TEXTURES OF IGNEOUS ROCKS

Today, Geologist working with igneous rocks has to apply a wide range of skills, including the analysis of field relationships, hand – specimen identification in the field, description and interpretation of thin sections, the quantitative interpretation of rock and mineral analyses, the interpretation of experimental equilibria, phase diagrams and structures and textures of igneous rocks.

Therefore textures of igneous rocks play a significant role in determining the identification of rocks.

The 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 sufficient 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.

So what are Textures of Igneous Rocks….

The term texture is defined as the mutual relationship of different mineralogical constituents in a rock. It is determined by the size, shape and arrangement of mineral grains in a rock. The grain size of an igneous rock depends on the rate of cooling of the magma. In general, slower is the rate of cooling, the coarser is the grain of the rock.

In the study of the texture four points are considered. They are,

- Degree of crystallization
- Granularity or Size of grains
- Shape of crystals
- Mutual relationship between mineral grains

Degree of crystallization

In igneous rocks crystallanity ranges from entirely of Crystals to entirely of Glass. And they are described on following scale.

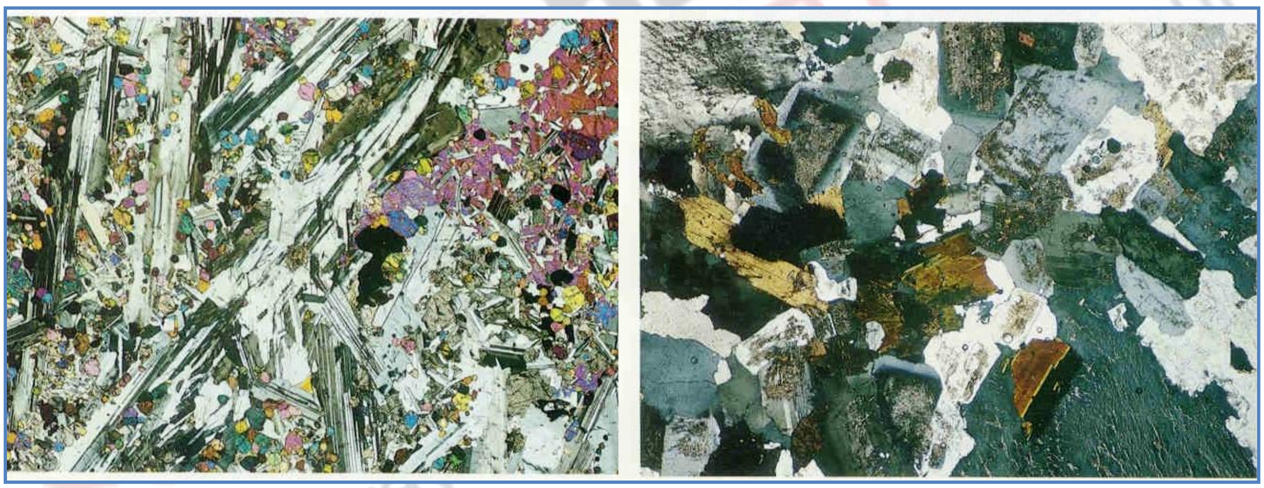
CRYSTALLANITY

HOLOCRYSTALLINE (entirely made up of crystals)

MEROCRYSTALLINE (partly crystals & partly glass)

HOLOHYALLINE (completely glass)

