Chapter 4 Detailed account of petrographical characters

By J. J. H. Teall, written in 1894 and 1895.

In speaking of the geology of that portion of the north-west of Scotland which lies west of the zone of thrusting, it has become customary to use the term "Lewisian gneiss" for the rocks forming the old floor on which the Torridonian sediments were deposited. These rocks, however, vary in age and character, and they are not always gneisses in the ordinary petrographical sense. Detailed mapping has revealed the fact that the oldest group of rocks has been invaded by a set of later intrusions in the form of dykes and sills. These later rocks are in some cases clearly separable from the older complex; but in others they have been so modified by subsequent movements and so incorporated, as it were, in the older group, that the work of separation becomes extremely difficult, if not actually impossible. It is clear, therefore, that the Lewisian gneiss is not a geological formation in the ordinary sense of the word. Even if we exclude from it the later dykes and sills, there still remains a petrographical complex which future research will probably separate into its component parts. As matters stand at present, the pre-Torridonian rocks may be roughly grouped as follows:-

1. Fundamental Complex
2. Ultra-basic dykes
3. Dykes and sills of dolerite (diabase), epidiorite, and hornblende-schist
4. A few dykes of exceptional composition
5. Granites and pegmatites

Turning now to the Fundamental Complex, the first point to be noticed is that notwithstanding its extreme petrographical diversity and the occurrence of a few exceptional types, the rocks, over the greater portion of the area in question, have decided affinities, both as regards chemical and mineralogical composition, with plutonic igneous products. They are mainly composed of olivine, augite (including diallage), hypersthene, hornblende, biotite, plagioclase, microcline, orthoclase, and quartz; or, in other words, of the minerals which enter into the composition of peridotites, gabbros, diorites, and granites. Not only are the minerals the same as those of plutonic rocks, but the laws of paragenesis are also the same; and this is true, not only of the essential minerals above alluded to, but also to a great extent of the accessory constituents which do not form any large portion of the rocks. It is mainly when attention is paid to the distribution of the minerals in the rock-masses that the distinctive features of the complex become apparent. No one petrographical type is found to be persistent over any extensive area. Gradual or sudden changes in the relative proportions of the constituent minerals are almost everywhere recognisable. Some reference to what may be called the architectural features of the complex will be made after the rocks have been described, but at present it will suffice to refer to (Plate 6), (Plate 7), (Plate 8), (Plate 9), (Plate 10), (Plate 11),(Plate 12), (Plate 13), (Plate 14), (Plate 15), (Plate 16), (Plate 17), (Plate 18).

Although, as a general rule, the rocks of the Fundamental Complex of gneiss and schist show decided affinities with plutonic igneous products, this is not always the case. Thus, as already mentioned, in the neighbourhood of Gairloch and Loch Maree, we find platy mica-schists, limestones, graphite-schist, and other rocks more or less resembling metamorphosed sedimentary deposits. It will be convenient, therefore, to separate the description of the rocks of the Fundamental Complex into two parts, and to deal first of all with those which have affinities with igneous products, and afterwards with the more or less exceptional rocks of the Gairloch and Loch Maree district. It must, however, be remembered that sediments of the arkose type approximate very closely in chemical and even in mineralogical composition to certain plutonic rocks, and that, in the process of metamorphism, the distinctive structural features may be lost. Some gneisses of really sedimentary origin may. therefore, be included in the group of rocks having affinities with plutonic rocks.

In any attempt to deal with these rocks from a petrographical point of view, we are met at the outset with the difficulty as to the use of the term gneiss. As ordinarily employed this term connotes not only a certain structure, but also a certain mineralogical composition. A gneiss should contain the same minerals as a granite, and also some form of parallel structure. Now, the Lewisian gneiss contains the mineralogical equivalents of biotitegranites, hornblende-granites, and augite-granites, as well as other rocks to which the term gneiss is mineralogically inapplicable.

The parallel structure implied by this term varies greatly in different cases. It may be due simply to the orientation of one or more of the constituents, or to a variation in the relative proportions of the different constituents in different layers. In the latter case, the banding may be on so small a scale as to be easily recognisable in hand specimens; or it may occur on so large a scale as to be only visible in the mass. When this is the case, hand specimens may appear perfectly massive; though, as a general rule, some trace of orientation of the constituents may be recognised.

In the biotite-gneisses other types of parallel structure may occur. Aggregates of biotite may form thin and more or less wavy films or "flaser". These films may be isolated in the quartzofelspathic mass, or they may run together, thus separating the quartzo-felspathic portion of the rock into phacoids or lenticles. Such rocks are termed "flaser-gneiss" in Germany, and we may conveniently adopt the same expression. They are rare in the north-west of Scotland, where the gneisses are usually of the banded type.

In classifying the rocks either with reference to structure or composition, difficulties arise in consequence of transitions in various directions. Many schemes have been drawn up, and the following one, based primarily on mineralogical composition and, to a subordinate extent, on structure, has been finally adopted for descriptive purposes. Theoretical considerations have been excluded, so that, whatever views may be finally established as to the origin of this remarkable complex, it is hoped that the broad general facts will be found to have been correctly recorded.

I — Rocks composed of ferro-magnesian minerals; without felspar or quartz.

A. Peridotites, serpentines, pyroxenites and banded hornblende-rocks.

B. Hornblende-rocks not included in the banded group.

(1) Those which consist of pale-coloured hornblende, occurring in confused aggregates.

(2) Those in which hornblende occurs as compact grains and prisms.

(3) Those in which anthophyllite is present.

(a) Anthophyllite-hornblende-rocks.

(b) Calc-anthophyllite rocks.

II — Rocks in which pyroxenes are the dominating ferro-magnesian minerals; felspar always, and quartz sometimes, present.

A. Without quartz, or containing it only as an unimportant accessory.

(1) Hypersthene-augite-plagioclase rocks.

(a) With garnet: pyroxene-granulite.

(b) Without garnet: rocks of the Baltimore-gabbro type.

(2) Augite-plagioclase-rocks.

(3) Augite-microcline rocks.

B. With quartz.

(1) With hypersthene: quartz-bearing hypersthene-augite-plagioclase-rocks.

(2) Without hypersthene: augite-gneiss (proper).

III. Rocks in which hornblende is the dominating ferro-magnesian constituent; felspar almost always present.

A. Without quartz, or containing it only in small quantity; rocks basic in composition.

(1) Rocks massive or only slightly foliated.

(a) Epidote-amphibolite.

(b) Zoisite-amphibolite.

(c) Garnet-aniphibolite.

(2) Rocks foliated.

(a) Hornblende-schist or -gneiss.

Note: Many of the hornblende-schists associated with the fundamental complex are foliated dykes.

B. With quartz: rocks intermediate or acid in composition.

(1) Rocks with compact hornblende and a granular structure hornblende-gneiss (proper).

(2) Rocks with hornblende occurring in fibrous ,or other aggregates.

(3) Rocks with compact horriblend.e and a granulitic structure: granulitic hornblende-gneiss.

IV Rocks in which biotite is the dominating ferro-magnesian constituents; felspar and quartz both present.

(1) Biotite occurring as independent plates or in aggregates of two or three large individuals: biotite-gneiss (proper).

(2) Biotite occurring in aggregates of smaller individuals.

(3) Biotite occurring as independent plates; structure granulitic.

V Rocks in which biotite and muscovite occur; quartz and felspar present.

Muscovite-biotite-gneiss.

In the following account of the petrographical characters of the Lewisian gneiss no reference will be made to the rocks of the Outer Hebrides. The descriptions apply only to the strip of country which is bounded on the one side by the zone of thrusting and on the other side by the sea. For purposes of reference this strip may be conveniently divided into a northern area, extending from Durness and Cape Wrath to Loch Laxford, a central area lying between Loch Laxford and Gruinard. Bay, and a southern area, comprising the portion which lies between Gruinard Bay and the islands of Rona and Raassy.

1A. Peridotites, serpentines, pyroxenites, and hornblendites

The ultra-basic rocks which occur as integral parts of the Fundamental Complex rarely contain a sufficient amount of olivine to justify the use of the term peridotite. They usually form more or less banded masses of pyroxenite and hornblendite.

The minerals entering into the composition of these banded masses are augite (including diallage), hypersthene, hornblende, olivine, magnetite, and a green spinel. Secondary hornblende, serpentine, and sometimes chlorite are found in the altered rocks. Scapolite was observed in one specimen No. (1823) from Badcall, near Scourie.

The augite is pale green, in thin section, and without definite form. Sections out of the zone of the vertical axis give a maximum extinction of about 40°. In some specimens this monoclinic pyroxene is entirely free from inclusions and from any other divisional planes than those due to the ordinary prismatic cleavage; but, as a general rule. it contains parallel rows of very minute, dark brown, almost opaque plates and rods. One or more parallel rows may be present. When only one set is present, the inclusions are arranged parallel to the orthopinacoid. As a rule they are not uniformly distributed through the individual grains; thus, the centre of a grain may be crowded with them, while the marginal part is perfectly free. In addition to these minute plates and rods we find grains of magnetite and green spinel also occurring as inclusions.

The pyroxene above described is precisely similar to that of the Baltimore gabbros described and figured by the late Professor G. H. Williams.<ref>The Baltimore Gabbros. *Bull. U.S. Geol. Survey,* No. 28, 1886.</ref> It is found not only in the rocks of the group now under consideration, but in all the other augitic rocks belonging to the Lewisian gneiss; it is, in fact, the characteristic monoclinic pyroxene of these rocks. A similar pyroxene occurs in a pyroxenite from Madagascar,<ref>Notes on the Petrographical Characters of some Rocks collected in Madagascar by the Rev. R. Baron. By F. H. Hatch. *Quart. Jour. Geol. Soc.*, vol. xlv., p. 340.</ref> in the augite-norites (hyperites), and pyroxenites from the Cortlandt series on the Hudson River,<ref>The Norites of the Cortlandt Series. By G. H. Williams. *Amer. Jour. Sci.,* vol. xxxiii., 1887, p. 135.</ref> and in the anorthosite rocks of Canada.<ref>Ueber das Norian oder Ober-Laurentian von Canada. F. D. Adams. *Nelms Jahrbuch,* Beilage Band viii.. 1893, p. 419.</ref>

The hypersthene, which is almost always present in the banded pyroxenites, is easily distinguished from the monoclinic pyroxene by its strongly marked pleochroism. It occurs in irregular grains of approximately the same form and size as the green monoclinic pyroxene. The prismatic cleavages are often well-developed; and cross-sections, in which these cleavages intersect at right angles, show in convergent light the emergence of a positive bisectrix. Such sections give, for rays vibrating parallel to X, red; and for those vibrating parallel to Y, pale yellowish-brown to nearly colourless. Longitudinal sections, which are distinguished by parallel cleavage cracks, give straight extinction and appear green when viewed by rays vibrating parallel to Z. The pleochroism of this mineral, as a rule, is very intense, corresponding to the highly ferriferous variety for which Professor Judd proposed to revive Vom Rath's term, amblystegite.

Inclusions similar to those already described as occurring in the monoclinic pyroxene are occasionally found, likewise, in the hypersthene. This hypersthene is also similar to that occurring in the Baltimore gabbros.

Hornblende is rarely absent from the rocks under consideration. In some cases it occurs only as an accessory constituent; in others it is the only, or almost the only, ferro-magnesian silicate present.

By the gradual increase in the amount of hornblende the pyroxenites pass into the hornblendites. Like the other constituents, the hornblende occurs in irregular grains and often contains parallel rows of minute rods or plates, arranged in one or more directions. The maximum extinction in the zone of the vertical axis is about 20°, and the colour scheme of a common variety is as follows: X = a yellowish-green; Y and Z = dull dark green. In consequence of the absence of any colour differences for rays vibrating parallel to Y and Z, many sections show no dichroism.

The colours of the hornblende in different specimens are not absolutely constant. Thus, in a variety from the neighbourhood of Dhrombaig (Drumbag) we find: X, nearly colourless; Y and Z, brown; and in another, Lochan-an-Daimh, near Gruinard House, Ross: X, pale greenish-yellow; Y, bright green; Z, bluish-green. There is no difference in the mode of occurrence of these different varieties; they all appear to be as much entitled to be regarded as original constituents as any other mineral present.

One other feature of the original hornblende deserves mention. The cleavages are often far less perfectly developed than is usual with this mineral. Dr. Hatch<ref>A Peridotite from Kilamanjaro. *Geol. Mag.,* 1888, p. 257.</ref> has already called attention to this peculiarity of the hornblende in rocks of the type now under consideration.

Olivine is by no means so important or so constant a constituent of the rocks as the minerals above described. It is often entirely absent, and only in one or two specimens has it been found to occur in such abundance as to justify the use of the term peridotite. It occurs in colourless, irregular grains, which are traversed by the black veins of magnetite so commonly found in this mineral. It is often absolutely unaltered, but in a few specimens is more or less replaced by serpentine in the usual manner.

Magnetite and a dark-green spinel are almost invariably present in the banded pyroxenites. They occur independently of each other, and also in composite grains. The opacity of the spinel is often very great, so that the characteristic olive-green colour can only be seen in very thin sections. The natural opacity is also often increased by the presence of numerous minute black particles. Both magnetite and spinel are without definite crystallographic form.

