Chapter 22 Ben Buie, Corra-Bheinn, and Beinn Bheag gabbros

Introduction

The three olivine-gabbros dealt with in the present chapter are lettered E on the one-inch Map, Sheet 44. The Ben Buie and Corra-bheinn Gabbros lie outside the earlier of the two central calderas of (Plate 5) (p. 165), and the Beinn Bheag Gabbro inside, but otherwise the Corra-bheinn and Beinn Bheag Gabbros roughly balance one another on the two sides of the north-west axis of symmetry which runs through Beinn Chàisgidle. Certain small masses of allivalite, lettered U on the one-inch Map, and of porphyrite, lettered P, are also treated in the sequel—in connexion with the internal relations of the Ben Buie Gabbro.

The Ben Buie Gabbro is responsible for the finest rock-scenery of the island, with characteristic dark ice-moulded surfaces of particularly massive appearance. The Corra-bheinn Gabbro behaves similarly, though largely masked by later intrusions. The Beinn Bheag Gabbro gives rise to lines of crag in Beinn Bheag itself, where it is greatly cut up by the Late Basic Cone-Sheets of Chapter 28; but in Glen Forsa it is scenically quite inconspicuous.

A discussion of the many points of interest presented by these three gabbros is grouped below under the following headings: Intrusion-Form, Internal Relations, Relations with Cone-Sheets, Relations with Vent-Agglomerates, and Petrology.

E.B.B., G.V.W.

Intrusion-form

The well-marked agreement of the inner boundary of the Ben Buie and Corra-bheinn Gabbros with the general arcuate distribution of Mull geology must not be lost sight of. In (Plate 5) (p. 165), the inner boundary of the Ben Buie Gabbro is interpreted as approximately guided by the fault-margin of the early southeastern caldera. Such a connexion, if firmly established, would involve a recognition of the Ben Buie Gabbro as an irregular example of a ring-dyke. The evidence, however, is not so precise that it can be relied on in detail. All that one knows for certain may be recapitulated under three headings:

1. Inside the gabbro, lavas with pillow-structure are easily found, but none has been met with outside (Fig 18, p. 133).

2. Outside the gabbro lies the Derrynaculen Granophyre, which seems to correspond naturally with the Glas Bheinn Granophyre, and this latter skirts the outside of the caldera ((Plate 5), Chapter 13).

3. Outside the gabbro, the vent-agglomerates of the southern slopes of Ben Buie, with their granophyre- and gneiss-fragments, agree in type with the vent-agglomerate found farther east outside the caldera ((Figure 29), p. 201).

Another type of evidence suggests that the Ben Buie and Corra-bheinn Gabbros (but not that of Beinn Bheag) may have a closer analogy with cone-sheets than ring-dykes. Both masses occasionally show flow-banding, marked by a parallel arrangement of somewhat wavy layers of darker and lighter minerals, and this flow-banding is always inclined at high or moderate angles in rough agreement with the cone-sheets of the neighbourhood. Examples from the Ben Buie Gabbro may be cited as follows:

1. The banding of the complex margin, to be described presently, of Creag na Comhla near Loch Fuaran, is inclined north-east. G.V.W.

2. Good banding is exposed south of Uillt Gharbha between ¾ and 1 mile west-north-west of Ben Buie summit. The inclination is north-east at 30° or 40°.

3. Steep banding striking north-west, or west, is shown by exposures within the angle of the path south-west from Craig Cottage across the river-junction.

4. Banding inclined east, or north-east, sometimes at about 70°, is seen 300 yds. north of the Glen More Road, 150 yds. east of the gabbro-margin.

Banding in the Corra-bheinn Gabbro has been noted somewhat often in the more westerly stream below the Coir' an t-Sailein Quartz-Gabbro, and also on the hill-slopes farther east. The dip of the banding is persistently north-east, and the inclination varies from 25°–80°. (C.T.C)

The Beinn Bheag Gabbro is locally well-banded, where it overlooks Coire Gaibhre from the north, but in this case the inclination of the banding contrasts with that of adjacent cone-sheets. In fact, the banding inclines north-east and the cone-sheets south-west. E.E.B.

Unfortunately, the available mountains are not sufficiently large to reveal whether any of the three gabbros have an inclination in bulk corresponding with the suggestions afforded by the local flow-banding. What they do show is that these great masses are of irregular outline and steeply bounded, and that they undoubtedly continue in depth for some considerable distance without serious diminution. (C.T.C), E.B.E., G.V.W.