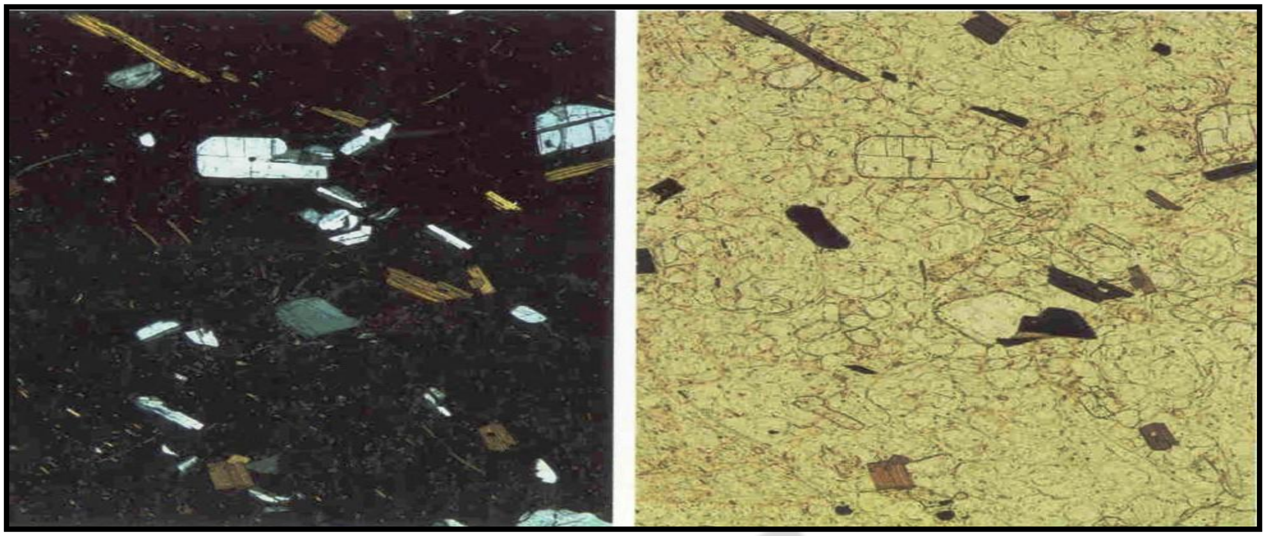
(i) Holocrystalline: when a rock is made up entirely of crystals, it is described as holocrystalline



For example,

This figure shows Holocrystalline anorthositic gabbro*, where Elongate crystals of plagioclase feldspar, some wrapped round olivine Crystals, form a framework in this rock, the interstices of which are filled with smaller plagioclase, olivine and augite crystals. The purplish-blue area at the top right of this photograph is an augite crystal which includes a number of small plagioclase and olivine crystals. Magnification x7. XPL.*

(ii) Holohyalline: when a rock is composed entirely of glassy material, it is called holohyalline.



(iii) Merocrystalline: when a rock is composed partly of crystals and partly of glass, called merocrystalline or hypocrycrystalline

Hypocrystalline pitchstone with perlitic cracks: *Crystals of plagioclase, biotite and magnetite in the rock are set in glass (black in XPL) which has spherical fractures known as perlitic cracks, these appear as circles in thin section. Magnification x 20, XPL, PPL.*

Granularity or Size of grains

It defines the grain size of various components of a rock. The size of grains in an igneous rock varies considerably. The slow cooling gives crystals time to grow to sizes greater than 5 mm. whereas in rapid cooling mineral grains crystallize quickly as mass of tiny crystals which are generally less than 1 mm in size. In some lavas, the cooling is so rapid and so they fail to crystallize and "glassy texture" results.

GRANULARITY

PHANERITIC (Grains distinguishable with naked eye)

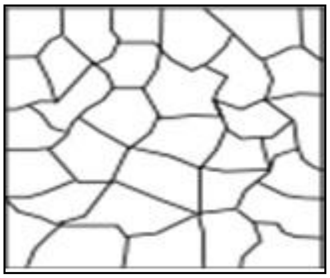
- Coarse >5mm
  Ex. Pegmatite
- Medium 1-5mm
  Ex. Granite

APHANITIC (grains not visible with naked eye)

CRYPTOCRYSTALLINE (not visible even with microscope)

