MINERALOGICAL COMPOSITION OF IGNEOUS ROCKS

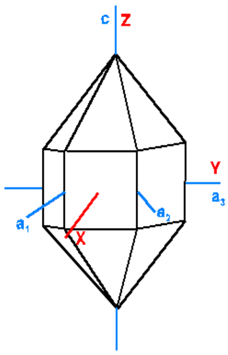
The common igneous rocks are composed usually of three to six-phase combinations of a few widely distributed minerals. These <u>essential constituents</u> are: feldspars, quartz, pyroxenes, amphiboles, micas, olivines, felspathoides and glass. <u>The accessory minerals</u> occurring in amounts less 5% contain the elements excluded from on not completely accommodated in the principal phases (apatite, sphene, zircon, rutile, etc.).

The other division is based on colour of minerals. Felsic minerals are light and of relatively low density, about 2.5 – 2.7 (quartz, feldspars, feldspehoids). Mafic minerals are dark and with densities mostly from 3.0 to 3.6 (olivines, pyroxnes, amphiboles, biotite).

Apart from the above mentioned <u>primary minerals</u>, crystallizing directly during the magmatic processes, there is the group of the <u>secondary minerals</u>, formed during the postmagmatic deuteric processes or simply during the weathering. Their list includes: sericite, kaolinite, chlorite, epidote, chalcedony, calcite, Fe-hydroxides, etc.

There is the short list of more important minerals below, together with their chemical formulas and short characteristic:

Quartz SiO_2



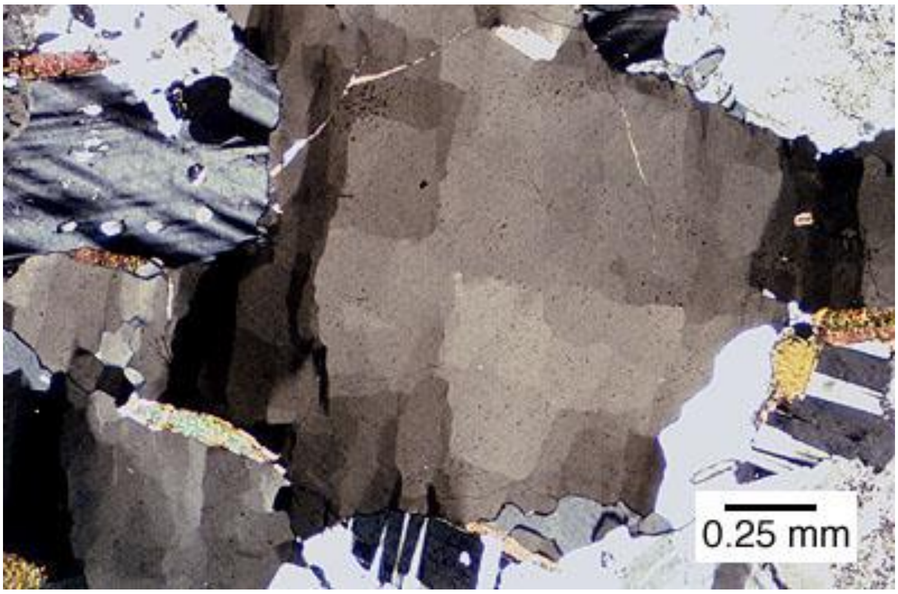
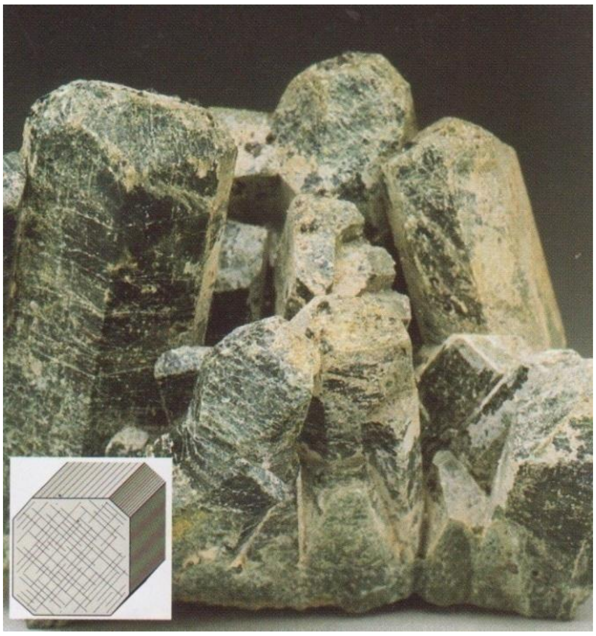
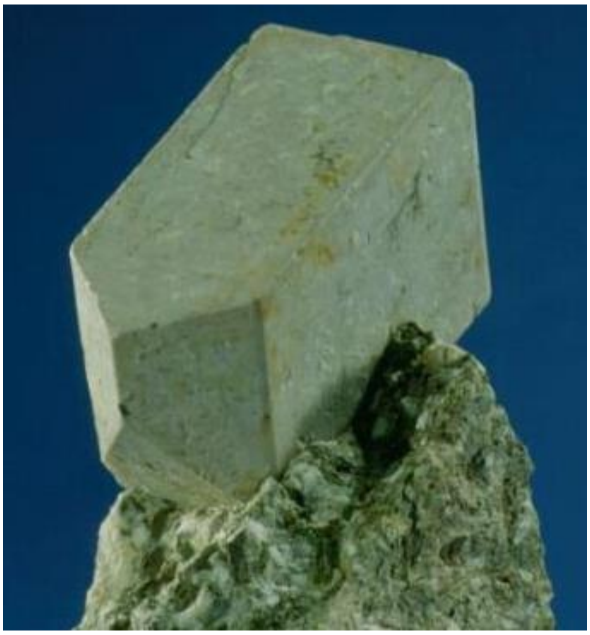


Figure 37 *Quartz*

Feldspars

K-feldspars and Na/Ca-feldspars (plagioclases) sanidine – anorthoclase (K, Na) ($AlSi_3O_8$) – (Na, K) (Si_3O_8) disordered high-temperature varieties, monoclinic at the potassic and triclinic towards the sodic end,





