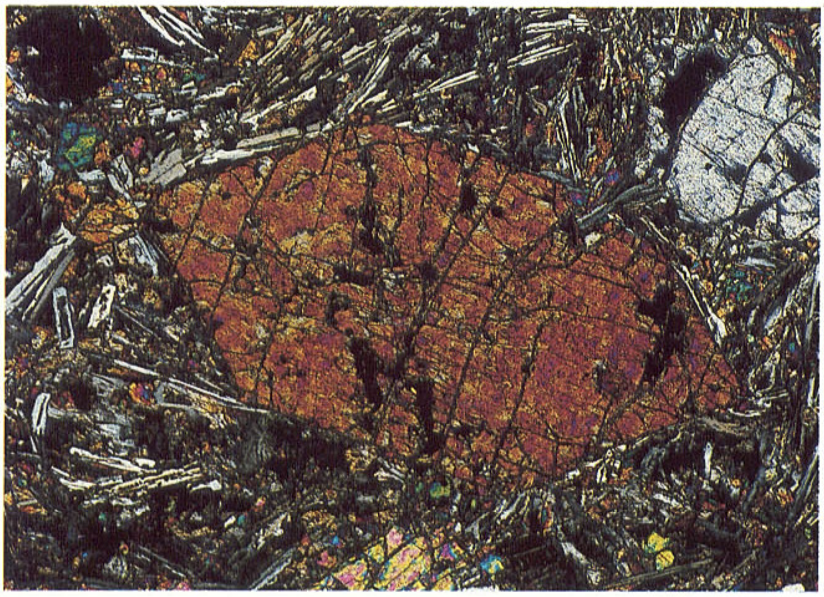
Crystal shapes

Two kinds of term are used to describe crystal shape: (1) those relating to the quality of the development of faces on crystals and (2) those specifying the three-dimensional shapes of individual crystals (p. 19).

Terms indicating the quality of the development of faces on crystals

Regrettably, three sets of words are in use to describe the same ideas, the most commonly used set being that in the first column of the following table.

Preferred terms	Synonymous terms	Synonymous terms	Meaning
Euhedral	Idiomorphic	Automorphic	Crystal completely bounded by its characteristic faces.
Subhedral	Hypidiomorphic	Hypautomorphic	Crystal bounded by only some of its characteristic faces.
Anhedral	Allotriomorphic	Xenomorphic	Crystal lacks any of its characteristic faces.



23 Euhedral olivine in olivine basalt

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

Olivine basalt from Ubekendt Ejland, West Greenland; magnification × 40, XPL.

24 Subhedral olivine in picritic basalt

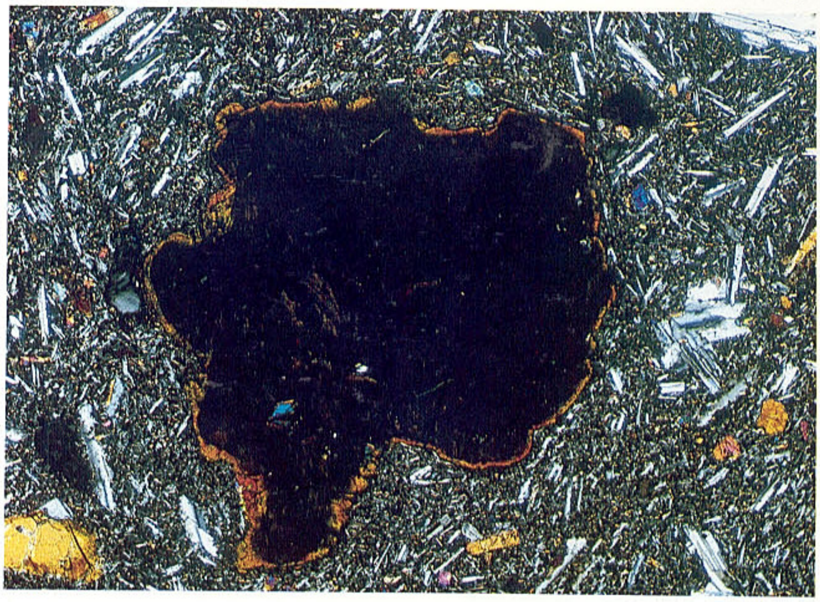
Some of the faces on this equidimensional olivine crystal are flat, planar ones, whereas others are curved and embayed.

Picritic basalt from Ubekendt Ejland, West Greenland; magnification × 72, XPL.

25 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.)

Olivine basalt from Mauritius, Indian Ocean; magnification × 32, XPL.



Terms indicating three-dimensional crystal shape

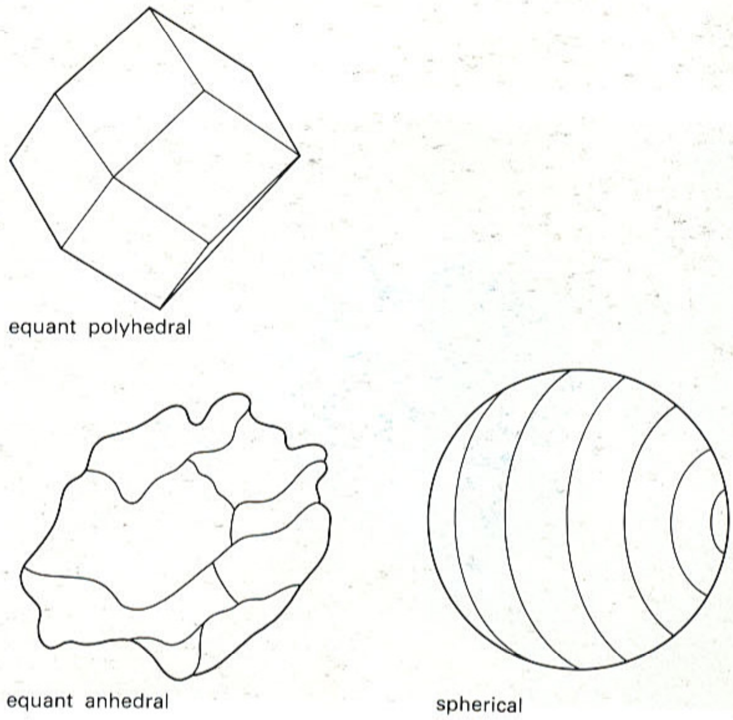
In hand specimens of coarse-grained rocks it is often possible to see the three-dimensional shape of a crystal on a broken surface. For finer-grained rocks, however, the crystals have to be examined in thin sections and the two-dimensional shapes of several crystals of different orientations used to deduce the three-dimensional shapes of the crystals in general.

General three-dimensional terms

The shape may either be an *equidimensional* (syn. *equant*) or an *inequidimensional* one, as illustrated in figs. A and B where the names applied to the various shapes are shown.

Fig. A Examples of equidimensional crystal shapes

The words *grain* and *granule* are often used for equidimensional crystals, and *drop* and *bleb* for particularly small examples.



Crystal shapes

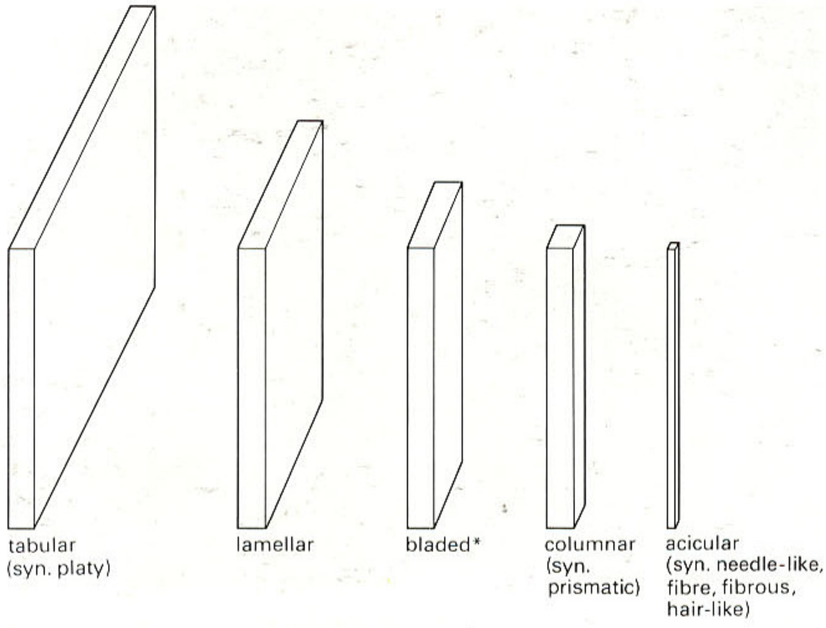


Fig. B Examples of inequidimensional shapes

N.B. Although these are euhedral examples, they could be subhedral or anhedral.