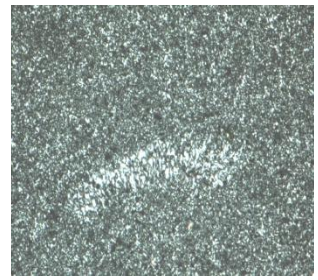
→ Fine < 1 mm

Aplite



Phaneritic

Aphanitic



Cryptocrystalline

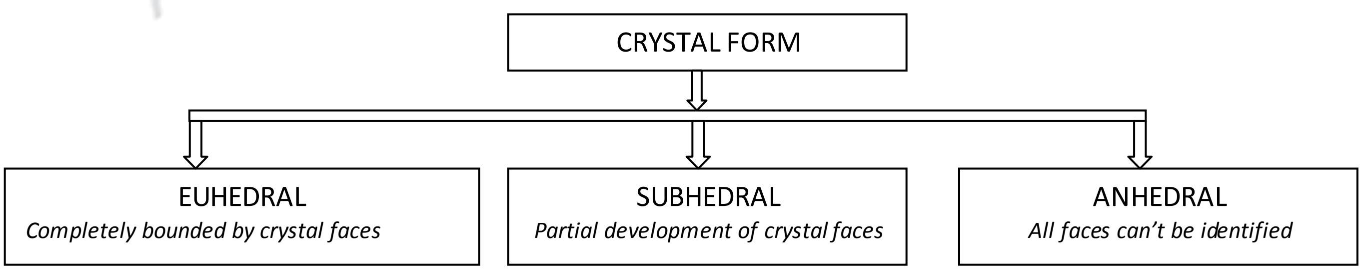
Phaneritic: It means that the size of matrix grains in the rock is large enough to be distinguished with the unaided eye.

Aphanitic: If the size of the grains in the rock is so small that crystals cannot be distinguished with naked eye, but can be identified with help of microscope.

Cryptocrystalline: The size of the grains of the rock are too small that cannot be distinguished even with microscope, so the rocks possessing this character is said to be cryptocrystalline.

Shape of the crystal

It describes the dimensions of the grains that denote their boundary characteristics with respect to their crystals. And they are classified as,



- Euhedral : If most of the grains are euhedral, that is they are bounded by well-formed crystal faces.
- Subhedral : If most of the grains are subhedral , that is they bounded by only a few well-formed crystal faces.
- Anhedral : If most of the grains are anhedral, that is they are generally not bounded by crystal faces.

They are developed under two heading.

(i) With reference to their perfection of their crystal face.

(ii) With reference to their relative development of crystals in 3 direction of space.

(A) Perfection of crystal face and crystal form.

They are described with reference to the development of their faces.

(B) Crystal shape

They are described with reference to their relative dimension in the three direction of the shape.

(a) Crystals equally developed in all the three direction. They are referred as equidimensional crystals. They form equal, granular and blocky.

(Ex) Polyhedral crystals of garnet, leucite, augite etc.

(b) Crystals better developed in the two directions than third. They are referred as tabular and sheets. They form plate tables, flakes and scale.

(c) Crystals better developed in one direction with reference to the other two they are referred as prismatic .they form columns prisms, rods, needles fibres etc. (eg) hornblende,tourmaline, sillumanite etc

Degrees to which the crystals exhibits crystals out line depends upon its place in the order of crystallization

The following rule helps in determining the order of crystallization

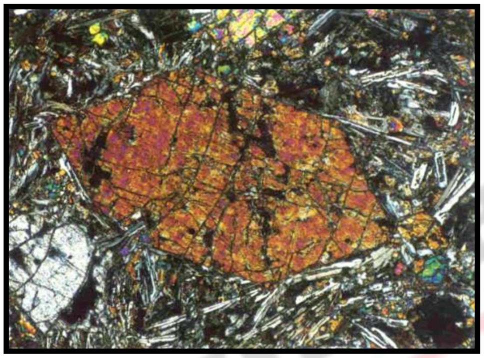
(1) if a mineral x is surrounded by mineral y the enclosing mineral y is generally younger

(2) Early formed crystals are generally euhedral or more nearly than the larger crystals.

