, its flowage changes away from the contacts. The suspended crystals under such conditions get concentrated along the axis (centre) of such channels where the flow velocity is higher. Thus, there is preferential accumulation of early formed minerals along the axes of the channels resulting in rock types of different composition.

(c) Crystal Zoning: when minerals belonging to solid solution series crystallize, for e.g. plagioclase feldspar, the early formed crystals are rich in calcic composition and the crystallization proceeds. The early formed crystals react continuously with the melt to form plagioclase of uniform composition. However, if equilibrium is disturbed the successive liquid will have a different composition. This mechanism when very extensive can affect the composition of the residual liquid and thus different rock types are formed.

(d) Filter Pressing: it involves mechanical separation of coexisting magma from the crystal-liquid mixture. When crystallization of magma is far advanced, the crystal builds a continuous mesh, in the interstices of which lies the melt. If this crystal-liquid mixture is now subjected to any stress or the magma chamber collapses, the residual liquid is forced out and thus tends to move towards the region of lower pressure to form rocks having different composition.

(e) Liquid Immiscibility: some magmas break up into immiscible liquid fractions through fall of temperature. These may separate as droplets, bubbles of the sub-ordinate phase suspended in the bulk of liquid. Thus, with falling temperature, the homogeneity in magma is lost and different phases try to separate.

(f) Gaseous Transfer: gases like H_2O, CO_2, P_2O_5, S, etc. migrate upwards from the magma chamber establishing a compositional gradient.

(g) Thermal Gradient: merely change in temperature results in differentiation as lot of heat is lost at the periphery and a thermal gradient is established. This will result in movement of material which ultimately results in a compositional gradient.

2) **Assimilation**
It is a process wherein the intruding magma incorporates the fragments of country rock and a new rock different in composition from that of magma and the country rock is formed.
The first stage of the process of assimilation involves the fracturing of the country rock during the period of intrusion. Much of the shattering may result from the heating and differential expansion of the rocks in contact with the magma. Wall or roof rock which has been mechanically shattered and engulfed in the magma survives for a time in the form of angular blocks of all shapes and sizes and are known as xenoliths. Initially xenoliths are clearly demarcated from the invading rock and contrast with it in colour, texture and composition. But as a consequence of heating to magmatic or near magmatic temperatures and soaking by magmatic fluids, they gradually merge their identity into that of the host rock.

3) **Magma Mixing**
If two magmas mix a third magma is formed of different composition. Thus by mixing of basaltic and an acidic magma, a magma of intermediate composition may be formed. However magma mixing is not as simple process as there is a great

variation in the density, viscosity, % of volatiles and temperature of the two magmas. Acidic magmas are more viscous and less dense while basic magmas are fluid and dense. Even basic magma may mix with another basic magma. This usually happens in replenish magma chamber.