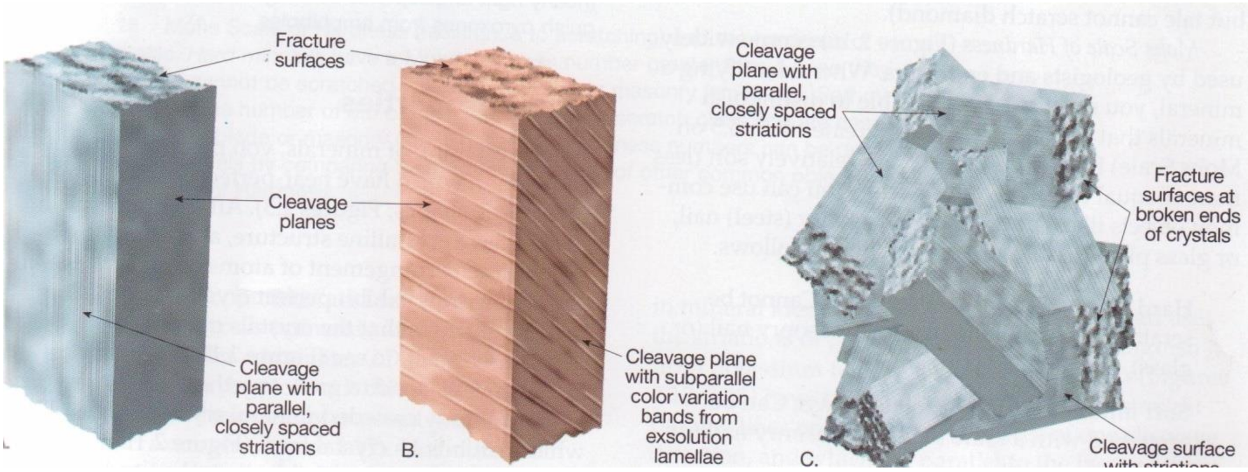


Figure 38 *Feldspars*

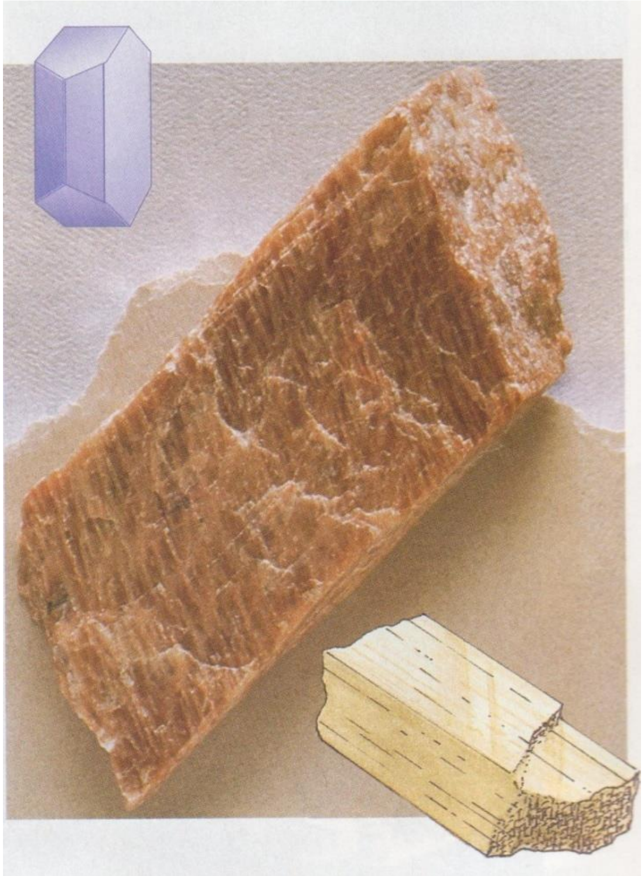
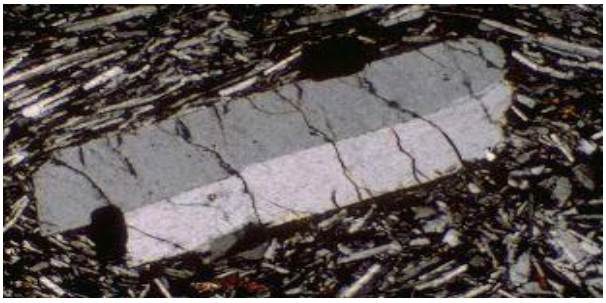


