CHAPTER: IV

ORIGIN OF MAGMATIC ROCKS AND THEIR MODE OF DEPOSITS:

I. Introduction:

Molten magmas migrate upwards through the earth's crust and depending on the speed of migration and cooling, two main types of magmatic rocks are formed: plutonic rocks that form at depth and volcanic rocks that form on the surface. (Figure 1).

Between these two main groups, there are intermediate rocks between plutonic and volcanic called vein rocks that geologists considered a separate group, but the current general trend is to consider that they are part of one or the other of the two groups, depending on their structure.

Igneous rocks are formed by the cooling of molten rock.

- There are two major classifications of igneous rocks: **Intrusive** and **Extrusiv**e.
- **Intrusive igneous rocks** are formed by magma that cools below the Earth's surface.
  Extrusive igneous rocks are formed by lava that cools at the Earth's surface.
  - **Intrusive igneous rocks** generally cool very slowly deep below the earth's surface or as the magma is rising to the earth's surface.
  - **Extrusive igneous rocks** generally cool quickly when they reach the earth's surface usually through volcanoes or fissure.

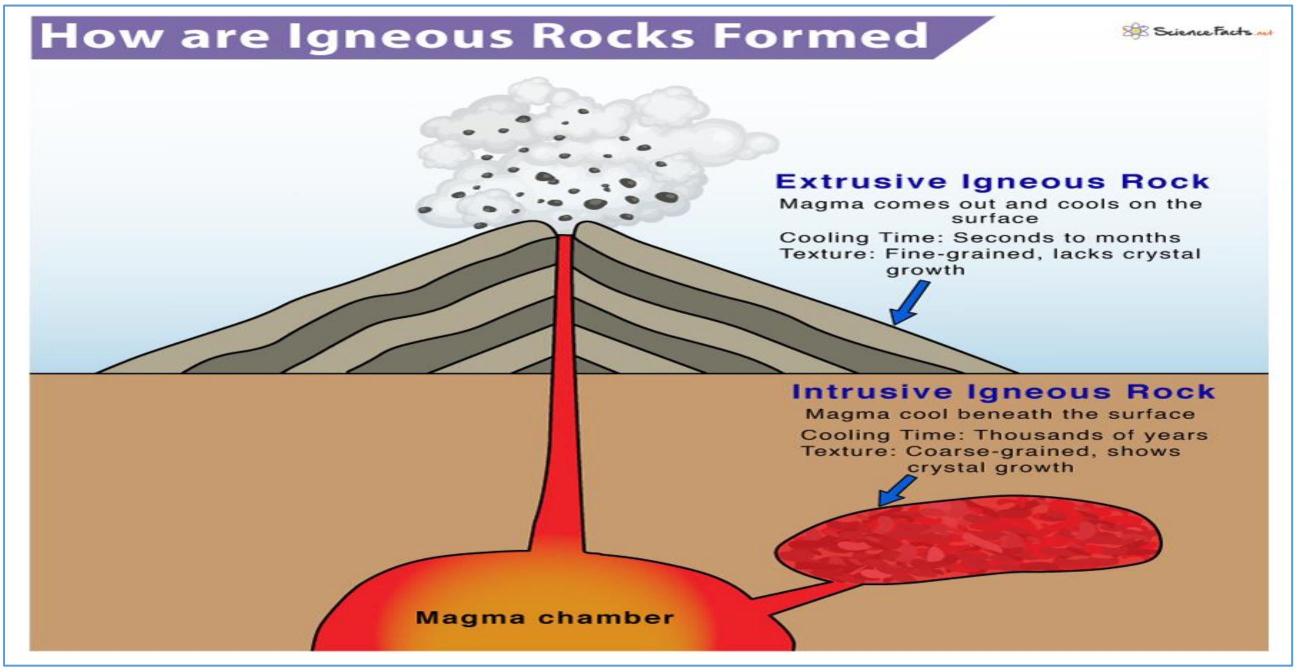


Figure 1: Genesis of igneous rocks

II. Volcanic rocks:

When migration is rapid, the magma reaches the surface of the crust and spreads there, cooling is then relatively rapid and leads to the formation of lava, a general term for volcanic rocks (also called extrusive or effusive rocks). While the vast majority of lava is composed of a rather dense dark rock, called basalt, it spreads on the surface of the Earth's crust in two main forms.

III. Plutonic rocks – different forms of intrusion:

When migration is slower, the magma crystallizes in depth (often in the lower part of the crust) to form rock masses called intrusive rocks, another term for plutonic rocks. The vast majority of intrusive rocks are made up of granites, light-colored, relatively light rocks.

Intrusive igneous rocks are formed from magma that cools and solidifies within the crust, surrounded by pre-existing rock (through sedimentary, metamorphic, or magmatic rocks) can be large, such as **batholiths** (from a few km to more than 100 km in diameter, the main constituent of which is granite), or **smaller**.