As minerals which occur occasionally, biotite, apatite, and scapolite may be mentioned. Scapolite has been observed only in one specimen from Badcall, near Scourie (No. (S1823) [NC 15 41]), collected many years ago, before the mapping was commenced. The mineral occurs in irregular grains, which are crowded with minute opaque rods arranged, for the most part, parallel to the vertical axis. Isolated grains, when placed in a diffusion column, scatter themselves so that the lightest are seen to have a specific gravity of about 2.76 These contain fewer inclusions than those which float at lower levels. The abnormal specific gravity is, therefore, doubtless due to the inclusions. Treated with hot hydrochloric acid the grains show no change after three or four evaporations; a fact which points to the conclusion that the mineral is rich in the marialite-molecule. The characteristic cleavages are not seen in the thin sections, but can be readily developed by crushing the isolated grains. Sections at right angles to the vertical axis show the negative, uniaxial figure characteristic of scapolite.

The rocks in which the above minerals occur are black or dark-green in colour, and usually of medium grain. Although well banded on the large scale, the hand specimens frequently appear massive. Some idea of the nature of the banding may be formed from a consideration of the following sequence seen in a low projecting crag to the west of Scourie House. It must be remembered, however, that the rocks are not so sharply separated from each other as the use of two distinctive names may seem to indicate; pyroxene occurs in the hornblendites, and hornblende in the pyroxenites.

Hornblendite	4 inches
Pyroxenite	9 inches
Hornblendite	5 inches
Pyroxenite	3 inches
Hornblendite	5 inches
Pyroxenite	1 foot 5 inches
Hornblendite	4 inches
Pyroxenite	6 inches
	4 feet 5 inches

The bands of hornblendite are, as a rule coarser in grain than those of pyroxenite, and they are frequently crossed by transverse joints which appear as furrows on the weathered surface.

The rocks of this group form only a very small portion of the Lewisian gneiss. They may be studied at the locality above referred to; also on the south side of Loch an Daimh Mòr., about 1 mile south of Scourie; near Dhrombaig, east of Oldany island; and at Lochan an Daimh, about 1½ miles E.N.E. of Gruinard House. The last mentioned locality is in Sheet 101; all the others are in Sheet 107. The most common varieties of the group may be termed olivine-hornblende-pyroxenites and hornblende-pyroxenites; but the Survey collection includes also hornblendites, olivine-hornblende-peridotites, and one specimen of dunite. The olivine-bearing rocks have often been more or less completely serpentinised.

IB. Hornblende rocks not included in the banded group

Rocks composed almost entirely of hornblendic minerals are found not only interbanded with pyroxenites, but also as knots, lenticles, and bands associated with felspar-bearing rocks. These may be roughly classified for purposes of description into three groups

1. Those which consist of pale-coloured hornblende occurring in confused aggregates.
2. Those in which the hornblende occurs in compact grains and prisms, usually dark-green in colour.
3. Those in which the rhombic hornblende, anthophyllite, is present. These may be again sub-divided into:(a) Anthophyllite-hornblende-rocks. (b) Calc-anthophyllite rocks.

(1) A specimen collected at the bend of the road near Loch Dhronibaig, and about ½ mile west of the village, may be taken as a type of the first group. This is a somewhat pale-green crystalline rock, composed almost entirely of a matted aggregate of irregular individuals of hornblende. The outlines of the individuals are rarely well defined, but a tendency to the prismatic form may be occasionally recognised. A large portion of the slide consists of very fine-grained aggregates, which cannot be resolved into distinct individuals with definite outlines. Here and there larger patches, showing the cleavages of hornblende and giving fairly uniform extinction, may be observed. The whole of the hornblende is practically colourless in thin section. Iron ores occur in irregular patches and as small grains. In some places parallel rows of minute inclusions, precisely similar to those occurring as inclusions in the minerals of the pyroxenites, may be seen. (Plate 40), fig. 2. (S3398) [NC 114 328].

It is well known that diallage, hypersthene, and sometimes olivine give rise to, hornblende, and in describing the ultra-basic dykes it will be shown that they occasionally become converted into rocks of the same character as those now under consideration. It is probable, therefore, that these rocks are metamorphic products, and that the hornblende is of secondary origin. The one selected as a type has probably originated from the alteration of pyroxenite, a rock known to occur in the immediate neighbourhood. In addition to hornblende and iron ore, the only other mineral present is chlorite. This forms small irregular patches wedged in between the other constituents. Its presence strengthens the view that the rock is a metamorphic product.

(2) In the second group of rocks the hornblende is entirely different in character. It is usually dark green in colour, and occurs in compact grains, which often interfere with each other so as to prevent the development of crystalline form. Sometimes, however, one grain is partially idiomorphic with respect to its neighbours and the forms {110} and {010} may then be recognised. It is this type of rock that so frequently forms knots and lenticles in the more acid gneisses. A specimen from the north-west of Rona (No. (S5013) [NG 63 61], (Plate 40)), Fig. I. may be taken as a type. It is a medium grained dark-green, almost black rock. The hornblende occurs in compact individuals occasionally showing the forms above mentioned. The colour scheme is as follows: X, pale yellow; Y, green; Z, green with a tinge of blue. In addition to the hornblende there are some irregular patches of iron-ore and one or two flakes of biotite. Biotite is very often associated With hornblende in the black lenticles, and is sometimes as abundant as the hornblende itself.

Under this head we also refer certain rocks occurring near Cape Wrath which consist of radiating masses of actinolite, the prisms of which sometimes measure two or three inches in length.

(3) Anthophyllite is found in two very distinct types of rock. The one (a) is a dark-green, medium to coarse-grained, massive rock; the other (*b*) a pale grey, medium-grained rock containing a considerable amount of carbonate. In the former group (a) the anthophyllite occurs in association with ordinary green hornblende: in the latter it is, as a rule, the only representative of the hornblende-group of minerals.

The specimen from Glac a Mhin Ath (about 700 yards N.N.W. of the north-west end of Caol Loch a' Mhin Ath, Sutherland, six-inch Sheet 31 S.E., 1 inch Sheet 107, (S3419) [NC 259 461]; (Plate 41), Fig. 1, is a moderately coarse-grained, black rock, composed of green hornblende, hypersthene, and a colourless mineral having the cleavages and prismatic angle of hornblende. Transverse sections of this mineral show the emergence of a positive bisectrix. Longitudinal sections give straight extinction. Cleavage flakes, produced by crushing the mineral, also give straight extinction and show the emergence of a negative bisectrix inclined to the plane of the flake. The optic axial plane is parallel to the brachypinacoid; which form, however, is not developed. The optic scheme is as follows: a = X; b = Y; and c = Z; where a, b, and c represent the crystallographic axes, and X, Y and Z the axes of the ellipsoid of elasticity or optical indicatrix. These facts prove conclusively than the mineral in question is anthophyllite. It is developed in the prismatic form, and is idiomorphic with respect to the green hornblende.

Rocks of the above type are represented only by two specimens in the Survey collection, one from the neighbourhood of Rhiconich (S1830) [NC 25 52], and the other from Glac a Mhin Ath (S3419) [NC 259 461].

(b) The talc-anthophyllite rocks effervesce freely with cold dilute hydrochloric acid, and weather brown owing to the presence of some iron in the carbonate. A specimen from a point south of Allt Mor Geisgeil, two and a half miles south-east of Scourie (Sutherland, Sheet 107, No. (S4651) [NC 177 416], (Plate 41), Fig. 2 may be selected as a type.

The anthophyllite occurs as long slender prisms which lie in all directions in a matrix of crystalline, granular calcite. A few scales of hematite and grains of opaque iron-ore are also present.

When attacked by the weather these rocks develop a rough carious surface, owing to the removal of the calcite. They occur one mile N.N.W. of Achfarry (south-east slope of Ben Stack, No. (S2723) [NC 277 404]), and south-west of Creag Lochan-nam-Breac (about a mile east of Badcall Bay, south of Scourie), Allt Crom Geisgeil (S4647) [NC 182 403]. An allied rock is found at Creag Tombaca (south side of Loch Glendhu, about a mile and 300 yards E.S.E. from Kyle Sku Inn; No. (S2955) [NC 246 332]). In this case. however, the colourless prisms of anthophyllite lie in a matrix of pale brown mica, which is the dominant constituent. Calcite is present.

Little can be said as to the origin of the anthophyllite-bearing rocks, but it is worthy of note that a dyke in the Lewisian gneiss, ½ mile south-west of the outlet of Lochan na Bearta (Ross six-inch Sheet 46, north-east; one-inch Sheet 92, No. (S5118) [NG 994 797]) is essentially ??inflosed of green hornblende and anthophyllite, with some felspar (basic), and rutile. The anthophyllite occurs in long slender prisms bounded by the prismatic faces and a pinacoid truncating the acute angles of the prism. The main mass of the rock is formed of pale green hornblende, which occurs as large irregular grains, long prisms, and confused aggregates of minute ⁱndividuals. The anthophyllite is idiomorphic with respect to the hornblende.

IIA. Pyroxene-felspar-rocks, without quartz, Or containing it only as an unimportant accessory

The rocks of this group are essentially characterised by a pale-green, monoclinic pyroxene and felspar. With one exception (No. (S2379) [NC 383 543]) the felspar is allied to labradorite, and the rocks, therefore, resemble gabbros in composition. In the exceptional case the felspar is microcline, and the rock is, therefore, allied to the augite-syenites. The plagioclase rocks may be separated into two sub-groups, characterised by the presence or absence of hypersthene, and the first of these may be again sub-divided according to the presence or absence of garnet; but it must be remembered that this classification is more or less artificial and that the different groups shade into each other. Garnet is very irregular in its distribution, often abounding in one spot and disappearing within a few yards. The hypersthene-augite-plagioclase rocks (IIA. 1) may, so far as the hand-specimens are concerned, be divided into, two main groups:

1. Garnetiferous hypersthene - augite - plagioclase rocks (pyroxene-granulites)
2. Hypersthene-augite-plagioclase rocks (Baltimore gabbro type)

(a) The members of the first group are medium-grained, dark, crystalline rocks, with a variable amount of garnet. The presence of garnet alone distinguishes them from the rocks of the second group. They are closely connected also by intermediate varieties, with the pyroxenites on the one hand, and with the hornblende-pyroxene-gneisses on the other. The addition of garnet and felspar to the pyroxenites causes them to pass over into the group now under consideration. The minerals common to the two groups are precisely similar in character. Although not forming an important constituent, hornblende is often present. In addition to the compact variety, which may be either brown or green, there is sometimes found a more or less fibrous green hornblende, which is intimately associated with the pale green augite. This sometimes forms a ragged zone round the latter mineral, and sometimes occurs in irregular patches in the interior, as if replacing it. These phenomena are usually taken to indicate that this variety of hornblende is of secondary origin, and it may be so in this case. But whether this view be correct or not, it is certain that every stage in the apparent replacement of the green augite by this variety d hornblende may be observed, not only in the rocks of this group, but also in the pyroxene-gneisses which remain to be described. Indeed, the phenomenon is more perfectly exhibited in the last' mentioned rocks, and will again be referred to when these are described.

The felspar occurs, like the other constituents, in allotriomorphic grains. It is sometimes twinned on the albite and pericline plans, and sometimes unstriated. The twin lamella) often die out in the middle of a grain; and in those rocks in which the felspar gives undulose extinction, indicative of strain, the lamellations appear to be, in part at least, of secondary origin. The plagioclase felspars of the rocks belonging to the fundamental gneiss range in composition from labradorite to oligoclase — the more basic felspars occurring in the more basic rocks. In the present group the felspars are allied to labradorite in composition.

The extraordinary freshness of the felspars, and, indeed, of all the minerals of the gneissose rocks is especially noteworthy. The grains are usually water clear, and only in rare cases show signs of turbidity or saussuritization.

The garnet is of a deep red colour and rarely, if ever, shows traces of idiomorphism. In this respect it offers a strong contrast to the garnets found in certain varieties of mica-schist. As already stated, it varies considerably in amount in different specimens, sometimes forming a large proportion of the rock, and at others sinking to the rank of an accessory constituent. The individual grains vary in size from microscopic particles to large masses measuring several inches across. In a few specimens the/ garnet forms narrow zones round the grains of iron-ore.

Biotite is occasionally present as an accessory constituent in the form of minute brown scales surrounding, or at least occurring in intimate association with the iron-ores. Magnetite, and less frequently pyrite, also occur as accessory constituents.

The hand specimens of the more typical varieties are devoid of foliation. They are neither banded nor do they show any parallel structure due to the orientation of the minerals. Under the microscope the structure is seen to be granular, with an occasional tendency to become granulitic. In the field they are intimately associated with the pyroxenites, and occur in the same districts. Most of the specimens in the Survey collection come from the neighbourhood of Scourie.

(b) The hypersthene-augite-plagioclase rocks, which differ from the above only in the absence of garnet, are dark, medium-grained, and usually massive in hand specimens. Both in structure and composition they are precisely similar to the gabbros of Baltimore, so well described by Prof. G. H. Williams.

A specimen from Strathan, 1¼ mile south-west of Lochinver Bay, near Loch Inver (S3392) [NC 08 21], may be taken as typical of the group It is a dark, medium-grained, massive rock composed of augite, hypersthene, plagioclase, and magnetite, with pyrite and biotite as accessories. The augite belongs to the pale green variety already described, and occurs in grains averaging about 1mm in diameter. The hypersthene is strongly pleochroic, and occasionally shows traces of idiomorphism in the prismatic zone. The felspar occurs i allotriomorphic grains of uniform dimensions in the different directions, averaging somewhat less than 1mm in diameter. Many sections do not show twinning, and in those which do it is often seen to be impersistent. Undulose extinction is common, and their twinning is most marked in those which show this phenomenon. The specific gravity of the felspar is about 2.69.

It was isolated in as pure a state as possible and analysed.

