UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
DEPARTMENT OF GEOLOGY

GG 4070

IGNEOUS PETROLOGY

LECTURE NOTES
TEXTURES OF IGNEOUS ROCKS

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TEXTURES OF IGNEOUS ROCKS

Compulsory Reading: Ehlers and Blatt (1982) pp. 44-47, 166-144; Best (1982) pp. 62-70. Additional Reading: Williams, Turner and Gilbert (1982), pp. 53-67.

INTRODUCTION

The term texture is essentially meant to describe the interrelationships between the various minerals in a rock. It includes the size and shape of the different minerals, the way in which they are distributed through a rock, and their relation to each other. The texture reveals much about the origin and the crystallization history of the magma form which the rock was derived, for instance, the rate of cooling and the sequence in which minerals were formed. Therefore, a discussion of the texture forms an essential part of a rock description.

This chapter aims at a complete as possible overview of all existing textures of igneous rocks, although it would be quite an achievement of the fourth year petrology student to know them all by heart. An attempt has been made not only to describe the various textures, but also to explain them.

GRAIN SIZE

The grain size of minerals in igneous rocks varies greatly from very fine grained to very coarse. In **aphanitic** rocks the minerals are so fine grained that they cannot be observed with naked eye. In phaneritic rocks the minerals can be observed without optical aid. This category is roughly subdivided according to grain size into fine grained, medium grained and coarse grained in the following way:

Diameter 5mm or more : Coarse grained phaneritic

Diameter 1 to 5mm large : Medium grained phaneritic

Diameter up to 1mm : Fine grained phaneritic

Too fine to see with unaided eye : Aphanitic

As was already observed while discussing the classification of igneous rocks, the plutonic rocks are typically phaneritic, whereas the matrix of volcanic lavas is either glassy or aphanitic. The coarseness of the crystals in intrusive rocks reflects the slow cooling history of the magma. This is in sharp contrast with the high cooling rate of a lava. The crystallization of an intrusive basic magma may take 1000's to millions of years, whereas a acid lava can solidify in one year or less! Hypabyssal rocks occupy an intermediate position between the plutonic and volcanic rocks: they crystallize below the surface of the earth, but at shallow depth, usually in dykes or veins, or in relatively thin sills. Cooling rates are therefore high and consequently the resulting rock is fine grained.

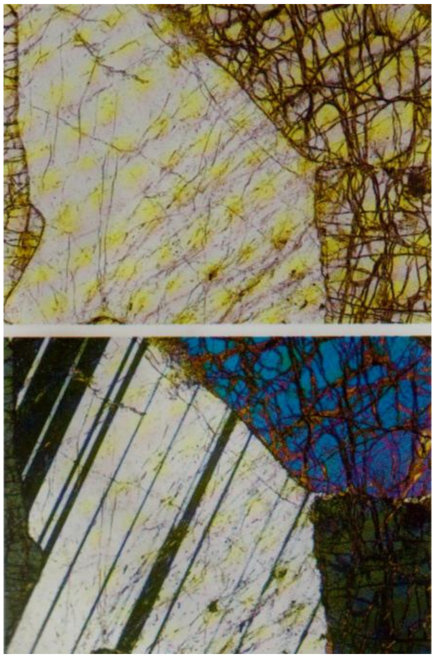
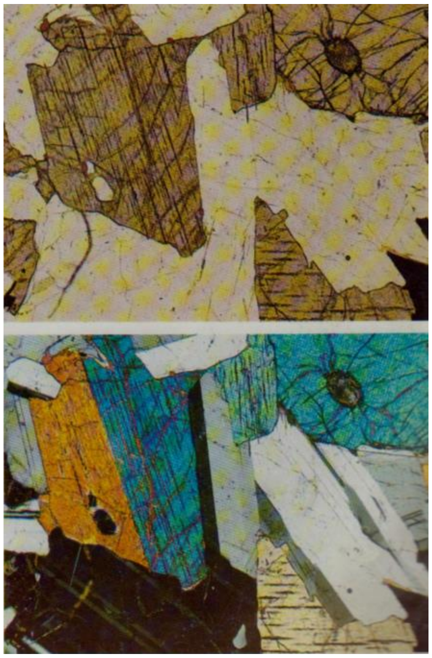
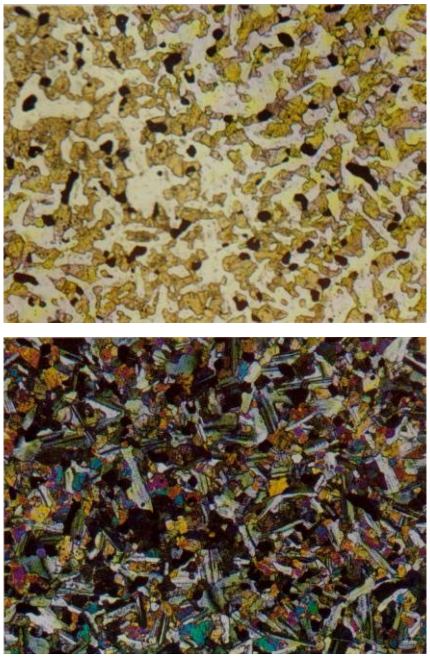


Fig. 1a-Coarse-grained



1b-Medium-grained



1c-Fine-grained

GRAIN SHAPE

Shapes of crystals are characterized by the degree of development of crystal faces. In igneous rocks the grain shape often reflects the sequence of crystallization: if a mineral is among the first to crystallize from a melt it has the space and time to develop its proper habit. Hence these minerals tend to develop their ideal crystal shape. Later formed minerals can grow only in spaces left between the earlier crystals. They tend to have an irregular shape. Commonly used terms for grain shapes are as follows:

Euhedral (idiomorphic) : Well-developed crystal faces, grains show perfect or nearly perfect shape.

Subhedral (hypidiomorphic: Partly developed crystal faces, grains show an imperfect but still recognizable crystal shape.

Anhedral (xenomorphic) : No crystal faces developed, grains show no regular shape.

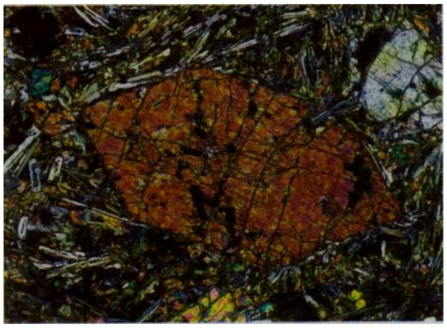


Fig. 2a-Euhedral olivine in olivine basalt

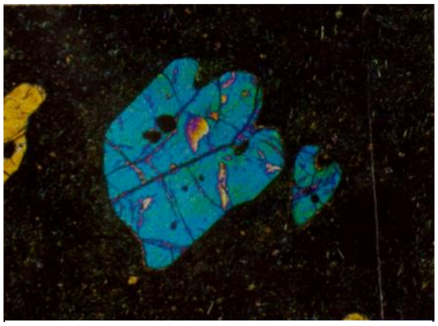


Fig. 2b-subhedral olivine in picritic basalt

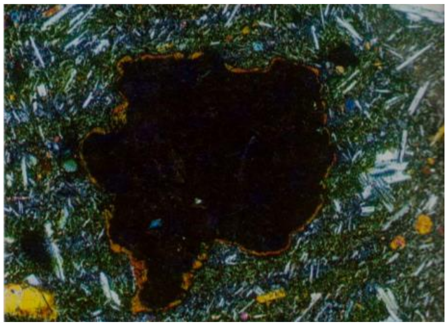


Fig. 2- Anhedral olivine phenocryst in basalt

Common examples of euhedral minerals in igneous rocks are phenocrysts of plagioclase or mafic minerals in basalts or andesites. Granites consist of predominantly subhedral quartz and feldspar crystals. In gabbros you can usually establish easily the order of crystallization from grain shapes (See Figure 6-1) and sometimes also from reaction rims (See Figure 3).

Fig. 3a-Euhedral granular hornblendite

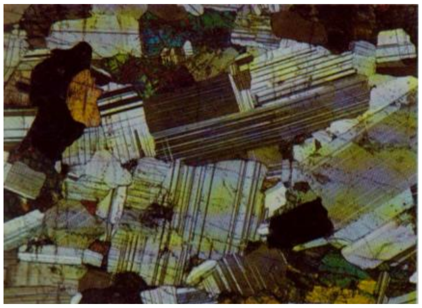


Fig. 3b-Subhedral granular gabbro

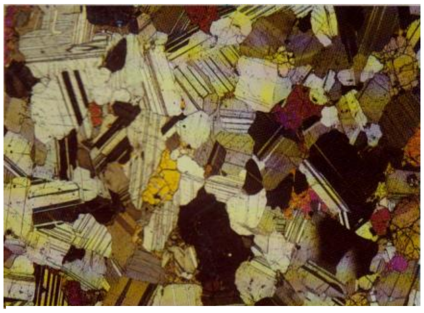


Fig. 3c-Anhedral granular troctolite

Many igneous rocks consist largely of equal-sized, anhedral or subhedral grains. This rock texture is referred to as **equigranular**. If the grains are not equal in size the terms to be used is **inequigranular**. If a mineral species is conspicuously larger than others in an igneous rock, the texture of the rock is called **porphyritic**.

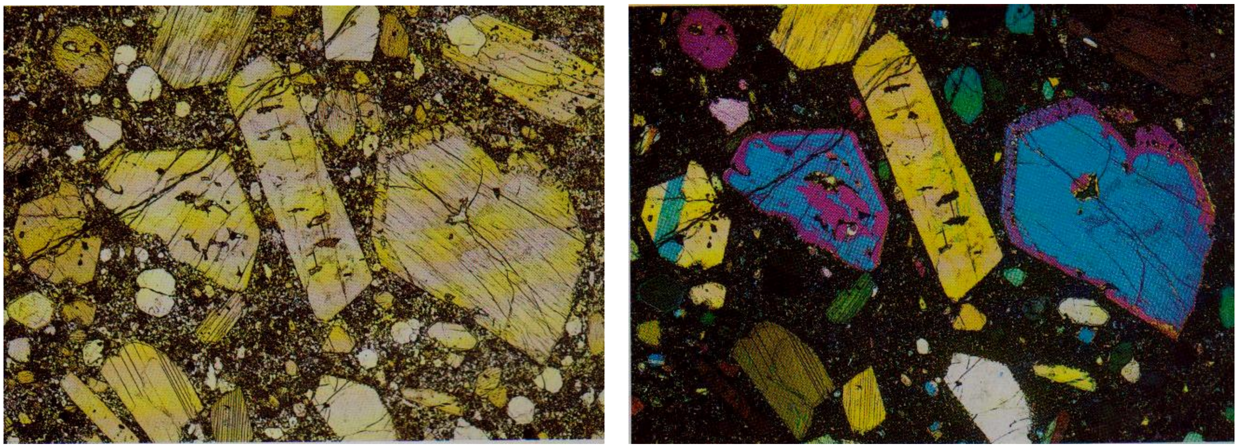


Fig. 4 Porphyritic texture

The larger minerals are called porphyries or **phenocrysts**, the latter terms is especially used when describing porphyries in volcanic rocks. The porphyritic minerals are the first minerals to crystallize from the magma, which explains their larger size and the fact that they are usually euhedral in shape. Porphyries that contain inclusions of other minerals are said to be **poikilitic**.