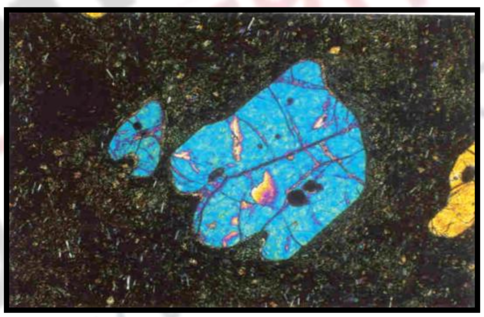
(3) If the smaller and larger crystals occur together the larger one are those that begin to develop first.

And Two kinds of term are used to describe crystal shape: (I) those relating to the quality of the development of' faces on crystals and those specifying the three-dimensional shapes of individual crystal.

Euhedral olivine in olivine basalt: *The photograph shows the characteristic six-sided euhedral shape of olivine in section through the prism and dome faces. Note the slight enclosure of matrix material by one of the prism faces.*

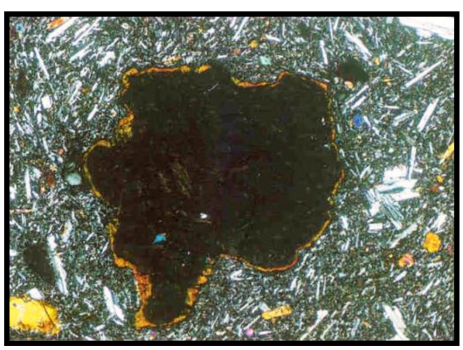


Subhedral olivine in picritlc basalt: *Some of the faces. on this equidimensional olivine crystal are flat, planar ones, whereas others are curved and embayed.*



Anhedral olivine phenocryst in basalt*: the entire perimeter of the large olivine crystal, at extinction in this picture, has an irregular outline and no planar faces are present*

. (The narrow brown rim on the crystal is 'iddingsite' formed by hydration and oxidation of the olivine).



Mutual relationship of grains

It describes the various patterns of crystal arrangements and the mutual relationship of grains. And depending on the mutual relations of grains, the textures of igneous rocks may be classified into four major groups.

Fabrics

- Equigranular
- Inequigranular
- Directive
- intergrowth

Equigranular texture

Igneous rocks containing mineral grains of more or less equal size are said to have an "equigranilar texture". It is classified into many sub textures depending on their characters.

Equigranular

- Panidiomorphic texture
- Hypidiomorphic texture
- Allotriomorphic texture
- Microgranular texture
- Orthophyric texture
- Felsic texture

EQUIGRANULAR

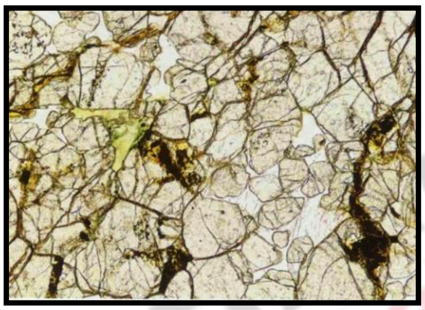
PANIDIOMORPHIC	ALLOTRIOMORPHIC	HYPIDIOMORPHIC
(majority of grains are crystalline euhedral)	(most of the grains are anhedral)	(most of the grains are subhedral)
Ex: Lamprophyre	Ex: Apalite	Ex. Granite

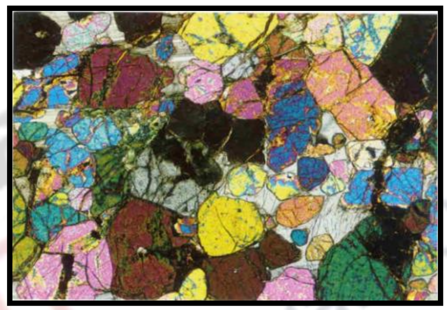
Panidiomorphic refers to a texture in which, theoretically all the component mineral grains are subhedral.