Intrusive rocks can also be classified according to the shape and size of the intrusive body and its relation to the other formations into which it intrudes. Typical intrusive formations are batholiths, stocks, laccoliths, sills and dikes (Figure 2).

• **Batholiths**: are large mass of intrusive igneous that forms from cooled magma deep in the Earth's crust. Batholiths are almost always made mostly of felsic or intermediate rock types, such as granite, quartz monzonite, or diorite.

• **Stock**: is a discordant igneous intrusion having a surface exposure of less than 100 km2, differing from batholiths only in being smaller. The term stock usually refers to individual, relatively small plutons (<20 km diameter.

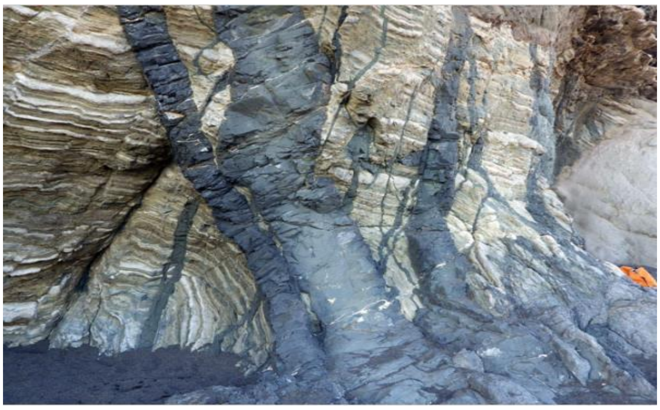
• **Lopoliths**: a large igneous intrusion which is lenticular in shape with a depressed central region. Lopoliths are generally concordant with the intruded strata, with dike or funnel-shaped feeder bodies below the body.

• **Laccolith**: is a sheet intrusion (or concordant pluton) that has been injected between two layers of sedimentary rock. The pressure of the magma is high enough that the overlying strata are forced upward, giving the laccolith a dome or mushroom-like form with a generally planar base.

.

• **Phacolith**: are pluton parallel to the bedding plane (or foliation) of folded country rock. More specifically, it is a typically lens-shaped pluton that occupies either the crest of an anticline or the trough of a syncline.

• **Sills**: is a tabular sheet intrusion that has intruded between older layers of sedimentary rock, beds of volcanic lava or tuff, or along the direction of foliation in metamorphic rock.



• **Dikes**: are discordant tabular plutons; they form from magma that is forced into cracks rather than between beds of sedimentary rock.