The difficulties with which the geologist is faced in accounting for the disappearance of pre-existent country-rock in the case of these great gabbro masses are epitomized between Creach Beinn Bheag and the south-east slopes of Meall nan Capull, where a series of miniature outcrops of fine-grained gabbro appear on the one-inch Map as outposts beyond the main Ben Buie front. Their individual form contasts markedly with that of surrounding cone-sheets through which they abruptly rise. One feels that there must have been a considerable displacement of country-rock, either bodily or piecemeal, either up or down, to clear pipe-like cavities for rising gabbro-magma. Possibly explosion to some extent prepared the way.

Internal relations

Beinn Bheag Gabbro

(Figure 37) summarizes the distribution of rock-types. There is no junction exposed between the coarse and fine varieties of black-and-white gabbros. Contacts of black-and-white with dark gabbro suggest, if anything, that the former is the younger of the two. The belts with acicular crystallization (recalling exactly that of the big augite-diorites of Chapter 18) merge insensibly into adjacent coarse black-and-white gabbro.

E.B.B.

Ben Buie Gabbro

Three features of special interest may be noted in connexion with the Ben Buie Gabbro

1. On the south of Loch Fuaran, and particularly along the ridge of rock which runs north-west from Creag na Còmhla, the margin of the gabbro shows a well-marked banding. Some of the bands are rich in magnetite, which is magnetized, and occurs in strings up to 4 inches wide, but of no great lateral extent. Other bands exhibit a pock-marked appearance due to the presence of olivine-rich portions. No single origin can be ascribed to the bands; in some instances they are, no doubt, included, and highly altered portions of cone-sheets; in others, appearances indicate that they are magmatic segregations or the gabbro-complex. G.V.W.

2. Several small allivalite masses (U one-inch Map) occur enveloped in the Ben Buie Gabbro of the Glen More district. The largest and most conveniently placed outcrop is exposed on either side of the road, about a third of a mile west of Craig Cottage. It measures 700 by 200 yds. Wherever seen, the gabbro-allivalite junctions are not quite sharp. In one occurence on Sròn Dubh, too small to show on the one-inch Map, gabbro clearly veins allivalite (S17868) [NM 5998

2777]. Elsewhere age-relationships are not obvious, but it is possible that the allivalite-masses are, in all cases, of somewhat earlier date than the surrounding gabbro.

3. Another type of intrusion, associated with the Ben Buie Gabbro is the Craig Porphyrite (P on one-inch Map), named after the road-side cottage already mentioned. The porphyrite occurs in several detached outcrops shown on (Plate 5) (p. 165). It is characterized by a comparatively fine texture, abundant small felspar-phenocrysts, and, also, by a profusion of xenoliths derived from the surrounding gabbro. It does not chill against the gabbro, though manifestly of later date, so that it looks as if the time-interval between the two was small enough to leave the gabbro warm when the porphyrite appeared. The porphyrite carries enstatite in place of olivine, and thus differs somewhat markedly in composition from the gabbro. (C.T.C)

Relations with cone-sheets

As is clear on the one-inch Map, all three gabbros have an outer part comparatively free from intrusions, and an inner part cut to pieces by the Late Basic Cone-Sheets of Chapter 28 (the words outer and inner are used with reference to the centre about which the three gabbros are grouped). In the Ben Buie Gabbro, the relatively simple outer part is far more extensive than the inner more complicated part; whereas, in the other two gabbros, the division is fairly equal (Figure 37). The simplicity which characterizes the outer portions of the outcrops of the Ben Buie and Coire-bheinn Gabbros has been attained at the expense of a pre-existing intrusive complex including Derrynaculen Granophyre, vent-breccia, and a host of Early Cone-Sheets. On the other hand, the simplicity of the outer portion of the Beinn Bheag Gabbro is much less informative: the gabbro in this case, where its outcrop is simple, is bounded by lavas which are equally free from other intrusions. E.B.B. G.V.W