Figure 39 *Potassium (K) feldspar exhibiting two directions of cleavage at* 90^0



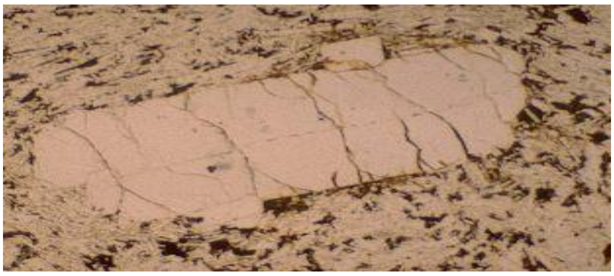


Figure 40 Plagioclase feldspar showing twining

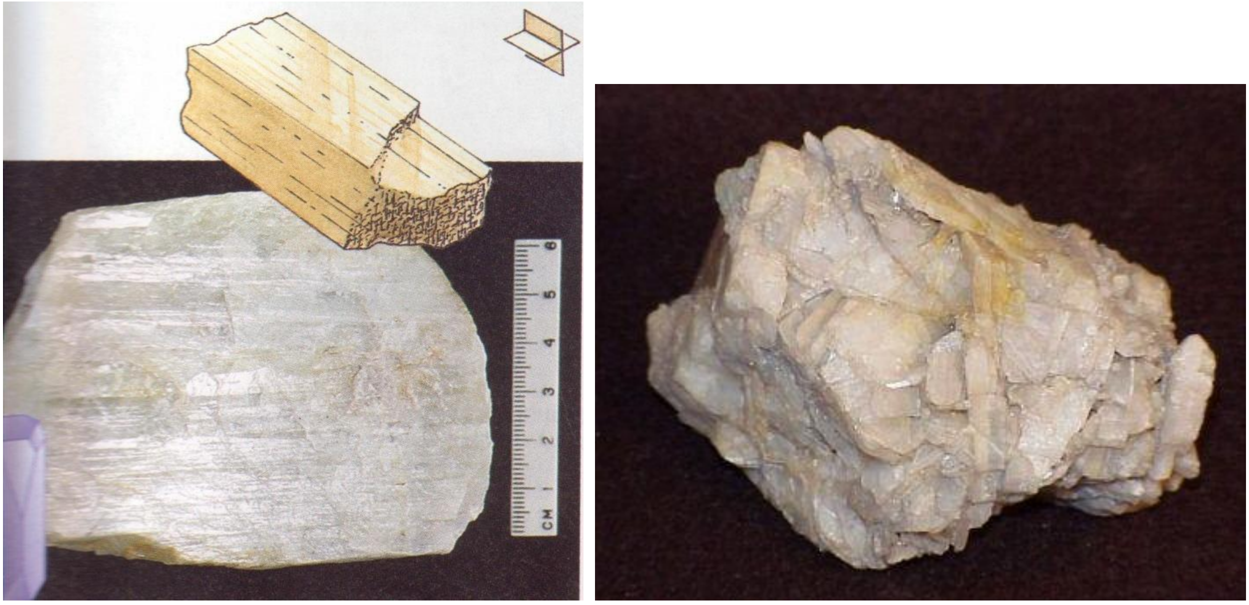


Figure 41 Plagioclase feldspar

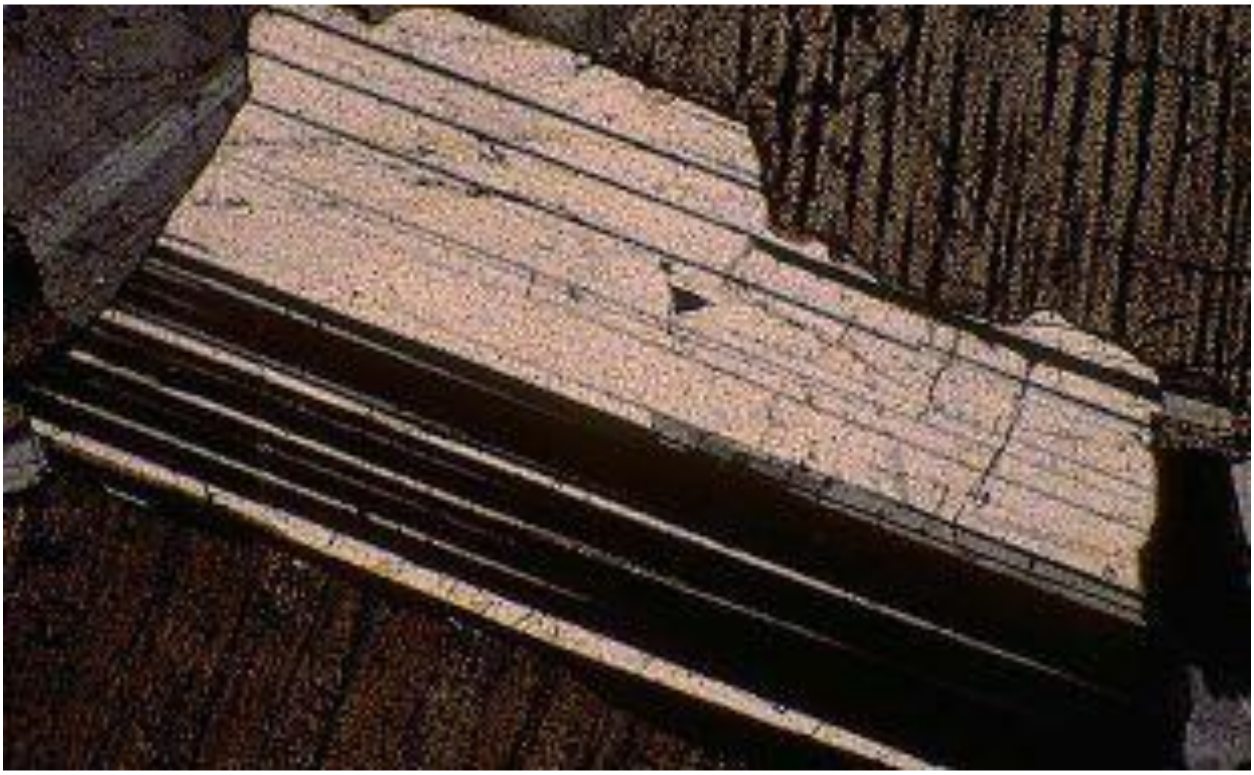


Figure 42 Plagioclase feldspar showing twining

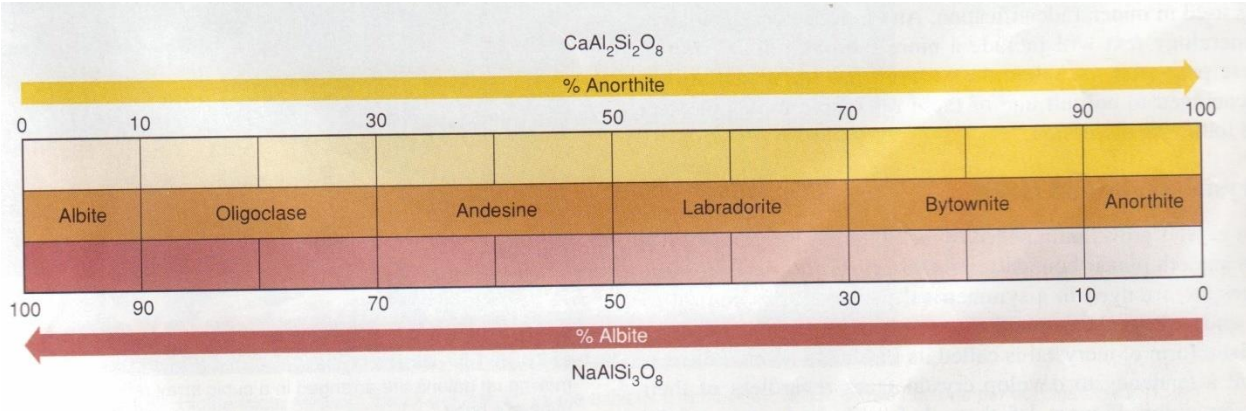


Figure 43 Plagioclase series

Feldspathoids

Olivines

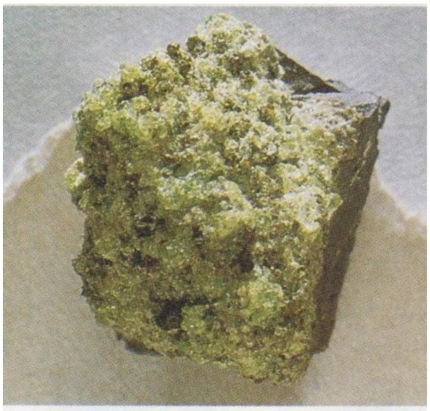


Figure 44 *Olivine*

Pyroxenes

orthopyroxenes $(Mg,Fe)_2(Si_2O_6)$, namely enstatite, bronzite, hypersthene, up to 50% of Fe-molecule.