SiO_2	53.98
Al_2O_3	27.85
Fe_2O_3	1.55
CaO	10.15
MgO	tr.
K_2O	0.29
Na_2O	4.76
Loss on ignition	0.64
	99.22

If we neglect the iron and loss on ignition and calculate to 100 we have:

SiO_2	55.64	55.4
Al_2O_3	28.69	28.5
CaO	10.46	10.4
K_2O	0.30	—
Na_2O	4.91	5.7
	100.00	100.0

The figures in the second column correspond to the composition Ab_1 An_1. The felspar is, therefore, on the border line between labradorite and andesine. It would be classed as the former by Tschermak, and as the latter by Dana.

The type rocks contain no hornblende, but this mineral occurs in many rocks which naturally belong to the group. It is similar to that occurring in the pyroxenites and granulites.

The specimens of this group in the Survey collection come from Strathan Bay, near Loch Inver, Rientraid, 2½ miles west of Kyle Sku, and north-west of Pairc-a-Chladaich, one mile north-west of Scourie. The rocks above described, though of considerable interest from a petrographical point of view, do not form a large portion of the fundamental complex. They occur rather as local and exceptional varieties. Those which remain to be considered are, as a rule, much more widely distributed.

(2) The augite-plagioclase rocks differ, so far as composition is concerned, from those of the last group merely in the absence of hypersthene, and from the pyroxene-gneisses in the absence of quartz. They are often massive in the hand specimen, but occasionally show traces of foliation due to the tendency of the augite and felspar to concentrate in thin and impersistent The definite parallel banding so commonly seen in the hand specimens of the hornblende- and biotite-gneisses is not present in those portions of the complex in which augite is the dominant ferro-magnesian constituent.

A specimen from Strathan Bay, near Loch Inver (S3406) [NC 08 21], may he selected as a type of the augite-plagioclase-rocks. It is a dark, medium-grained, massive rock composed of plagioclase, augite, and magnetite. The plagioclase belongs to the labradorite-andesine series. It is devoid of twinning except where the grains have been strained. In these places two sets of impersistent twin-lamellae have often been developed at right angles to each other, reminding one to some extent of the cross-hatching of microcline. The pale green pyroxene is of the same type as that occurring in the pyroxenites, pyroxene-granulites, and hypersthene-augite-plagioclase rocks. In addition to the two ordinary cleavages it occasionally shows the structure of diallage and contains rows of minute, dark rods and plates, as well as scales of hematite. The magnetite is in irregular grains; like the other constituents, and often of considerable size. It is present in sufficient quantity to make the rock distinctly magnetic.

The mutual relations of the constituents are the same as those of typical gabbros with which these rocks have very close relations.

The principal deviations from the type above described depend on the occurrence of hypersthene, garnet, quartz, and original hornblende as accessory constituents; These represent passages into the other groups. In one or two instances uralitic horn- blends has been formed at the expense of the augite. The best specimens in the Survey collection come from the neighbourhood -of Lock Inver; but the type is probably not uncommon in the extensive region characterised by the pyroxene-gneisses.

(3) The last type under the present head is represented only by one specimen from Polls, near the head of Loch Eireboll (S2379) [NC 383 543]; but it is so remarkable as to deserve a somewhat detailed description. It is a moderately coarse-grained, massive rock, essentially composed of microcline and a green pyroxene. Hornblende, sphene, apatite, quartz and magnetite occur as accessories.

The dominant constituent is microcline. It occurs in irregular individuals which often measure 2mm in diameter. There is no trace of alteration, and the cross-hatching is very perfectly developed. The pyroxene is also allotriomorphic. It is green in colour, but the tints are more vivid than those of the augite of the rocks above described. The extinction is that of normal augite, not that of wgirine. The mineral is probably an cegirine-augite. The accessory minerals form only a small portion of the mass. The hornblende is green and similar to that of the hornblende-geisses. Sphene, apatite, and quartz all occur as irregular grains. Th e magnetite shows traces of idiomorphism. This rock, if igneous, would be termed augite-syenite.

IIB. Pyroxene-felspar rocks, with quartz

The Lewisian gneiss between Scourie and Loch Inver, and for some distance both north and south of these localities, is largely composed of quartzose pyroxene-gneisses. These rocks frequently show a marked foliation due to the presence of streaks and ill-defined bands of dark and light colour. The principal ferro-magnesian constituent is the green, monoclinic pyroxene; but hypersthene, biotite and original hornblende occasionally occur. Garnet is also sometimes present.

The felspar, in all cases examined, is some variety of the andesine-oligoclase series. In unstrained individuals twinning is usually absent, but in those which give undulose extinction impersistent lamellce may frequently be observed. Much of the twinning is certainly of a secondary character. In the case of a rock from Duartmore Bridge, between Kyle Sku and Scourie, the felspar was definitely determined by analysis to be andesine corresponding to the formula Ab_4, An_3.

The quartz occurs in large irregular individuals, and is remarkable for the bluish, opalescent tinge which enables one to recognise it easily in the hand specimens. In the foliated rocks the grains are often tabular in form ' but the direction in which the grains are flattened has no relation to the crystallographic characters of the mineral. Under the microscope- this blue quartz, which is so characteristic of the pyroxene-gneisses, is always seen to contain minute inclusions. These are of four types:(1) rows of minute dots; (2) extremely thin hairs formed, in all probability, of the same substance as the dots; (3) cavities with very dark borders; and (4) minute irregular flecks and grains.

A similar blue quartz occurs in the grits of the Southern Highlands, and there also it contains the minute hairs and rows of dots. As inclusions of this character are absent from the quartz of the hornblende and biotite-gneisses, which does not show the blue colour, it seems probable that this colour is due to the inclusions.

The other minerals of these rocks are precisely similar to those of the rocks already described.

Cataclastic structures are not uncommon. The effects of pressure on the felspar — undulose extinction and secondary twin lamellation — have been already referred to. These effects are even more marked on the quartz, where they consist of undulose extinction, an irregular striping, seen only under crossed nicols, and partial granulitization.

The specimens in the Survey collection may be separated into two groups, corresponding to the two main groups of the pyroxene-plagioclase rocks, the one being characterised by the presence, the other by the absence, of hypersthene. Seeing that gneissose structures are almost always recognisable in the hand-specimens, these may be termed:

1. Hypersthene-augite-gneiss
2. Augite-gneiss

A specimen from the shore of Loch Glencoul at Unapool (S3397) [NC 238 325] may be taken as a type of the first group. It is a dark rock traversed by streaks of grey material, which occasionally die out within the limits of the hand-specimen.

The green pyroxene occurs in irregular grains which measure 1mm or less in diameter, and are usually of equal dimensions in the different directions. More rarely they are flattened in the direction of foliation and are then five or six times longer than broad. Several grains usually occur in juxtaposition, and the aggregate is elongated in the direction of foliation.

The hypersthene belongs to the strongly pleochroic variety (amblystegite). It also forms irregular grains, and is associated with the augite. The felspar presents the characters already described. Quartz occurs as irregular grains, and also as small rounded inclusions. It does not form an important constituent, and is limited to the lighter portions of the mass. Magnetite and apatite occur as accessories.

The other specimens of the group differ from the one selected as a type principally in the relative proportions of the constituents, and in the extent to which cataclastic structures have been developed. The two pyroxenes seem capable of replacing each other to almost any extent. In some specimens augite is the dominant ferro-magnesian mineral; in others hypersthene. Again there are great variations in the relative proportions of the ferro-magnesian and the quartzo-felspathic constituents. The tendency of these two groups to separate is seen in almost every exposure, and just as hand specimens, composed entirely of ferromagnesian minerals, may be obtained (pyroxenites), so also may hand specimens entirely composed of quartzo-felspathic constituents be procured (S3405) [NC 2 3].

In one specimen, referred to in this group, from the roadside north of Badcall Church, Scourie (S2989) [NC 166 421], garnet is present in considerable amount. This is merely a quartz-bearing variety of pyroxene-granulite. It illustrates the fact that each variety of rock described under IIA., has its corresponding representative under IIB.

The second group of rocks differs from the first only in the absence of hypersthene. It is well represented by a specimen taken from a point west of Pairc-a-Chladaic, Scourie (S4889) [NC 152 451]. This is a moderately coarse-grained, grey rock of typical gneissose structure. The quartz is abundant and occurs in lenticular folia, which are distinctly recognisable on a weathered surface. There is no marked banding in the hand specimen; but the two principal constituents, quartz and plagioclase (oligoclase-andesine), occur in folia. Augite is recognisable in the microscopic slide, but is not abundant. Some of the augite has been replaced by uralitic hornblende.

The rocks of this.group pass over into Group IIIB., 2, by imperceptible gradations in consequence of the replacement of augite by hornblende. Two specimens, in which this replacement has more or less taken place, have been analysed by Mr. Wilson.

	I.	II.
SiO_2	54.86	60.39
Al_2O_3	17.3	16.14
Fe_2O_3	2.25	3.56
FeO	7.43	3.88
MnO	0.17	0.86
CaO	7.45	6.36
MgO	3.97	3.43
K_2O	1.06	0.87
Na_2O	3.27	3.75
Loss on Ignition	1.76	0.91
Total	99.52	100.15
Sp. Gr.	3.02	2.77

I — Garnet-quartz-pyroxene-gneiss, north of Loch Beannach, north-west of Little Assynt (S7842) [NC 134 272] This rock is without any well-marked parallel structure, but the constituents are somewhat unequally mixed. It is composed of augite, uralitic hornblende, plagioclase, quartz, iron-ores, and garnet. There is also a little dark brown biotite occurring in aggregates of small scales. It is an intermediate form between IIB. and IIIB, 2.

II — Quartz-pyroxene-gneiss, north-west of wood, Loch-a-Bhaid-Daraich, Scourie (S7841) [NC 172 447]. This rock shows a well-marked parallel banding. The same constituents are present as in the last, with the exception of garnet. The ferro-magnesian constituents are less abundant, and there is more secondary hornblende. The augite forms cores in the hornblende-aggregate. This rock might equally well be placed with IIIB, 2.

Owing to the extreme petrographical diversity of the Lewisian gneiss as a whole, it is difficult to determine the average composition of the complex. No system of sampling can be devised which will give a reliable result. The general impression left after the examination of rocks from the whole of the area under review is that if the mass were uniform it would be of intermediate composition, not, perhaps, very different from that represented by the second of the above analyses.

As already stated, the pyroxene-gneisses are the dominant rocks between Scourie and Loch Inver. Most of the specimens in the Survey collection come from the neighbourhood of Scourie and Kyle Sku.

IIIA. Hornblende-felspar rocks (Basic)

Rocks into which hornblende enters as the principal ferromagnesian constituent, in associationwith felspar, or with felspar and quartz, play a very important part in the composition of the Lewisian gneiss. They vary considerably in character, and doubtless owe their origin to various causes. In the present condition of knowledge it is by no means easy to formulate or apply any scheme of classification based on genetic principles. The rocks will, therefore, be described without reference to their mode of origin. They are partly basic and partly intermediate in composition; the former answering to basic diorites and epidiorites, the latter to quartz-diorites and hornblende-granitites. It will be convenient to take the basic division first.

The basic hornblende-plagioclase rocks may be divided, according to structure, into those which are massive or only slightly schistose (amphibolites) and those which are markedly foliated. The two are often intimately associated, so that one and the same mass may be an amphibolite in its centre and a hornblende-schist or gneiss on its margins.

The typical amphibolites consist of hornblende and a saussuritic aggregate of felspar and epidote or zoisite. Some rocks which resemble the amphibolites contain garnet with or without epidote. These will be classed as garnet-amphibolites. A somewhat serious difficulty arises from the overlapping of the terms amphibolite and epidiorite. The general plan hitherto adopted is to use the term amphibolites for the basic hornblende-felspar rocks (with or without a mineral of the epidote-group) which cannot be separated from the fundamental complex, and the term epidiorite for the corresponding rocks which belong to the later basic intrusions. But this plan has its disadvantages, for some of the modified dyke-rocks are indistinguishable from rocks described under the present head as epidote-amphibolite, It would, perhaps, be more satisfactory to limit the term epidiorite to those rocks which show traces of the original igneous structure; but even this would not be free from difficulty in consequence of the innumerable passage-forms. The facts can best be described without attempting to give rigid definitions to the terms.

In addition to the two principal constituents, the amphibolites usually contain epidote, zoisite, or garnet. The hornblende is pale green in colour and usually shows a bluish tint when viewed with rays vibrating parallel to Z. It often occurs in fibrous or other aggregates, and when present as compact grains the outlines are, as a rule, very irregular. The felspar either forms a mosaic, with or without quartz, or else occurs in irregular patches, which give uniform extinction over large areas and interlock with each other, so as to form a kind of ground-mass in which grains and crystals of epidote or zoisite are often scattered. The aggregates of felspar and zoisite or epidote answer to the description of saussurite given by Cathrem.<ref>*Zeitsch. f. Kryst.* Band VII., 1883, p. 234.</ref> Iron-ores, sphene, and chlorite occur as accessory constituents.

The typical amphibolites are dark-coloured, medium-grained, massive rocks. They differ from normal igneous rocks in the mutual relations of the different minerals and in the frequent presence of epidote or zoisite.

One of the most remarkable masses of amphibolite in the district occurs at Cnoc-an-Sgriodach 1½ mile E.N.E. of the village of Stoer ((S3409) [NC 064 294], (Plate 43)., Fig. 1). It is devoid of foliation over a large area and might, at first sight, be taken as a normal igneous product. The hornblende individuals show, under the microscope, a marked tendency to elongation in the direction of the vertical axis, and traces of crystalline faces in the prismatic zone may be recognised; but the terminations are always ragged. The rudimentary prisms lie scattered in all directions in a saussuritic aggregate of andesine and epidote. This mass of epidote-amphibolite contains patches and veins of a white, granular rock, composed almost entirely of andesine.