It will be understood from the above that a fairly accurate age-comparison is possible between the Ben Buie and Corra-bheinn Gabbros. Detailed evidence will now be given to illustrate certain features of the time-scale already enunciated in Chapter 21, namely: (1) Main Early Basic Cone-Sheet s—non-porphyritic; (2) Ben Buie Gabbro; (3) Early Basic Cone-Sheets, with small felspar-phenocrysts; (4) Corra-bheinn Gabbro. It will be convenient to consider this time-scale backwards rather than forwards, and to deal first with the marginal relations of the Corra-bheinn Gabbro:

Corra-bheinn Gabbro

Most of the hill-side south-west of the gabbro-margin consists either of basalt-lavas or of Derrynaculen Granophyre, in both cases cut by numerous olivine-dolerite cone-sheets dipping steeply north-east; non-porphyritic and porphyritic dolerites occur, the latter distinguished by crowded small felspar-phenocrysts. Quite commonly, these dolerite-sheets (Early Basic Cone-Sheets of Chapter 21), make up about half the rock just outside the gabbro. Individual sheets may be 20 or 30 ft. thick, and they strike at a considerabl angle against the gabbro-margin, there abruptly to terminate. The relationship is very obvious, since the gabbro, for 200 or 300 yds. in from the margin, is almost entirely free from intrusion by cone-sheets of any kind whatever. Moreover, examination of the marginal zone shows that about a mile south-west by south of Cruachan Dearg, and in various other localities, the cone-sheets just outside the gabbro are veined by numberless irregular granophyre-strings, giving rise to an injection-brece,ia; and these strings are also cut off by the gabbro. In harmony with this, the gabbro, for 20 yds. or so in from its edge, encloses and veins numerous shapeless masses of earlier basic igneous rock. Contact-alteration has masked the original character of these xenoliths; but it is natural to conclude that many of them have been derived from neighbouring cone-sheets.

There is little or no evidence of a recrudescence of Early Basic Cone-Sheets after the Corra bheinn Gabbro. All, or almost all, the numberless basic cone-sheets, shown on the one-inch Map as a complex forming the summit region of Corra-bheinn and Cruachan Dearg, are of types referable to the Late Basic Cone-Sheets of Chapter 28.

Ben Buie Gabbro

Anyone wishing to satisfy himself that the Ben Buie Gabbro is cut by dolerite-sheets with small felspar-phenocrysts, and that these sheets form part of the suite cut off by the Corra-bheinn Gabbro, should commence by ascending Uisgeacha Geala from the bill-track, one-third of a mile north-west of Craig Cottage. Several typical exposures of porphyritic dolerite

sheets piercing gabbro are seen, both in the stream, and in the neighbouring slopes on the east. The same relation is again exposed near the gabbro-margin above and below the path about half a mile farther north-west. It is impossible to follow individual sheets with certainty from exposure to exposure, but the sheets, just mentioned, are identical in type with some of the suite, which, another half-mile farther on along the same line of strike, is cut across *in toto* by the Corra-bheinn Gabbro. This particular locality has been chosen merely because of its situation relative to the Corra-bheinn Gabbro. The mere fact that a certain number of olivine-dolerite sheets carrying small felspar-phenocrysts cut the Ben Buie Gabbro can be illustrated almost anywhere in the outcrop of the latter.

To realize the relationship that, in bulk, the Early Basic Cone-Sheets are cut off by the Ben Buie Gabbro, one has to leave the north side of Glen More and go, for instance, to the gabbro-edge on Tòrr a' Ghoai, about a mile south-east of Derrynaculen Cottage. A great mass of doleritic sheets occurs here just outside the gabbro; as a rule, sheet cuts sheet, but occasionally a lenticle of a pre-sheet granophyre is preserved in an interval. Against these lenticles, and against one another, the sheets, at a hundred yards and more from the gabbro, are for ever showing chilled margins. Sixty or seventy yards from the gabbro, such chilling begins to be lost sight of, and, within fifty yards from the same, it cannot be recognized. The last twenty yards consists of rather fine-grained basic igneous rock—no doubt contact-altered cone-sheets with blurred individuality—intricately veined and mixed with gabbro, and, to a less extent, with granophyre. A visible field-indication of contact-alteration in these dolerite cone sheets is a development of reticulate cracks. The porphyritic type of dolerite-sheet is also represented by a few examples, which retain their chilled edges in proximity to the gabbro, and continuing across its margin actually chill against it. These manifestly later dolerites cut the granophyre-veins and do not show the characteristic crack-system just alluded to. (C.T.C)