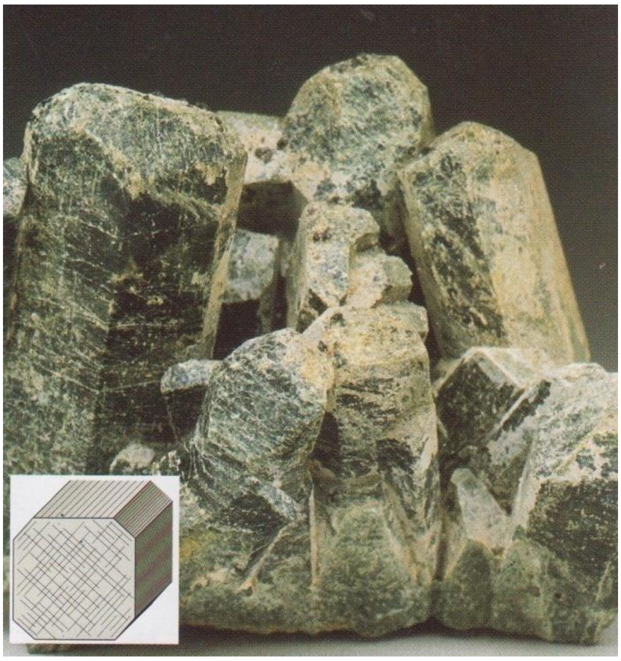


Figure 44 *Pyroxene*

clinopyroxenes of mainly augite-pigeonite group (Ca-Mg-Fe, sometimes also with Ti), sometimes aegirines (Na-Fe bearing).