PORPHYRITIC TEXTURES

In basic igneous rocks four different types of porphyritic texture can develop, involving the textural relation between plagioclase and pyroxene crystals. These are (See Illustrations in Figure 6-2).

(i) **Ophitic textures.** Laths of fine grained, euhedral plagioclase crystals are enclosed by a large pyroxene crystal. The texture is common in basic intrusive rocks, as is the related texture (ii).

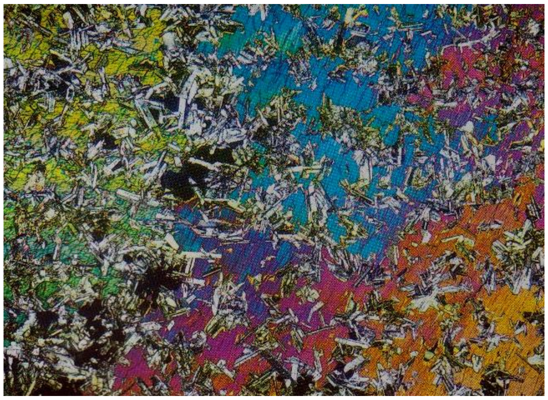


Fig. 5 Ophitic-textured alkali olivine dolerite

(ii) **Subophitix texture**. Similar to (i), but the plagioclase laths lie partly inside, partly outside the pyroxene porphyry.

Fig. 6 Subophitic texture in olivine dolerite

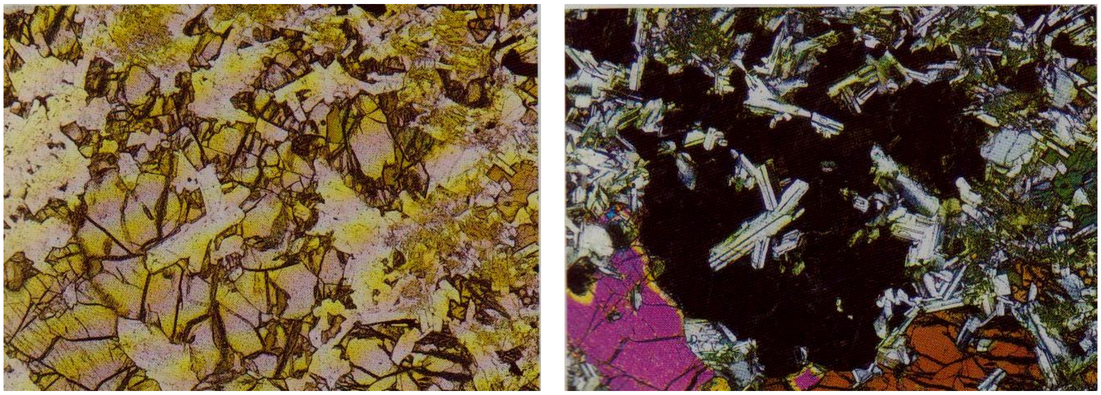


Fig. 7 Subophitic alkali olivine dolerite

(iii) **intergranular textures.** Crisscross orientated plagioclase laths, the interstitial spaces filed by finer grained pyroxene crystals. This is the typical texture of dolerite dykes, but may also occur in basalts.

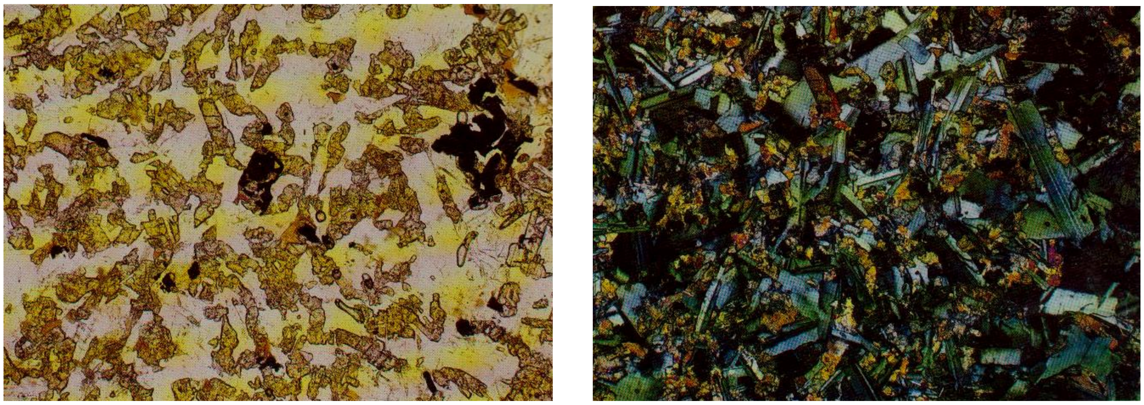


Fig. 8 Intergranular dolerite

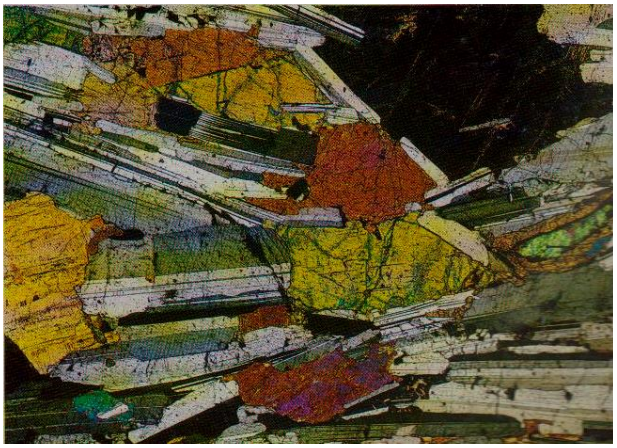


Fig. 9 Intergranular olivine gabbro

(iv) **Intersertal textures.** Similar to (iii), but the interstitial spaces between the plagioclase laths are filled with basaltic glass. This texture only occurs in basic volcanic rocks.

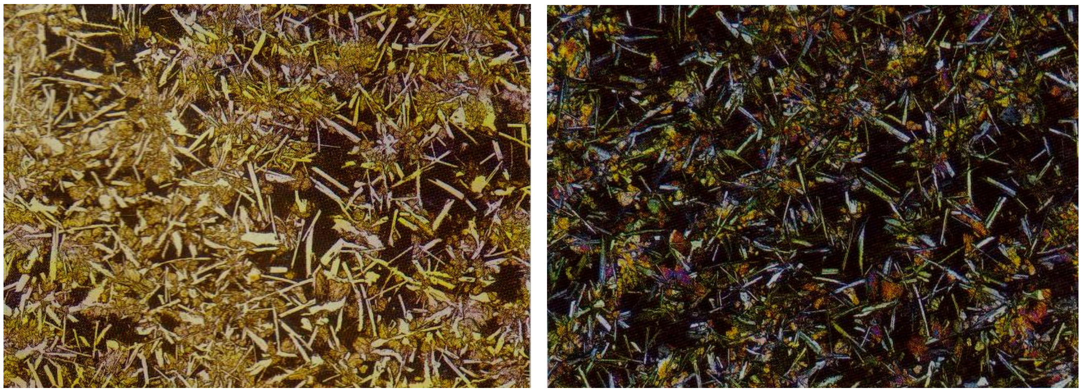


Fig. 10 Intersertal, intergranular and subophitic textures in dolerite

The intergranular texture can be explained with the aid of the ternary system Anorthite-Diopside-Forsterite. It is produced by the crystallization of a melt with a composition such as L in Figure 6-3a, which starts with formation of primary plagioclase crystals, followed by minor olivine, and finally by pyroxene. Ophitic texture also is produced by primary crystallization of plagioclase laths, followed by simultaneous crystallization of plagioclase and pyroxene during which pyroxene forms poikilitic grains surrounding the plagioclase laths. This is illustrated with the aid of the ternary system Diopside-Albite-Anorthite (See Figure 6-3b).

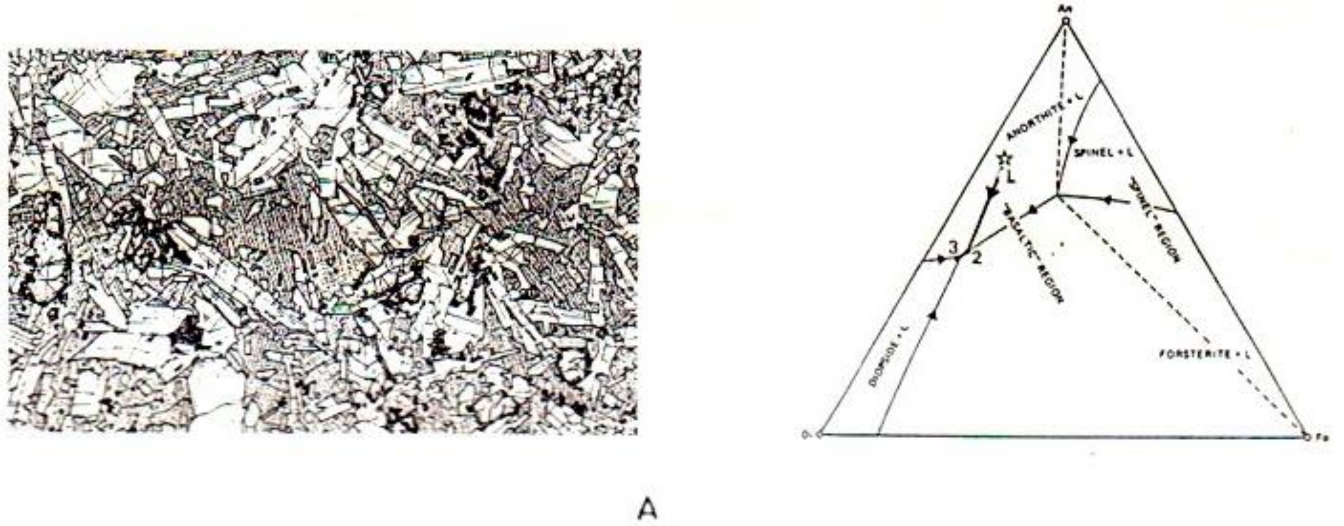


Fig. 11 (a) Origin of intergranular texture explained by crystallization path of a liquid L in the system an Di Fo.