The distinction between epidote and zoisite in the amphibolite is not always satisfactory, because one and the same grain will sometimes show marked variations in the strength of the double-refraction. But the Survey collection includes two specimens of typical zoisite-amphibolite; one from Sango Bay (S2345) [NC 410 675] near Durness, and the other from Lochan nam Breac Buidhe, Eireboll ((S2415) [NC 444 565], (Plate 43), Fig. 2. Both are fine-grained, somewhat foliated rocks, composed of green hornblende and saussurite. The rocks are mottled in consequence of the unequal distribution of the saussurite and hornblende. Under the microscope the saussurite is seen to be a fine-grained aggregate of zoisite and felspar. The hornblende is fibrous or uralitic.

The garnet-amphibolites are dense, dark green, medium-grained rocks in which the garnet is very irregularly distributed. They are often intimately associated with the garnetiferous hypersthenaugite-plagioclase rocks, out of which they have probably been formed by the uralitization of the pyroxenes and the'saussuritization of the felspar.

In addition to the amphibolites we frequently find bands of basic, foliated, hornblende-felspar rocks associated with the hornblende and biotite-gneisses of the northern and southern portions of the area under consideration. These agree very closely in composition and sometimes also in structure with the foliated portions of the later basic intrusions, so that in regions where the complex has been affected by powerful earth movements, since these intrusions, as, for example, in the district south of Poolewe, it becomes difficult to separate the early from the later basic material.

The region between Laxford and Durness is very largely composed of hornblende-gneiss. The darker and more basic portions of this gneiss are essentially composed of hornblende and a plagioclase belonging to the labradorite-andesine series. A pale green pyroxene, epidote, and sphene not unfrequently occur as accessory constituents. Garnet is also sometimes present. One *or* two examples of the group will now be referred to.

A specimen from Cape Wrath (S2992) [NC 256 745] is of medium grain, and almost black. The rock is composed of green hornblende, more or less altered plagioclase, a pale green pyroxene, sphene, iron-ores, apatite, and epidote. The hornblende is compact, and gives no evidence of secondary origin.

Another specimen, [redacted] mile E.N.E. of Badcall store house, Loch Laxford, 1 inch Sheet 107 (S3475) [NC 233 476], contains numerous small red garnets, and shows a more definite separation of the ferro-magnesian and felspathic constituents. The felspar occurs in small lenticular granulitic patches, which may have originated by the granulitization of larger individuals. This rock differs from a garnet-amphibolite only in the presence of a slight foliation.

Both the specimens here referred to contain pyroxene but there are several others which do not contain this mineral. Thus a specimen from the shore at Torran, in the northern part of the Isle of Raasay (S5846) [NG 592 489], is a moderately coarse-grained, dark, basic, foliated rock, composed of hornblende and plagioclase, with biotite and sphene as accessory constituents.

In the southern part of the area, between Gairloch and Loch Maree, on Loch Torridon, and in the islands of Rona and Raasay there are many bands of hornblende-schist which appear to form an integral part of the Lewisian Gneiss. Here and there, however, clear evidence of their original intrusive character may be obtained, and it is probable, therefore, that, in the majority of cases, they belong to the series of later basic intrusions.

IIIB. Hornblende-felspar rocks, with quartz

The remaining rocks in which hornblende is the dominating ferro-magnesian constitutent may be most conveniently subdivided according to the character of the hornblende and the structure of the rocks.

1. Rocks with compact hornblende and a more or less granular<ref>The term granular refers only to the relations of the constituents. The rock$_{s}$ are always foliated; often banded.</ref> structure. Hornblende-gneiss (proper).
2. Rocks with hornblende occurring in fibrous or other aggregates.
3. Rocks with compact hornblende and a more or less granulitic structure. Granulitic hornblende-gneiss.

The typical varieties of these three groups are well-defined; but, as so frequently happens when any large number of rocks has to be dealt with, cases arise in which it is by no means easy to say to which group a particular specimen should be referred. The rocks with compact hornblende and a granular structure ((Plate 42), Fig. 1) are especially characteristic of the northern and southern areas, that is north of Loch Laxford and south of Loch Broom. They graduate on the one side into the pyroxene-gneisses and on the other into biotite-gneisses.

The rocks with hornblende occurring in fibrous or other aggregates (Plate 44), Figs. 1 and 2 are common in the central zone in which the pyroxene-gneisses abound, and they are connected with these in such a manner as to suggest that the hornblende is in many, if not in all cases a secondary product after pyroxene.

The rocks with compact hornblende and a more or less granulitic structure (Plate 45), Figs. 1 and 2 are especially characteristic of the narrow zones in which shearing has taken place. The rocks of the three groups will now be described in the order mentioned above.

(1) The minerals of the first group are hornblende, pyroxene, biotite, felspar, quartz, epidote, iron-ores, sphene, and apatite.

The hornblende rarely shows any traces of idiomorphism. It is frequently moulded both on the quartz and on the felspar. In many rocks rounded grains of quartz occur as inclusions. The characteristic cleavages are well marked, and twinning of the common type may sometimes be seen. The colour is somewhat variable, both as regards tint and intensity, but it is always some shade of green. The colour schemes of two common types are as follows:

Yellowish green	Green	Dark green
Greenish yellow	Green	Bluish green

Pale green pyroxene of the type found in the pyroxene-gneisses is sometimes present as an accessory constituent. It is always sharply defined from the hornblende. Whatever may have been the condition under which the rocks assumed their present form, the one mineral is as much entitled to be regarded as an original constituent as the other. Inclusions of pyroxene may sometimes be seen in the hornblende, but the junctions are always sharply defined. The pyroxene never resembles an unaltered core, as it so often does in rocks belonging to the second group.

Biotite is found in the more acid members of the group. It is present in well-defined plates. The basal plane is developed, but the mineral is without definite crystallographic outlines in the prismatic zone. In sections parallel to the vertical axis the colour for rays vibrating parallel to this axis is yellowish brown, and for rays vibrating at right angles to this axis deep brown. The pleochroism is very strongly marked, and the absorption is so great in the case of rays vibrating at right angles to the principal axis that the mineral is nearly opaque in ordinary sections.

Different varieties of felspar are present in different rocks. The more basic members of the group contain a variety allied to labradorite; while the more acid members contain oligoclase and sometimes also orthoclase or microcline. It is not, however, until the biotite- gneisses are reached that potash felspars are at all common. The mineral always occurs in irregular grains, and twinning is sometimes present, sometimes absent. The alteration when present is always of the micaceous type.

Quartz occurs in the form of rounded grains and irregular patches. It is sometimes moulded on the felspar, but occurs also, in the form of rounded grains, as inclusions in the felspar and hornblende. The hair-like inclusions, so characteristic of the blue quartz of the pyroxene-gneisses are entirely absent.

Epidote is sometimes present. It occurs as irregular grains alid occasionally as more or less idiomorphic crystals. Although in some cases undoubtedly a secondary product, in others it is as much entitled to be regarded as an original product as any other mineral present. This is especially the case with certain varieties of gneiss found in the neighbourhood of Laxford Bridge (S4471) [NC 242 470]. The idiomorphic epidotes are not as a rule elongated in the direction of the orthodiagonal axis; but occur in crystals of about equal dimensions in the different directions. The forms {100} {001}, and {T01} are common in the zone of the orthodiagonal axis and terminal faces, if, indeed, they may be so called, seeing that there is no marked elongation of the individuals, may also be recognised, but not easily identified. Cleavages parallel to {001} and {100} occur, and the characteristic pleochroism is strongly marked.

Colourless epidote, quite distinct from the above, arising as a consequence of saussuritization, may be seen in some specimens , (S4437) [NG 873 770].

The other minerals occur only as unimportant accessories. Iron-ores are represented by magnetite and pyrite. Sphene is by no means uncommon. It occurs as aggregates of colourless and often spindle-shaped grains (S2390) [NC 459 594] (Plate 42), Fig. 2); less frequently as detached grains which are sometimes coloured. Apatite is occasionally found as short stumpy prisms, or as irregular grains.

The rocks, as a rule, are remarkably fresh, but the felspars occasionally show the micaceous type of decomposition, and chlorite sometimes occurs as a consequence of the alteration of the ferromagnesian constituents.

The rocks are medium to coarse in grain, and vary considerably in the relative proportions of the different constituents. Although corresponding, as a rule, to plutonic rocks of intermediate composition they merge on the one side into basic, and on the other into acid rocks. There is also considerable diversity as regards the extent to which parallel structure is developed. This is more or less recognisable in all the specimens; but it may vary from a vague orientation of the minerals in a rock of uniform composition to a well-marked banding in which the ferro-magnesian and quartzofelspathic constituents have been concentrated along definite layers. The foliation is generally of the plane-parallel type; but the linear type may be observed in districts where " mullion-structure " is prominent.

This type of rock is so widely distributed in the northern and southern areas that it is scarcely nececossary to mention any special areas. It may be well studied near Durness, at Poolewe, and in the islands of Rona and Raasay. The principal varieties may be designated by such terms as hornblende-pyroxene-gneiss (S3476) [NC 233 476], (S2390) [NC 459 594], hornblende-biotite-gneiss (S1836), (S2378) [NC 43 65], (S3474) [NC 228 475], and hornblende-epidote-gneiss (S4474) [NC 233 480].

(2) The hornblende of the second group of rocks does not occur in compact masses, but as aggregates (Plate 44., Figs. 1 and 2). The individuals of which these aggregates are composed vary considerably in size. In the interior of a patch they are usually small and intimately associated with grains of quartz. Sometimes calcite is present, but this is rare. The peripheral portions of a patch are usually formed of larger grains than the central parts, and with these larger individuals quartz is not associated ((Plate 44), Fig. 2). The above must be regarded as the more common mode of occurrence, but sometimes the grains forming the interior portions of a patch are uniformly orientated, or even connected up with hornblende-substance, so as to constitute one individual, in spite of the great number of minute and more or less rounded grains of quartz. This is the micro-poikilitic structure of Williams.

The outlines of the patches of hornblende are irregular, and the adjacent mineral, whether quartz or felspar, accommodates itself perfectly to these outlines. The hornblende of these rocks is identical with that of the gabbro-diorite of Williams. An interest- ing question arises, therefore, as to the relation of this form of hornblende to the pyroxene of the pyroxene-gneisses. The rocks are found in the same area as the pyroxene-gneisses. Moreover, pyroxene is sometimes present; and when this is the case, the relations of the pyroxene to the hornblende are such as to suggest that the latter mineral is of secondary origin. Thus the pyroxene occurs as cores in the aggregates of hornblende (S855) [C 15 44], (S4468) [NC 146 458]; its outlines are ragged and ill-defined, and there is, as it were, a blending of the two minerals, so that it is often difficult to say where one ends and the other begins.

It thus appears that there is a marked contrast between the hornblende of these rocks and that of the hornblende-gneisses of the northern and southern areas. In the latter the hornblende occurs in the compact form as individuals of considerable size, and although it occasionally contains one or two rounded grains of quartz these never occur in such numbers as to produce the typical micro-poikilitic structure. Moreover, the relations between pyroxene and hornblende are quite different in the two cases. In the one pyroxene appears to shade off gradually into the hornblende-aggregates; in the other the two minerals are always sharply separated, and both are compact.

Biotite is very frequently present as a constituent of the rocks now under ' consideration. Like the hornblende it occurs in aggregates — not in isolated flakes of considerable size. The small flakes are brown or reddish brown in colour; in fact the mineral, both in its character and mode of occurrence, more closely resembles that of contact rocks than that of normal igneous products. The aggregates of biotite are usually associated with those of hornblende, and bear the same relation to the adjacent quartz and felspar.

The felspar is similar to that of the pyroxene-gneisses. It is generally fresh and free from inclusions, but occasionally contains prisms of colourless epidote. Decomposition of the micaceous type has, in a few instances, given rise to turbidity.

The quartz is precisely similar to that of the pyroxene-gneisses, and contains the same hairs and rows of dots. The other minerals which do not call for detailed description are magnetite, pyrite, sphene, and apatite. They are not always present, and, when present, occur only as unimportant accessories.

The rocks bear the closest external resemblances to the pyroxene-gneisses with which they are associated, and into which they pass by imperceptible gradations. So close is this resemblance that it is almost impossible to distinguish in the field between the two groups. They are of medium grain and generally grey in colour; but the constituents are rarely distributed uniformly through the mass, and, of course, the colour varies with the relative proportions of the different constituents. A more or less well-marked parallel structure due to concentration of the black and white constituents along planes or folia can generally be detected. This parallel banding is not, however, so well defined as in the normal hornblende-gneisses. The folia are not so persistent, and their boundaries are less sharply defined.

It thus appears that as regards distribution, general aspect, character of the foliation, and the nature of the quartz, these rocks are intimately related to the pyroxene-gneisses. Taking all these facts into consideration, as well as the peculiar relation of the pyroxene and hornblende in certain specimens, it seems impossible to avoid the conclusion that they have been formed from the pyroxene-gneisses by secondary metamorphic processes.

The general distribution of the rocks has already been referred to. The Survey collection includes good examples from Unapool, near Kyle Sku (S853) [NC 237 322], Scourie (S849) [NC 15 44], a promontory in Loch Maree, 3.5 miles south-east of Poolewe (S4187) [NG 886 762], and 200 yards north-west of the bridge over the Inver, Loch Inver (S4461) [NC 096 233]. Specimens con-taming cores of pyroxene come from Scourie (S853) [NC 237 322] and from Craig-a-Mhail, north of Scourie Bay (S4468) [NC 146 458].