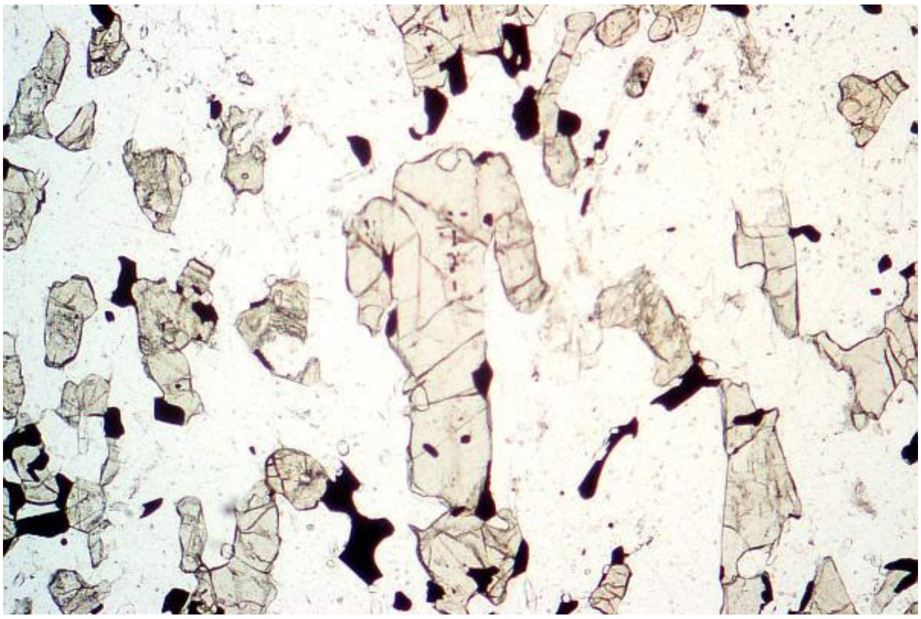


Figure 45 *Augite in thin section*

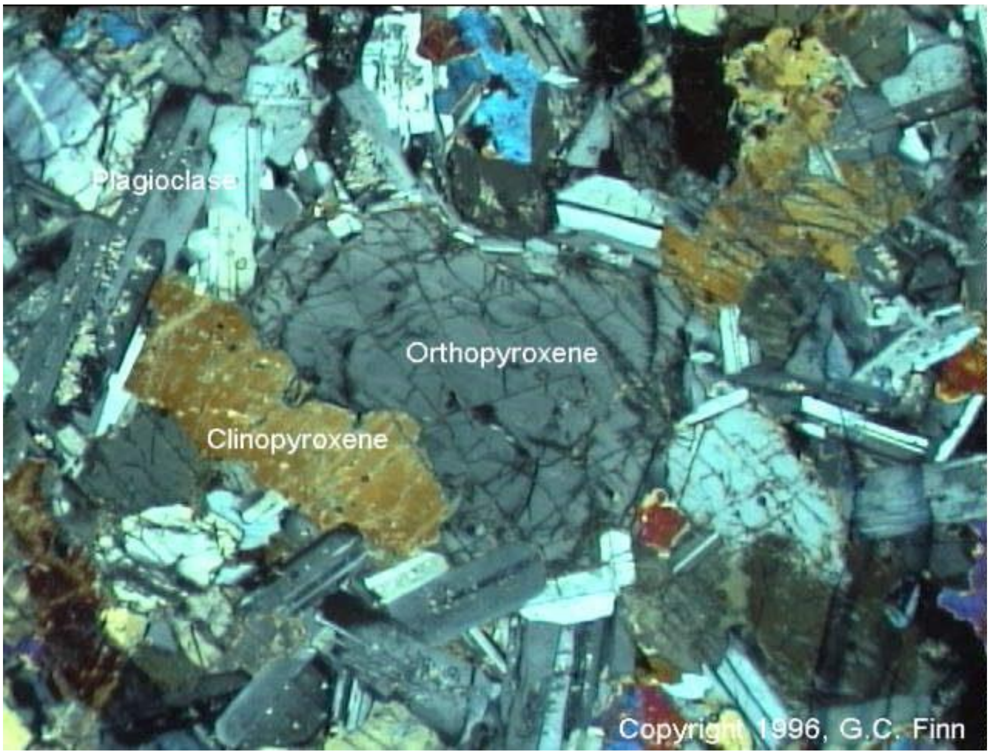


Figure 46 *Pyroxenes in thin section*

Amphiboles

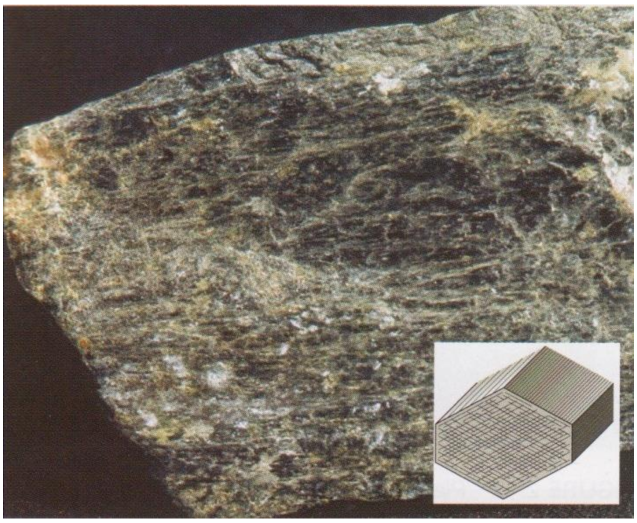


Figure 47 *Amphibole*

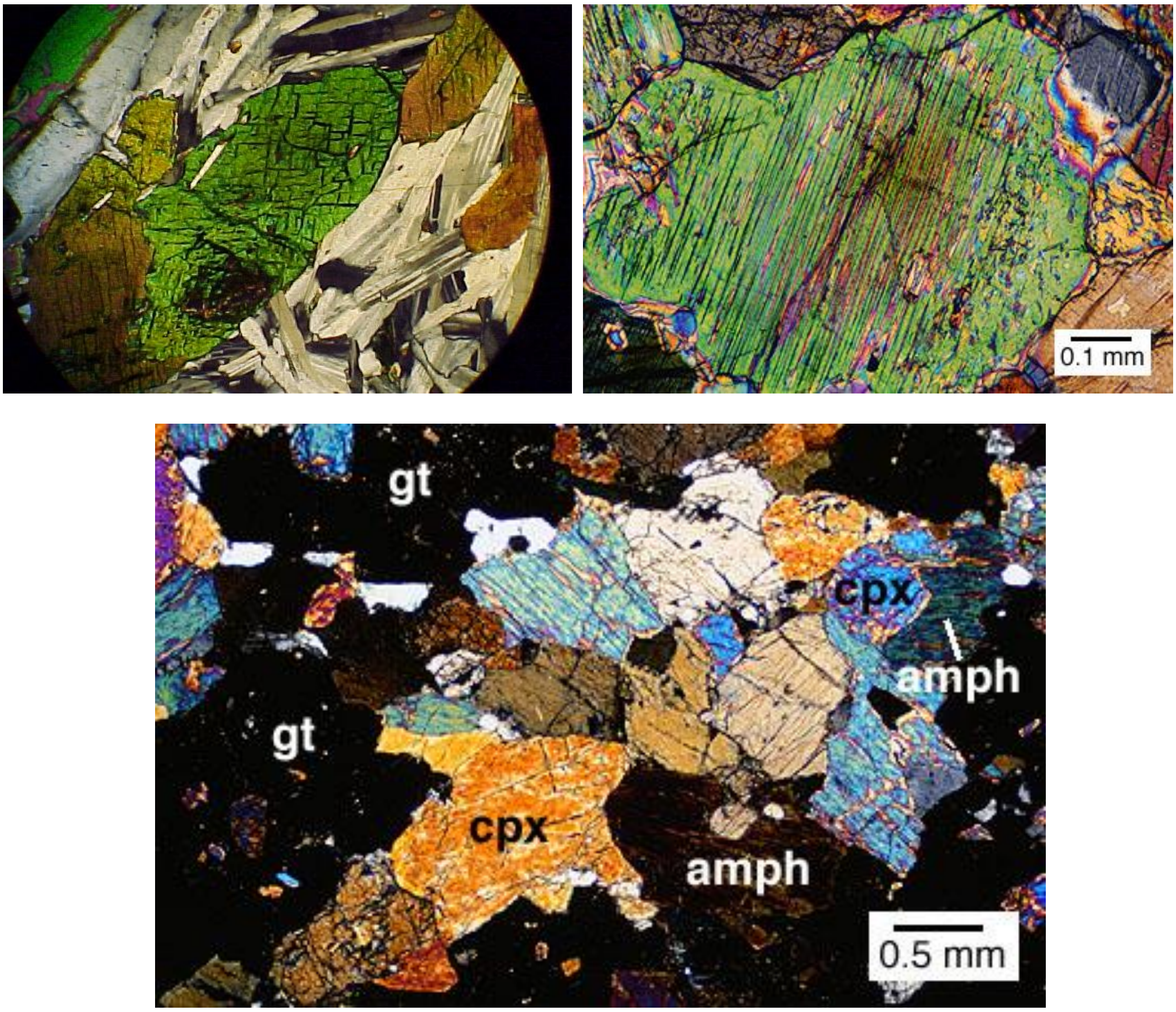


Figure 48 *Amphibole in thin section*

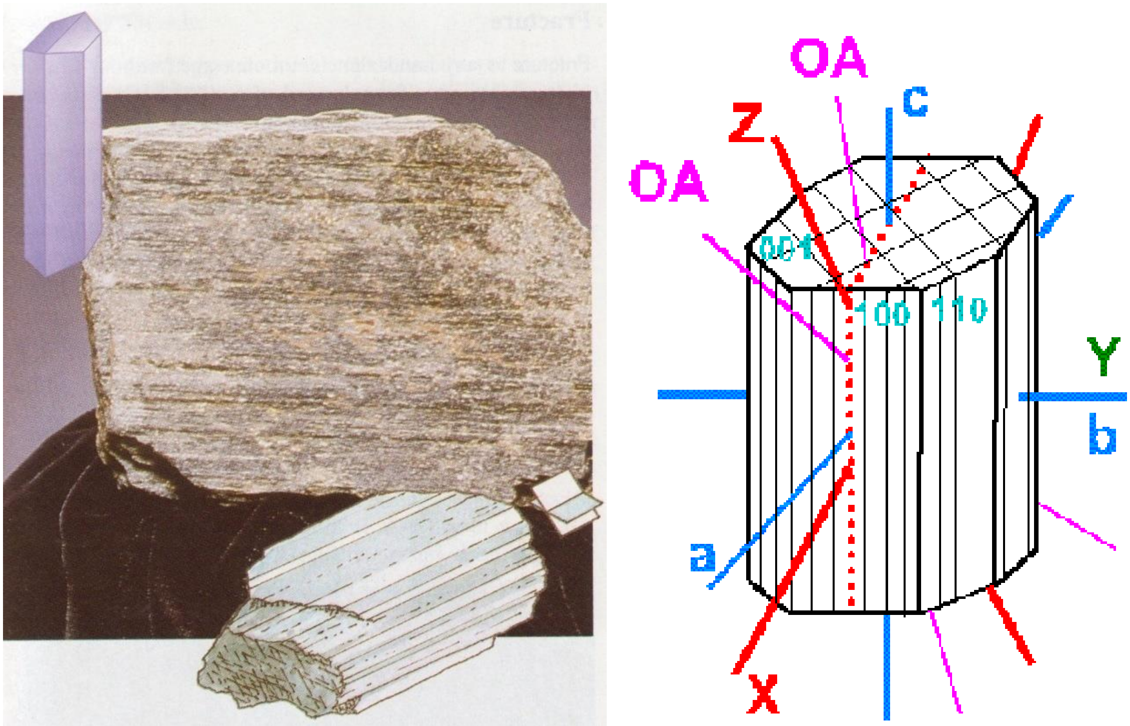


Figure 49 *Hornblende specimen and crystal*

hornblendes Na = Ca = Mg = Fe bearing and Ti-rich variety kaersutite

Micas

