Chapter 1: The earth's crust materials

Part 2 : Rocks - Magmatic rock

1. 2. Rocks

1.2.1 Definitions and major rock types

A rock is a material formed by a natural aggregate of minerals, fossils, and/or elements of other rock(s).

Petrography (from the Greek petra= stone, and graphê= to describe) is the science of describing and analyzing rocks.

Petrology is the science that studies the formation and transformation of rocks.

Classification

- **By origin**

Rocks are classified according to their composition, origin or mode of formation; firstly, into three main categories:

- magmatic rocks (also called igneous or eruptive), formed by the solidification of magmas : volcanic or extrusive or effusive rocks, cooled suddenly at the surface after a volcanic eruption, plutonic or intrusive rocks, which cooled at depth, slowly and without degassing in the magma chamber; vein or hypoabyssal (hypabyssal) rocks, intermediate between extrusive and intrusive rocks, and having undergone partial degassing..
- sedimentary rocks, formed on the earth's surface or in the seas by the layered accumulation of materials under the action of exogenous agents, such as wind, water or the external skeletons of small aquatic organisms;
- metamorphic or crystallophyllous rocks, formed by the recrystallization (and generally deformation) of sedimentary or magmatic rocks. This occurs under the action of temperature and pressure, which increase with depth in the earth's crust, or in contact with other rocks and lava.

- **According to their properties**

- Hardness

Rocks can also be classified into three types, according to their properties:

- loose rocks such as sand or clay; les roches meubles comme le sable ou l'argile

- friable rocks such as chalk;
- coherent rocks such as granite.

Rocks vary enormously in hardness. Talc and gypsum have a very low index and erode very easily. Corundum and diamond, on the other hand, are among the hardest rocks.

CF. The Mohs scale of mineral hardness is a qualitative ordinal scale, from 1 to 10, characterizing scratch resistance of minerals through the ability of harder material to scratch softer material. (CF. Pratical Work)

➢ **Homogeneity**

Coherent rocks : "stone" ;

Plastic rocks : "clays"

Loose rocks : " granite arena ", " sand"

Fluid rock = liquid : "oils", petroleum

Fluid rocks = gaseous: "gases".

➢ **Based on mineral composition**

- Monomineral rocks: composed of a single predominant mineral, e.g. pure limestone.
- Pluri-mineral rocks: aggregates of several minerals, e.g. granite

1.2.2. Magmatic rock

Magmatic rocks result from the solidification (crystallization, cooling) of magma. Magma is a fused silicate bath, made up of a liquid phase (the most important), a solid phase (crystals) and a gaseous phase (0.1- 3%). Depending on how the magma cools, there are two types of magmatic rock:

- Plutonic rocks: formed by the slow cooling of magma at depth. The magma will have time to crystallize, and the rock will contain large minerals visible to the naked eye.
- Volcanic rocks, formed by the rapid cooling of magma at the surface. The minerals will not have time to crystallize properly. Volcanic rocks, are therefore characterized by the presence of minerals invisible to the naked eye.
- Texture of magmatic rocks
- The texture (sometimes called structure) of a magmatic rock is the term used to describe the dimensions, shape and arrangement of minerals in magmatic rocks. The main textures are as follows:

- Grainy texture (or phaneritic) : refers to magmatic rocks whose minerals are visible to the naked eye (large in size). This is the case with plutonic rocks.
- Microlithic texture (or aphanitic) : refers to magmatic rocks with no crystals visible to the naked eye. This is the case of volcanic rocks.
- Vitreous texture: refers to magmatic rocks that are entirely or largely composed of vitreous material. This is the case for magmatic rocks that have cooled very rapidly (usually under water).
- Porphyry texture: refers to magmatic rocks with large minerals (phenocrysts) in the middle of an aphanitic or vitreous texture. This is the case for magmatic rocks that have undergone two cooling processes (slow and rapid).

Fig. 6 Texture of magmatic rocks

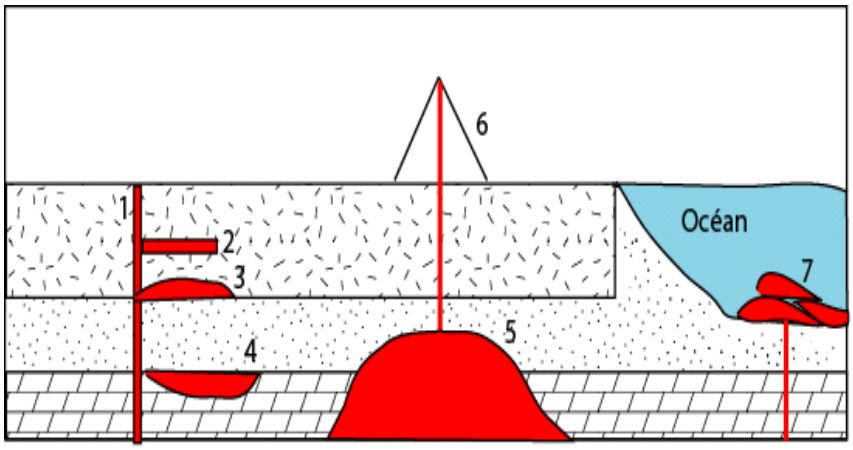


Fig. 7 How magmatic rocks are formed

1 : dyke ; 2 : sill ; 3 : laccolite ; 4 : lopolite ; 5 : batholite ; 6 : volcano ; 7 : Pillow-Lavas

Types of magma

Types are determined by their chemical composition, temperature, gas content and viscosity (resistance to flow).

