CHAPITER : VI

Classification of Igneous Rocks

I. Introduction:

Igneous rocks are classified according to their mode of formation, their petrographic texture, their chemical composition, and the minerals present, whether in the form of crystals or amorphous glass.

II. Classification of igneous rocks:

1. Genetic classification: According to the mode of emplacement:

- A volcanic or "effusive" rock is produced by the very rapid cooling of magmatic fluid upon contact with air or water (a quenching phenomenon resulting in a hyaline (glassy) rock). These rocks generally do not develop phenocrysts and exhibit varied microlithic textures, with varying amounts of volcanic glass.
- A plutonic or "intrusive" rock is produced by the slow cooling of magma at depth. It exhibits numerous phenocrysts in a more or less significant microlithic paste (matrix), with a grainy texture. Some of these rocks are entirely crystallized.
- A whole range of intermediate rocks exists between these two classical poles. These are referred to as periplutonic or hypovolcanic rocks; these are semi-surface rocks with a micrograined texture, typically vein intrusions.

2. Chemical classification:

For incompletely crystallized rocks, a mineralogical classification can be difficult or even erroneous. It is then simpler to carry out a chemical classification, considering the chemical elements independently of the minerals from which they come. For major elements, the mass percentage of the oxide of a given element is used. For example, for Si, the oxide SiO_2 is used in the classification. For trace elements, the quantity in parts per million (ppm) is used.
The SiO_2 "content" gives an idea of the "acidic" or "basic" character of an igneous rock:

- ❖ An acidic rock is saturated with silica, with 66% or more by weight of silica (SiO_2), resulting in quartz crystals and low iron, magnesium, and calcium contents;
- ❖ An intermediate rock contains between 52% and 66% by weight of silica;
- ❖ A basic rock is undersaturated with silica, with a content between 45% and 52% by weight of SiO_2, resulting in the absence of quartz crystals;
- ❖ An ultrabasic or ultramafic rock contains less than 45% by weight of silica, and is therefore very rich in iron, magnesium, and calcium.

The aluminous or alkaline character of a rock is measured by the ratio of alumina (Al) to the major alkalis (Na, K, Ca).

- ✓ Alkaline rocks with alkali feldspars
- ✓ Calc-alkaline rocks with alkali feldspars and plagioclase
- ✓ Calc-sodic rocks with plagioclase

Note that it is possible to calculate a fictitious mineralogical composition based on chemical analysis, using a CIPW-type framework. The relative proportion of minerals thus estimated is the standard.

3. Classification based on texture:

The texture of a rock is defined by the average grain size and the arrangement of the crystals. It is closely linked to the formation process, reflecting the cooling rate and therefore the depth at which the rock formed.

A. Grainy texture: slow-cooling rocks formed at depth (plutonic rocks + mantle rocks)

- Grainy texture (etym. "grainy") characterizes a holocrystalline rock (fully crystallized) whose minerals are visible to the naked eye (phenocrysts).
- It characterizes rocks formed at depth (examples: gabbro in the oceanic crust, granite in the continental crust), by slow cooling, which allowed the crystals to grow reasonably well.
- Igneous rocks with a grainy texture are called plutonic rocks (intrusive rocks). This term comes from the word pluton, which refers to the deposit of plutonic rocks in the form of large masses intruding into the crust during their formation.

B. Micrograined texture: rocks that cool relatively slowly (vein rocks)

- The micrograined texture characterizes a holocrystalline (fully crystallized) rock in which some of the minerals are invisible to the naked eye (microcrystals), forming a paste. Phenocrysts (visible to the naked eye) may or may not be present.
- It characterizes rocks formed at medium depth (e.g., microgranite in the continental crust), by relatively slow cooling, which allowed the crystals to grow but without reaching a size visible to the naked eye.
- Igneous rocks with a micrograined texture are called microplutonic rocks or vein rocks. Their deposit mode is often a vein, a flat tongue measuring a few centimeters to tens of centimeters.