Allotriomorphic refers to a texture in which all the component mineral grains are anhedral**.**

Hypidiomorphic refers to a texture, in which the grains of some mineral species are anhedral, those of others subhedral, and those of some may even be anhedral. The texture is typical of granitic rocks in many of which quartz and orthoclase tend to be anhedral, and plagioclase and biotite are subhedral to euhedral. (a geometrical impossibility in a holocrystalline rock.). The terms are commonly applied to the texture of lamprophyres, which are characteristically densely and conspicuously crowded with enhedral mafic phenocrysts. However, one has to overlook the anhedral nature of the groundmass minerals, although again the groundmass may be glassy, in which case all the crystalline components can be euhedral.

As an example when





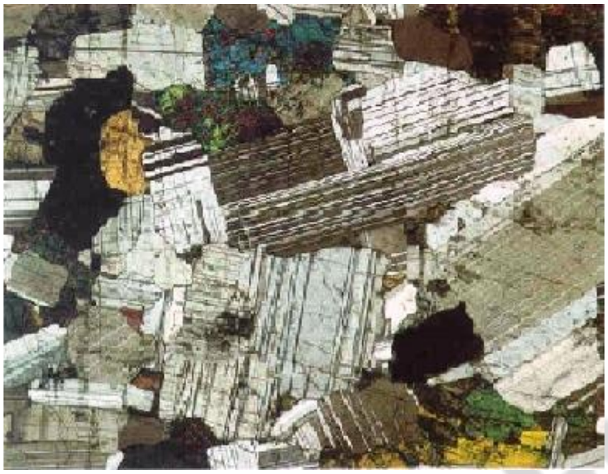
Equigranular

***peridotite** is concerned, its properties are uniformly-sized olivine crystals. Some of them in clots form the bulk of this rock, with plagioclase filling the interstices. The black material is microcrystalline haematite formed by oxidation of olivines and the green material is a clay mineral.*

(i) Panidiomorphic texture: When most of the grains are euhedral, the texture of the rock is called "Panidiomorphic". This texture is usually found in lamprophyres.

***Euhedral granular hornblendite:** Rocks possessing truly euhedral textures are very rare. The one in this figure is a good example of a more common situation in which only some of the crystals of the principal mineral.*

(ii) Hypidiomorphic texture: When most of the crystals are subhedral, the texture is called "hypidiomorphic". This texture is characteristic of many plutonic rocks such as granites and syenites.



Subhedral granular gabbro: *The stout prismatic plagioclase feldspar crystals which dominate this rock are mostly subhedral.*

(iii) Allotriomorphic texture: When most of the crystals are anhedral, the texture is called "allotriomorphic". This texture is found in Aplites.

Anhedral granular troctolite: *Only a few of the plagioclase in this equigranular rock possess a face and none of the olivine do. The crystals are therefore predominantly anhedral and the mosaic texture is granular.*

(iv) Microgranular texture: Microcrystalline igneous rocks may also have an equigranular texture. The crystals of these fine grained rocks are commonly anhedral or subhedral, they are called microgranular texture.

(v) Orthophyritic texture: Some highly felspathic rocks such as orthophyres and plagiophyres possess a fine grained panidiomorphic texture. This texture is called orthophyritic texture.

(vi) Felsitic texture: An igneous rock containing a uniform mass of cryptocrystalline matter is said to have a felsitic texture.

Inequigranular texture

Igneous rocks having variations in size mineral grains are said to have the "Inequigranular texture". It refers to an igneous rock texture in which the diameters of component minerals are comparable, allowing of course for the inherently tabular and prismatic, rather than equent, habits of some minerals.

And they are as follows,

INEQUIGRANULAR TEXTURE

- PORPHYRITIC
- POIKILITIC
- OPHITIC
- INTERGRANULAR & INTERSERTAL

(i) Porphyritic texture : When an igneous rock contains large crystals some minerals set in a matrix which is much finer grained or even glassy, the texture is called "Porphyritic". The large crystals are called "Phenocrysts" and fine grained material is called "groundmass". Igneous rocks showing porphyritic textures are known as porphyrites such as a granite porphyry, diorite porphyry and rhyolite porphyry. This texture develops when some of the crystals grow to a considerable size before the main mass of the magma consolidates into finer and uniform grade material. Porphyritic texture is found largely in volcanic and hypabysal rocks.