Fig. 11(b) Ophitic texture explained with the aid of the system Di-Ab-An (after Bard, 1986).

Porphyritic textures are also very common in granitic and syenitic rocks. It is either alkali feldspar (orthoclase or microcline) or plagioclase that develops porphyritic dimensions

(See Figure 6-6). A special type of porphyritic granite texture is the **Rapakivi texture**, which is characterized by very large, pink alkali feldspar porphyries that are rimmed by bluish plagioclase. Granites showing this texture are called Rapakivi granites after the type locality in Finland. The origin of the texture is as yet not well understood.

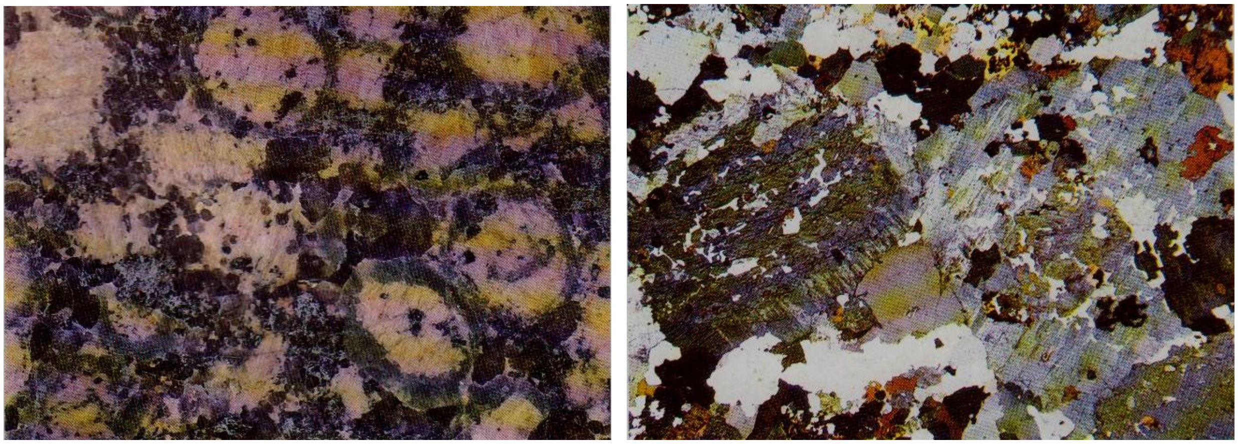


Fig. 12 Rapikivi texture

6.5 TEXTURES TYPICAL OF PLUTONIC ROCKS

6.5.1 Cumulate textures

Rocks with a **cumulus fabric** are the result of gravitational differentiation in basic intrusions. The so-called **cumulate rocks** are formed from the accumulation of crystals that have sunk to the bottom of a magma chamber under the influence of gravity. The crystals that settle in melt and build up these cumulates are called **cumulus minerals**. The liquid that surrounds the cumulus minerals is the **intercumulus liquid**, which will eventually crystallize into the **postcumulus minerals**. Various types of cumulate rocks and their nomenclature are shown in Figure 6-4.

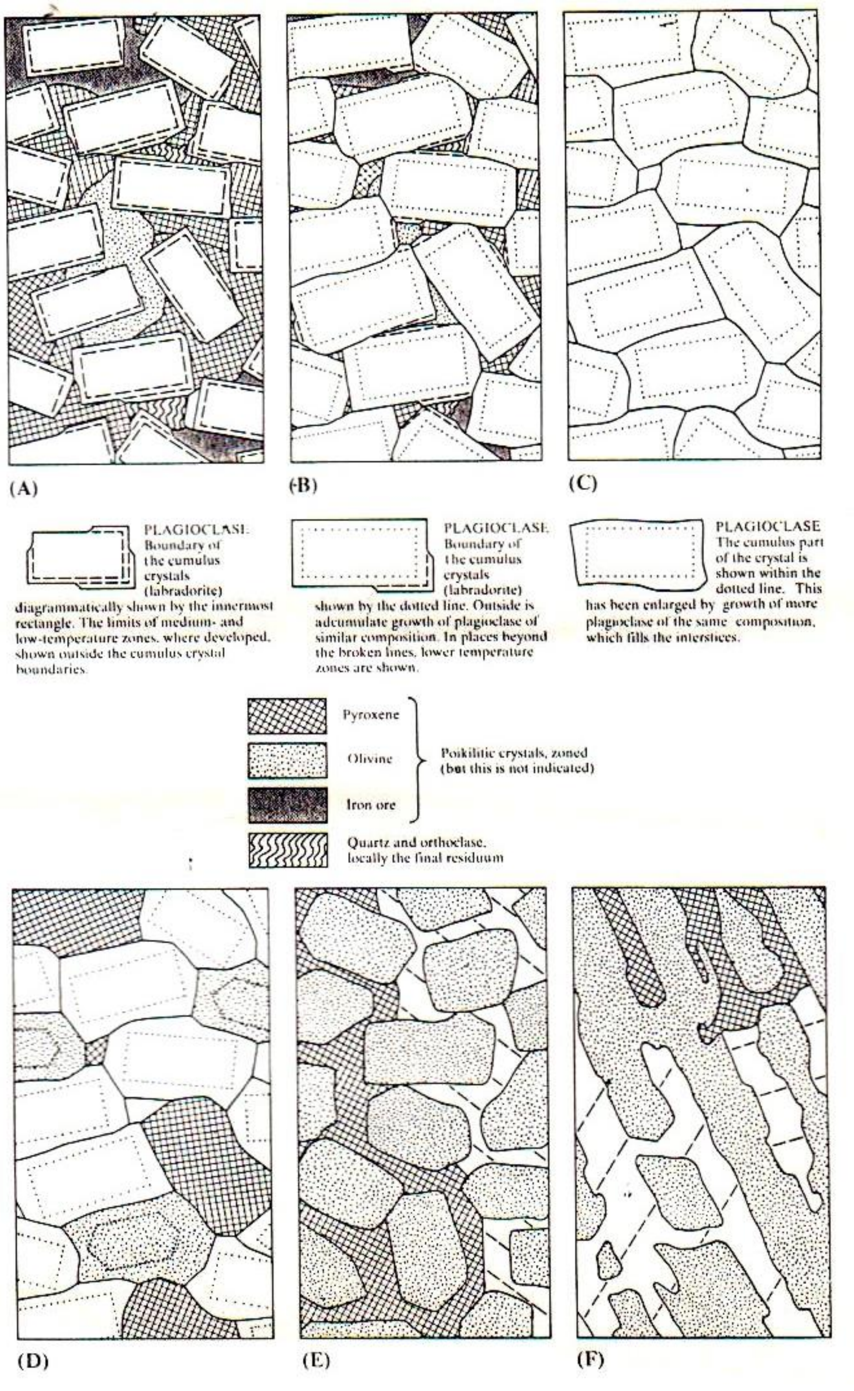


Fig. 13 Cumulate textures. (A) Plagioclase orthocumulate. Early-formed euhedral plagioclase is originally surrounded by a melt of different composition. The melt crystallized to anhedral postcumulus minerals while a rim grew around the plagioclase crystals. (B) Mesocumulate, intermediate between ortho – and adcumulate. (C) Plagioclase adcumulate. Cumulate rock in which the intercumulus phase is almost, or totally, absent. (D) Polymineralic adcumulate. (E) Olivine heteradcumulate. The cumulus olivine grains show no evidence of postcumulus growth; the surrounding melt formed large poikilitic pyroxene and plagioclase. (F) Olivine crescumulate. Cumulate olivine has grown upward into the liquid above, preserving its optical continuity.

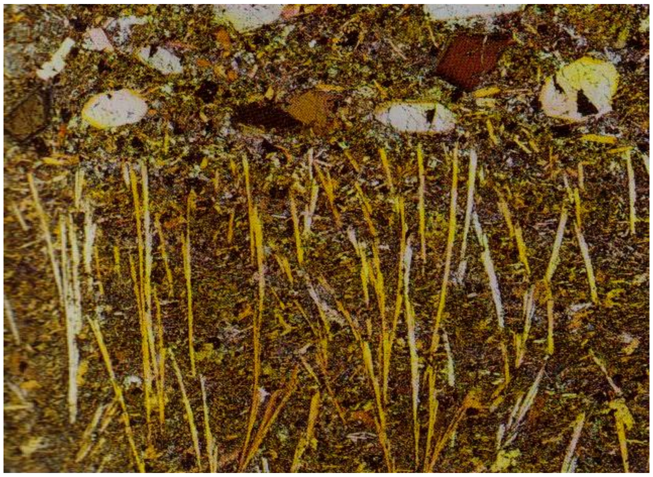


Fig. 14 Pyroxene comb layer in a thin lamprophyre (fourchite) dyke

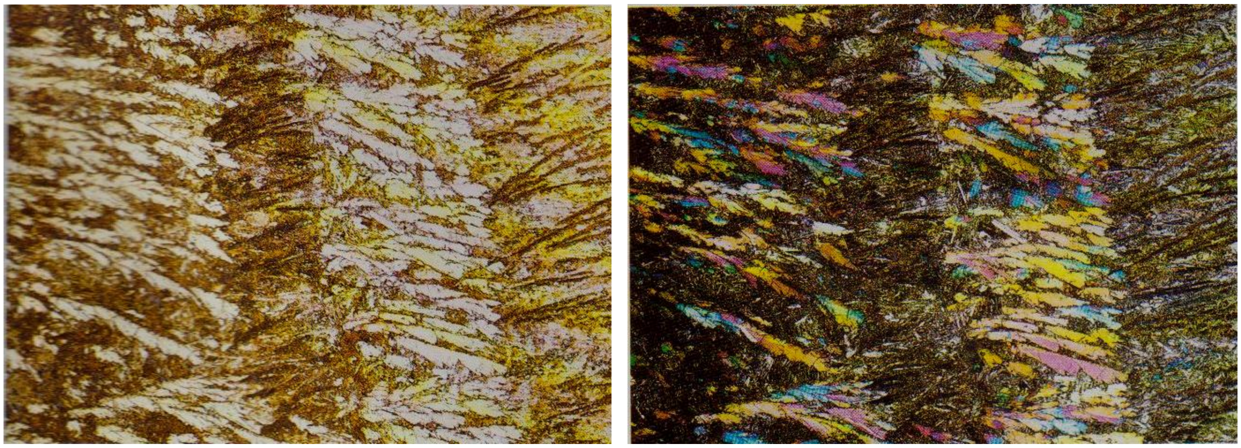


Fig. 15 Comb layers in dolerite dyke

Examples of cumulates are found in basic layered intrusions, which will be further discussed in Chapter 10. The most common cumulus minerals include chromite, olivine, pyroxene, and plagioclase. Intercumulus minerals may include any of these and most of the minor late-stage minerals (magnetite, apatite, sometimes amphibole and so on). The cumulate rocks can be either classified with the aid of the gabbro classification triangle or the peridotite classification triangle, depending on the amount of mafic minerals and plagioclase.