The same general phenomena are met with, wherever, between Tòrr a' Ghoai and Creach Beinn, a contact of Ben Buie Gabbro with Early Basic Cone-Sheets is exposed. The evidence afforded by the south face of Ben Buie and Beinn Bheag is summarized in (Figure 38), where gabbro is shown cutting out a great development of Early Acid, Intermediate; and Basic Cone-Sheets (Chapter 19 and 21) The few basic cone-sheets, which; in (Figure 38) traverse the Ben Buie Gabbro, are in part referable to the Late Basic Cone Sheets of Chapter 28, and in part to the porphyritic representative of the Early Basic Suite. G.W.L., G.V.W.

The minor isolated outcrops of fine-grained gabbro, which are shown on the one-inch Map (three on the south face of Meall nan Capull, two on the south face of Creach Beinn, and one on Creach Bheinn Bheag) furnish additional illustrations; and these all the more striking because in them one can easily see the Early Basic Cone-Sheet Complex, interrupted on the one side of each little gabbro mass, and reappearing on the other. The largest of the Meall nan Capull gabbro outcrops is readily found at the head of Coire na Febla. It is cut by about ten cone-sheets (one of them acid), but these ten are as nothing to the basic sheets that are obviously intersected.

Beinn Bheag Gabbro

The geographical position of this mass precludes a direct age-comparison between it and any appreciable proportion of the Early Basic Cone-Sheets. It is, however, clearly of earlier date than all the very numerous Late Basic Cone-Sheets of its locality.

Relations with vent-agglomerates

The age-relationships of the Ben Buie, Corra-bheinn, and Bheinn Bheag Gabbros to the vent-agglomerates of their neighbourhood may be summarized thus: (1) main agglomerates; (2) gabbros; (3) subordinate agglomerates. Direct field-evidence will be presented to prove that some agglomerates are older and others younger than the gabbros. That the former are the more important follows at once when it is remembered that most of the agglomerates in the region with which we are at present concerned are clearly earlier than the Early Basic Cone-Sheets of Chapter 21, and, therefore, *a fortiori,* earlier than the Ben Buie and Corra-bheinn Gabbros.

Ben Buie Gabbro

A comparison of the north and south slopes of Ben Buie brings to light a most interesting dual relationship between agglomerate and gabbro (Figure 38). On the south side, the Ben Buie Gabbro cuts through a great mass of volcanic breccia largely made up of granophyre-fragments. This circumstance is rendered particularly obvious, because the breccia is abundantly penetrated by massive pre-gabbro cone-sheets of various compositions; each sheet has a chilled top and bottom, except in the immediate vicinity of the gabbro where the latter cuts across the complex in clear exposures. Moreover, the gabbro-margin is quite unbroken at its contact with the agglomerate; in fact, where seen about the 600 ft. contour on the west slope of Gleann a' Chaiginn Mhòir, the gabbro develops a fine-grained crystallization against the agglomerate. On the north side of Ben Buie, all this is reversed, for here a later agglomerate is found at the edge of the gabbro. Not only is this agglomerate largely made up of gabbro blocks and fragments, but also there is often a marginal passage from mixed agglomerate into shattered gabbro, so that nothing could be clearer than that the Ben Buie Gabbro has been locally broken up by subsequent explosions. G.V.W.

Corra-bheinn Gabbro

The Corra-bheinn Gabbro is manifestly later than the vent-agglomerate that is shown on the one-inch Map traversed by Early Basic Cone-Sheets in Sleibhte-coire (pp. 187, 207). On the other hand, it is earlier than a narrow strip of agglomerate (too small to show) about a third of a mile west-south-west of Cruachan Dearg. This little agglomerate-patch is in contact with the Corra-bheinn Gabbro, from which it has derived most of its material. In addition to pieces of gabbro, it carries a small proportion of some non-local acid igneous rock. (C.T.C.)

Beinn Bheag Gabbro

(Figure 37) (p. 244) indicates where the fine-grained dark gabbro of the Beinn Bheag complex locally chills against agglomerate; and, on the other hand, where it locally breaks up into agglomerate. The fine-grained black-and-white gabbro of the same complex is seen, east of Glen Forsa, to be later than neighbouring agglomerate. E.B. B.

Petrology

The petrological treatment of the subject will be divided under three main headings: Ben Buie Complex, Corra-bheinn Gabbro, and Beinn Bheag Gabbro.

