DSPMU UNIVERSITY, RANCHI.
DEPARTMENT OF GEOLOGY

B.Sc. SEMESTER-II **DATE-02/05/2020**

THE GEOCHEMICAL VARIABILITY OF MAGMAS

The composition of magma depends on the rock it was formed from (by melting), and the conditions of that melting (such as Pressure,Temperature etc.). Magmas can vary widely in composition, but in general they are made up of only eight elements; in order of importance: oxygen, silicon, aluminum, iron, calcium, sodium, magnesium, and potassium. Apart from these major elements, all magmas have varying proportions of elements such as hydrogen, carbon, and sulphur, which are converted into gases like water vapour, carbon dioxide, and hydrogen sulphide as the magma cools.

The two most abundant types of magmatic rocks are basalt in ocean areas and granite in continental areas. A basalt reaches the surface at a temperature of 1150–1250 ◦C, and a granitic liquid (rhyolite) at about 1000 ◦C. Basalt is rich in iron, magnesium, and calcium, whereas granite is rich in silica and alkaline elements.Table 1 gives the characteristic major element compositions of magmatic rocks in their standard form, i.e. by oxide weight.

Table 1- Characteristic major element compositions of some important magmatic rocks.

Locality	Rock	SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	K_2O	Na_2O	P_2O_5
Mid-ocean ridge	Tholeiitic basalt	50.9	1.2	15.2	10.3	7.7	11.8	0.1	2.3	0.1
Hawaii	Alkali basalt	45.9	4.0	14.6	13.3	6.3	10.3	0.8	3.0	0.4
Hawaii	Tholeiitic basalt	49.3	2.8	13.4	11.5	7.7	11.0	0.4	2.3	0.3
Siberia (trap)	Tholeiitic basalt	48.7	1.4	14.8	10.3	7.3	9.7	0.9	2.4	0.1
Cascades	Andesite	60.4	0.9	17.5	6.4	2.8	6.2	1.2	4.3	0.2
Australia	Granite (I)[a]	69.5	0.4	14.2	3.2	1.4	3.1	3.2	3.5	0.1
Australia	Granite (S)[b]	70.9	0.4	14.0	3.2	1.2	1.9	2.5	4.1	0.2

[*a,b*- I and S-Type granites.]

Over the years, various process have been suggested to explain the variation of magma compositions observed. We now look at the mechanisms responsible for the variability of magmatic rocks-

1. **Distinct melting events from distinct / different sources-** Most Granitic or Rhyolitic magma appears to result from wet melting of continental crustal rocks whereas, much evidence suggests that basaltic magmas result from dry partial melting of mantle rocks.

2. **Various degrees of partial melting from the same source-** Incomplete melting of parent rock, characteristically producing a melt whose chemical composition differs from that of the parent material. It is thought that partial-melting processes play a major role in generating different magma compositions.

In general more siliceous magmas form by low degrees of partial melting. Rock types produced by small degrees of partial melting in the Earth's mantle are typically alkaline (Ca, Na), potassic (K) or peralkaline (in which the aluminium to silica ratio is high). As the degree of partial melting increases, less siliceous compositions can be generated. So, low degrees of melting a mafic source thus yields a felsic or intermediate magma whereas melting of ultramafics (peridotite source) yields a basaltic magma.

3. **Crystal fractionation-** Crystal fractionation (or Fractional crystallization)is the removal and segregation of mineral precipitates from a melt, which changes the composition of the melt. This is one of the most important geochemical and physical processes operating within the Earth's crust and mantle.

4. **Mixing of two or more magmas-** Magma mixing is the process by which two magmas meet, comingle, and form a magma of a composition somewhere between the two end-member magmas. Magma mixing also tends to occur at deeper levels in the crust and is considered one of the primary mechanisms for forming intermediate rocks such as monzonite and andesite. Here, due to heat transfer and increased volatile flux from subduction, the silicic crust melts to form a felsic magma (essentially granitic in composition). Basaltic primary melts formed in the mantle beneath the crust rise and mingle with the granitic melts, the result being part-way between basalt and rhyolite; literally an 'intermediate' composition.

5. **Assimilation/contamination of magmas by crustal rocks-** Assimilation is a popular mechanism for explaining the felsification of ultramafic and mafic magmas as they rise through the crust. Assimilation assumes that a hot primitive melt intruding into a cooler, felsic crust will melt the crust and mix with the resulting melt. This then alters the composition of the primitive magma. Also pre-existing mafic host rocks can be assimilated, with little effect on the bulk magma chemistry.

6. **Liquid Immiscibility-** A cooling magma will sometimes precipitate droplets of a second magma that has an entirely different composition. Like oil and water, the two magmas will not mix (i.e., they are immiscible).

The individual process mentioned above for magma generation are possible, however in nature it is not so simple. These processes do not act individually, but rather a combination of the process could act to produce chemical change in magmas.