biotite $K(Fe,Mg)_3(AlSi_3O_{10})\ (OH)_2$

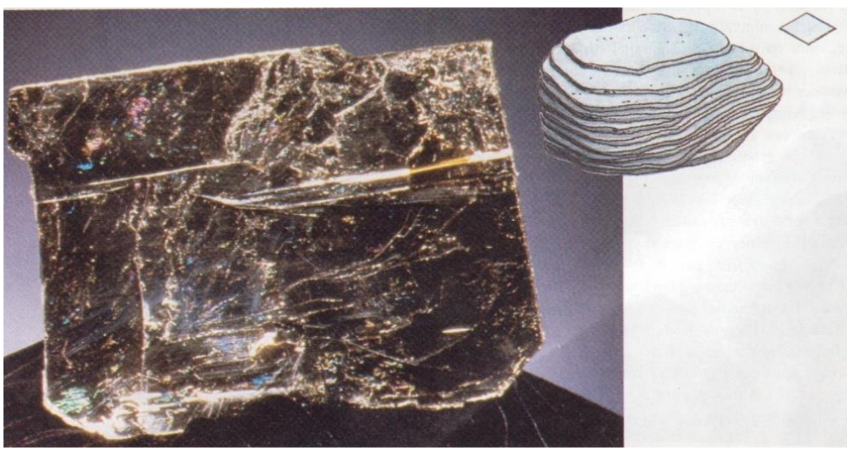


Figure 50 *Biotite specimen*

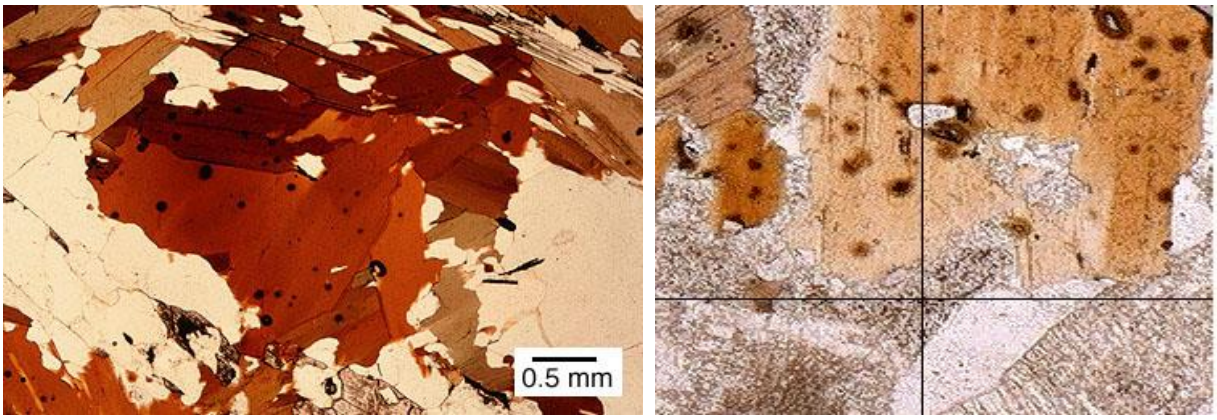


Figure 51 *Biotite in thin section*

Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$

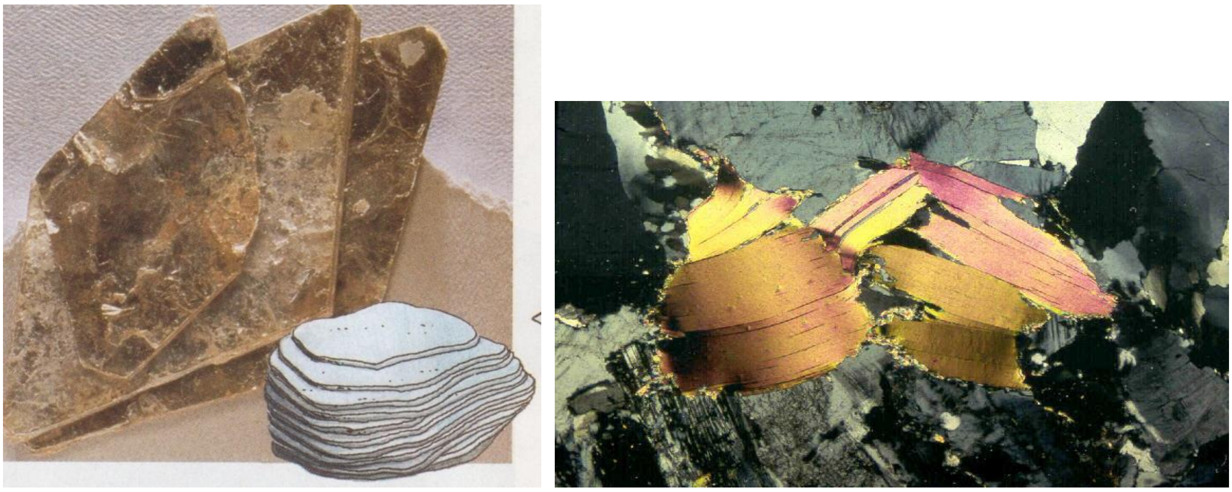


Figure 52 *Muscovite specimen and in thin section*

Glass

Figure 53 *Glass*

UNIT 4

Textures of Igneous Rocks

The main factor that determines the texture of an igneous rock is the *cooling rate* (dT/dt).