Ben Buie Complex

(Anal.. I.; (Table 5), p. 23)

The title Ben Buie Complex is used to cover the Ben Buie Gabbro (Eucrite) of the earlier part of this chapter, and, along with this great mass, the attendant small intrusions of allivalite and porphyrite, and also the banded granulitic marginal assemblage developed near Loch Fuaran. The word gabbro as applied to the bulk of the Ben Buie Complex is generally replaced in the sequel by the narrower term eucrite, since the Ben Buie Gabbro, unlike the Corra-bheinn and Beinn Bheag Gabbros, is predominantly of eucritic character. The allivalite-masses, it will be remembered, are supposed to be of older date than the eucrite that envelops them; in this case, the same general relations hold at Ben Buie as Dr. Harker found in Skye and Rum, where ultrabasic plutonic rocks have been succeeded by others of less basic, but allied character. The Craig Porphyrite is clearly later than the eucrite; but, as pointed out already, it should be regarded, according to its field-relations, as part of the same complex.

The chemistry of the allivalite-eucrite assemblage has already been discussed (p. 21) in relation to analyses from Ben Buie and Rum.

The Ben Buie Complex has escaped pneumatolysis to such an extent that it retains a large proportion of its olivine in a fresh state. This is in keeping with the observations that the two most massive Early Basic Cone-Sheets also contain fresh olivine (p. 239).

Allivalite

Several small masses (p. 245), by reason of the dominating presence of olivine and anorthite (Figure 39)A, may best be designated anorthite-peridotites or allivalites (S15630) [NM 5778 2932], (S15624) [NM 5772 2990], (S18452) [NM 5763 2998]. As was noted by Dr. Harker,<ref>A. Harker, Geology of the Small Isles of Inverness-shire, Mem. Geol. Surv., 1908, p. 89.</ref> the rocks of this group show considerable variation in the relative proportions of their essential constituents, but olivine usually makes up at least half of their bulk. In some cases, the almost complete suppression of felspar (S15629) [NM 5760 2993], and the concentration of the usual chromiferous spinellid, produce a rock that approximates to dunite; while, in the other direction, an increase in the proportion, and a slight drop in the basicity, of the felspar (S16499) [NM 5811 3017], taken in conjunction with the presence of diallagic augite and a rhombic pyroxene (S2645) [NM 605 272], (S15625) [NM 5775 2988], indicate a leaning towards the eucrites of which the Ben Buie complex is mainly composed.

Olivine in these rocks is usually in an unaltered condition, and occurs chiefly as rounded to sub-idiomorphic crystals that often attain large dimensions. The crystals are characteristically colourless in thin section, but are locally rendered almost opaque by inclusion of dust-like particles and dendritic growths of magnetite. In its structural relations, the olivine commonly occurs in poecilitic fashion imbedded in large plate-like masses of felspar. As was pointed out by Dr. Harker, in those members of the allivalite group, which are richest in olivine, this mineral is the first to separate from the magma, but as the proportion of olivine decreases we find it moulded upon, and often enclosing, an earlier-formed felspar (S2645) [NM 605 272].

The felspar of these ultra-basic rocks is optically negative and has extinction angles that prove it to be near anorthite in composition. It is always twinned according to both carlsbad and albite laws, but pericline lamellation is not such a common feature as in the more normal gabbroic rocks subsequently described. Most frequently, it is unzoned, but occasionally, more especially when augite is present in appreciable quantity, it is zoned with an optically positive felspar of basic labradorite composition.

The constant presence of a chromiferous spinellid as an accessory is an essential character of this group of rocks. Generally, it builds well-shaped crystals of fair size which appear coffee-brown by transmitted light, and are referable to picotite (S15631) [NM 5774 2931], (S15624) [NM 5772 2990]. But in some instances, it is opaque, and then we may assume that the mineral is either chromite or chrome-magnetite (S16499) [NM 5811 3017].

This spinellid is an early product of consolidation, but, seemingly, did not always precede the separation of the other constituents. It may be observed enclosed in olivine in very limited quantity, but shows a distinct tendency to segregate in the more felspathic portions of the rock; and veins of anorthite and picotite (Figure 39)B are not infrequent (S15631) [NM 5774 2931].