**Bladed feldspar crystals by common usage are frequently described as 'lath-shaped' or as 'laths of feldspar', in allusion to the slats (laths) in a Venetian blind.*

Specific three-dimensional terms

Skeletal, dendritic and embayed crystals
Skeletal crystals are those which have hollows and gaps, possibly regularly developed, and usually with particular crystallographic orientations. In thin section these spaces appear as embayments[1] and holes in the crystal, filled with groundmass crystals or glass. *Dendritic crystals* consist of a regular array of fibres sharing a common optical orientation (i.e. all part of a single crystal) and having a branching pattern resembling that of a tree or the veins in a leaf or a feather. In practice, many crystals can be described as either skeletal or dendritic because they have characteristics of both.

[1] *A common misconception among petrologists is that the terms 'embayment' and 'embayed' imply resorption of a crystal by reaction with liquid. While this may be true of some crystals (e.g.* ***29****), others (e.g.* ***26*** *and* ***27****) have embayments which probably formed during growth.*

26 Skeletal olivines in picritic basalt

All the large crystals in this rock are olivines and each shows a different shape in section; some are complex skeletal crystals (e.g. elongate yellow crystal on the left), others are relatively simple skeletons (e.g. equant orange crystal, middle right) and yet others have only small embayments.

Picritic basalt from Ubekendt Ejland, West Greenland; magnification × 40, XPL.

27 Skeletal olivine

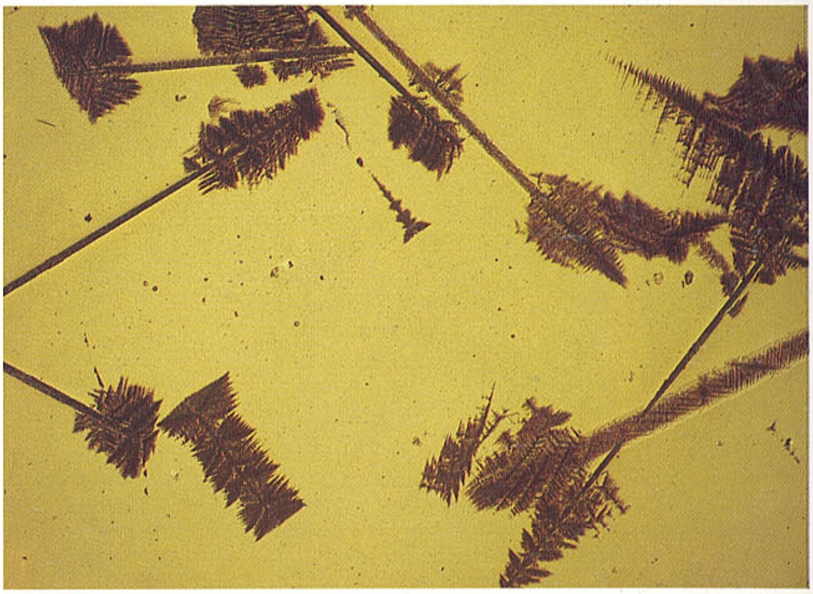
While superficially resembling the euhedral outline of the olivine in **23**, the crystal occupying the bulk of this picture has a complex interior form and incomplete prism and dome faces.

Picritic basalt from Ubekendt Ejland, West Greenland; magnification × 15, PPL.

28 Dendritic olivines

All the delicate, dendritic crystals in this photograph are olivines which formed during exceedingly rapid solidification of the basalt melt, part of which became the yellow glass.

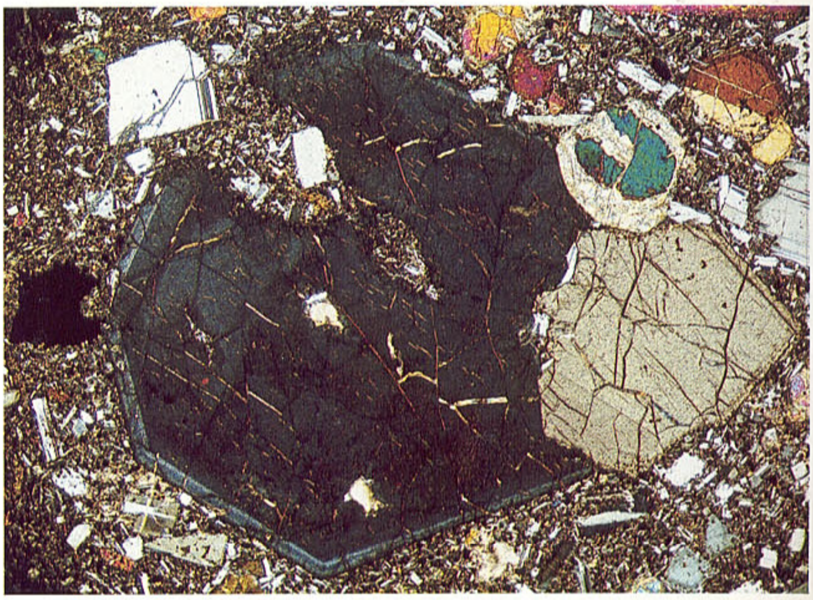
Specimen of olivine basalt melted and then cooled at 1400°/hr in the laboratory; magnification × 40, PPL.

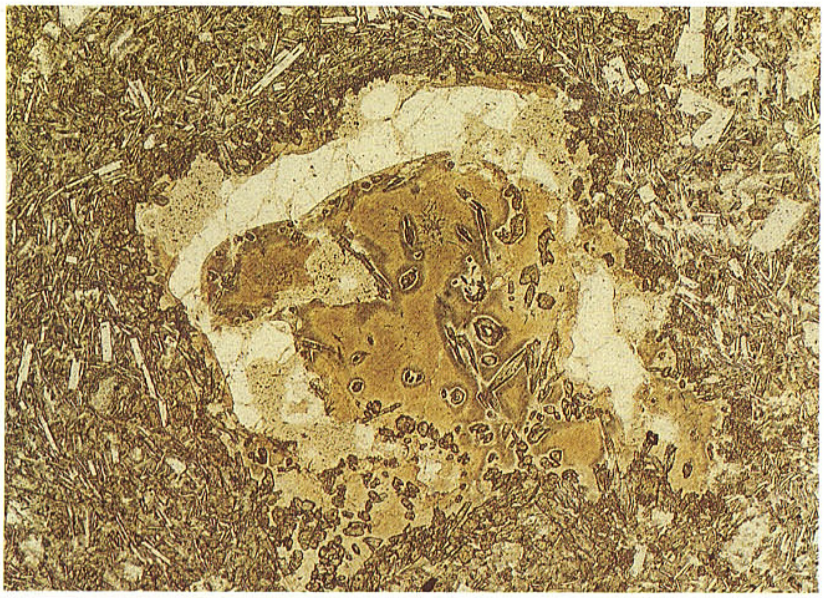


29 Embayment in augite phenocryst

The large augite crystal in this photograph contains a deep embayment filled with the basaltic groundmass. The irregular outline of this embayment distinguishes it from the embayments in the skeletal crystals in **27**. Note also the distinct marginal zoning and the delicate 'patchy zoning' within the crystal.