(3) The typical rocks of the third group differ in a most marked manner from those of the other two. They are grey in colour, fine in grain, granulitic in texture, and split readily into thin slabs.

The hornblende is compact, and the individuals are often elongated in the direction of the vertical axis. Along with this goes a tendency to idiomorphism, so that the forms {110} and {010} may be frequently recognised. Inclusions of quartz sometimes occur in the central portions of the larger individuals (Plate 45), Fig. 1. The pleochroism is similar to that in the group last described: X yellowish green, Y green, Z bluish green. Twinning parallel to the ortho-pinacoid is sometimes present. In some rocks the mineral occurs as long prisms (Plate 45), Fig. 1; in others as grains of fairly uniform dimensions (Plate 45), Fig. 2.

Brown biotite may be present as small, thin, isolated plates; epidote as minute crystals and grains; iron-ores as grains and crystals of magnetite or pyrite, and more rarely as thin plates of ilmenite. Sphene and rutile sometimes occur as accessories. The above constituents lie in a granulitic mosaic of quartz and felspar (Plate 46), Fig. 1.

When the hornblende is developed in long prisms the contrast between the crystals of this mineral and the constituents of the ground-mass is very striking; but when this form is absent the individuals approximate in size to those of the ground-mass, and the rock then becomes a typical hornblende-granulite (S4454) [NC 047 268], (Plate 45), Fig. 2. The foliation is plane-parallel, with a tendency in some specimens to the linear type.

Rocks of this type are especially characteristic of the narrow shear-zones which traverse the Lewisian gneiss, and which are indicated on the one-inch map by opaque yellow lines. As bearing on their origin, a specimen, selected by Mr. Clough (S3454) [NC 183 437] "to show the old broad planes of original foliation in contact with the newer and thinner planes developed in a pre-Torridonian slide", will be more fully described. It comes from the west-end of Loch na-h-Airidh Sleibhe [Sutherland, 6-inch Sheet 39, north-east, 1-inch Sheet 107]. One portion is a dark, medium-grained rock with bands due to a variation in the relative proportions of the darker and lighter coloured constituents. The limits of the bands are not sharply defined, but they are sufficiently distinct to leave no doubt as to the structure of the rock. Under the microscope this portion is seen to be composed of oligoclase, quartz, hornblende, and biotite, with iron-ores and apatite as accessories. The quartz and felspar are related to each other as in many granitic rocks. Sometimes the oligoclase shows a slight tendency to idiomorphism, and is more or less turbid in consequence of alteration. The hornblende is of the porous, spongy type found in the last group of rocks. The biotite is also similar in colour and mode of occurrence to that found in the same group; but the individuals are somewhat larger.

Another portion of the same specimen is foliated in a direction nearly at right angles to that of the part just described. The folia are thinner, and the micro-structure ofthe rock is different. The constituents are felspar, quartz, hornblende, and iron-ores (magnetite and pyrite); with epidote as an accessory. The hornblende occurs in grains which are sometimes elongated in the direction of the vertical axis, and when this is the case the individuals are arranged with their longer axes more or less parallel to the planes of secondary foliation. There are a few large turbid individuals of felspar which sometimes show traces of idiomorphism, but the bulk of the quartz and felspar forms a typical granulitic mosaic.

There is no hard and fast line between the two varieties of rock.

The direction of foliation changes rapidly, and along with this change in direction goes the change in structure of the rock. The moderately coarse granitic structure, as seen in the relation of the quartz and felspar of the one variety, passes over into the fine granulitic structure as seen in the relation of the same two minerals in the other.

A change of this kind is frequently seen, not only in the gneiss, but also in the dykes which cut the gneiss. As it occurs in both rocks, notwithstanding their difference in age, along narrow zones which shift the dykes as faults and which give independent evidence of having been zones of shearing, it is supposed to owe its origin to secondary dynamic causes. It is worthy of note that this change from a granitic to a granulitic structure is unaccompanied by those evidences of fracture and trituration which are invariably associated with the development of mylonites. The difference in the two cases is probably due, as Professor Judd has suggested,<ref>On static and dynamic metamorphism. *Geol. Mag.,* ser. 3, vol. pp 243–249.</ref> to differences in the temperature and pressure under which the deformation was effected. In the one case (granulitization) the straining of the rock produces molecular and in the other (mylonitization) molar displacements.

It follows, as a necessary consequence of the above view as to the origin of the granulitic hornblende-gneisses, that the grains of quartz and felspar should not be uniformly distributed through the granulitic mosaic. Lenticular folia of quartz should alternate with corresponding folia of felspar; the grains of each separate folium representing collectively one of the larger individuals of the granular aggregate. Such a mode of distribution of quartz and felspar may frequently be observed. Thus in the typical hornblende-granulite (S4454) [NC 047 268], (Plate 45), Fig. 2, the quartz-felspar mosaic is formed of narrow lenticular folia. This cannot be distinctly seen in ordinary light, because both minerals are colourless and occur in grains of about the same size. But if the slide be uncovered and treated, first with hydrofluoric acid and afterwards with fuchsine-solution or some other staining medium, the separate folia of quartz and felspar can be easily distinguished (Plate 46), Fig. 2. Typical examples of granulitic hornblende-gneiss may be observed on the roadside west of Loch-an-Clachtoll, near Loch Inver (S4454) [NC 047 268]; 250 yards north of the bridge over the Inver, near Loch Inver (S4450) [NC 096 233]; at Loch-an-Eun, 1¼ miles E.N.E. of Loch Inver (S3740) [NC 108 238]; and many other localities in Sheet 107.

IV. Rocks in which biotite is the dominating ferro-magnesian constituent; felspar and quartz both present.

If biotite-gneiss be defined as a foliated crystalline rock, composed of biotite, felspar, and quartz, it includes rocks formed in many different ways. Taken in this broad, general sense, it is one of the most widely distributed rocks in the Highlands of Scotland. But it may be in one place a foliated granite, in another a granite modified by dynamic action, in a third a part of a gneissose complex, and in a fourth a metamorphosed grit in which all the original clastic characters have disappeared. Even this does not exhaust the list of the possible modes of origin of biotite-gneisses, for there is good reason to believe that many rocks of the Central Highlands, to which the term is applicable, have originated by the metamorphism of argillaceous sediments.

The pre-Torridonian rocks of the north-west of Scotland contain representatives of at least two of the above groups. Mr. Clough has shown that in the neighbourhood of Laxford Bridge there are numerous intrusions, often of a, sill-like character, of gneissose-granite. These belong to the first or second groups — possibly they contain representatives of both. Biotite-gneisses also enter into the composition of the fundamental complex, especially in the northern and southern areas. These constitute the third group, which may be subdivided very much in the same way as the hornblende-gneisses:

1. Rocks with biotite occurring in independent plates or aggregates of two or three large individuals. Structure more or less granular. Biotite-gneiss (proper).
2. Rocks with biotite occurring in aggregates of small scales.
3. Rocks in which the biotite occurs as more or less independent plates; structure granulitic.

(1) The minerals of the first group are biotite, oligoclase, alkali-felspar, and quartz, with epidote, orthite, apatite, and sphene occurring as accessories. Hornblende and pyroxene sometimes occur in passage varieties, indicating transitions into groups already described.

Biotite, which is the distinctive mineral of the group, though by no means the most abundant, occurs in independent plates or in aggregates of two or three large individuals which mutually interfere with each other. The basal plane is often well-developed, but the boundaries in the prismatic zone are usually irregular and often very ragged. The pleochroism is strongly marked. The usual colour is brown; but a green variety is sometimes present.

The felspars include oligoclase and an alkali felspar which usually presents the structure of microcline. Oligoclase occasionally, though rarely, shows a faint tendency to idiomorphism; microcline is invariably interstitial. The felspars have suffered but little from alteration. A slight turbidity due to the micaceous type of decomposition may occasionally be seen in the oligoclase, but the microcline is always water-clear.

In the typical rocks of this group the boundaries of the felspar are more or less rounded, and lobes of quartz project into this mineral. Rounded grains of quartz also appear to occur as inclusions; but these may be sections of lobes so cut as not to show he connection with adjacent quartz. This is the "quartz de corrosion" of French authors. It occurs in granites, and therefore serves to connect the biotite-gneisses of this type with plutonic igneous rocks.

The quartz, which is abundant, contains many minute, indeterminable specks and flecks; but the hair-like bodies, so common in the blue quartz of the pyroxene-gneisses, are absent. Liquid inclusions have not been observed.

The hornblende and pyroxene, when present, are precisely similar to the minerals of the hornblende and pyroxene-gneisses. Epidote is often visible and appears, in most cases, to be an original constituent. It occurs as irregular grains and more or less perfect crystals. The pale yellowish-green variety sometimes contains a kernel of deep brown orthite (S5858) [NG 602 495], (S5893) [NG 587 465]. Epidote, as is well known, is frequently formed, together with chlorite, by the alteration of ferro-magnesian constituents, and instances of this mode of origin are not wanting in the group of rocks now under consideration; but there are many other cases, as for example when epidote occurs in perfectly fresh biotite, which cannot be explained in this way. Again the occurrence of cores of orthite tells in favour of the original character of some of the epidote.

Apatite is commonly present, but never in any quantity. It forms grains or thick prisms with rounded angles. Iron ores are, as a rule, absent.

The rocks are, for the most part, medium grained grey gneisses, which often show a well-marked parallel banding. One or two specimens referred to in this group may possibly belong to the later granitic gneisses; but pink gneisses, which cannot be separated from the fundamental complex, occur in some localities, as for example in the north of Raasay. As a rule there is no marked difference in size between the different constituents, but true augen-gneiss occurs on a limited scale in the island of Rona. It contains large, lenticular crystals of pink orthoclase in Carlsbad twins.<ref>Mr. Clough has observed augen-gneiss to be common in the Gairloch and Loch Maree district.</ref>

A specimen from ½-mile east of Sangobeag (S8128) [NC 434 663], Durness, composed of biotite, microcline, oligoclase, and quartz, with accessory hornblende, was analysed by Mr. Wilson, with the following result:

SiO_2	66.76
Al_2O_3	14.38
Fe_2O_3	2.04

FeO	3.75
MnO	0.14
CaO	4.62
MgO	2.71
K_2O	3.33
Na_2O	1.44
Ignition	0.49
Total	99.66
Sp. Gr.	2.72

The group, as a whole, is intimately connected with that of the hornblende-gneisses. By an increase in the amount of biotite and a decrease in the amount of hornblende, the hornblende-gneisses pass into hornblende-biotite-gneisses, and finally into biotite-gneisses. Along with this change there is an increase in the amount of alkali-felspar and quartz.

Biotite-gneisses of the above type are abundant in the area north of Laxford, and also in the islands of Rona and Raasay.

Specimens from the west side of the Kyle of Durness (S2384), from a point one mile south of Rhiconich (S4475) [NC 26 74], and from Beinn-na-h'Iolaire, north portion of Raasay (S5909) [NG 602 500], (S5910) [NG 602 500], may be referred to as typical examples. The two specimens from the last-mentioned locality illustrate the extreme variability of the group so far as the relative proportions of the different constituents are concerned. The one is a dark rock rich in biotite, the other a light-coloured rock almost entirely composed of quartz and felspar.

(2) The rocks of the second group in which biotite occurs in aggregates of small scales are intimately related to those of the second group of hornblendic rocks (III. B2). They occur in the same district and pass into the rocks of that group by imperceptible gradations. The biotite occurs in aggregates of reddish-brown or greenish scales. The reddish-brown variety, both in character and mode of distribution, is very similar to that of many contact rocks. Felspar occurs in irregular grains and may be either striated or unstriated. The mean refractive index is higher than that of oligoclase, and no difference can be detected between the average refractive indices of the striated and unstriated sections. In a specimen from one mile north-east of Cnoc Odhair, south of Scourie (S4445) [NC 235 393], the felspars show a fibrous structure. The included fibres have a lower refractive index than the felspar which surrounds them, and the structure is therefore probably due to an intergrowth of two felspars, not of felspar and quartz; in other words, it is microperthitic, not micropegmatitic.

Quartz occurs in irregular grains and granular or granulitic aggregates. It resembles the quartz of the pyroxene-gneisses and contains the thin hair-like bodies and rows of dots. Iron ores are invariably present, and apatite may usually be recognised.

The rocks are medium grained, grey or brown gneisses, and they resemble the pyroxene-gneisses in the character of their foliation. The brownish tint of many of these rocks is due to the biotite. The intimate connection between these rocks and the pyroxene-gneisses has already been referred to. They contain the same variety of quartz, occur in the same areas, and possess the same structure. Biotite of the same type has already been described as occurring in the second group of hornblendic gneisses, which therefore occupy an intermediate position between the pyroxene-gneisses and the rocks now under consideration. A specimen from Craig a Mhail, on the north side of Scourie bay (S4447) [NC 145 457], may be taken as typical of the group.

(3) The third group consists of granulitic biotite-gneisses. These rocks are developed in the shear-zones under the same conditions as the granulitic hornblende-gneisses. A typical specimen from a point 20 yards south-west of Loch nan Eun, near Loch Inver (S4449) [NC 108 238], is composed of small scales of biotite, grains of epidote, and a granulitic mosaic of quartz and felspar. In general appearance it may be described as a grey, laminated granulite, differing only from the hornblende-granulites in containing biotite instead of hornblende. The slabby mode of fracture characteristic of the granulitic rocks is well marked.

Other specimens contain hornblende as an accessory. The derivation of these rocks from others of a coarser and more granular structure is often clearly traceable in the field.