The rocks as a whole are remarkable for their freshness, and seldom show any alteration other than a partial serpentinization of their olivine along cracks; some slight rise in temperature, probably on the intrusion of the subsequent eucrite, may account for the occasional development of fibrous and almost colourless hornblende at the margin of the olivine-crystals (S15624) [NM 5772 2990].

As has been stated above, the genetic connexion of these rocks with the eucrites is established by the occasional presence of augite and of a plagioclase of less basic composition. Augite is never abundant in the rocks of undoubted ultrabasic character, but occurs in small quantity in association with olivine (S15629) [NM 5760 2993]. Occasionally, it appears in larger amount, and may even enclose, poecilitically, the large characteristic crystals of olivine (S16499) [NM 5811 3017]. A rhombic pyroxene occurs most sparingly, and is, as far as can be judged, an enstatite or non-pleochroic variety (S15625) [NM 5775 2988].

Eucrite

(Anal. I.; (Table 5), p. 23).

Passing now to the more prevalent, and presumably later, type of intrusion, we find that, although it presents much variety in texture, and in the relative abundance of constituents, there is a fairly constant mineral-assemblage. It is characterized, usually, by an abundance of olivine, and by the presence of an ophitic diallagic or normal augite, and of a

felspar near bytownite in composition (Figure 40). The consistent basicity of the dominant felspar, as well as other characters described below, enables us to place the greater part of the Ben Buie complex with the eucrites rather than with the normal gabbros.

The olivine presents the same general characters as in the peri-dotitic rocks described above. It is usually an abundant constituent, and many of the eucritic rocks approximate to the allivalites by reason of the prevalence of this mineral and the basicity of their felspar (S18451) [NM 5763 2998], (S18453) [NM 5785 2954]. With an increase in the amount of augite (S16711) [NM 5811 2665], there is a corresponding decrease in the amount of olivine, and in some varieties of the gabbro it may fail completely (S16720) [NM 5893 2613], (S17903) [NM 5908 2972], (S18454) [NM 5890 2956]. It is usually an early product of crystallization, and occurs poecilitically enclosed by either felspar or augite (S16715) [NM 5843 2619], (S17386) [NM 6218 2656]. Rarely, it shows schiller structure (S17386) [NM 6218 2656]. Sometimes a narrow reaction-border separates olivine from the enveloping felspar (S17388) [NM 6195 2728], and, as is usual in such cases, consists of an aggregate of enstatite and colourless augite with a little actinolitic hornblende. Some of the olivine is distinctly yellow in thin sections, and entirely free from all striations other than those due the traces of the prismatic cleavages (S16710) [NM 5822 2677].

A rhombic pyroxene occurs but rarely; in some examples, it appears to be a colourless enstatite, but in others it has the pleochroism of hypersthene (S16713) [NM 5838 2627]. It is occasionally associated with a little fox-red biotite. Uusally, it is either intergrown with augite or occurs in close association with olivine.

The felspar is always more basic than normal labradorite, and most frequently ranges in composition from basic labradorite to near anorthite. It is generally of later consolidation than olivine, which it poecilitically encloses, but occasionally part is of an early generation and may occur within the olivine or with olivine moulded upon it (S17386) [NM 6218 2656]. It is usually twinned according to both Carlsbad and albite laws, and quite. often pericline twinning is a striking feature (S17316) [NM 6300 2767]. Zoning is much more frequent than in the felspars of the allivalitic rocks, and it is common to find an optically negative felspar (bytownite-anorthite) surrounded, with perfect transition, by a zone of optically positive material (labradorite-bytownite) (S16710) [NM 5822 2677], (S16711) [NM 5811 2665].

Accessory minerals are comparatively rare in these rocks, apart from scattered patches and crystals of magnetite, and, in the more basic rocks, a chromiferous spinellid. Apatite is of infrequent occurrence, but when present builds moderately large crystals (S15623) [NM 5757 2959].