Olivine basalt from Arthur's Seat, Edinburgh, Scotland; magnification × 23, XPL.





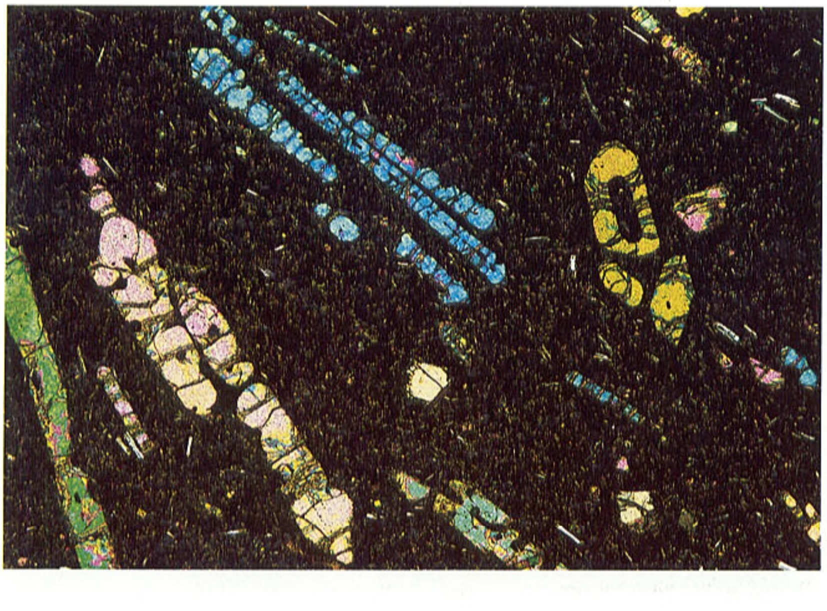
30 Embayed quartz

The deeply embayed quartz crystal in this olivine basalt contains brown glass and small, columnar, skeletal pyroxenes. It is also surrounded by a film of the glass and an aggregate of equant granular augite crystals which separate it from the basaltic groundmass.

Olivine basalt from Lassen Park, USA; magnification × 42, PPL.

Parallel-growth crystals

The term is applied to an aggregate of elongate crystals of the same mineral whose crystallographic axes are mutually parallel, or almost so. Although in thin section the individual parts of the aggregate may be isolated from one another, in the third dimension they are probably connected. A parallel-growth crystal is therefore a single, incomplete crystal formed by a particular style of skeletal growth.



31 Olivine parallel growth

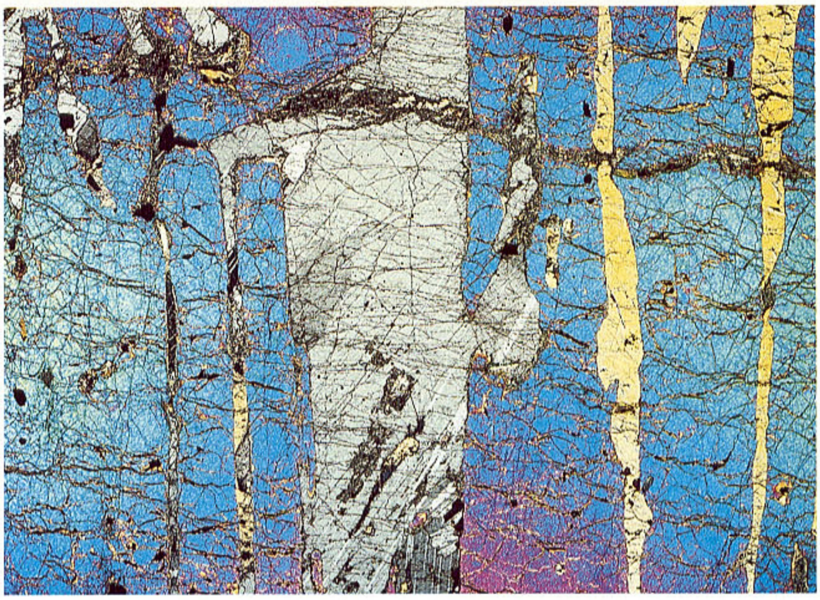
The elongate olivines near the middle of the photograph and showing blue interference colour all have the same crystallographic orientation, and hence represent a single, parallel-growth crystal. The crystal with yellowish-green interference colour shows how the parallel-growth crystal *might* appear, if sectioned at right angles.

Picritic basalt from Ubekendt Ejland, West Greenland; magnification × 23, XPL.

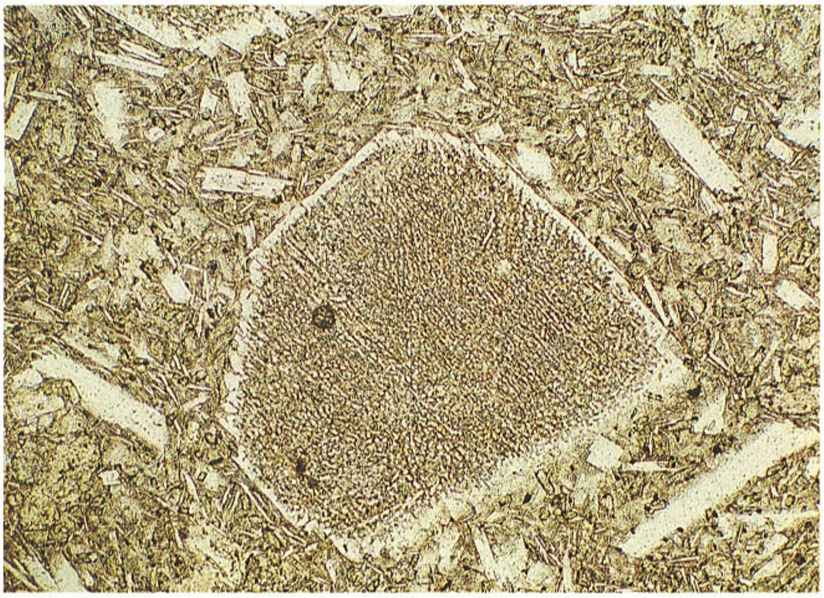
32 Parallel growth in a very coarse-grained rock

Here the parallel growth is of a very large olivine crystal. The actual width of the field of view is 1.7 cm and this shows only a small part of the parallel growth, whose total width is 50 cm and height is 150 cm. The whole comprises several hundred parallel units like the ones shown here. Plagioclase and augite occupy the 'channels' between the parallel growths. In the XPL picture the polars have been rotated so that the olivine is not in extinction. The slight differences in birefringence of the olivine at the top and bottom of the picture are caused by the section being thinner there. This rock has the special textural name *harrisite*.

Feldspathic peridotite from Rhum, Scotland; magnification ×7, PPL and XPL.



Sieve-textured crystals
These contain abundant, small, interconnected, box-shaped glass inclusions, giving the crystals a spongey, or porous, appearance.