Cumulates often show **preferred orientation** of the cumulus minerals as a result of magma flow along the floor of the magma chamber.

6.5.2 Symplectitic intergrowths

Symplectite is the name used for an intimate intergrowth texture involving two minerals of different type. One mineral occurs as beps or vermicular (worm-shaped) or lamellar inclusions in the other mineral, the latter is said to act as a host to the first. The term symplectite should be used purely as a descriptive term, it gives no genetic implication. In fact, several mechanisms can account for the development of a symplectitic intergrowth, of which the most important are:

(i) Eutectic crystallization. In Chapter 3 we have seen that the final stage of crystallization of many melts is represented by the eutectic crystallization of two or three minerals at the same time. An example of the resulting texture can be seen in Figure 6-5a, which is the most common example in igneous rocks, the granophyric or micrographic intergrowth, characterized by regularly shaped and orientated quartz inclusions in alkali feldspar. This texture is the result of eutectic crystallization of S¡O2 polymorph (later to become quartz) and alkali feldspar, as is illustrated in Figure 6-6. **graphic intergrowth**. The name of the texture is derived from the Egyptian script which it resembles.

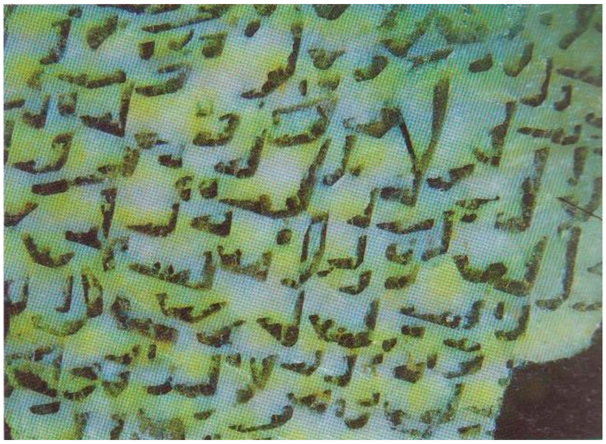


Fig. 16 Graphic granite

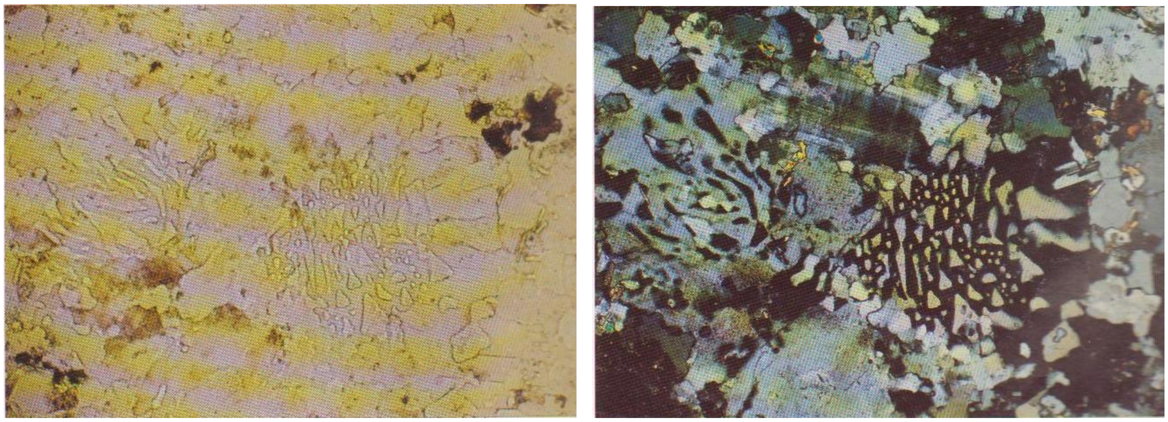


Fig. 17 Micrographic texture in aplite

(ii) Replacement. When a mineral is unstable under the prevailing T and P conditions, it may be replaced by one or more other minerals that are stable. This may lead to symplectitic intergrowths, especially common in high-grade metamorphic rocks (See Figure 6-5b). In igneous rocks one common example of this replacement texture is known: **myrmekitic intergrowth**. It is characterized by vermicular quartz inclusions in plagioclase crystals. It is thought to form due to replacement of alkali feldspar by plagioclase, whereby excess S¡O2 from the replacement reaction accounts for the origin of the quartz inclusions (See Figure 6-5d).'

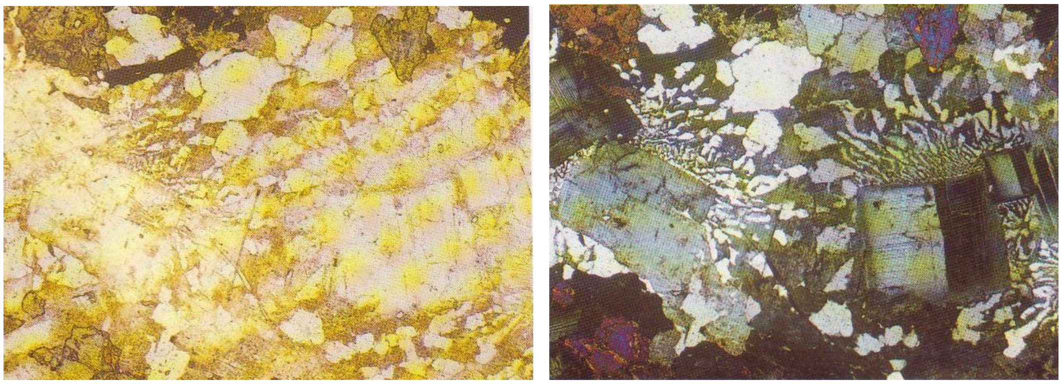


Fig. 18 (a) Granophyric texture

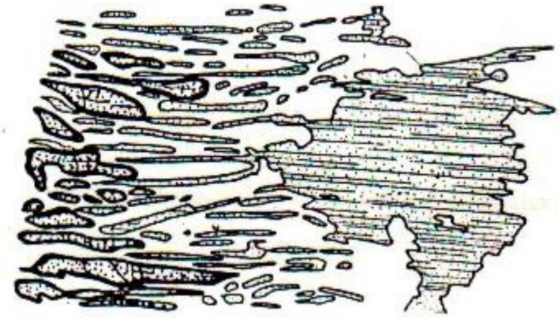


Fig. 18 (b) Replacement symplectite in high grade metamorphic rock

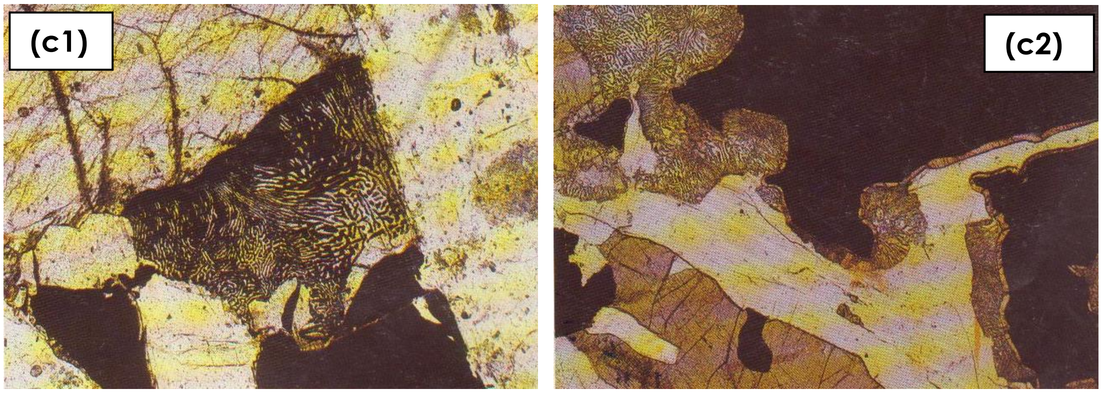


Fig. 18 (c1) Symplectite of iron ore and orthopyroxene; (c2) Fayalite-quartz symplectite