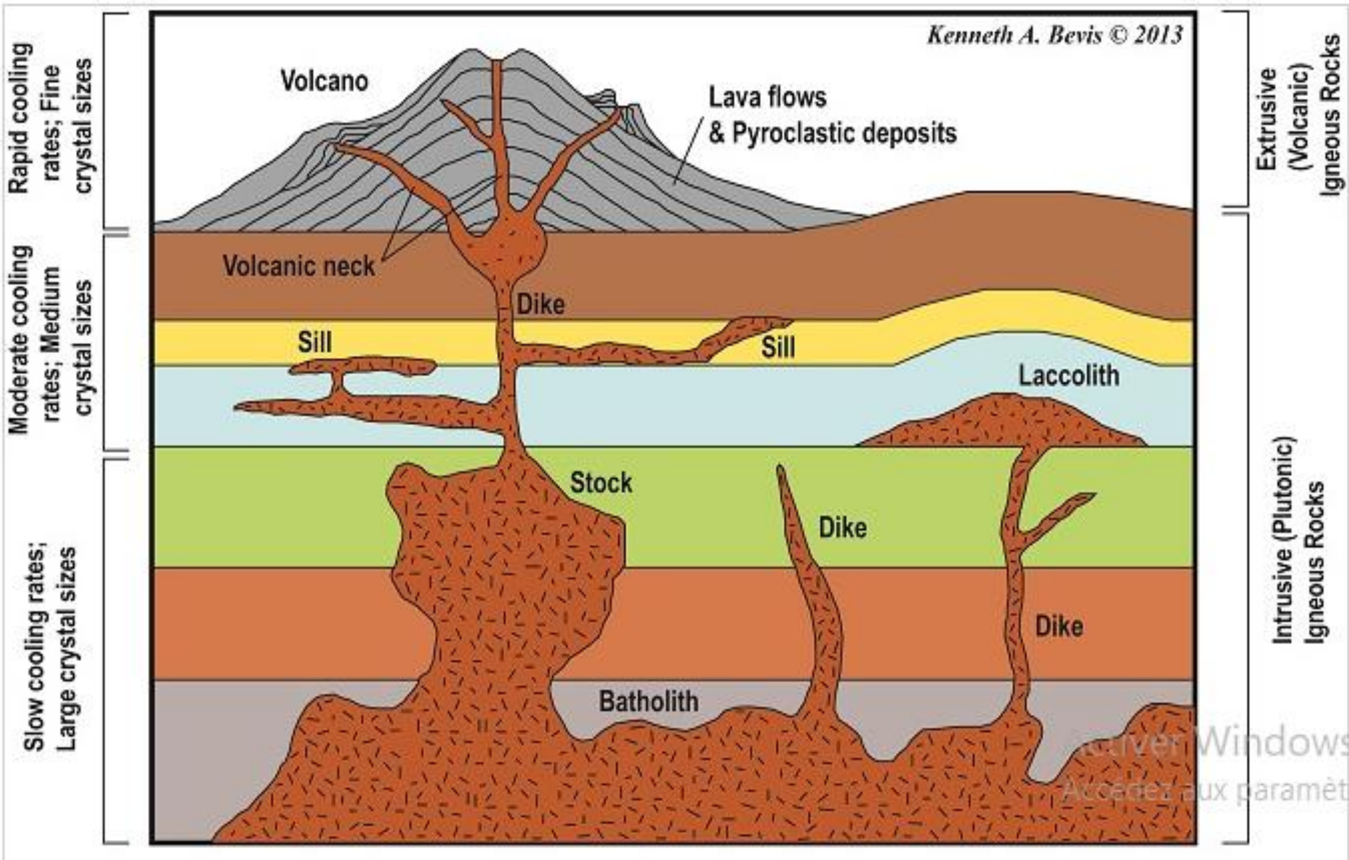


Figure 2: Formation of plutonique rocks

IV. Magmatic differentiation: التمايز الصخري

Definition

Magmatic differentiation is a process by which a magma sees its chemical and mineralogical composition evolve over time.

Magma differentiation is the process by which a single magma body evolves and differentiates into multiple types of igneous rocks with different chemical compositions. It occurs through mechanisms like fractional crystallization, where minerals crystallize at different temperatures and settle out of the melt, altering the chemical makeup of the remaining liquid. This process is crucial in understanding the diversity of igneous rocks found on Earth, as it explains how a wide range of mineral compositions can arise from a single source.

Magmas result from the partial melting of an initial rock (most often a mantle peridotite $(Mg,Fe)_2SiO_4$). This partial fusion leads to the formation of a first magma called "primary magma". This magma slowly cools and crystallizes. The first crystals to form are olivines (forsterites Mg_2SiO_4), they are rich in magnesium and iron, and poor in silica. The high density olivine crystals will sediment by gravity and therefore separate from the magmatic liquid.

Par exemple, considérant la cristallisation forsterites (Mg_2SiO_4), le liquide résiduel va s'appauvrir en Magnésium (Mg) alors que tous les autres éléments vont s'enrichir relativement. Par conséquent, à partir d'un liquide basaltique, on obtient par cristallisation fractionnée des quantités décroissantes de liquides de plus en plus différenciés appauvris en Mg, Ca et Fe et passivement enrichis en silice et alcalins (Na et K).

They will deplete the magma in magnesium and iron and enrich it in silica. The remaining magma is called "differentiated magma". This differentiated magma will continue its crystallization (and therefore its differentiation), a whole series of other minerals will emerge and can be partially segregated, we speak of **fractional crystallization**. This evolution of the composition of magmas over time is responsible for the evolution of certain physical parameters such as viscosity, and therefore governs the eruptive dynamics in the case of volcanism for example.

V. Assimilation, mixing of magmas, contamination: الاستيعاب، اختلاط الصهارة التلوث:

The phenomenon of differentiation by fractional crystallization is not the only phenomenon capable of changing the chemical composition of magmas. Indeed, magmas can be contaminated by the surrounding rocks (exchanges of certain chemical elements) but also by "assimilation" of fragments of the surrounding rock.

The second process also allows the chemical composition of a magma to be profoundly modified. It is called "magma mixing". Indeed, it is not uncommon for a differentiated magma chamber to be re-fed by injections of more "primary" magmas. Often, only a detailed petrographic study can identify the mixtures of magmas. Recent studies indicate that in acid volcanism, these injections of basalt

in superficial chambers are often the cause of eruptions (e.g. Mount Pinatubo 1991).

VI. Gisement des roches magmatiques:

Magmas form at depth and rise towards the surface.

A deposit is the location where the magma has solidified and cooled to form a igneous rock (consolidated). When the magma reaches the surface, a volcano is formed with a volcanic cone composed of lava and pyroclastic deposits (breccia, tuffs and volcanic ash);

A magma that stops at depth gives rise to plutonic and vein Igneous rocks that form intrusion deposits in the form of pluton, sill or vein;

Volcanic rocks that reach the surface undergo rapid cooling, rocks that crystallize at depth undergo slow cooling;

The mode of deposit and the cooling rate of the magma determine the architecture of the ignous rocks (shape of the crystals inside the rocks).