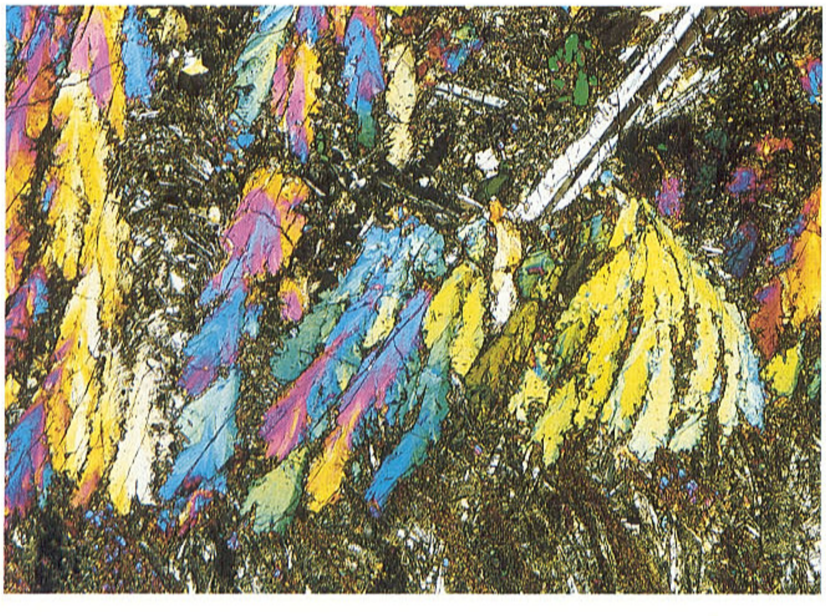


33 Sieve-textured feldspar

The core of this xenocryst consists of glass and alkali feldspar in a fine-mesh-like arrangement; the narrow rim is an overgrowth of plagioclase.

Olivine basalt from Lassen Park, USA; magnification ×62, PPL.

Elongate, curved, branching crystals
These are rarely genuinely bent, rather the curvature is caused by development of branches along the length of the crystal, each branch having a slightly different crystallographic orientation to its neighbours (e.g. **34**–**36**).



34 Curved branching augite

The highly coloured crystals in this photograph are complex, branching crystals of augite in subparallel alignment. They form part of a pyroxene-rich band in a differentiated dyke. (See also **71**.)

Dolerite from North Skye, Scotland; magnification ×21, XPL.

35 Branching augite in lamprophyre dyke

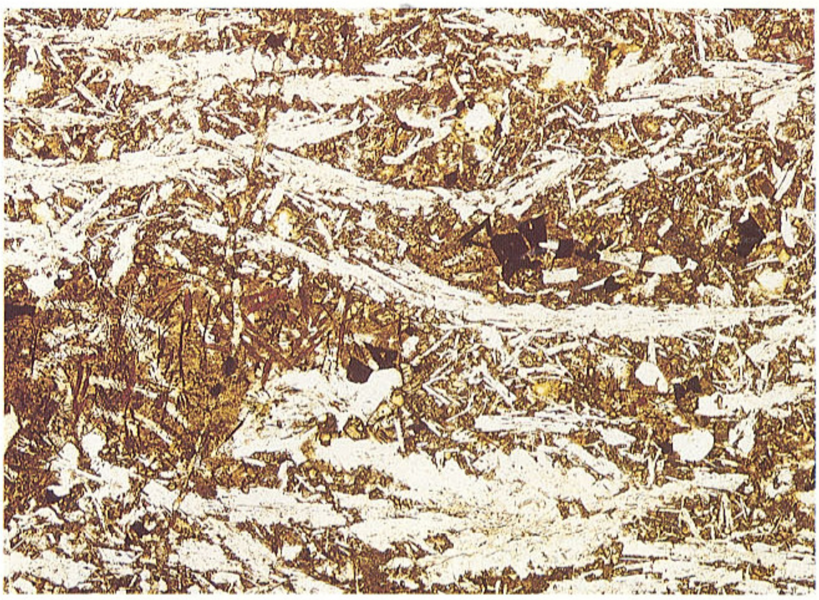
The acicular, aligned phenocrysts in this photograph are all of augite, forming composite, radiating, curved and branching groups. Individual needles can be seen to consist of several straight portions offset slightly from one another, and having very slightly different orientations; this gives each 'needle' its curved appearance. The margin of the dyke lay to the left. (See also **70**.)

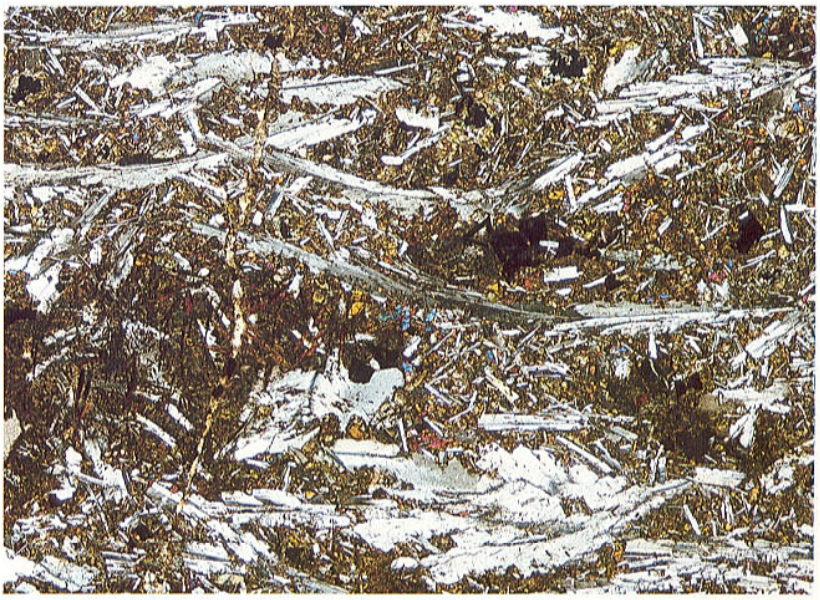
Fourchite from Fiskaenesset area, South-west Greenland; magnification × 20, XPL.

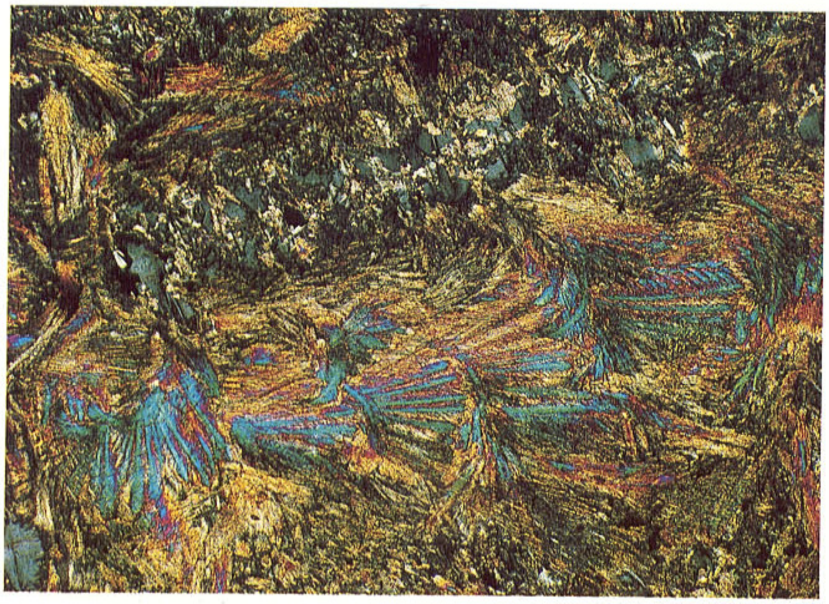
36 Curved and branching plagioclase crystals in dolerite

The large composite plagioclase crystals in this rock are elongate parallel to the *c* crystallographic axis and flattened parallel to (010). From the direction in which they branch, and from that in which the crystal at the bottom widens, it can be deduced that the crystals grew from right to left. The matrix consists of fine-grained plagioclase, olivine, pyroxene, amphibole, devitrified glass and clay minerals.

Feldspathic dolerite, Ubekendt Ejland, West Greenland; magnification × 16, PPL and XPL.







37 Composite branching augite crystal

These photographs illustrate a particularly intriguing shape of branching augite crystal: it consists of groups of slightly diverging needles, subparallel to the length of the crystal, which apparently have grown from curved branching needles oriented approximately at right angles to the crystal length. Despite the uniform interference colour of many of the needles, a sweeping style of extinction occurs when the microscope stage is rotated under crossed polars, indicating that the needles are not all of the same crystallographic orientation.

Peridotitic komatiite from Munro Township, Ontario, Canada; magnification × 52, PPL and XPL.