V. Rocks in which two micas are present, together with quartz and felspar

Muscovite-biotite- gneiss

Rocks answering to the above definition form a somewhat variable group. They are found in the southern area, between Gruinard Bay and Loch Torridon.

Three more or less distinct types, which will be referred to as the (a) Cabeg type (Cadha Beag — at the bend of the road, ■ mile northwest of Little Gruinard), (b) the Meall Riabhach (a hill one mile north of Rhn Noa pier at the head of Loch Maree) type, and (c) the Ben Dearg (a hill three miles N.N.E. of Torridon House) type, may be recognised.

(a) The rocks of the Cabeg type may be either banded (S5509) [NG 941 900] or fairly massive, with only faint indications of parallel structure (S4661) [NG 99 81]. White mica is by no means conspicuous, either in the hand-specimens or in microscopic sections. The constituents are oligoclase, microcline (sometimes absent), biotite, muscovite, and quartz, with epidote, sphene, and apatite as accessories. The special feature of this type is the occurrence of large, irregular grains of oligoclase crowded with minute, idiomorphic crystals of epidote. Dr. E. Weinschenck has described and figured a similar occurrence of epidote (zoisite) in the oligoclase of the Gross Venediger.<ref>Beitrige zur Petrographie der ostlichen-central-alpen. *Abh. d. Akad. d. Wiss.,* Munchen</ref> He regards the mineral as an original product of the granitic magma.

Microcline, when present, is always subordinate to the oligoclase. Quartz occurs in large grains containing liquid inclusions. Biotite forms flakes of considerable size, several of which usually occur together. Muscovite occurs in well crystallised flakes, but never in abundance. Epidote is found not only as inclusions in the felspar, but also as grains of considerable size in association with the biotite. Sphene and apatite are present as unimportant accessories. This type occurs 300 yards west of the summit of the Cabeg road, south of Gruinard Bay (S5509) [NG 941 900]; near Loch Bad na Cuileg, south of Little Gruinard, in the same neighbourhood (S5515) [NG 950 881]; south of Loch na Curaich, 2 miles W.S.W. Poolewe (S4991) [NG 824 796]; and at Creag Mheall Mhor, on the north-east side of Loch Maree (S4661) [NG 99 81].

(b) Gneisses of the Meall Riabhach type are developed on the north-east side of Loch Maree, between Ben Slioch and Ben Lair. The region is one in which the rocks have been profoundly modified by dynamic action; and many of the distinctive characters of the group are the result of this action. Thus, in the hand-specimens, the constituents are not, as a rule, sharply separated from each other as they are in most of the rocks already described, in which the dynamic action has been either anterior to or simultaneous with the crystallisation. The explanation of this macroscopic character is furnished by microscopic examination. The larger constituents are seen to lie in a matrix of secondary crush material.

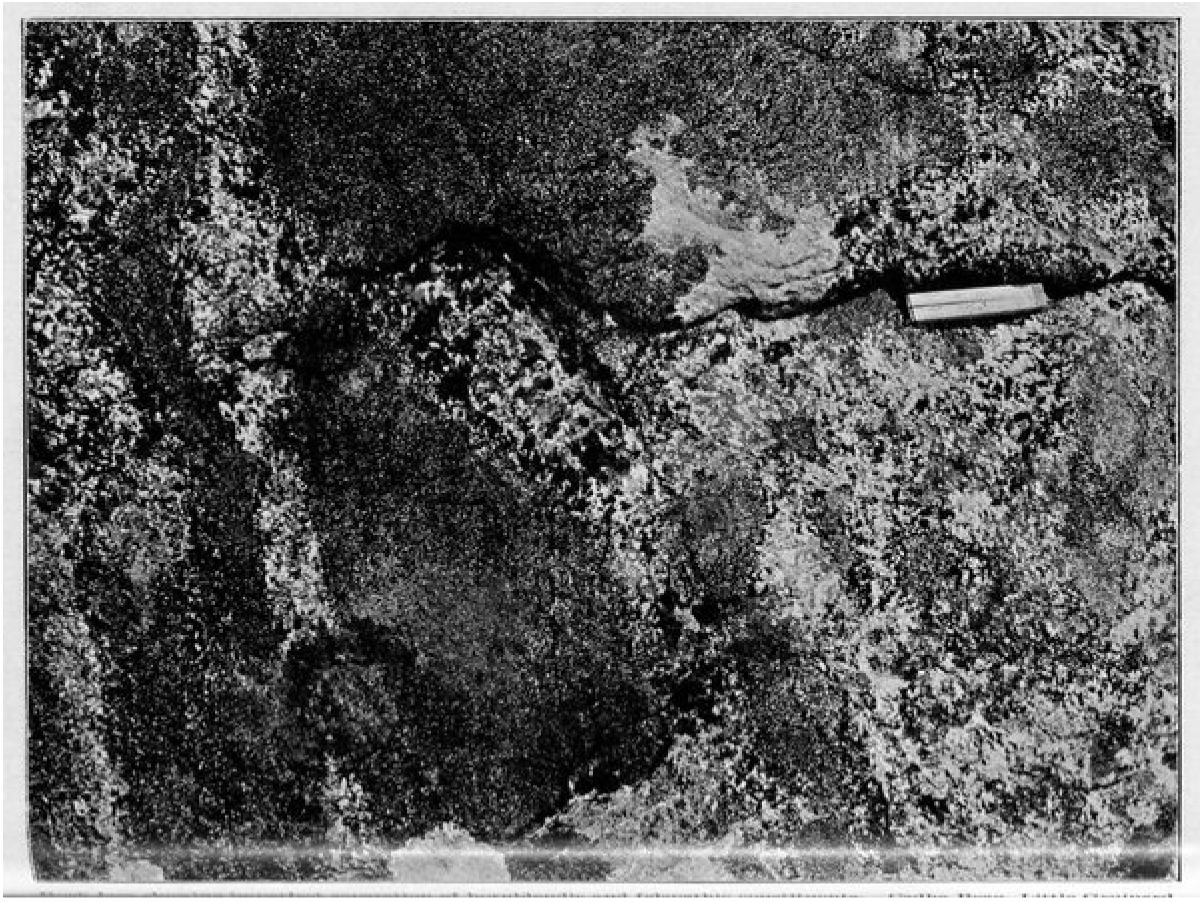
A typical specimen of the group from Leth Chreag. about halfway between Letterewe and Loch Garbhoig, is mainly composed of oligoclase, microcline, and quartz (S4429) [NG 975 714], with some biotite, muscovite, and epidote. Crush-structures are strongly marked and affect all the constituents. The larger grains lie in a secondary matrix, mainly composed of quartz, but containing also crushed felspar and muscovite. The original quartz grains have been drawn into lenticles and "flaser" with the development of micro-crystalline and even crypto-crystalline material.

Another specimen from the west side of Leth Chreag burn (S4432) [NG 97 71] is a pinkish gneissose rock containing "eyes" and long spindle-shaped folia of microcline. It shows marked linear foliation and is intermediate between "augen-gneiss" and hälleflinta-like mylonites, both of which occur in the same district.

(c) The rocks of the Ben Dearg type show a well marked plane-parallel foliation. White mica is abundant, and gives the characteristic silvery lustre to the flat surfaces of schistosity. The constituents are microcline, oligoclase, quartz, biotite, and muscovite. Traces of cataclastic structure may be observed in some specimens. The type rocks come from Ben Dearg, three miles N.N.E. of Torridon House, Loch Torridon ((S4356) [NG 899 601], (S4357) [NG 899 601], (S4358) [NG

899 601]); but similar rocks occur north of the bend in Allt Coire nan Dearcag, 1½ miles N.N.E. of Ardlair, Loch Maree (Sheet 92, (S5484) [NG 903 773]), and about ■ mile northwest of Carnmore old house, four miles N.N.E. of Letterewe, Loch Maree (S5216) [NG 971 772].

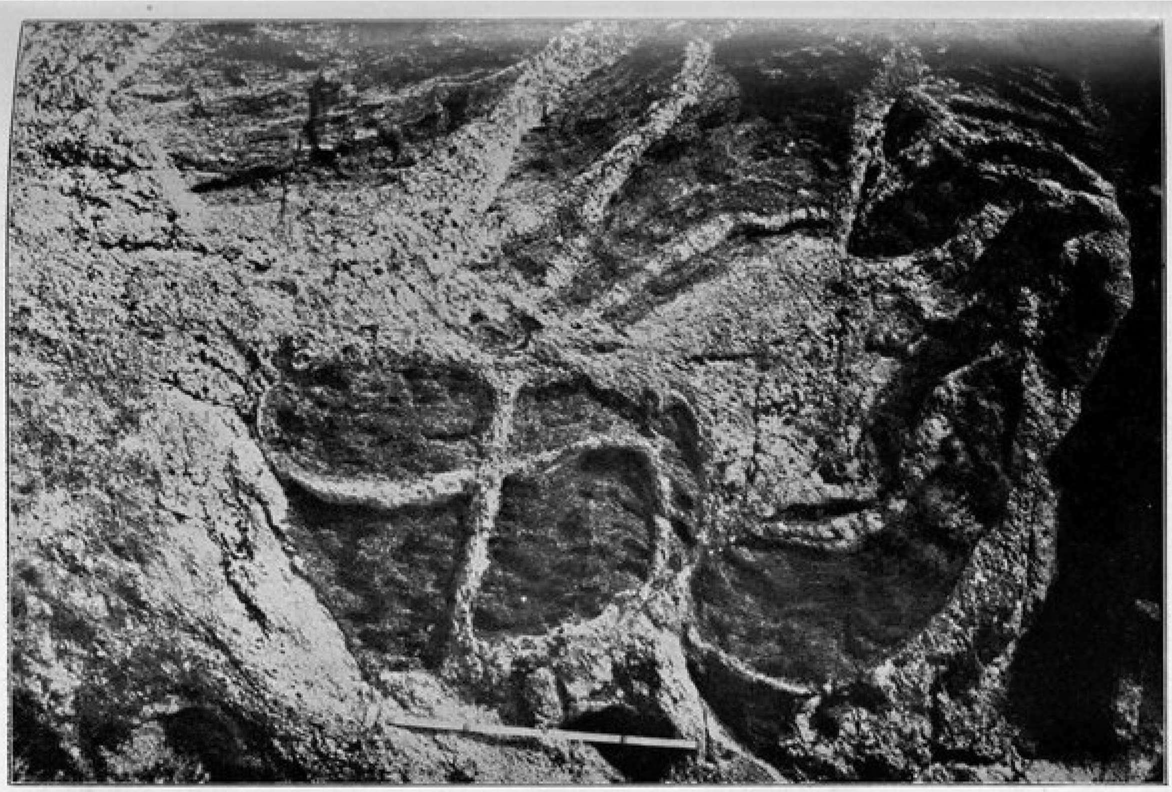
In addition to the rocks above referred to there are others which do not fall readily into the above scheme of classification. There are, for example, granulitic muscovite-biotite-gneisses resembling in structure the rocks of the shear-zones (S5486) [NG 902 769]; highly schistose rocks containing much silvery white mica (S5113) [NG 954 792]; and gneisses containing thin lenticular folia of quartz which project on the weathered surface ((S4406) [NG 986 737], (S4339) [NG 866 730]). Micas are not conspicuous in the last mentioned group, which is in other respects allied to the gneisses of the Ben Dearg type.



(Plate 6) Rock face showing imperfect separation of hornblendic and felspathic constituents, Cadha Beag, Little Gruinard, Ross-shire

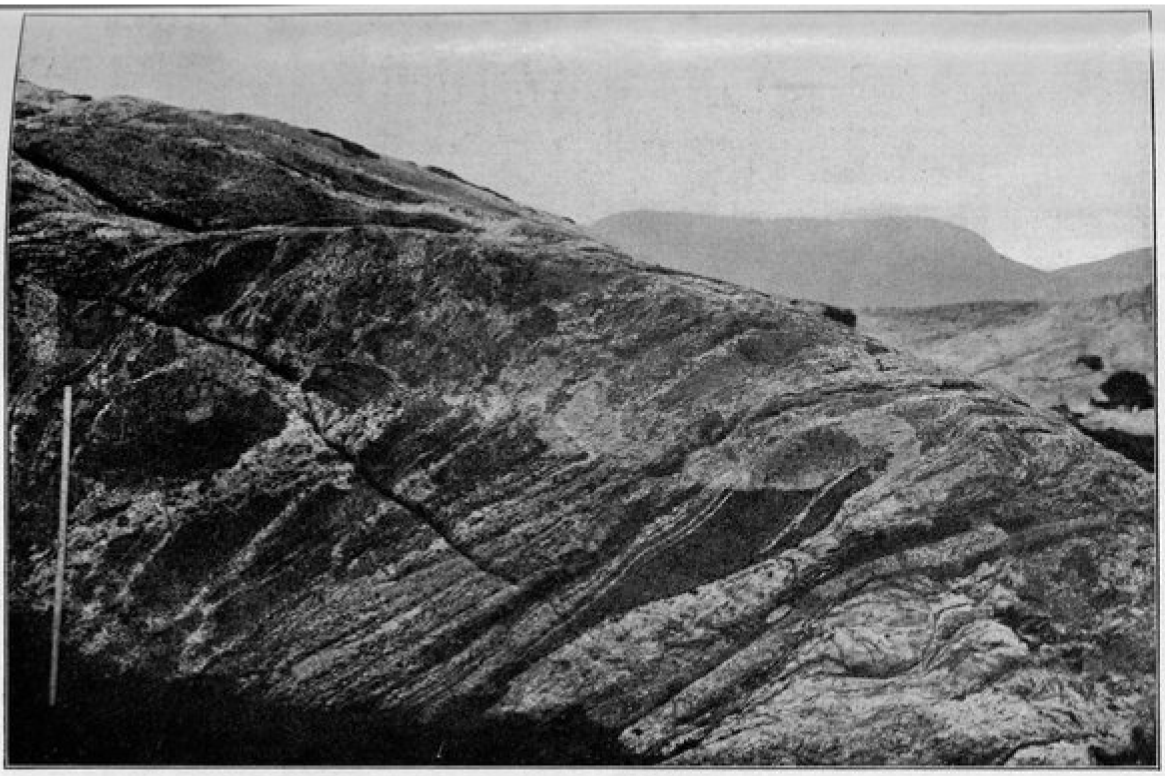
Lumps of basic rock mainly composed of hornblende, separated by quartzo-felspathic material.
Cadha Beag, Little Gruinard, Ross-shire.