Before leaving the subject of the normal Ben Buie Gabbro, a word may be said concerning the banding which locally is a feature of the mass. This banding is due in part to textural, and in part to compositional, variation (S15626) [NM 5790 2937], (S17205) [NM 5890 2954]. The observed structures are in every way comparable to those presented by the banded gabbros of Skye, so fully described by Sir A. Geikie, Sir Jethro Teall, and Dr. Harker.<ref>A. Geikie and J. J. H. Teall, On the Banded Structure of some Tertiary Gabbros in the Isle of Skye, Quart. Journ. Geol. Soc., vol. 1, 1894, pp. 650, 654; A. Harker, Tertiary Igneous Rocks of Skye, Mem. Geol. Surv., 1904, pp. 117–120.</ref>

Banded granulites, Loch Fuaran

Sharply separated petrographically from all other components of the Ben Buie complex, is a group of granulitic and banded rocks which occurs to the west of Ben Buie, in the neighbourhood of Loch Fuaran (p. 245). These rocks are shown on the one-inch Map as part of the Ben Buie Gabbro (Eucrite), but their appearance suggests recrystallization; and, although in some cases they reproduce the characters of that type of micro-gabbro known as beerbachite, they are most probably metamorphosed masses of an earlier gabbro, or remnants of other early basic intrusions. Similar occurrences were encountered by Dr. Harker<ref>A. Harker, op. cit., pp. 115, 116.</ref> in Skye.

A series of specimens collected from the western shores of the loch are of fine-grained compact rocks that consist mainly of granules of strongly pleochroic hypersthene, granulitic augite, and small elongated crystals of labradorite, is a granulitic matrix of clear labradorite and magnetite (S16864) [NM 5852 2619], (S16736) [NM 5819 2649]. In some bands the ferro-magnesian minerals may fail altogether, and magnetite become extremely abundant in a granulitic matrix of recrystallized labradorite (S16799) [NM 5850 2600]. The pyroxene, either hypersthene or augite, may combine, on

occasion, an ophitic with a granulitic structure (S16729) [NM 5895 2615].

As in Skye, the true nature of such rocks is a matter of some uncertainty; but, from a variety of characters that they present, it is clear that they have resulted from the recrystallization of earlier basic rocks. A somewhat coarser type of granulitic rock that may be termed a granulitic hypersthene-gabbro (S16722) [NM 5846 2599], consists mainly of hypersthene in ragged to ophitic crystals, small fresh olivines, and labradorite. Evidence of partial fusion of an earlier rock is furnished by minute inclusions of hypersthene in the felspar arranged in straight and curving lines indicative of flow.

Again, an augite-granulite (S16716) [NM 5829 2635], composed for the most part of equigranular augite, labradorite, and magnetite, has clear areas of recrystallized labradorite that probably represent the larger felspathic constituents of the original rock. Also, a band of more augitic character running through the mass suggests that the rock was in all probability a banded gabbro.

From Garbh Shlios, north of Loch Fuaran, a rather coarser rock has been collected from just outside the margin assigned on the one-inch Map to the Ben Buie Gabbro. The specimen may be styled a granulitic gabbro, and is mainly composed of augite, hypersthene, and recrystallized labradorite (S16521) [NM 5786 2774]. A similar rock has been collected, away from the Loch Fuaran district, from just within the south-eastern margin of the Ben Buie Gabbro, north-west of Loch Uisg (S17387) [NM 6235 2628]. In both cases, fresh olivine is enclosed in a thoroughly granulitic matrix.

Granulite-inclusions

Turning to granulitic rocks that can definitely be proved from their field-relations to be inclusions of earlier rocks, we find that a dolerite-sheet to the west-south-west of Sròn Dubh (S17902) [NM 5981 2836] has been completely granulitized to a mass of augite, rhombic pyroxene, and olivine (decomposed), in a recrystallized mosaic of labradorite. A similar rock, in its more coarsely ophitic parts (S16520) [NM 5748 2929], has given rise to recrystallized labra-dorite, ophitic hypersthene and augite, and a little biotite, more particularly in association with iron-ore. In its finer portions (S16519) [NM 5813 2818], it has furnished what may be termed a granulitic gabbro composed of the same minerals. The rhombic pyroxene is occasionally pseudomorphed by hornblende. The type of granulitization and the mineral assemblage are similar to what is met with in basaltic lavas metamorphosed by the Corra-bheinn Gabbro (p. 155).