Pseudomorphs

It may be found that crystals in a thin section, although having the characteristic shape of a particular mineral, prove to be of another mineral, or an aggregate of crystals of another mineral. The name *pseudomorph* is used for such a crystal. If the pseudomorph has the same composition as the original crystal (e.g. 'quartz' in place of tridymite) it is known as a *paramorph*.

38 Carbonate pseudomorphs after olivine

The phenocrysts in this altered basalt show typical sections of skeletal olivine, with inclusions of groundmass in the embayments. However the photograph shows the phenocrysts to be occupied by finely crystallized carbonate, indicating that replacement of olivine has occurred.

Altered basalt from Castleton, Derbyshire, England; magnification × 27, XPL.

Another example of pseudomorphs is shown in ***149***.

Mutual relations of crystals (and amorphous materials)

The various patterns of crystal arrangement which can exist are conveniently introduced under the following headings: equigranular textures; inequigranular textures; oriented textures; intergrowth textures; radiate textures; overgrowth textures; banded textures; and cavity textures. Particular textures may belong to more than one of these categories and some also belong to the categories of **crystallinity**, **granularity** and **crystal shape**. Thus certain of the textures introduced in this section have already been mentioned and reference is made to photographs of them in previous sections.

Equigranular textures

Depending on the general shape of the crystals, three textures can be distinguished in which crystals of the principal minerals in a rock are of roughly uniform grain size:

name	synonyms	definition
euhedral granular	panidiomorphic granular	bulk of the crystals are euhedral and of uniform size
subhedral granular	hypidiomorphic granular	bulk of the crystals are subhedral and of uniform size
(anhedral)[1] granular	allotriomorphic granular (granitic and granitoid textures apply to siliceous rocks only)	bulk of the crystals are anhedral and of uniform size

Boundaries between these categories are not sharply defined and consequently the terms are applied very subjectively. Furthermore a rock may not fit neatly into a single category, thus one in which ~50% of the crystals are euhedral and ~50% anhedral might best be described as having a mixed euhedral and anhedral granular texture.

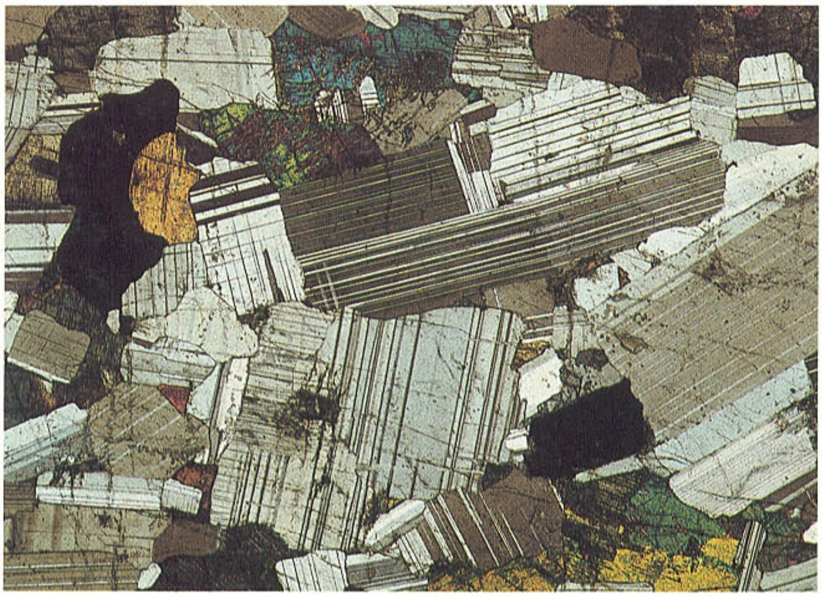
In addition to the examples of these textures in **39–43**, others may be found in **18, 111, 113, 117, 125, 130, 134, 140** and **168**.

[1] *This adjective is commonly omitted from this textural name.*

39 Euhedral granular hornblendite

Rocks possessing truly euhedral granular 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, hornblende, are euhedral and some strictly are subhedral. In contrast to **40**, there are a higher proportion of crystals with faces and the term 'euhedral granular' is therefore suggested as most appropriate. It should be appreciated, however, that another petrologist might prefer 'subhedral granular'.

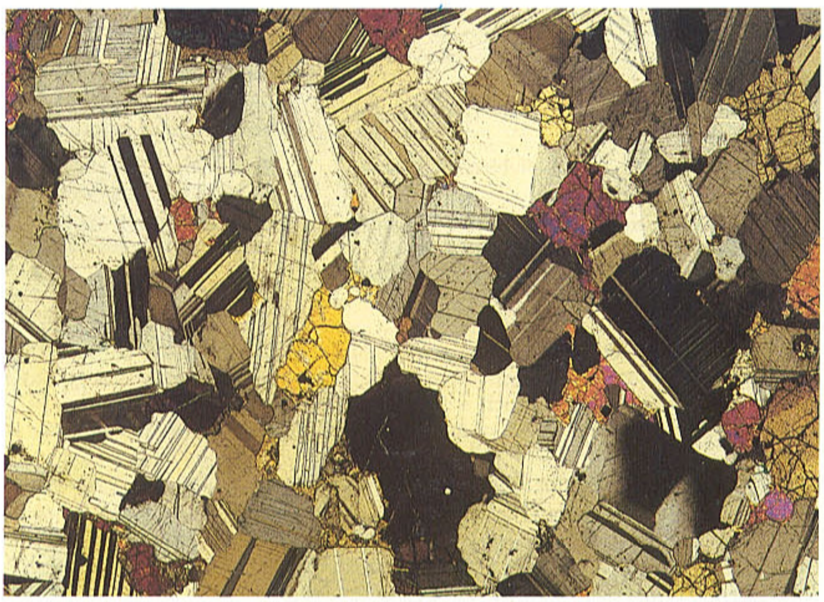
Hornblendite from Ardsheal Hill, Scotland; magnification ×7, XPL.



40 Subhedral granular gabbro

The stout prismatic plagioclase feldspar crystals which dominate this rock are mostly subhedral. The anhedral interstitial crystals are of orthopyroxene, augite and magnetite.

Gabbro from Middle Zone of the Skaergaard intrusion, East Greenland; magnification × 20, XPL.



41 (Anhedral) granular troctolite

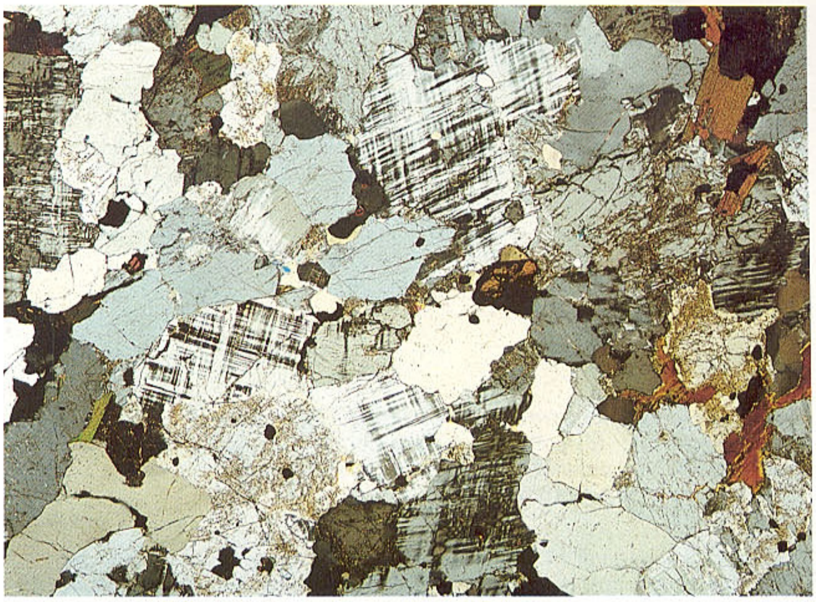
Only a few of the plagioclases in this equigranular rock possess a face and none of the olivines do. The crystals are therefore predominantly anhedral and the 'mosaic' texture is granular.