C. Microlitic texture: rapidly cooling rocks formed on the surface (volcanic rocks)

- The microlitic texture characterizes a hemicrystalline rock (partly crystallized) with crystals visible to the naked eye (phenocrysts), microcrystals, often in rod-like forms, visible only under a microscope (microlites), and a non-crystallized mass (glass) containing the crystals.
- It characterizes rocks formed at shallow depths (examples: basalts in the oceanic crust, andesites or trachytes at continental level), by rapid cooling, which explains why part of the mass did not have time to form crystals.

- Magmatic rocks with a microlitic texture are called volcanic rocks (effusive rocks). They are emitted in the form of lava that solidifies on the surface by structures called volcanoes.

Note:
There are even rocks composed entirely of glass (vitreous texture), such as obsidians. These are volcanic rocks that cooled extremely abruptly.
Ultrabasic rocks or ultramafic rocks are mantle rocks.

4. Mineralogical classification:

Mineralogical classification is more expressive than chemical classification and allows for broad classification of rocks. There are two types of mineralogical classification:

A. Qualitative aspect:

Igneous rocks contain a wide variety of minerals, but the predominance of basalts and granites has led geologists to establish a classification system that takes into account a few minerals, which are classified into four groups:

- Cardinal minerals: These determine the major groups of the classification. These are quartz, feldspars, and feldspathoids.
- Essential minerals: These complete the definition of the rock and determine second-order divisions. These are generally ferromagnesian elements.
- Accessory minerals: These are not included in the classification but are consistently present in the rock, most often in small quantities (apatite, zircon, etc.). □ Accidental minerals: They are only present in certain particular types of rocks (garnets, corundum, etc.).

B. Quantitative Aspect:

Despite wide variations in silica and other oxides, and since there is a simple correlation between the chemical and mineralogical composition of these igneous rocks, the minerals in these rocks can be divided into two main groups:

- Light-colored minerals: These are represented by quartz, potassium feldspars, plagioclases, feldspathoids, and white micas. Rocks of this type are acidic and are mainly represented on the Earth's surface by granites. Lavas of the same chemical composition are rhyolites.
- Colored minerals: These are olivines, pyroxenes, amphiboles, black micas, and iron and titanium oxides.

This type of rock is basic. It represents the most widespread category of igneous rocks. Their most common type is basalt. The plutonic equivalent is gabbro.

To these two major groups must be added purely plutonic rocks, formed entirely of colored minerals. They are subdivided into peridotites, pyroxenites, and amphibolites according to the nature of the predominant mineral (Olivine, Pyroxene, Amphibole).

Between acidic and basic rocks, there are also rocks of intermediate mineralogical and chemical composition, containing roughly equal proportions of light-colored and colored minerals. These are represented by volcanic rocks, andesites, and their plutonic equivalents, diorites.

In this classification method, the exact proportions of minerals in the rock are quantitatively examined. These are measured using special instruments.

The transition from chemical classification to mineralogical classification is easy thanks to the P standard. Indeed, unlike plutonic rocks, the mineralogy of volcanic rocks does not allow direct access

to mineralogical classification because of the glassy phase; it is therefore necessary to use a bias called "calculation of the standard".

Based on this standard, the parameters that lead to the rock's classification and nomenclature are defined. These are:

- ✓ The class, determined by the ratio: **P = coupholites/barylites (in %).**

Coupholites are light-colored, silico-aluminous minerals, and barylites are dark, ferro-magnesian minerals.
Based on this P parameter, which is linked to the rock's visible color to the naked eye, five groups are distinguished:

- ❑ Hololeucocratic rocks: P > 95%
- ❑ Leucocratic rocks: P = 65 to 95%
- ❑ Mesocratic rocks: P = 35 to 65%
- ❑ Melanocratic rocks: P = 5 to 35%
- ❑ Holomelanocrat rocks: P < 5%

- ✓ The order, given by the ratio Q1 or Q2 with:

Q1 = quartz/feldspars and Q2 = feldspathoids/feldspars (in %).