(Plate 7) Lumps of basic rock, mainly composed of hornblende, separated by quartzo-felspathic material; Cadha Beag, Little Gruinard, Ross-shire.



Basic Hornblende-Gneiss traversed by quartzo-felspathic veins. Cadha Beag, Little Gruinard, Ross-shire.

(Plate 8) Basic hornblende-gneiss traversed by quartzo-felspathic veins; Cadha Beag, Little Gruinard, Ross-shire. B60.



Hornblende-Gneiss with veins of pegmatite, showing transition from brecciated condition on left to banded condition on right. Ard Shieldaig, Loch Torridon.

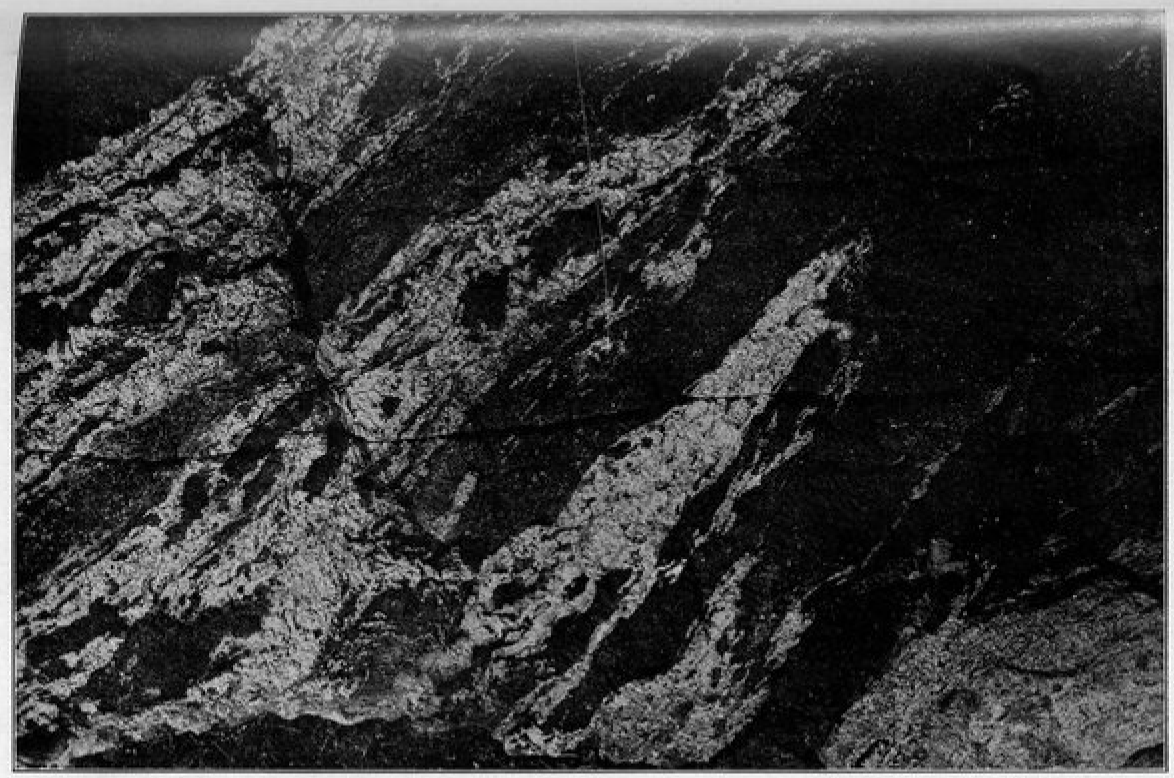
(Plate 9) Hornblende-gneiss with veins of pegmatite, showing transition from brecciated condition on left to banded condition on right; Ard Shieldaig, Loch Torridon. B116.

Fragments of banded Hornblende-biotite-gneiss in more acid material : a plutonic breccia. Near Creag Mhor Thollie, Poolewe, Ross-shire.

(Plate 10) Fragments cf banded hornblende-biotite-gneiss in more acid material — a plutonic breccia; near Creag Mhor Thollie, Poolewe, Ross-shire. B100–B101.

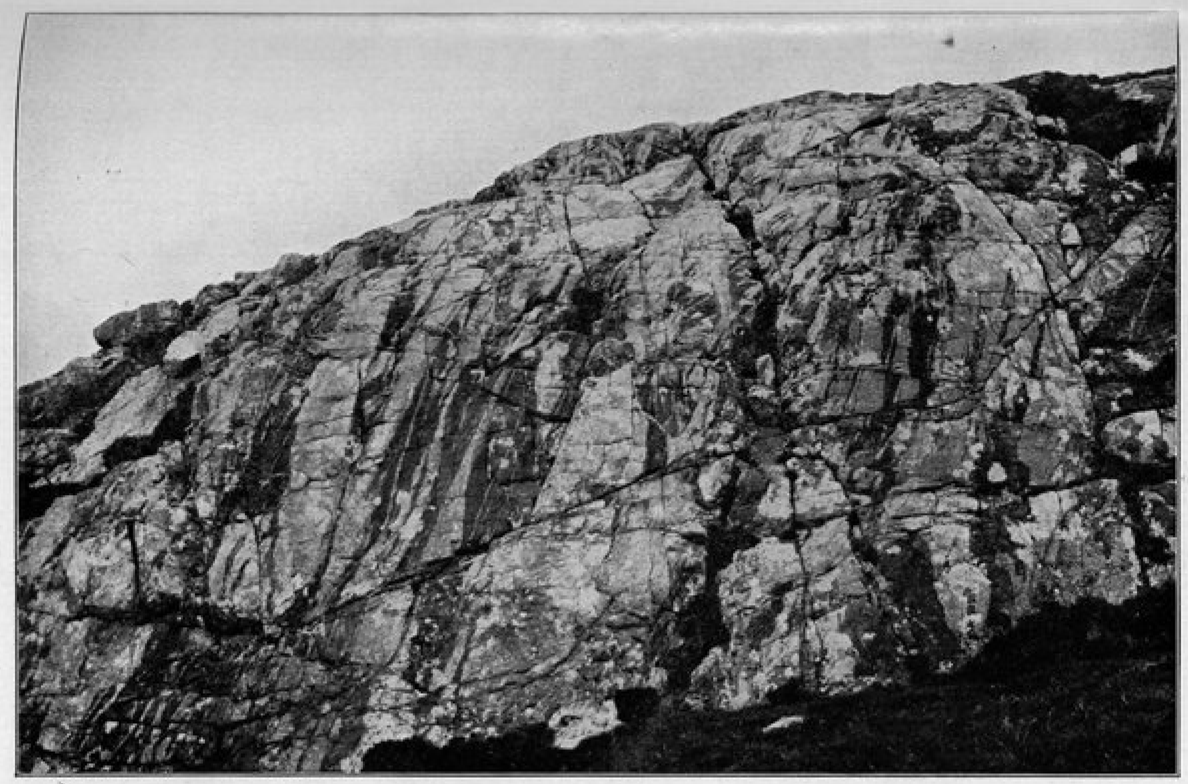
Junction of one of the included fragments with the matrix shown in Plate X. 1200 yards S.E. of the top of Creag Mhor Thollie, two miles south of Poolewe, Ross-shire.

(Plate 11) Junction of one of the included fragments with the matrix shown in



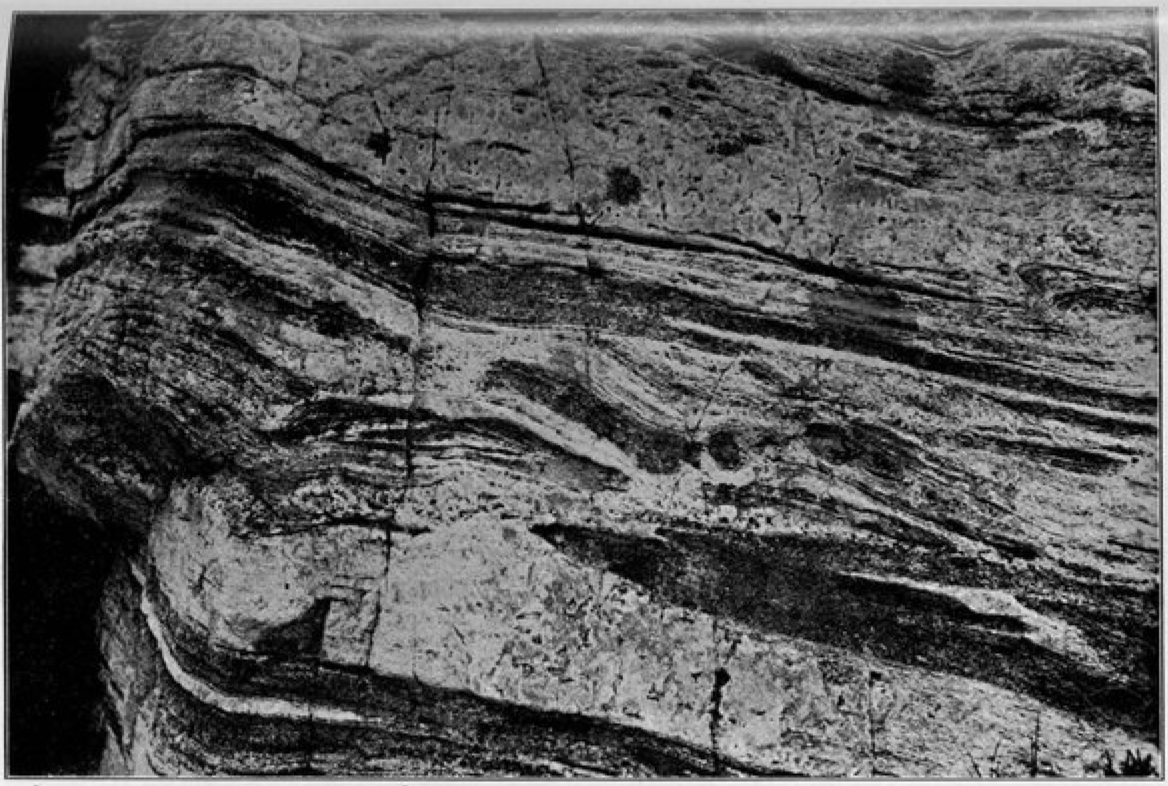
Imperfect banded structure in Hornblende-Gneiss. Creag a' Mhail, north side of Scourie Bay, Sutherlandshire.

(Plate 12) Imperfect banded structure in hornblende-gneiss; Crew' a' Mhail, north side of Scourie Bay, Sutherlandshire. B9.



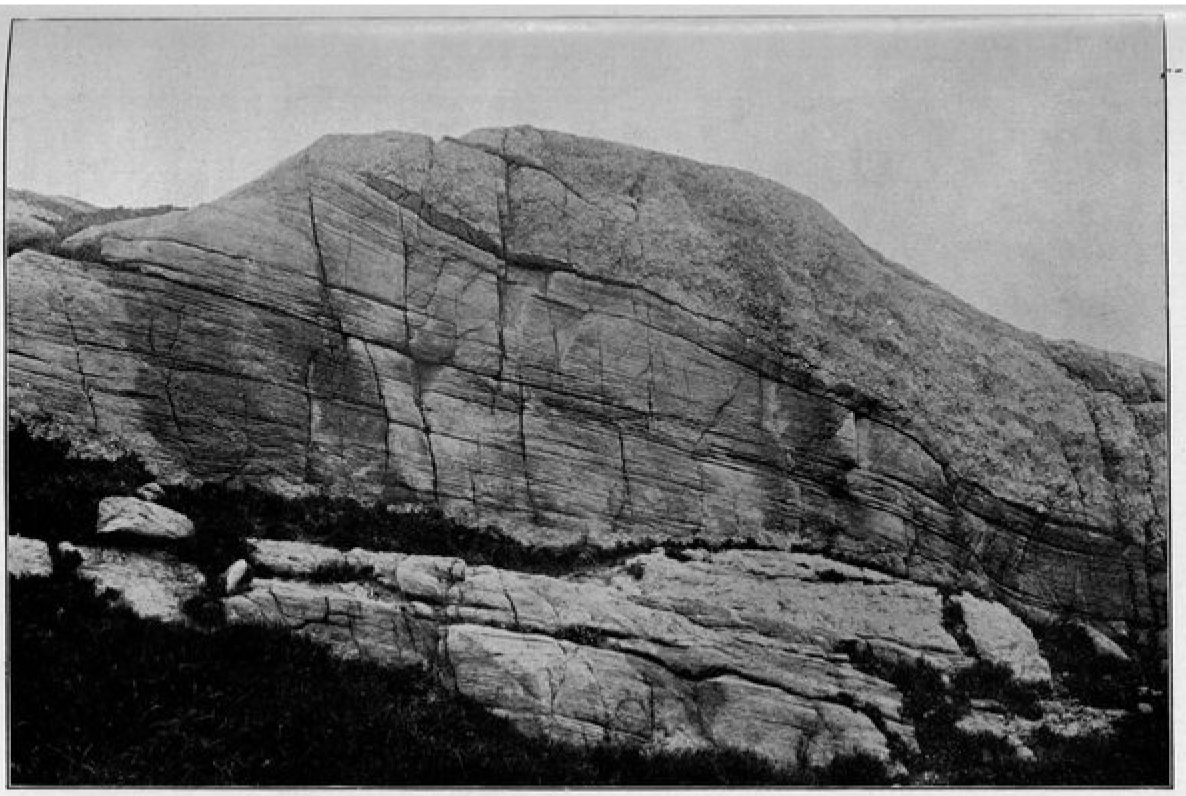
Felspathic Gneiss with streaks and lenticles of basic (hornblendic) rock. Cliff face about 20 feet high.