Troctolite from Garbh Bheinn intrusion, Skye, Scotland; magnification × 17, XPL.

42 Granular granite

Excepting the scarce biotite crystals, the quartz, microcline and albite crystals which make up the bulk of the rock are anhedral and have slightly interdigitating boundaries (i.e. *consertal texture* – see p. 45).

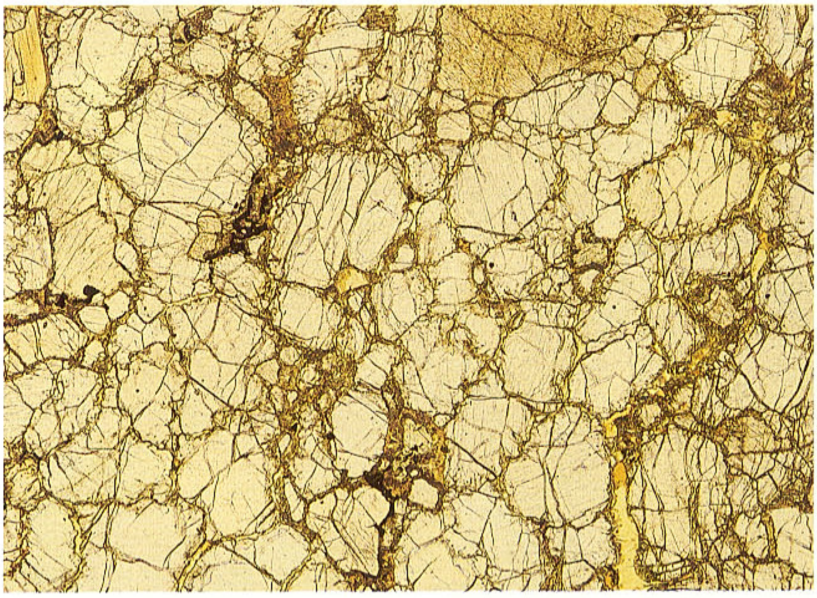
Granite from Madagascar; magnification × 13, XPL.

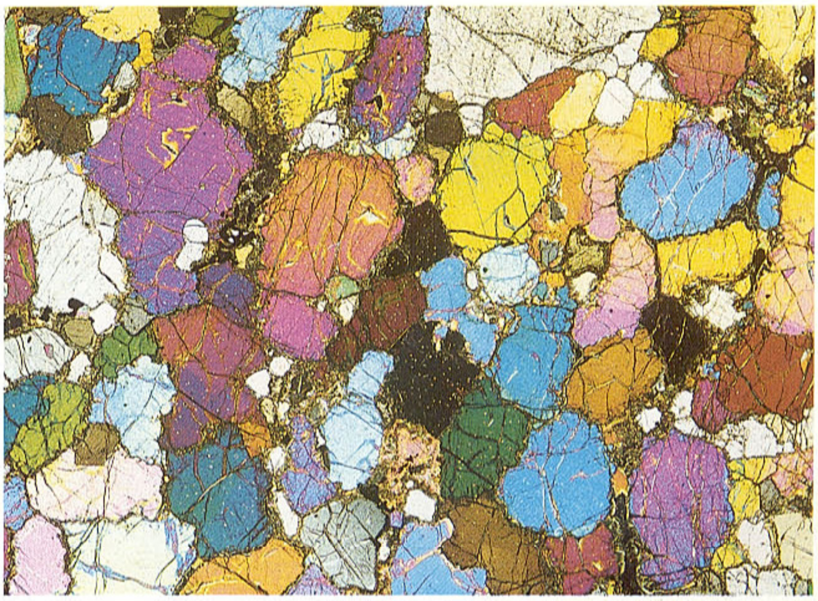


43 Granular lherzolite

The crystals of olivine (colourless in PPL), and pyroxenes (pale brown in PPL) which make up 95% of this rock, lack any crystal faces.

Lherzolite xenolith from the Matsoku kimberlite pipe, Lesotho; magnification × 16, PPL and XPL.





Inequigranular textures

This category includes seven kinds of texture: (a) seriate; (b) porphyritic; (c) glomeroporphyritic; (d) poikilitic; (e) ophitic; (f) subophitic; and (g) interstitial (intersertal and intergranular). It is not uncommon for a single thin section to display more than one of these textures.

Seriate texture

Crystals of the principal minerals show a continuous range of sizes. (See also p. 14.)

44 Seriate-textured basalt

This basalt, consisting of just plagioclase, augite and a small proportion of magnetite, shows a range in sizes of plagioclase and augite crystals from <0.01–0.5 mm.

Basalt from Island of Mauritius; magnification × 43, PPL and XPL.

*See **22** and **137** for other seriate-textured rocks.*

Porphyritic texture

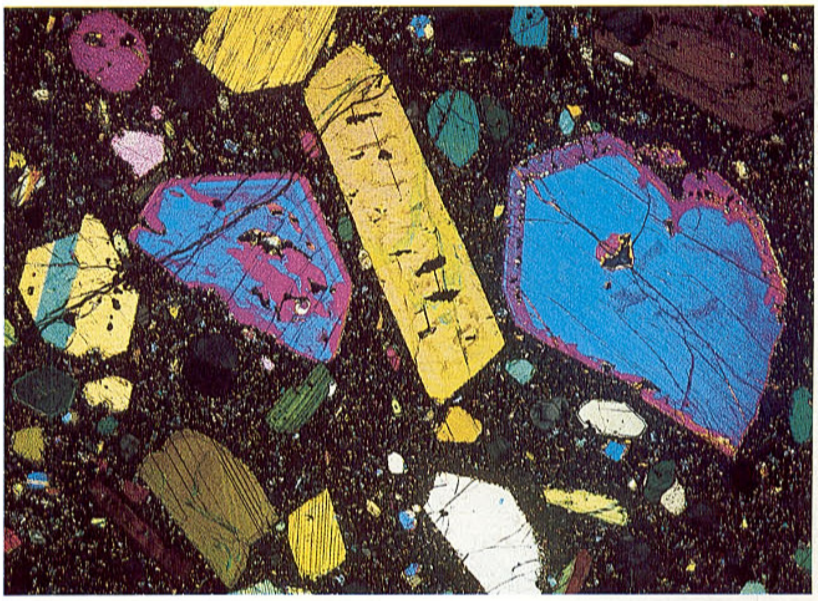
Relatively large crystals (phenocrysts) are surrounded by finer-grained crystals of the groundmass. (See also p. 14.)

45 Augite-olivine-leucite-phyric melilitite

Augite (greyish-green and green in PPL) is present in three generations in this sample – large euhedral phenocrysts, subhedral microphenocrysts and minute groundmass crystals. The leucite occurs as colourless, equant euhedral microphenocrysts, most easily identified by their very low birefringence in the XPL picture, and the olivine as faint-grey, euhedral, columnar microphenocrysts. Note the complicated zoning pattern in one of the augite phenocrysts, the prominent marginal zoning and the line of small inclusions of groundmass crystals in another. Melilite is confined to the fine-grained granular groundmass and cannot easily be seen in these photographs.

Melilitite from Malawa, Celebes; magnification × 11, PPL and XPL.

Many more examples of porphyritic texture may be found by leafing through the book.



Glomeroporphyritic texture

A variety of porphyritic texture in which the phenocrysts are bunched, or clustered, in aggregates or clots called *glomerocrysts*. (A minority of petrologists maintain that the term applies only to monomineralic clots and for polymineralic clots they use the term *cumulophyric texture*.) *Glomerophyric* is usually used synonymously with *glomeroporphyritic*, though the former term strictly should be reserved for clusters of equant crystals (Johannsen, 1931). (*Synneusis texture* also describes crystal clots but includes the genetic implication that the crystals 'swam together' and is therefore best avoided.)