Other factors involved are:

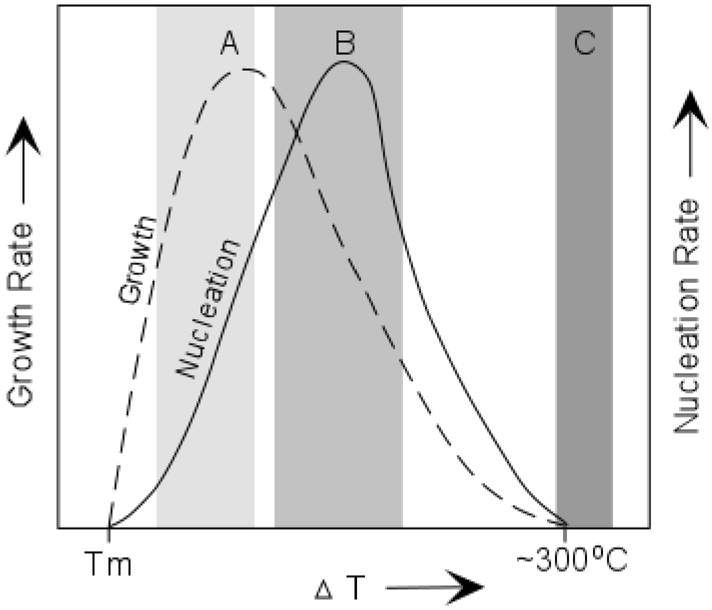
- The diffusion rate - the rate at which atoms or molecules can move (diffuse) through the liquid.
- The rate of nucleation of new crystals - the rate at which enough of the chemical constituents of a crystal can come together in one place without dissolving.
- The rate of growth of crystals - the rate at which new constituents can arrive at the surface of the growing crystal. This depends largely on the diffusion rate of the molecules of concern.

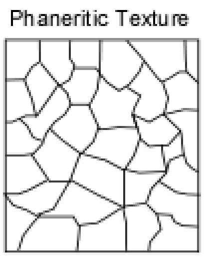
Figure 54 *Grain size, from left to right,coarse grain, medium grain and fine grain*

In order for a crystal to form in a magma enough of the chemical constituents that will make up the crystal must be at the same place at the same time to form a *nucleus* of the crystal. Once a nucleus forms, the chemical constituents must diffuse through the liquid to arrive at the surface of the growing crystal. The crystal can then grow until it runs into other crystals or the supply of chemical constituents is cut off.

All of these rates are strongly dependent on the temperature of the system. First, nucleation and growth cannot occur until temperatures are below the temperature at which equilibrium crystallization begins. Shown below are hypothetical nucleation and growth rate curves based on experiments in simple systems. Note that the rate of crystal growth and nucleation depends on how long the magma resides at a specified degree of undercooling (DT = T_m - T), and thus the rate at which temperature is lowered below the the crystallization temperature. Three cases are shown.

1. For small degrees of undercooling (region A in the figure to the right) the nucleation rate will be low and the growth rate moderate. A few crystals will form and grow at a moderate rate until they run into each other. Because there are few nuclei, the crystals will be able to grow to relatively large size, and a coarse grained texture will result. This would be called a *phaneritic texture*.





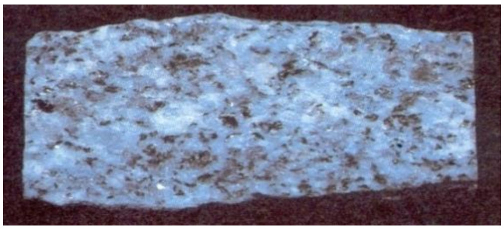


Figure 55 *Phaneritic texture ,coarse grained*

2. At larger degrees of undercooling, the nucleation rate will be high and the growth rate also high. This will result in many crystals all growing rapidly, but because there are so many crystals, they will run into each other before they have time to grow and the resulting texture will be a fine grained texture. If the size of the grains are so small that crystals cannot be distinguished with a handlens, the texture is said to be *aphanitic*.

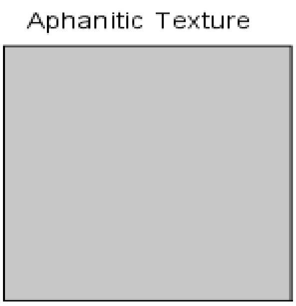


Figure 56 *Aphanitic texture, fine grained*

3. At high degrees of undercooling, both the growth rate and nucleation rate will be low. Thus few crystals will form and they will not grow to any large size. The resulting texture will be glassy, with a few tiny crystals called microlites. A completely glassy texture is called *holohyaline texture*.

Two stages of cooling, i.e. slow cooling to grow a few large crystals, followed by rapid cooling to grow many smaller crystals could result in a *porphyritic texture*, a texture with two or more distinct sizes of grains. Single stage cooling can also produce a porphyritic texture. In a porphyritic texture, the larger grains are called *phenocrysts* and the material surrounding the the phenocrysts is called *groundmass* or *matrix*

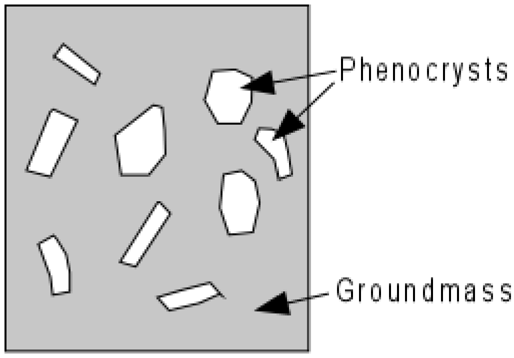


Figure 57 *Porphyritic texture*

In a rock with a phaneritic texture, where all grains are about the same size, we use the grain size ranges shown to the right to describe the texture:

<1 mm	fine grained
1 - 5 mm	medium grained
5 - 3 cm	coarse grained
> 3 cm	very coarse grained

In a rock with a porphyritic texture, we use the above table to define the grain size of the groundmass or matrix, and this table to describe the phenocrysts:

0.03 - 0.3 mm	microphenocrysts
0.3 - 5 mm	phenocrysts
> 5 mm	megaphenocrysts

Another aspect of texture, particularly in medium to coarse grained rocks is referred to as fabric. *Fabric* refers to the mutual relationship between the grains. Three types of fabric are commonly referred to:

1. If most of the grains are *euhedral* - that is they are bounded by well-formed crystal faces. The fabric is said to be *idomorphic granular*.