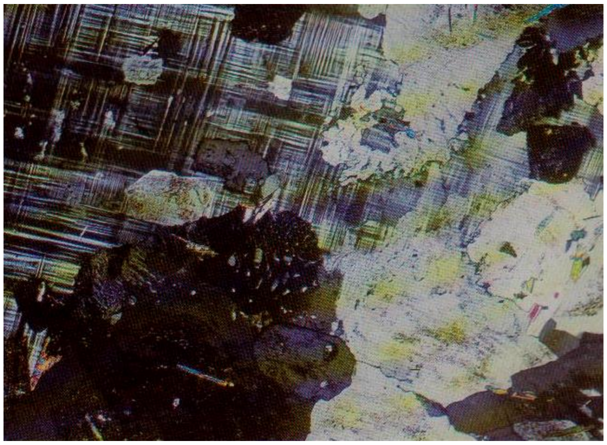


Fig. 18 (d) Myrmekitic texture in granite

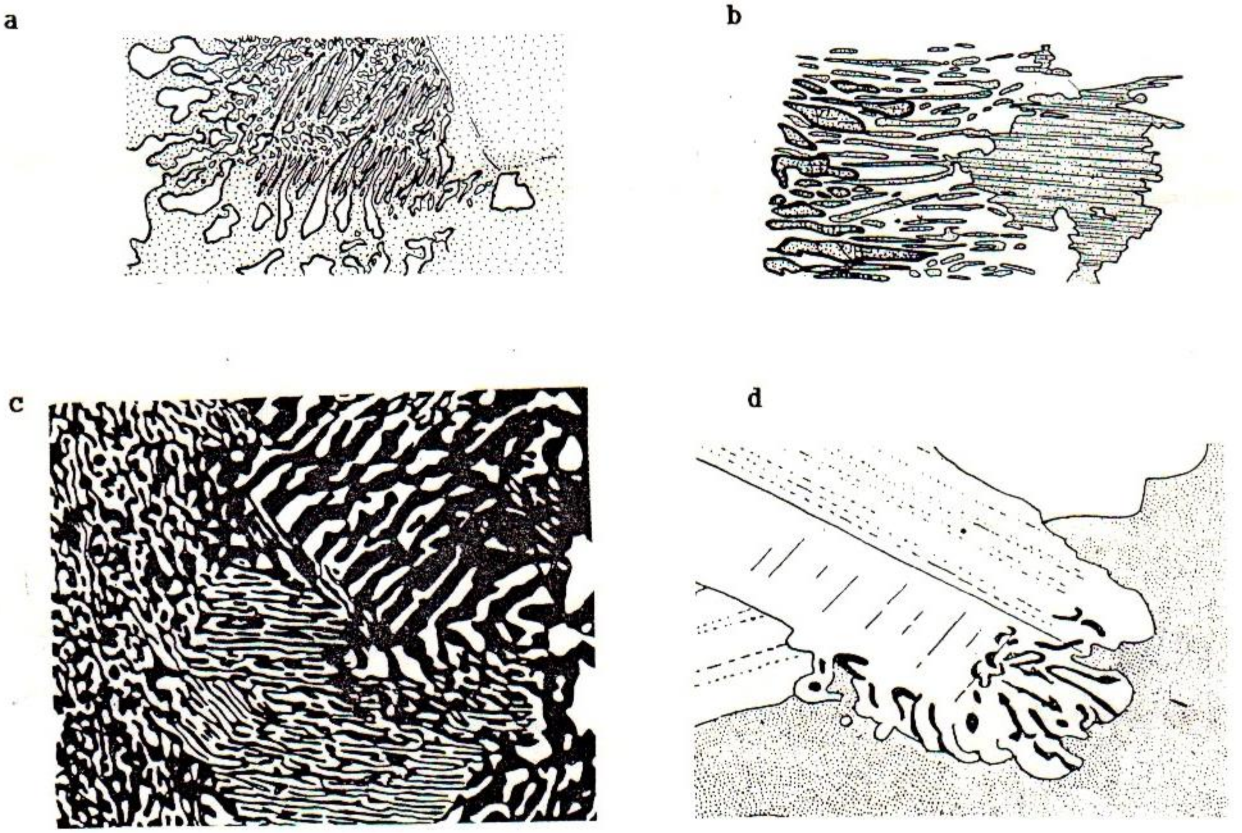


Fig. 19 Different types of symplectitic intergrowths. (a) granophyric intergrowth, a symplectite caused by eutectic crystallization of quartz and alkali feldspar; (b) replacement symplectite in high grade metamorphic rock, representing the reaction biotite + quartz --→ hypersthene + H_2O, (c) symplectite as a result of exsolution of chalcopyrite (white) from bornite (black) (d) myrmekite, a symplectitic intergrowth of plagioclase (white) and quartz (black) replacing microcline (stippled). (from Bard, 1986 and Hatch, Wells and Wells, 1972).

(iii) Exsolution. When temperatures drop below that of the solvus of solid solution minerals, these minerals will start to expel the components that cannot be accommodated stably in their crystal lattice any longer. This process is called exsolution, and it produces symplectitic intergrowths between the host mineral and the exsolved mineral. The most common example of exsolution intergrowth in igneous rocks is that shown by feldspars in granites and syenites, and by pyroxenes in gabbroic rocks. Also important is exsolution in the spinel group (for example, Ti-bearing magnetite may exsolve bleeps of Fe_2TiO_4, ulvospinel) and in many ore minerals (for example, bornite, Cu_5FeS_4, is often seen to exsolve lamellae of chalcopyrite, $CuFeS_2$, See Figure 6-5c).

The exsolution processes taking place in feldspars have already been discussed in Section 3.3.5. Alkali feldspar exsolving albite is called perthite and plagioclase exsolving alkali feldspar is called antiperthite. The different forms that the perthitic intergrowths may obtain are shown in Figure 6-7.

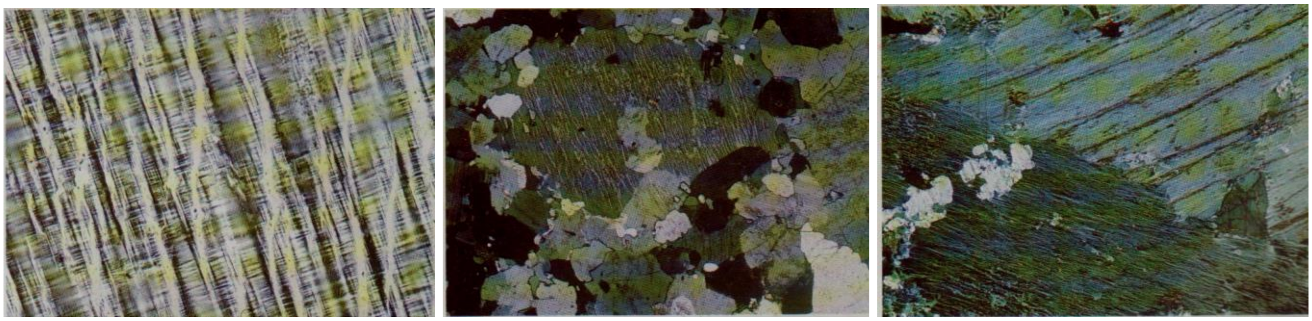


Fig. 20 Microperthitic textures

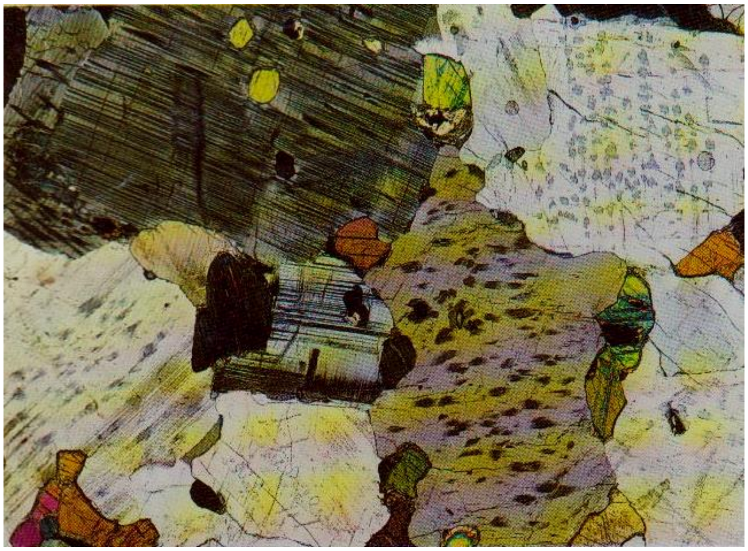


Fig. 21 Microperthitic textures

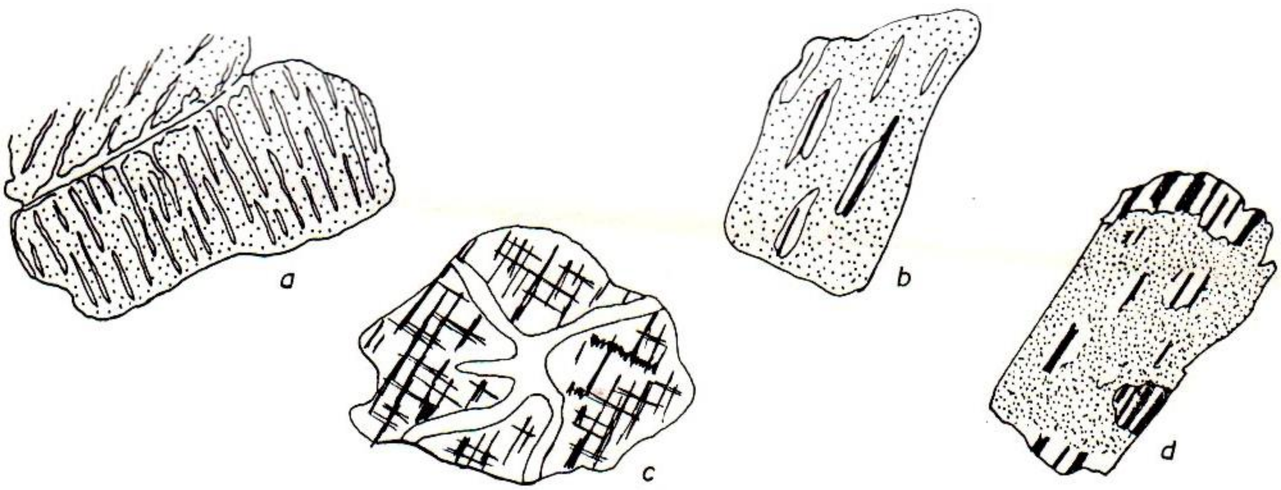


Fig. 22 Perthite textures. (a) string perthite: thin lamellae of albite in orthoclase, (b) rod perthite: albite as thin leaves in orthoclase, (c) vein perthite: albite veins in microcline, (d) patch perthite: patches of twinned albite replacing orthoclase.

When clinopyroxene crystallizes from a melt the first crystal to form is rich in magnesium. With falling temperature the composition shows progressive iron enrichment. This Fe-enrichment is accompanied by Ca-enrichment, as can be observed in the simplified crystallization diagram of pyroxenes (See Figure 3-14). Subsolvus reactions involve the unmixing of orthopyroxene from clinopyroxene, thereby relatively enriching the clinopyroxene in calcium, and the usually form lamellae or bleps parallel to the (100) or (001) planes of the crystals, i.e. parallel to the twin planes of the clinopyroxene. A special texture which may evolve in a twinned clinopyroxene is called herringbone texture (a herring is a fish); it can be seen when the pyroxene is twinned according to (100) and shows exsolution lamellae of orthopyroxene parallel to (001), as is illustrated in Figure 6-8a.

The above described exsolution processes and textures in pyroxenes may be superimposed by another symplectitic texture, called Schiller structure, caused by the exsolution of iron from pyroxenes. The Schiller texture is characterized by tiny, hair-like rodlets of magnetite or ilmenite (when Ti is expelled from the pyroxene as well), which are usually orientated parallel to the Z-axis of pyroxene (See Figure 6-8b). Schiller texture is common in igneous pyroxenes, but it is also rarely observed in other minerals such as plagioclase.