46 Glomeroporphyritic tholeiitic basalt

The photograph shows crystal clots of different sizes composed of plagioclase, augite and olivine crystals, enclosed by fine-grained intergranular- and intersertal textured groundmass.

Basalt from unknown locality; magnification × 11, XPL.

47 Glomeroporphyritic hawaiite

Discrete phenocrysts of plagioclase and olivine, and clots consisting of a few crystals of the same minerals, are set in a fine-grained groundmass, in places showing slight alignment of plagioclase needles. Some plagioclases in individual clots are aligned – this arrangement is common in plagioclase glomerocrysts.

Hawaiite from plateau lavas of North Skye, Scotland; magnification × 11, XPL.

Additional views of glomeroporphyritic texture may be seen in ***122**, **127**, **154** and **158**.*

Poikilitic texture

Relatively large crystals of one mineral enclose numerous smaller crystals of one, or more, other minerals which are randomly oriented and generally, but not necessarily, uniformly distributed. The host crystal is known as an *oikocryst* (or *enclosing crystal*) and the enclosed crystals as *chadacrysts*. Although *chadacrysts* are generally equant, or nearly so, they need not be uniform in size; sometimes they display progressive change in size from the interior to the margin of an oikocryst, indicating differences in extent of chadacryst growth at the time of enclosure. It is not customary to apply *poikilitic texture* to the arrangement in which scarce minute crystals of accessory minerals are embedded in a crystal, nor to that in which the enclosing mineral is approximately the same size as that included.

48 Poikilitic enclosure of olivine crystals by augite

In this photograph approximately 100 crystals of olivine of fairly uniform size are enclosed by a single augite crystal (at extinction).

Peridotite from Quarsut, West Greenland; magnification ×22, XPL.

49 Plagioclase chadacrysts enclosed by augite

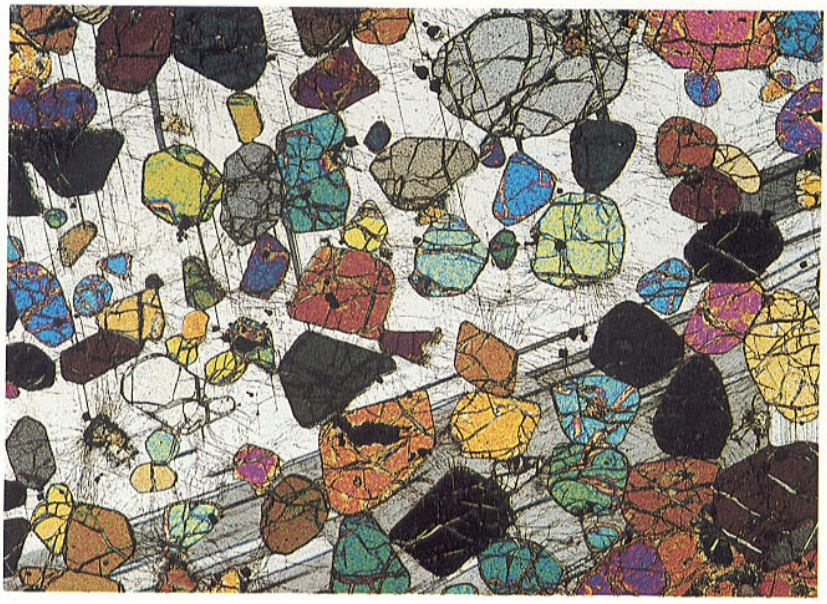
Part of a single augite crystal (yellow colour), exceeding 30mm in size, is shown here enclosing plagioclase crystals, some of which form clots. The orange crystal at upper right is olivine and the crystal almost at extinction is another augite crystal.

Gabbro from North Skye, Scotland; magnification ×7, XPL.

50 Olivine gabbro containing poikilitic domains

Large plagioclases, enclosing or partially enclosing, round olivines at their margins provide a framework to this rock, the interstices of which are occupied by large augites also enclosing round olivines and small stubby crystals of plagioclase.

Olivine gabbro from Middle Border Group of the Skaergaard intrusion, East Greenland; magnification × 12, XPL.



51 Olivines enclosed by plagioclase oikocryst

Subhedral, equant olivine crystals here are enclosed in a single large plagioclase crystal.

Feldspar peridotite from Rhum, Scotland; magnification × 21, XPL.

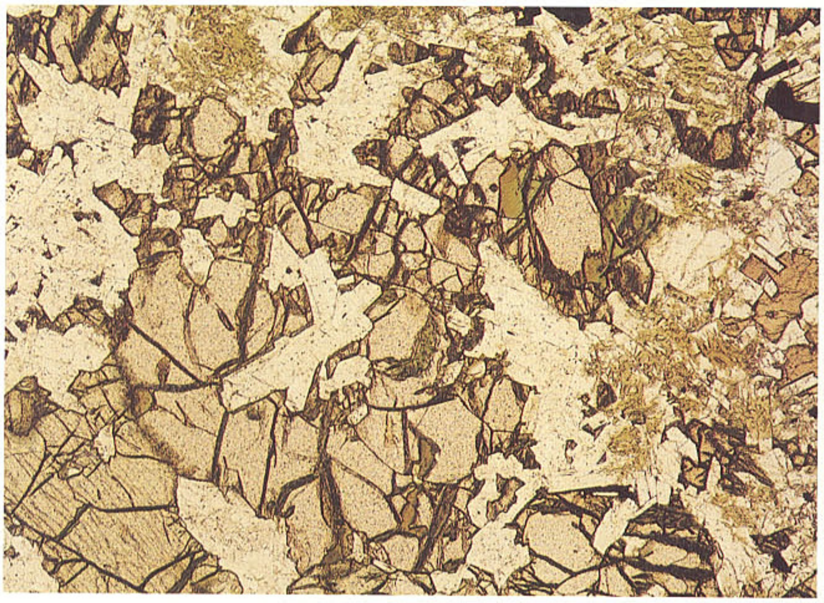
*Additional views of poikilitic texture may be found in **111, 114** and **167**.*

Ophitic texture

This is a variant of *poikilitic texture* in which the randomly arranged chadacrysts are elongate and are wholly, or partly, enclosed by the oikocryst. The commonest occurrence is of bladed crystals of plagioclase surrounded by subequant augite crystals in dolerite (sometimes referred to as *doleritic texture*); however the texture is not confined to dolerites, nor to plagioclase and augite as the participating minerals.

Some petrologists distinguish the arrangement in which the elongate chadacrysts are completely enclosed (*poikilophitic texture*) from that in which they are partially enclosed and therefore penetrate the oikocrysts (*subophitic texture*). *Poikilophitic texture* could also be used when oikocrysts surround elongate chadacrysts of one mineral and equant chadacrysts of another.

Fine- and medium-grained rocks made up of many small oikocrysts have a patchy appearance, sometimes described as *ophimottled*.



54 Subophitic alkali olivine dolerite

In this view plagioclase laths are embedded in olivine rather than pyroxene. One olivine crystal is at extinction in the XPL photograph and another shows orange interference colour. The other mafic mineral in the pictures is augite showing a purple interference colour.

Olivine dolerite from Shiant Isles sill, Scotland; magnification × 26, PPL and XPL.

See ***121, 126, 128*** *and* ***164*** *for additional examples of subophitic texture;* ***121*** *is particularly interesting because here the pyroxene is subophitically enclosed by plagioclase, and in* ***164*** *pyroxene is subophitically enclosed by kalsilite.*

55 Poikilophitic texture in olivine gabbro

For the texture shown here the term poikilophitic is preferable to ophitic because (a) the large augite encloses some equant olivines in addition to plagioclases, and (b) many of the plagioclases are not markedly elongate.

Olivine gabbro from Lower Zone a of the Skaergaard intrusion, East Greenland; magnification × 10, XPL.