(Plate 13) Felspathic gneiss with streaks and lenticles of basic (hornblendic) rock; Meall Buidhe, Cadha Beag, Little Gruinard, Ross-shire. B54–B55



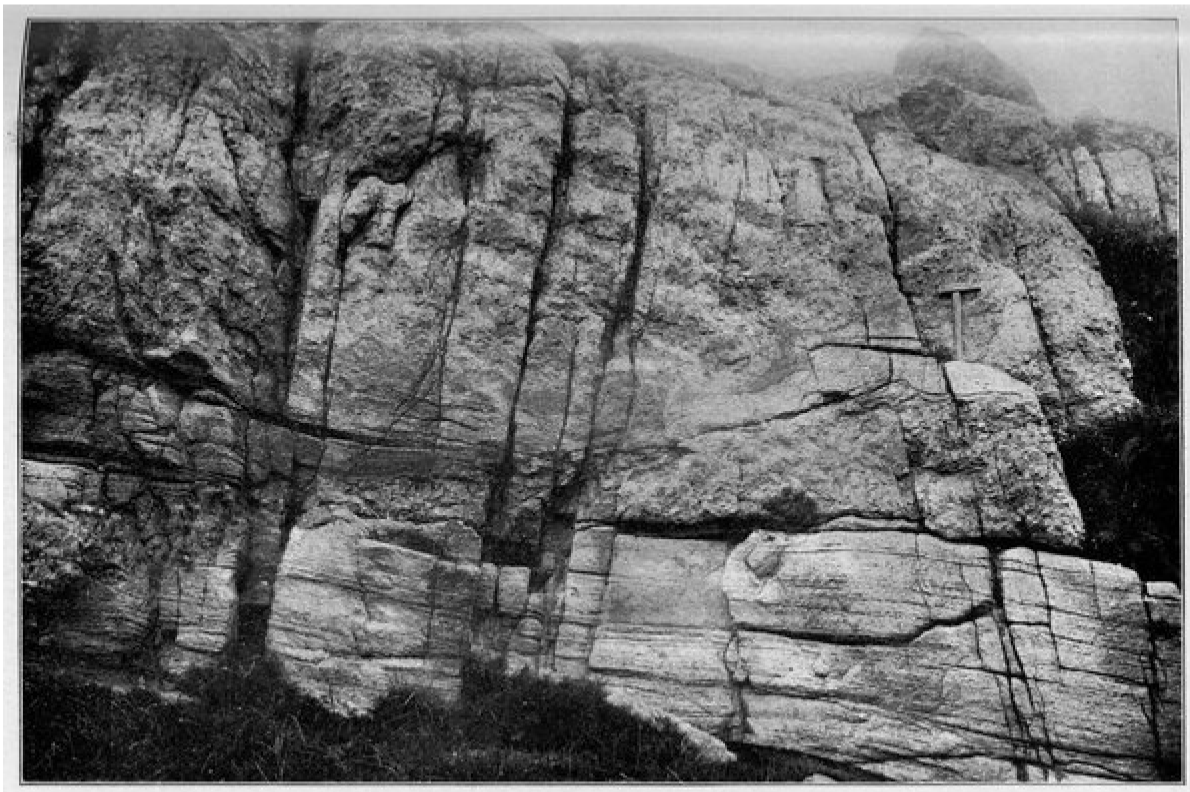
Bands and fragments of foliated basic material in more acid gneiss, near Loch a Bhaid Daraich, Scourie, Sutherlandshire.

(Plate 14) Bands and fragments of foliated basic material in more acid gneiss, near Loch a' Bhaid Daraich, Scourie, Sutherlandshire.



Rock face—upper part consists of coarse pegmatite, lower part of Hornblende-Gneiss with parallel structure. About one mile south of Rhiconich, Sutherlandshire.

(Plate 15) Rock face — upper part consists of coarse pegmatite, lower part of hornblende-gneiss with parallel structure; about one mile south of Rhiconich, Sutherlandshire. B18

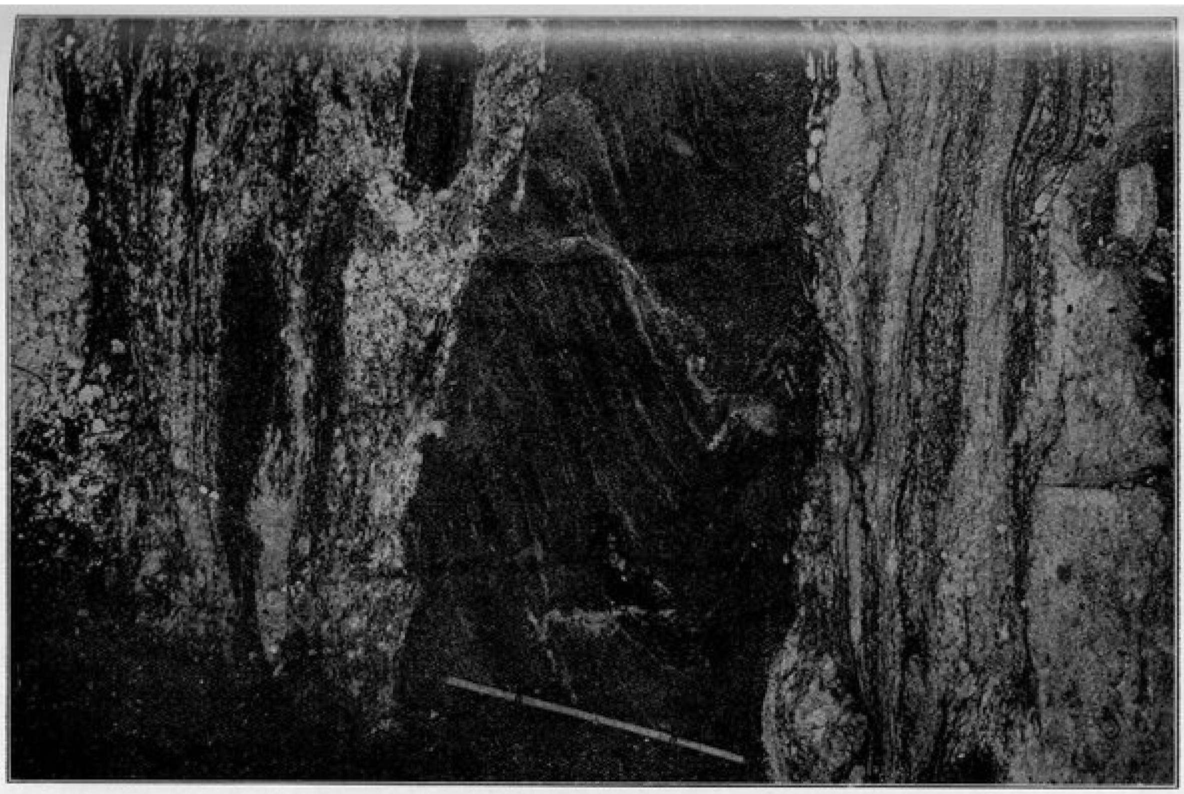


A portion of the rock shown in Plate XV., exhibiting the intrusive character of the pegmatite. One mile south of Rhiconich, Sutherlandshire.

(Plate 16) A portion of the rock shown in

Foliated pegmatite containing large "eyes" of microcline. Ard Shieldaig, Loch Torridon, Ross-shire.

(Plate 17) Foliated pegmatite containing large "eyes" of microcline; Ard Shieldaig, Loch Torridon, Ross-shire. B114



Fragment of banded and contorted Hornblende-Gneiss, enclosed in foliated pegmatitic Gneiss. Ard Shieldaig, Loch Torridon, Ross-shire.

(Plate 18) Fragment of banded and contorted hornblende-gneiss, enclosed in foliated pegmatitic gneiss; Ard Shieldaig, Loch Torridon, Ross-shire. B117

Plate XL.

Fig. 1. Hornblende Rock. x 35.

Fig. 2. Hornblende Rock x 35.

(Plate 40) 1.

Plate XLI.

Fig. 1. Hornblende-anthophyllite rock. x 35.

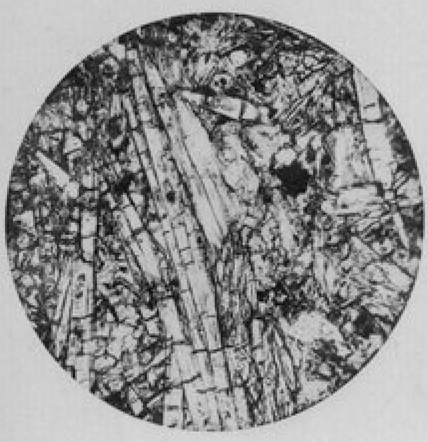


Fig. 2. Calc-anthophyllite rock. x 35.

(Plate 41) 1.

Plate XLIII.

Fig. 1. Epidote – amphibolite. × 35.

Fig. 2. Zoisite – amphibolite. × 35.

(Plate 43) 1.

Plate XLII.

Fig. 1. Hornblende-gneiss (basic) × 22.

Fig. 2. Hornblende-gneiss. × 35.

(Plate 42) 1.

Plate XLIV.

Fig. 1. Hornblende-biotite-gneiss. × 35.

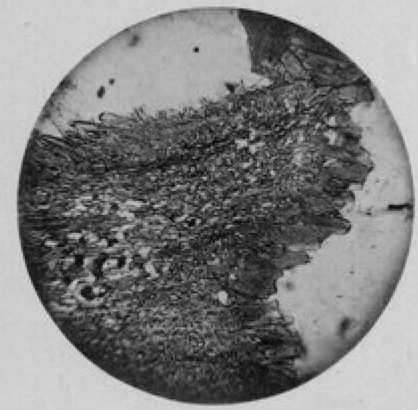


Fig. 2. Hornblende-biotite-gneiss × 60.

(Plate 44) 1.

Plate XLV.

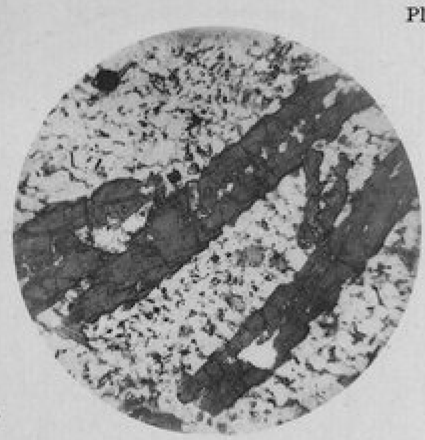


Fig. 1. Granulitic hornblende-gneiss × 35.

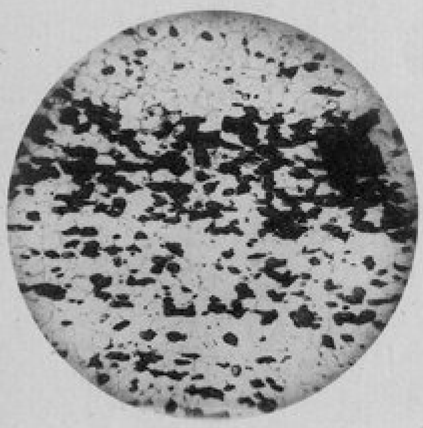


Fig. 2. Granulitic hornblende-gneiss. × 35.

(Plate 45) 1.

Plate XLVI.

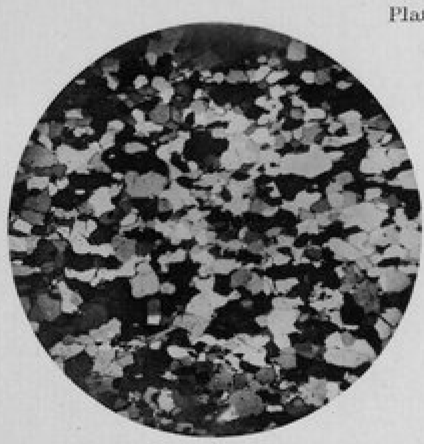


Fig. 1. Quartz - felspar - mosaic. × 35.

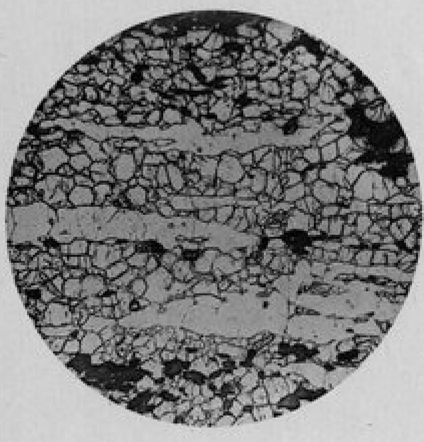


Fig. 2. Quartz - felspar - mosaic. × 35.

(Plate 46) 1.