Figure 6-8 (a) Herringbone texture in clinopyroxene, (b) Schiller texture in clino-or orthopyroxene.

INVERSION TEXTURES

When a chemical substance is capable of existing in two or more crystalline modifications with different physical properties, it is said to exhibit polymorphism. Well-known in igneous rocks are the polymorphs of S¡O^{2} quartz, tridymite and cristobalite, and in metamorphic rocks the Al^{2}S¡O5 polymorphs andalusite, sillimanite and kyanite. Reaction from one polymorph to another occurs in order to establish a new equilibrium under a new set of T, P conditions. Such a reaction is called inversion. The resulting texture is an **inversion texture.** As an example may serve the texture of tridymite in a granitic dyke, which upon cooling is inverted to quartz. The platy hexagonal habit of tridymite is preserved, but internally this crystal appears to consist of a mosaic of anhedral quartz grains (See Fig. 22).

Fig. 22 Tridymite inverted to a mosaic of quartz grains

Pigeonite is a clinopyroxene that cannot survive slow cooling, but inverts to hypersthene at a temperature between 980°C and 1140°C, depending on its Fe/Mg ration and the prevailing lithostatic pressure. Pigeonite contains more calcium and less (Fe+Mg) than hypersthene. The result is that the inversion is accompanied by exsolution: the surplus of Ca which cannot be accommodated in hypersthene is exsolved as Ca-rich augite lamellae within the hypersthene.

Note that inversion, like exsolution, is a process that takes place in the **solid** state. Therefore the resulting textures are sometimes called subsolidus textures. In many volcanic rocks inversion can not take place due to rapid cooling. In that case the rock contains metastable minerals such as tridymite or pigeonite. Exsolution is restricted to plutonic rocks as it can only take place when cooling of the rock is sufficiently slow. Therefore, perthites or exsolved pyroxenes are never found in volcanic rocks.

REACTION TEXTURES

The textural features that are related to the reaction of early-formed crystals with residual melt in a crystallizing magma are:

(i) **Zoning** is common in all minerals that belong to a solid solution series. In plagioclase crystals normal zoning implies the formation of concentric rings with different composition, whereby the central portion of the plagioclase is more Ca-rich (i.e. richer in anorthite component) than the outer zones, which are progressively richer in Na (i.e. richer in albite component). The texture originates from fractional crystallization in the system Anorthite-Albite (see Chapter 3).

Zoning is also very common in members of the olivine solid solution series and the pyroxene solid solution series. The cores of the olivines and pyroxenes are richer in magnesium than the rims. The explanation is also fractional crystallization (see Chapter 3).

A special type of zoning occurring in plagioclase crystals is **oscillatory zoning**. It consists of a rapid alternation of thin anorthite-rich and albite-rich layers (see Figure 6-10).

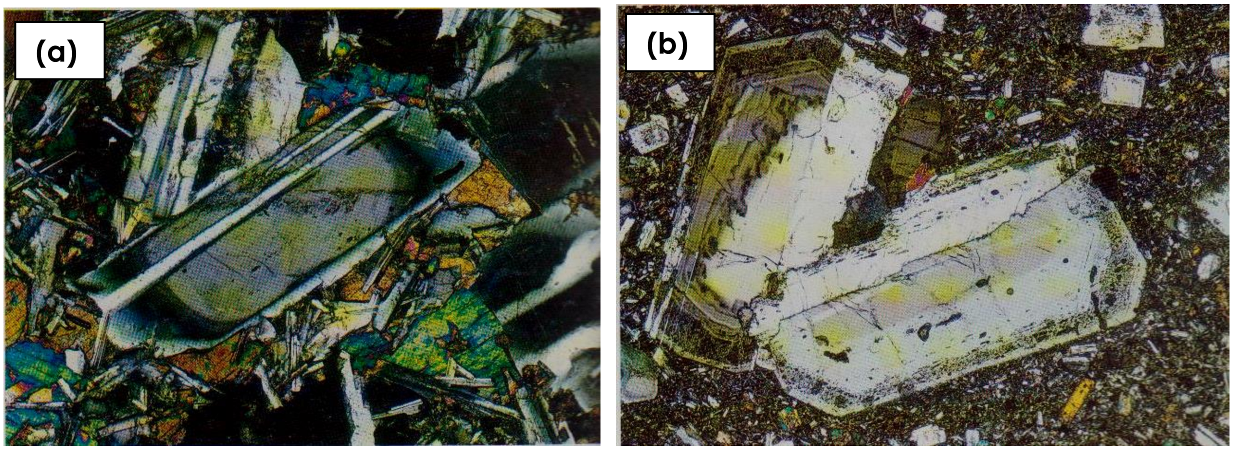


Fig. 23 Zoned plagioclase

The current explanation is that the layer alternation is due to rhythmic variations in temperature conditions and/or fluid pressure in the magma chamber. T, P and $PH^{2}O$ influence the equilibrium composition of the plagioclase crystals and of the coexisting residual liquid, so that fluctuations must be reflected in variations in the anorthite content of the plagioclase.

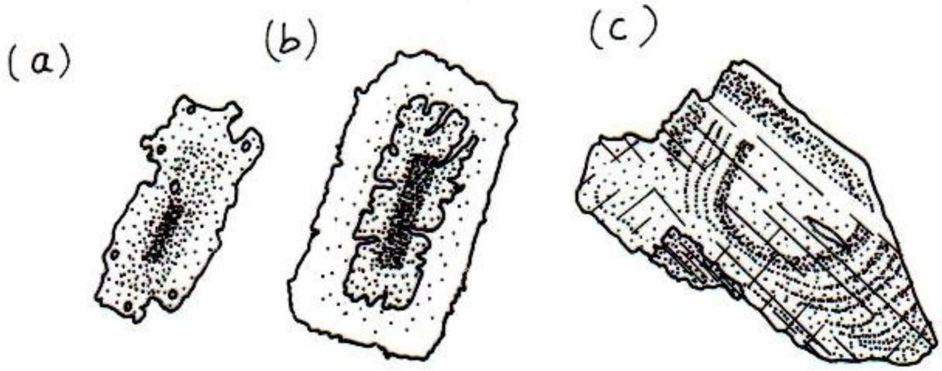


Fig. 24 Various types of zonation in plagioclase. (a) normal and continuous zoning, (b) normal and discontinuous zoning, (c) oscillatory zoning (from Bard, 1986).

(ii) **Reaction rims**, also called **coronas**, occur on minerals that form discontinuous reaction series in Bowen's Reaction Series. A well-known example, already seen in Figure 3-11, is the reaction of olivine with melt to pyroxene, resulting in anhedral olivine surrounded by a rim of orthopyroxene. Other reaction rims include clinopyroxene rims around olivine or orthopyroxene, amphibole rims around pyroxene, and biotite rims around amphibole.

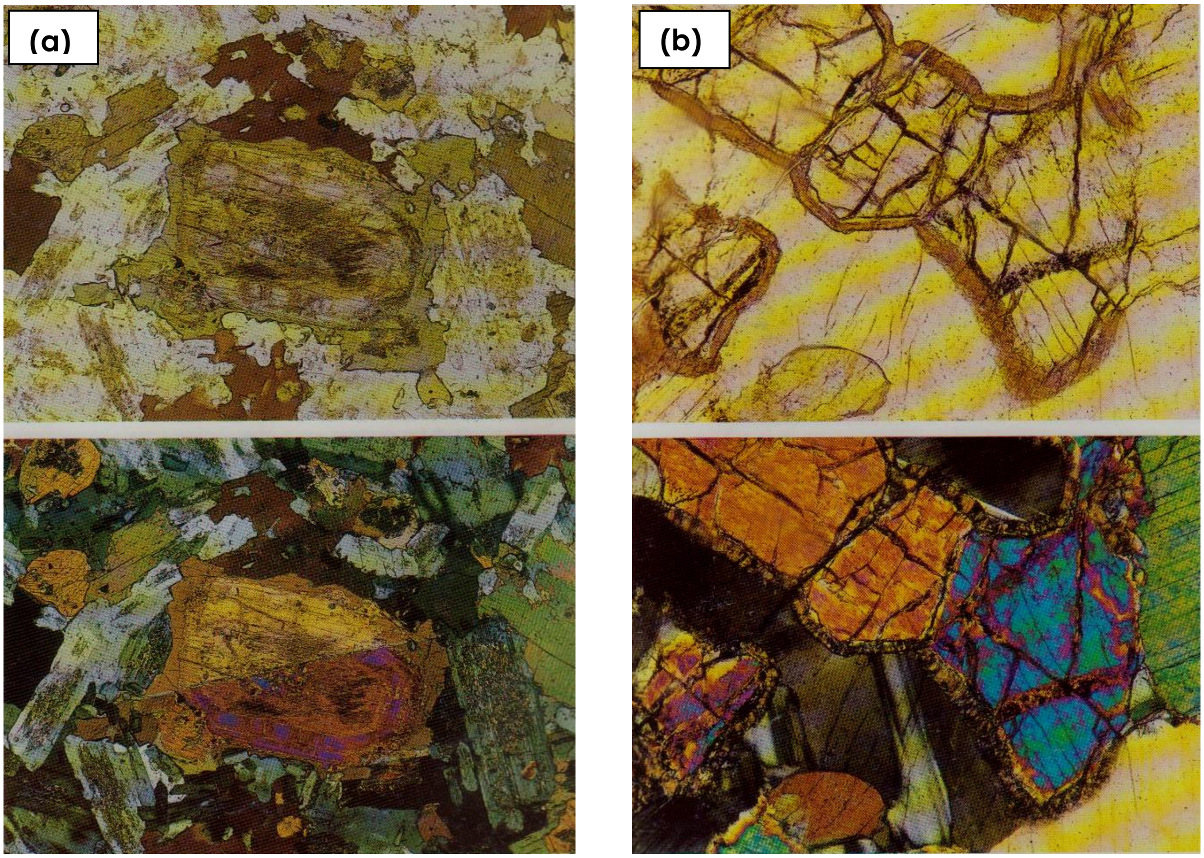


Fig. 25 Corona texture

TEXTURES TYPICAL OF HYPABYSSAL ROCKS

Hypabyssal rocks are either fine grained, equigranular or porphyritic with a fine grained matrix. In basis dykes intergranular texture (Figures 6-2 and 6-3) is commonly seen. Therefore this texture is also referred to as "doleritic texture". Granitic dykes frequently display granophyric quartz-alkali feldspar intergrowths; the rock is then often named a "granophyre" (Figure 6-6).