56 Ophimottled texture in olivine basalt

Approximately fifty augite crystals are shown here enclosing bladed plagioclases and giving the rock a mottled or speckled appearance.

Olivine basalt from Isle of Mull, Scotland; magnification ×14, XPL.

57 Feldspar-olivine-phyric ophimottled basalt

Phenocrysts of plagioclase and olivine, some in clots, are set in fine-grained ophimottled groundmass.

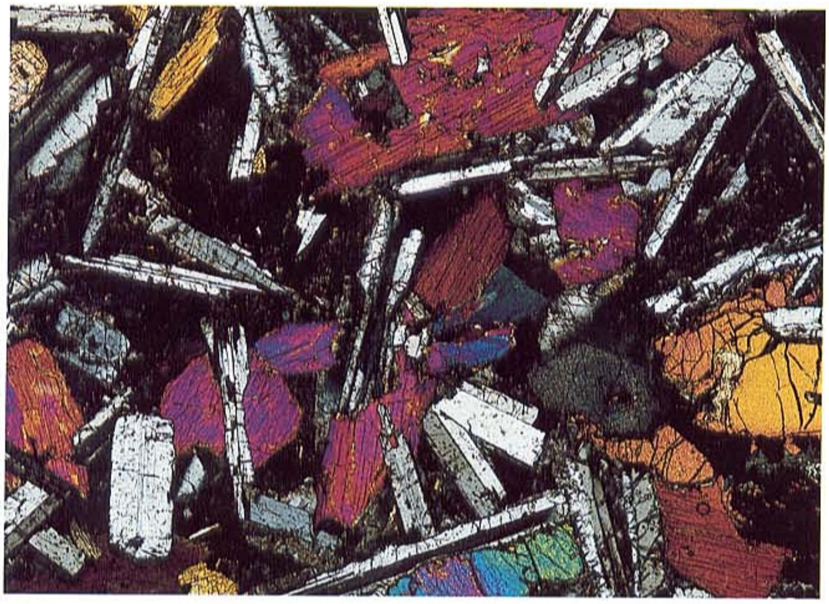
Olivine basalt from Skye, Scotland; magnification ×12, XPL.

Interstitial textures

Two varieties are recognized on the basis of the material occupying the angular spaces between feldspar laths:

1. *Intersertal texture* – glass or hypocrystalline material wholly, or partly, occupies the wedge-shaped interstices between plagioclase laths. The glass may be fresh or have been altered to palagonite, chlorite, analcite or clay minerals, or it may have devitrified. If a patch of glass is sufficiently large and continuous to enclose a number of plagioclases, some petrologists would describe the texture as *hyalophitic*. (See also *hyalopilitic* texture, p. 41.)
2. *Intergranular texture* – the spaces between plagioclase laths are occupied by one, or more, grains of pyroxene ($\pm$olivine and opaque minerals). Unlike ophitic texture, adjacent interstices are not in optical continuity and hence are discrete small crystals. The feldspars may be in diverse, subradial or subparallel arrangement (see also *pilotaxitic* and *felty* textures, p. 41).

As shown by some of the photographs illustrating these textures, a single thin section may contain both types of interstitial texture in separate, but contiguous, textural domains.



58 Intersertal (hyalophitic) texture in tholeiitic basalt

Certain parts of this photograph show lath-shaped plagioclases enclosed in pools of devitrified, deep-brown glass. Other plagioclases are surrounded by augite in a subophitic manner.

Oceanic tholeiite from Leg 34 of the Deep Sea Drilling Project; magnification × 65, PPL.

59 Intersertal texture in alkali dolerite

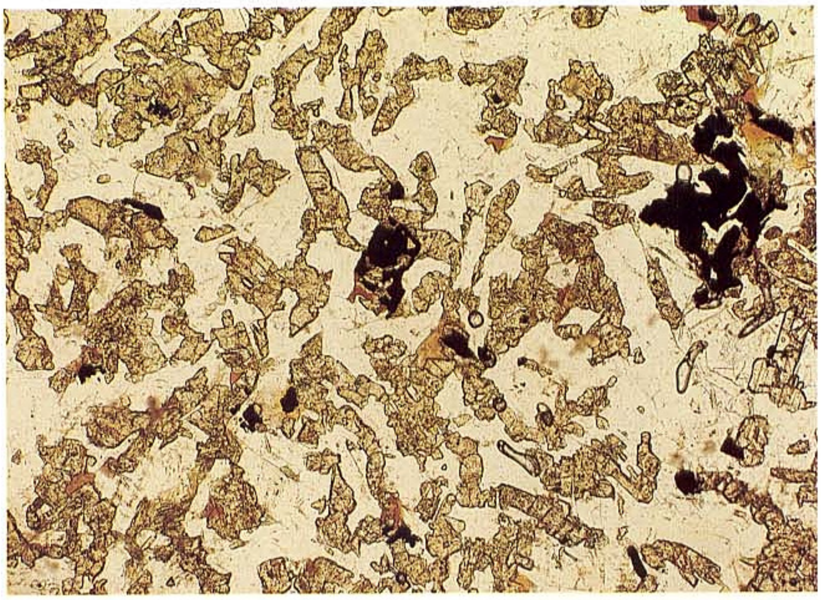
The intersertal texture in this dolerite consists of plagioclase crystals embedded in analcite (colourless in PPL and isotropic in XPL). Other plagioclases are partially enclosed by pyroxene in a subophitic manner. A crystal of olivine can be seen at the right-hand edge of the view in PPL.

Alkali dolerite from Howford Bridge sill, Ayrshire, Scotland; magnification × 23, PPL and XPL.
*See also **126** and **127**.*

60 Intergranular dolerite

Anhedral equant crystals of augite and pigeonite occupy the spaces between plagioclase crystals in this sample.

Dolerite from near the lower margin of Palisades sill, New Jersey, USA; magnification × 60, PPL and XPL.



61 Intergranular olivine gabbro

In this example of intergranular texture the rock is coarse-grained and the plagioclases have a subparallel arrangement. Note that the interstitial augites are anhedral against the euhedral plagioclases.

Olivine gabbro from Lower Zone b of the Skaergaard intrusion, East Greenland; magnification × 15, XPL.

62 Tholeiitic basalt with two types of interstitial texture

In this photograph patches between some of the plagioclases are occupied by brown glass (partly devitrified) and between others by clots of small augite crystals without any glass present, i.e. domains of both intersertal and intergranular texture are present.

Tholeiitic basalt from Ubekendt Ejland, West Greenland; magnification × 27, PPL and XPL.

63 Intersertal, intergranular and subophitic textures in dolerite

All three of these textures co-exist in this rock.

Dolerite from Whin sill, Northumberland, England; magnification × 26, PPL and XPL.

Intersertal, intergranular and subophitic textures in dolerite (continued).

Oriented, aligned and directed textures

Several classes of this textural type exist: (a) trachytic texture; (b) trachytoid texture; (c) parallel-growth texture; (d) comb texture; and (e) orbicular texture.

Trachytic texture

A subparallel arrangement of microcrystalline lath-shaped feldspars in the groundmass of a holocrystalline or hypocrystalline rock.

N.B. the term is not restricted in use to rocks of trachyte composition (e.g. see groundmass of **47**).

Some petrologists subdivide trachytic texture with microlite-sized feldspars into *pilotaxitic texture* and *hyalopilitic texture*, depending on whether the material between the feldspars is crystalline or glassy.[1] Strictly, however, the microlites in these textures may be more or less aligned. (For a pilotaxitic texture in which the microlites are essentially randomly arranged the term *felty texture* exists.)

Trachytoid texture

A subparallel arrangement of tabular, bladed or prismatic crystals which are visible to the naked eye (Holmes, 1921). While the term is usually applied to crystals of feldspar, Johannsen (1931) states that it may equally well be used for oriented crystals of any other mineral.

The terms *flow* and *fluxion texture* are sometimes used as synonyms for trachytic and trachytoid textures, however they should be avoided on account of their genetic implications.