(ii) Poikilitic texture: Smaller grains of one mineral are completely enclosed in large, optically continuous grains of another mineral without common orientation. This texture is called "Poikilitic texture". And it is commonly found in syenite and monzonites where orthoclase forms the host mineral.

(iii) Ophitic texture: Laths of plagioclase in a coarse grained matrix of pyroxene crystals, wherein the plagioclase is totally surrounded by pyroxene grains. This texture is common in diabases and gabbros, also the characteristics of diorites.

(iv)Intergranular and intersertal textures; A texture in which the angular interstices between plagioclase grains are occupied by grains of ferromagnesium minerals such as olivine, pyroxene, or iron titanium oxides. And when glassy or fine grained chloritic or serpentinous materials occur in the interspaces, the texture is called "intersertal textures".

And **porphyritic texture**, by contrast, connotes one or more minerals species, or a generation of one or more crystal species, that are conspicuously greater in size than those minerals consisting the rest of the rock. These relatively larger crystals are termed **phenocrysts.** An aphyric rocks aphenitic or fine – grained rocks thus an equigranular granite, for example, devoid of phenocrysts would not be termed aphyric.

Phenocrysts are generally conceived of as relatively larger crystals which were crystallized slowly from magma under intratelluric conditions ccurring in a finer-grained **groundmass** that reflects a subsequent more extrusion of a lava or emplacement of a hypabyssal rock. However, amusing example where phenocrysts of early crystallization are actually eclipsed in size by minerals formed during later sequential crystallization processes within the groundmass of granophyres.

Some relatively large crystals, for example, some alkali feldspars in certain mesozone granites may in fact have had an origin by growth essentially in the solid state with or without accompanying metasomatism. They may be in fact porphyroblasts rather than phenocrysts. However where the origin may be debatable, and in view of the specific genetic connotation of the terms porphyroblast, relatively large crystals of whatever origin on a rock conventionally regarded as may be termed phenocrysts for descriptive purposes.

Exceptionally large porphyritic crystals are termed **megacrysts.** Some notable examples are plagioclase megacrysts in some diabase dykes and large alkali feldspar crystals in some deep-seated granites.

Microphenocrysts, as the name implies are small phenocrysts in a rocks with an aphanitic groundmass. Microphenocrysts may occur to the exclusion of larger phenocrysts, an upper limit in grain size of 1mm is sometimes arbitrarily applied for the term micrphenocrysts, but it is the texture of the rock in question rather than arbitrary limits that governs the choice of the term, where as a complicated history of previous fractionation and /or accumulation.

Glomeroporphyritic texture results when phenocrysts aggregates in groups sometimes only some of several phenocrysts species may be so aggregated suggesting that those species not involved belong to a later period of intratelluric crystallization. Some glomeroporphyritic clusters represent the incorporation of texturally more complex material, perhaps consolidated early fractionated material some included clots of crystalline material have more problematic origin in that they may be mineralogically as well as texturally distinct from the phenocrysts assemblage in the rock.

Seriate porphyritic texture describes a situation where there is a continuous range in grain size of one or more mineral species from that of phenocrysts to groundmass size, and in which crystals of progressively smaller sizes are increasingly numerous. This texture is commonly shown by plagioclase in some andesite porphyries, for example, an explanation of this texture in terms of cooling rate and kinetics of crystallization.

Directive Textures

The textures produced as a result of flow of lavas during their consolidation, are called "directive textures". The chief directive textures are,

DIRECTIVE TEXTURES

TRACHYTE TEXTURE HYALOPILITIC TEXTURE

Hyalopilic texture: In a volcanic rock, a texture wherein microlites of plagioclase are more abundant than groundmass and the groundmass consists of glass which occupies the tiny interstices between plagioclase grains.