There are two special types of granatic dykes or veins, which are recognized by their macroscopic texture. The first is the coarse grained **pegmatite** with grain sizes ranging from 3cm up to several metres; on one occasion enormous crystals of 12 metres long have been observed! The pegmatites consist of alkali feldspar and quartz mainly, often showing graphic intergrowths, with or without plagioclase, muscovite and/or biotite and accessorial minerals such as apatite, tourmaline, topaz and other precious minerals. Pegmatites are crystallizing from the last melt fraction of a granitic magma, which is very rich in K^2O, Na^2O and SiO^2 and in H^2O and other minor volatiles such as P, B, F, Sn, Li and so on. The latter account for the unusual accessorial minerals that may be formed. The second type of late-magmatic granitic vein is the fine grained aplite which is produced from a water-saturated melt. Aplites are typically homogenous, white or pink rocks with a sugary appearance. They consist of quartz, feldspars and usually micas.

TEXTURES TYPICAL OF VOLCANIC ROCKS

Glassy Fabrics

One of the first textural characteristics to establish in a volcanic rock is its degree of crystallinity. As was mentioned before, very rapid cooling of high temperature silicate melts produces silicate glass. A rock may be wholly or partly consisting of glass, or it may be entirely crystalline. The nomenclature is as follows:

(i) Holocrystalline : The rock consists for 100% of crystals.

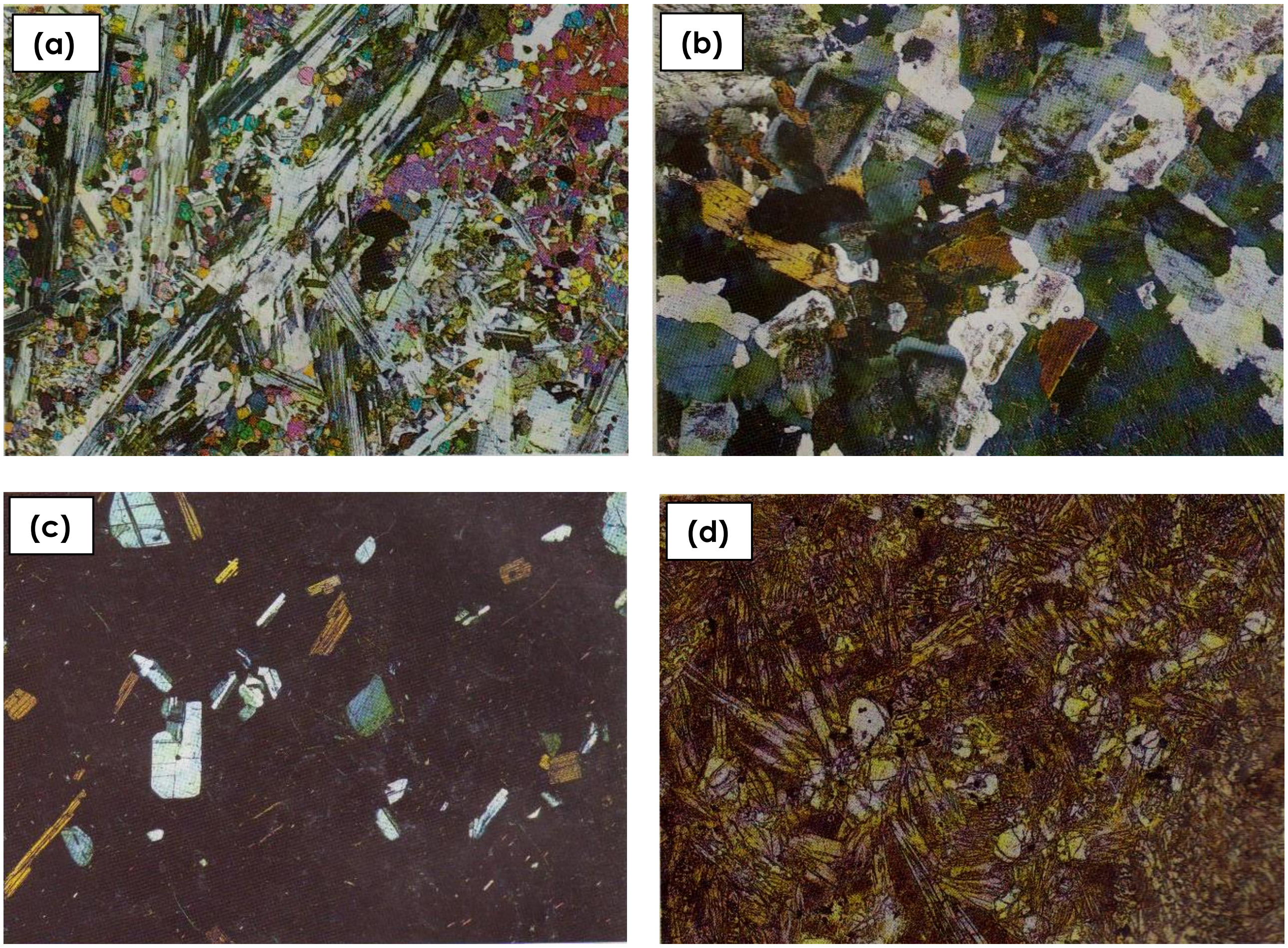


Fig. 26 Hypocrystalline texture

(ii) Holohyaline : The rock consists for 100% of glass. Rhyolitic glass is called obsidian, basaltic glass sideromelane; both can have a great variety of colours.

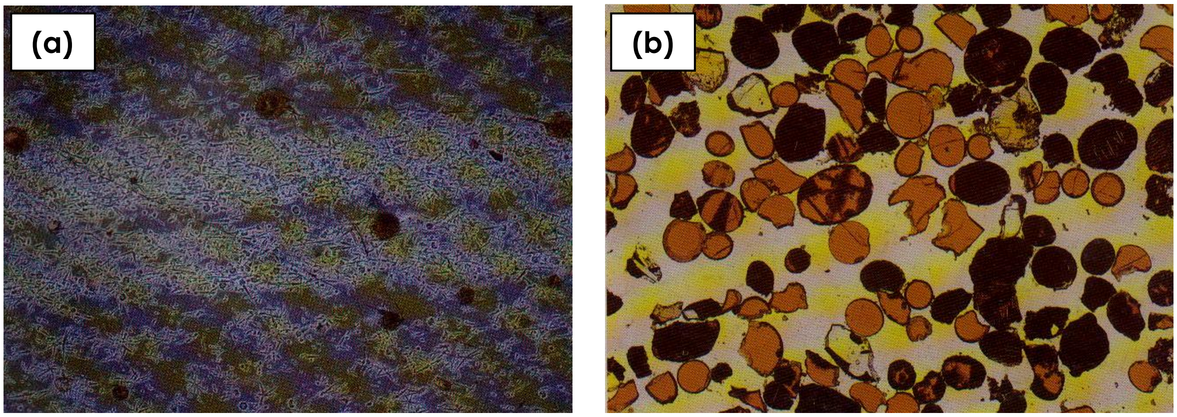


Fig. 27 Glassy rock

(iii) **Hemicrystalline** : The rock consists partly of glass, partly of (hypohyaline) crystals (Figure 6-11a).

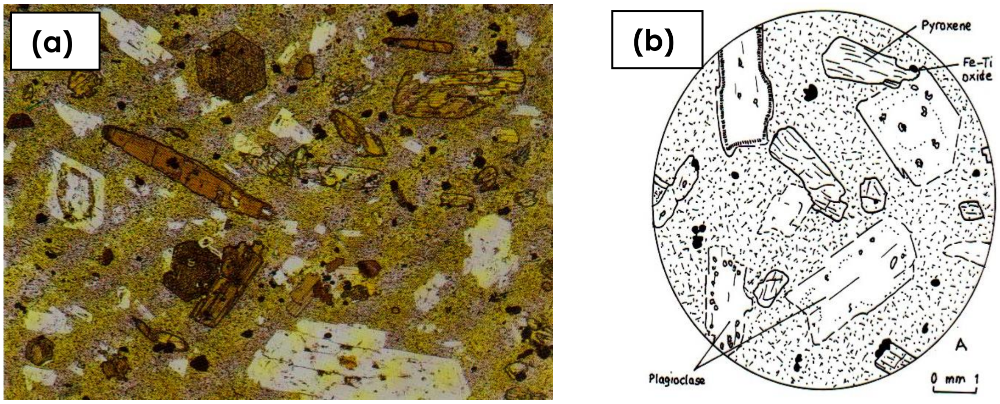


Fig. 28 Porphyritic andesite

(iv) **Vitrophyric** : Porphyritic texture, characterized by phenocrysts in a matrix of glass (Figure 6-11b).

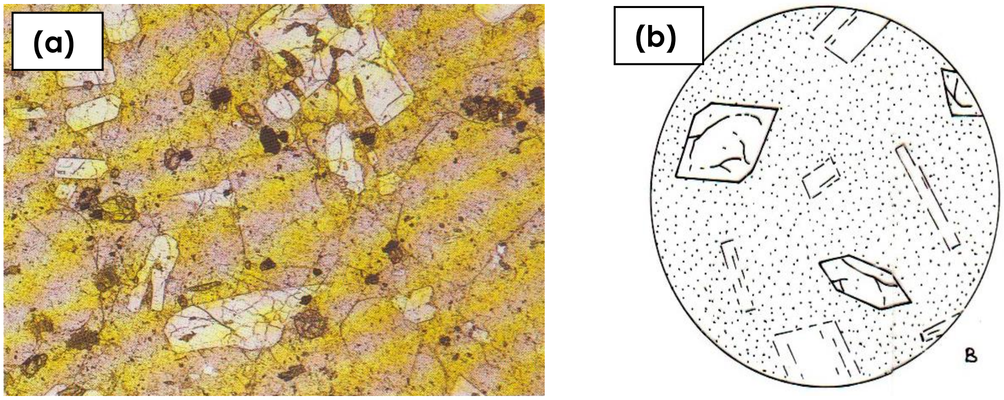


Fig. 29 Vitrophyre plagioclase-augite-magnetite

(v) Crystallites : Extremely fine crystals in glass, too fine to show interference colours.

(vi) Microlites : Extremely fine crystals in glass, but larger than crystallites, showing interference colours. (Figure 6-12d).

(vii) Pele's hair : Hair and tear shaped glass particles formed by drawing out of small, very fluid ejecta (see Figure 6-12e).

Fifure 6-11 (a) Porphyritic andesite with phenocrysts of plagioclase and pyroxene in a fine grained matrix of plagioclase, oxides and glass; (b) Vitrophyre: euhedral phenocrysts in glass matrix (from Best, 1982).