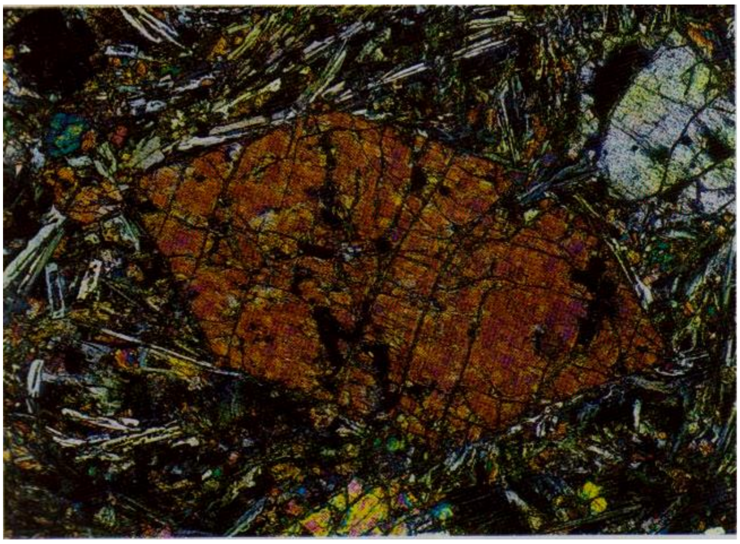


Figure 58 *Euhedral crystal*

2. If most of the grains are *subhedral* - that is they bounded by only a few well-formed crystal faces, the fabric is said to be *hypidiomorphic granular*.

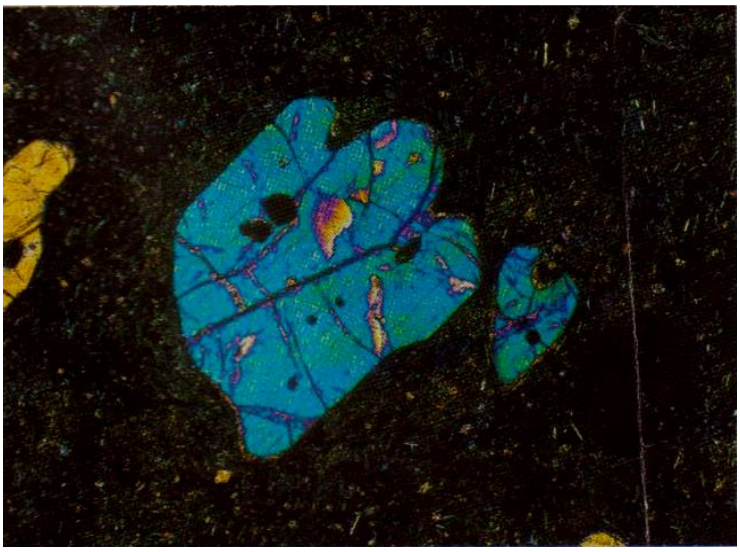


Figure 59 *Subhedral crystal*

3. If most of the grains are *anhedral* - that is they are generally not bounded by crystal faces, the fabric is said to be *allotriomorphic granular*.

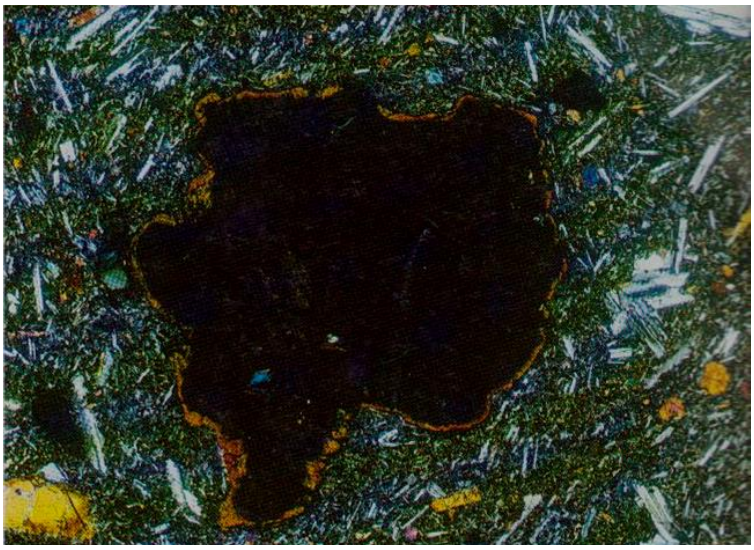


Figure 60 *Anhedral crystal*

If the grains have particularly descriptive shapes, then it is essential to describe the individual grains. Some common grain shapes are:

- ***Tabular*** - a term used to describe grains with rectangular tablet shapes.

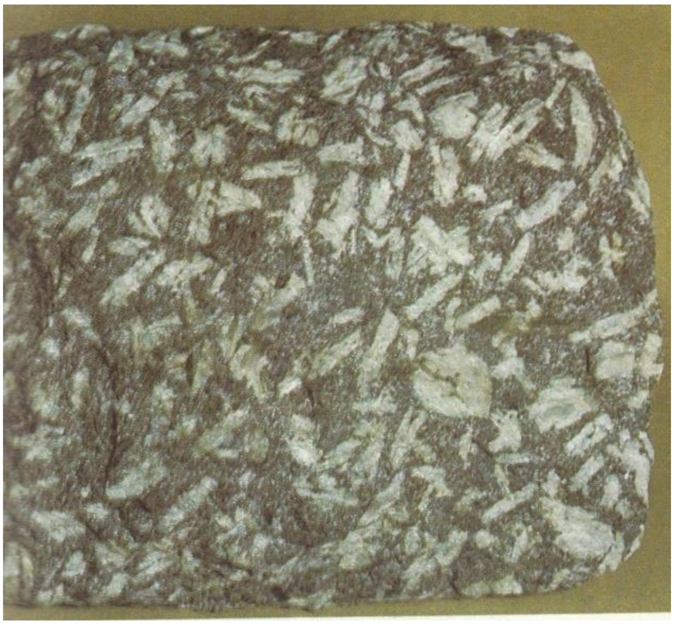


Figure 61 *Tabular crystal*

- ***Equant*** - a term used to describe grains that have all of their boundaries of approximately equal length.

- ***Fibrous*** - a term used to describe grains that occur as long fibers.
- ***Acicular*** - a term used to describe grains that occur as long, slender crystals.
- ***Prismatic*** - a term used to describe grains that show an abundance of prism faces.