Trachyte texture: A texture wherein plagioclase grains show a preferred orientation due to flowage, and the interstices between plagioclase feldspar grains are occupied by glass or cryptocrystalline material.

And **vitrophyric texture** refers to a rock which is composed of phenocrysts of intratelluric crystallization in a glassy matrix. The term mesostasis to refer to the glassy component, commonly devitrified in older rocks, often proves to have a composition close to that of ideal granite whatever the bulk composition of the rock. Many tholeiites, for example, commonly have a small proportion of glassy mesostasis of thoroughly acid composition) that partly or completely replaces a pyrogenetic mineral while preserving the characteristic crystal outline of the mineral being replaced. Students will appreciate the characteristic mesh textures of serpentine minerals replacing olivine, the pseudomorphing of orthopyroxene by bastite, the saussuritization of plagioclase, the replacement of biotite by lamellae of chlorite.

Devitrification refers in general to the transformation with time of originally glassy groundmass or mesostasis material to a fine-grained cryptocrystalline or microcrystalline product. The patterns of devitrification textures can be quite varied and superimposed, for example an primary features such as perlitic fractures or the outlines in an ignimbride, where varying degree of primary "devitrification" can be observed varying with height in the cooling unit.

Intergrowth texture

The intergrowth of quartz and orthoclase may take place when they crystallize simultaneously. This intergrowth frequently produces "graphic texture" in which skeletons of quartz crystals are embedded in the orthoclase. The two intergrown minerals have the same optical orientation over large area. A variety of granite, called the "graphic granite" shows the graphic texture.

Relict textures refer to such features as preservation of shard outlines and perlitic cracks in some devitrified ignimbrites and glassy rhyolite flows respectively, or the presence small kernels of fresh olivine within a crystal that may be nearly completely pseudomorphed by a mesh of serpentine.

Kelyphitic rims composed of secondary hydrous minerals such as hornblende may develop around the boundaries of crystals in altered coarse –grained igneous rocks reflecting the partial degradation of the pyrogenetic mineralogy under low-graded metamorphic conditions. Metamorphism at higher temperatures may result in spectacular **corona textures** comprising concentric rims of pyroxene, spinel, amphibole, etc produced by reaction between original olivine and plagioclase during the metamorphism, we are well as away from the igneous history of the and into the domain of subsequent metamorphism.

Specific intergrain textures related with intergrowth structures

Basaltic flows generally have a microcrystalline matrix consisting of augite where the grains of augite and accessory opaque mineral are small enough to fit between the plagioclase microlites and the texture is said to be **intergranular**.

Kinetic factors affecting crystallization often result in the augite nucleating lass readily than the plagioclase but forming relatively larger, anhedral grains which thus tend to partly or wholly enclose the plagioclase tabular grains where the dimensions of the augite crystals are substantially larger than those of the plagioclase, several or even numerous plagioclase tablets may come to be included within each grain of augite ; thus is known as **ophitic texture,** where, the augite grains are somewhat smaller, and not much larger than the plagioclase tablets, resulting in sub-ophitic texture. whereas intergranular and sub–ophitic textures are common in basaltic flow, ophitic texture is relatively rare in them, and where it is found the rock is generally an alkali basalt. however , is very common in the more slowly cooled hypabyssal rocks of all basaltic compositions such as sills and some thick dykes. For this reason, ophitic texture is sometimes referred to as diabasic texture; the two terms are not quite synonymous, however because in diabasic textures both orthopyroxene and opaque mineral as well as augite may develop a comparable poikilitic habit with respect to the plagioclase, whereas ophitic texture specifically connotes the poikilitic enclosure of plagioclase by augite alone**.**

Intersertal texture is characteristic of tholeiite flows where it may be present in addition to intergranular or sub-ophitic texture. Intersertal texture denotes the presence of small, disconnected, patches of a glassy mesostasis of acid composition, often containing numerous tiny inclusions of opaque mineral.

Hypalopilitic texture refers to a texture in which plagioclase microlites are set in an abundant glassy mesostasis.