Figure 6-12. Principle textures of volcanic rocks (a) perlitic texture; (b) vesicular texture; (c) axiolitic texture; (d) microlites in a seriate porphyritic lava; (e) Pele's hair; (f) trachytic texture; (g) corroded crystals in felsitic matrix; (h) glomeroporphyritic texture; (i) spherulitic texture; (j) skeletal olivine in basalt; (k) dendritic olivines in glass; (l) texture of pumice. See explanation in text. (from Bard, 1986; Best, 1982; MacKenzie, Donaldson and Guilford, 1982).

PORPHYRITIC TEXTURES

Most volcanic rocks are porphyritic. The common interpretation of this texture is that the phenocrysts have crystallized while the magma was still in the interior of the Earth, whereas the fine grained matrix formed during a period of rapid cooling following the extrusion of magma. If a volcanic rock is not porphyritic it is called **aphyric**. If the crystals of the principle minerals who a continuous **range** in sizes the texture is called **seriate texture** (See Figure 6-12d), but if the crystals show a broken range of sizes, the inequigranular texture is said to be **hiatal**.

Glomeroporphyritic texture is a variety of porphyritic texture in which the phenocrysts cluster together in small groups rather than being separate individuals (Figure 6-12h). The explanation of the texture is that conditions of nucleation were unfavourable, so that only a few nucleation sites existed.

QUENCH TEXTURES

Quenching is the process of sudden cooling and freezing of a melt. As a result some crystals are imperfectly formed into **skeletal** or **dendritic** crystals. The first type are crystals with hollows and gaps, usually regularly developed. The latter have a branching pattern resembling that of a tree, or the veins in a leave or a feather, due to preferential growth in certain crystallographic directions (See Figure 6-12j and k).

Figure 6-13. Main spinifex textures of ultrabasic komatiite lavas; 01 = olivine, Pyr = Pyroxene (from Bard, 1986).

A special type of skeletal crystal growth is shown in the MgO-rich ultrabasic volcanic rocks known as komatiites. They display a thorny or fishbone pattern, which is called spinifex texture (See Figure 6 – 13).

Embayment is a common feature observed in phenocrysts. In many cases embayments are the result of skeletal growth during quenching, but embayment may also result from resorption of a crystal by reaction with the melt (See Figure 6-12g and 6-14). In some text books the term corrosion is used; embayed crystals are then called corroded crystals.

Figure 6 – 14. corroded phenocrysts that have been partly resorbed due to instability in the melt. (a) Plagioclase in vitrophyric rock, (b) Pyroxene and plagioclase in andesite lava. (from Best, 1982).

GROUNDMASS TEXTURES

The equivalent of the term matrix is **groundmass**. A common texture for the matrix of basalts is intergranular texture or intersertal texture, already discussed before (See Figure 6 – 2). A matrix texture characterized by parallel or sub-parallel feldspar laths is called **trachytic texture** (Figure 6-12f). It is very common in trachytes and other alkaline volcanic rocks, where the feldspar laths are usually sanidine, but it is also observed in basalts, where the feldspar is plagioclase. The preferred orientation of the feldspar laths indicates the direction of flow within the lava, and is an example of a flow structure, which is not exclusive for volcanic rocks, but can also be found in plutonic rocks.

In a matrix consisting of glass **perlitic texture** is frequently seen, which is characterized by concentric fractures developed by slow progressive **hydration** of glass under atmospheric conditions. The hydration causes expansion and consequent cracking of the glass (See Figure 6-12a). 0ther textures occurring in or resulting from an initially glassy matrix are devitrification textures, which are discussed below.

DEVITRIFICATION TEXTURES

Volcanic glass is never very old – geologically speaking. In time crystals will grow from the glass which is said to become **devitrified**. The first Stage is the growth of minute crystals, microlites or crystallites. Continued devitrification gives way to the following textures:

(i) Spherulitic texture, radiating, skeletal needles of quartz, feldspars or other minerals forming spherules (See Figure 6-12i).
(ii) Variolitic texture, same as (i), but the needles grow in fan-shape.
(iii) Axiolitic texture, spherulus are formed along a central axis (See Figure 6-12c).
(iv) Felsitic texture, the matrix has been completely devitrified to a microgranular aggregate of small, more or less equant crystals of quartz and feldspar (Figure 6-12g).

VESICULAR TEXTURES

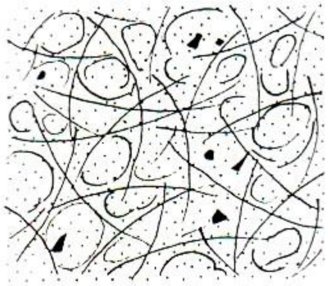
Vesicles are cavities in a lava, varying from spherical to irregular in shape, produced by the escape of gas. Vesicular lavas are typical of the tops of lava flows. If vesicles dominate the rock the term **scoriaceous** can be used. **Scoria** is a general name applied to highly vesicular basaltic rock. For rhyolitic scoriaceous rocks the term **pumice** is used. Pumice consists of sub-parallel silky glass fibres tangled together (Figure 6-121).

In amygdaloidal rocks post-magmatic minerals such as quartz, chalcedony, opal, chlorite, calcite or zeolites have been deposited in the vesicles. The minerals often have radial fibrous forms growing from the walls of the cavities inwards. Amygdaloidal basalts are very common.

TEXTURES TYPICAL OF PYROCLASTIC ROCKS

In Chapter 1 we have seen that pyroclastic rocks are sub-divided into ash-fall and ash-flow deposits and how the rocks are classified according to the size of the volcaniclastic material that constitutes these rocks. Ash-fall deposits are often sorted and stratified.

Ash-flow tuffs or **ignimbrites** consist of fragmental material which is welded together due to their deposition when still hot and sticky. Welding and compaction gives ignimbrite their typical **eutaxitic texture** with flattened **glass shards** in parallel orientation with **fiamme**, the name used for the flame-shaped pumice fragments, which were flattened due to collapse of their vesicles (See Figure 1-22 to 24). The ignimbrite may, like any other tuff, contain various types of lithic fragments (volcanic or other rocks picked up by the ash-flow during eruption) and of crystals (phenocrysts from the magma). The rock and crystal fragments usually form rigid bodies within the eutaxitic matrix.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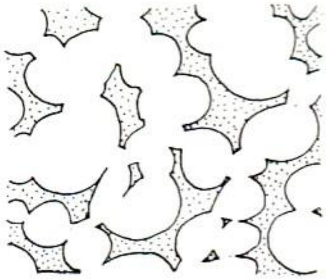
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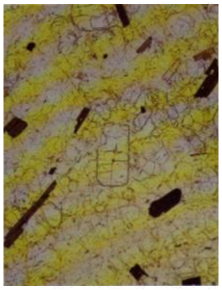

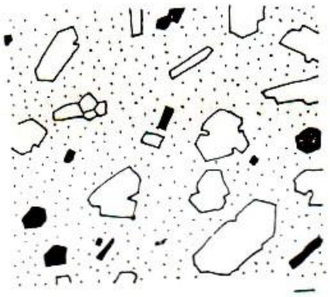
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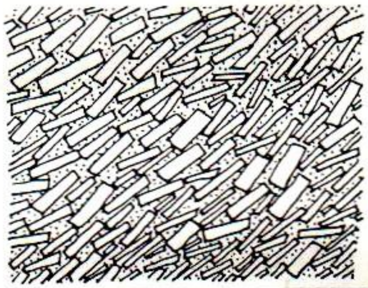
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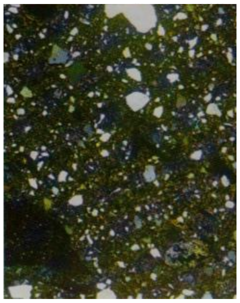

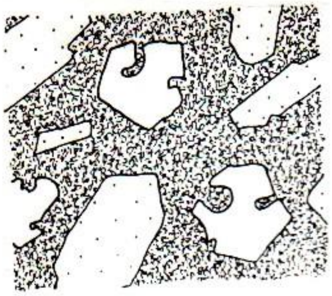
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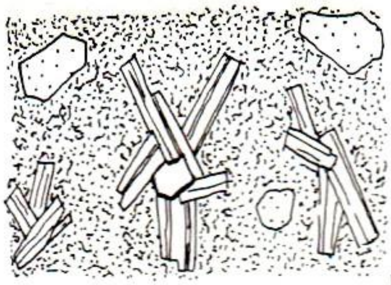
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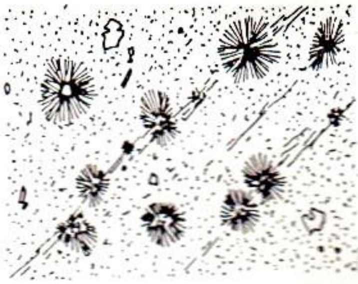
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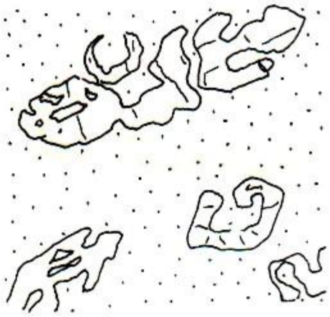
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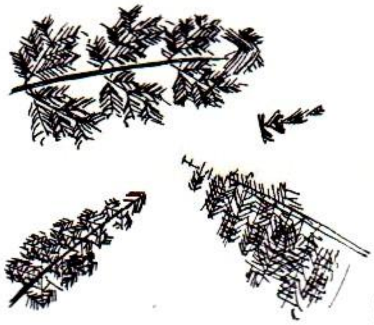
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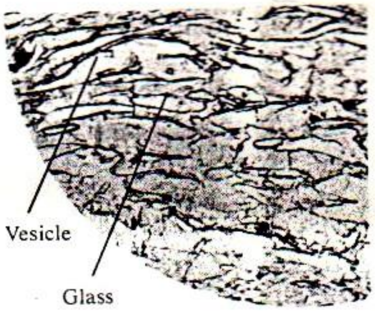

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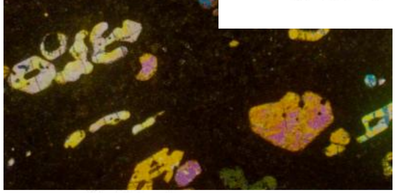
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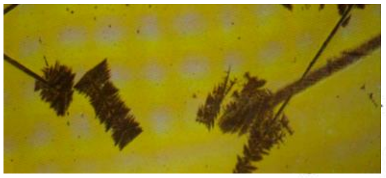
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