There are three main types of magma:

1- Basic or basaltic magmas: 45-55% SiO_2, rich in Fe, Mg, Ca, poor in K, Na. The temperature of these magmas: 1000 - 1200°C. Low gas content and low viscosity.

2- Intermediate or andesitic magmas: 55-65% SiO_2, intermediate in Fe, Mg, Ca, K, Na. Temperature of these magmas: 800 - 1000°C. Intermediate gas content and viscosity.

3- Acidic or rhyolitic magmas: 65-75% SiO_2, poor in Fe, Mg, Ca, rich in K, Na. Temperature of these magmas: 600 - 800°C. Gas-rich and highly viscous.

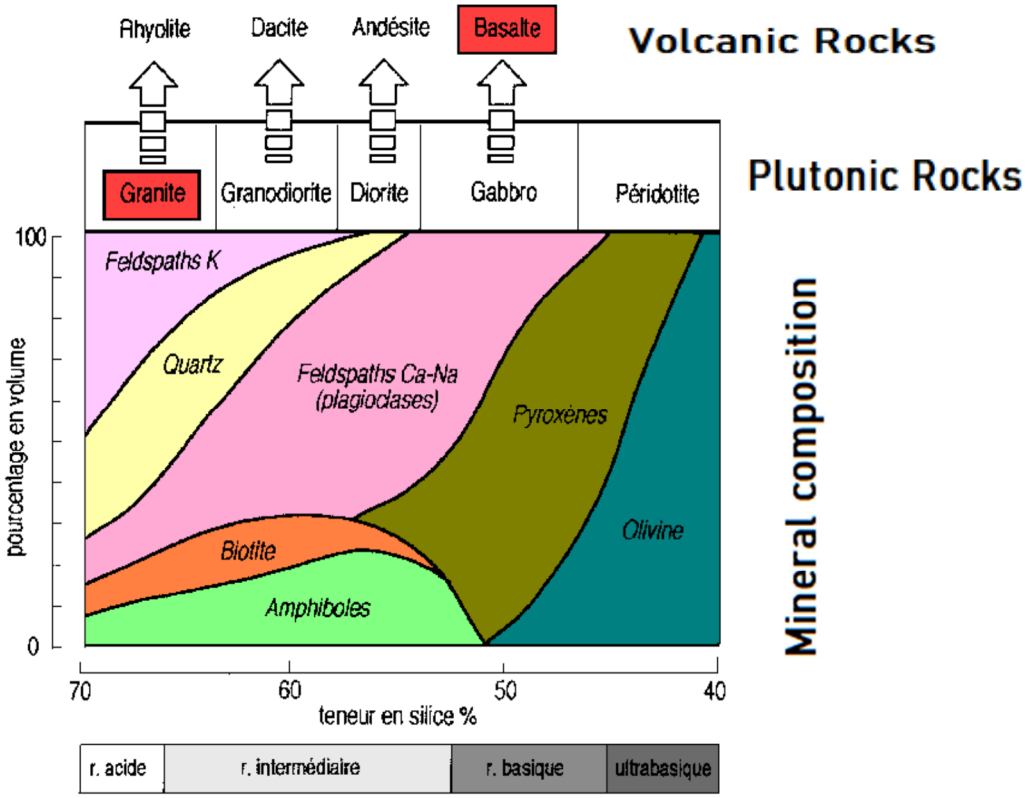
Around 80% of magmas emitted by volcanoes are basaltic, and andesitic and rhyolitic magmas each account for ~10% of the total.

Difference between magma and lava: lava is the liquid separated from the gas (degassed magma).

A simplified classification of magmatic rocks is based on texture (volcanic or plutonic rock), chemical composition and mineralogy (table). In terms of chemical composition, magmatic rocks are essentially composed of oxygen and silicon (these two elements make up over 70% of the chemical composition of magmatic rocks), expressed as a percentage of silica (SiO_2). A distinction is made between :

- Acid rocks : $SiO_2 > 65\%$. Example: granite.
- Intermediate rocks : $52\% < SiO_2 < 65\%$. Example: andesite.
- Basic rocks : $45\% < SiO_2 < 52\%$. Example: basalt.
- Ultrabasic rocks: $SiO_2 < 45\%$. Example: peridotite.

In terms of mineralogy, magmatic rocks are mainly composed of quartz, feldspars (alkali and plagioclase), olivine, pyroxenes, amphiboles and micas.


Rhyolite
Dacite
Andésite
Basalte
Volcanic Rocks
Granite
Granodiorite
Diorite
Gabbro
Péridotite
Plutonic Rocks
100
0
pourcentage en volume
Feldspaths K
Quartz
Feldspaths Ca-Na
(plagioclases)
Pyroxènes
Olivine
Biotite
Amphiboles
Mineral composition
70
60
50
40
teneur en silice %
r. acide
r. intermédiaire
r. basique
ultrabasique