Pilotaitic texture connotes abundant plagioclase microslites prominently fluxioned in an overall sub-parallel manner and locally around phenocrysts.

Orthophyric texture also quite common in andesite and related rocks, resulted where the plagioclase microslites have the form of stubby rather than flat tablets.

Felsitic texture, on the other hand results from slow devitrification over geologically long periods of time of rhyolitic material originally cooled to a glass. In felsitic texture aggregates of cryptocrystalline are very fine grained microcrystalline material extinguish together in small patches throughout the rock. Ignimbrites, the more characteristic volcanic product of eruptions of rhyolite contain a groundmass of glassy shards that show varying degree of flattening and welding results in **eutaxitic texture** (paralleling the eutaxitic structure displayed in the outcrops buy larger flattened pumice fragments if present).

Devitrification process in ignimbrites occurs in two stages. (1) A "primary devitrification" while the ignimbritic cooling unit is cooling, commonly result in complete fine grained devitrification of the groundmass of the entire upper portion of the ignimbrite cooling unit. (2) A secondary devitrification with prolonged passage of time will come to affect all glassy material not devitrified by the primary devitrification.

Many trachytes and some phonolytes are characterized by a high proportion of tabular sanidine microlites in the groundmass that are very flat in shape and thus prone to strong fluxioning; the resultant texture is known as **trachytic texture.**

Myrmekite is a symplectic intergrowth of quartz and oligoclase occurring in small cauliflower – shaped embayments into microcline or oligoclase. And pleochroic haloes are very obvious in many biotites of granitic rocks, much less commonly seen in hornblende. Lamprophyric texture refers to the voluminously porphyritic, apparently panidiomorphic texture that is common in lamprophyritic rocks.

Terms used to describe intragrain textures produced by Exsolution

These textures are highly specific and distinctive and merit separate consideration, particularly as they are common in the two most abundant igneous rock mineral genera, namely feldspar and pyroxene Partial or complete response to equilibrium at a later set of lower-temperature conditions than the temperature of formation of the mineral crystal in question, where exsolution occurs the element present in minor amount typically enters a phase that forms small exsolution lamellae or exsolution blebs, within the host mineral. Due to the observer extreme sluggishness of exsolution in silicate minerals (reflecting extremely slow diffusion rates within the lattices of silicate minerals), the relatively short cooling history of lava flows and small minor intrusions inhibits exsolution. In large plutonic bodies, however, the effects of exsolution are commonly conspicuous.

Plagioclase only rarely shows exsolution visible on a microscopic scale, although plagioclase in the compositional range An30-An22 are generally sub-microscopic intergrowths of relatively albite-rich and relatively anorthite-rich phases with slightly differing structure; such intergrowths are known as **peristerite,** and may result in some plagioclase crystal of this compositional range showing a characteristic schiller effect. Plagioclase of anorthosites within the Grenville province that have been subjected to presumably prolonged high temperature during regional metamorphism subsequent to emplacement of the intrusions commonly reveal antiperthite which consist of numerous tiny blebs and rods of orthoclase within the host plagioclase. **Antiperthite** is not commonly seen in igneous rocks, although included here for the sake of completeness it would appear to be strictly a texture produced during metamorphism. It is also common in granulites.

Perthite, however is very common in igneous rocks and consists of quantitatively minor lamellae, shreds, patches and rims of an albite component within and around host orthoclase or microcline. Whatever the orientation in this section, the albite component always has the higher birefringence and appears brighter under crossed nicols - a useful feature in identification, as the exsolution lamellae are visible only on a microscopic scale and cryptoperthite refers to even finer-grained intergrowths that are only resolvable by X-ray methods. The apparently optically homogeneous sanidines of older volcanic rocks are in fact **cryptoperthites**, their submicroscopic pattern of exsolution have been affected during the passage of time rather than during the cooling if the igneous rock**. Mesoperthite** refer to the typical perthite of epizone granitic bodies where the albite component is comparable abundance to the orthoclase component.

Thus the texture of igneous rocks

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