Segregation-veins

The Ben Buie Gabbro, in common with most gabbros of similar type, is sometimes traversed by narrow anastamosing segregation-veins of lighter colour. South-west of Craig, such veins are well-developed, and are seen to be granophyre, sometimes almost pegmatitic in character (S15628) [NM 5768 2993] and of extremely acid nature. They consist of plates of perthitic orthoclase, enclosing irregular patches of quartz in optical continuity with each other, and also of smaller rectangular perthitic crystals surrounded by a deep and coarsening fringe of granophyric material. In other cases, pale veins (S15627) [NM 5804 2949], that behave similarly, appear, when sectioned, to retain the normal doleritic or gabbroic character of the surrounding rock, and to differ only in an intense albitization of the labradorite-felspar.

Craig Porphyrite

This type of rock, (p. 245), which clearly must be regarded as part of the Ben Buie complex on account of the field-relations, is distinctly abnormal in character, and presents peculiarities that have resulted from the absorption of gabbro-material by an invading magma of less basic composition. Many features of this rock are paralleled in the hybrid zones that result from the interaction of granophyres and gabbros (Chapter 33). For the most part, as developed on Sròn Dubh, it is a fine-grained rock of dark colour, characterized by a micro-porphyritic development of its ferromagnesian and more basic felspathic constituents (Figure 41). It has a variable texture, and exhibits considerable differences in both mineral and chemical composition. In its most persistent development (S16525) [NM 5851 2874], the porphyritic constituents are mainly augite, a rhombic pyroxene, and basic plagioclase, with less frequent olivine. The augite is a pale variety, and occurs in small sharply idiomorphic crystals; while the rhombic pyroxene and olivine (S17880) [NM 5999 2867] are always in the form of well-shaped pseudormorphs. Labradorite builds individuals of all sizes, sometimes larger than, but usually of similar dimensions to, those of the other porphyritic constituents. Frequently, the felspars have the appearance of being more or less foreign to the matrix in which they lie (S17881) [NM 5999 2867]. Magnetite is fairly

abundant as large irregular crystals and grains, and is scattered indiscriminately throughout the rock, but more particularly through the matrix. Occasionally, it occurs in intimate association with augite and olivine. The rhombic pyroxene is usually pseudomorphed by fibrous serpentine and hornblende, and the olivine by serpentine. The internal structure of the respective pseudomorphs is quite distinct. The plagioclase phenocrysts are commonly albitized; strings of albite traverse them in all directions, epidote has separated out, and chlorite occupies veins and patches within them.

The matrix is a turbid mass of felspathic matter into the composition of which alkali-felspar enters to a considerate extent. Generally speaking, the amount of matrix is not large (S16525) [NM 5851 2874], but it varies in quantity (S17881) [NM 5999 2867], and, in some instances, (S16523) [NM 5820 3012], the rock becomes patchy in appearance, due to the separation of more basic clots by acid material that has the characters of soda-granophyre.

There can be little doubt that we are dealing here with a rock that has formed from a magma charged with more or less completely digested basic material. Most of its constituents, with the exception of certain of its felspars, have separated from the melt, and give the rock a somewhat delusive normal appearance.

Corra-Bheinn Gabbro

The olivine-gabbro of Corra-bheinn, as developed to the west of Cruachan Dearg and in Glen Clachaig, is a moderately coarse ophitic rock, less basic in general than the eucrites of Ben Buie. It is composed of augite, olivine, and labradorite, with subordinate iron-ore, Olivine is usually present, but most often as pseudomorphs of irregular form composed of serpentine, fibrous hornblende, or both (S14307) [NM 5530 3390]. The pyroxene is a brownish-yellowish augite without schiller structures, and is usually in coarse ophitic relationship to the felspar (S16501) [NM 5607 3263], (S17961) [NM 5772 3280], (S18450) [NM 5597 3318]. Occasionally, it may assume a hypidomorphic habit, and is then frequently clustered with crystals of labradorite in glomero-porphyritic groups (S14307) [NM 5530 3390]. The felspar is always strongly zoned labradorite, and usually forms moderately large mutually interfering crystals. The optical sign is positive, and other characters indicate that the labradorite is of more or less normal composition, and seldom, if ever, becomes as basic as bytownite. Iron-ore occurs with fair regularity as patches and crystals of magnetite (S14307) [NM 5530 3390], (S18450) [NM 5597 3318]; and apatite, when present, occurs as sparsely distributed large crystals (S16501) [NM 5607 3263].

Here, again, a more basic magma seems to have preceded the introduction of the main mass, but the phenomenon is on a smaller scale, or at any rate is less evident, than in the case of the Ben Buie Complex. We find in the Corra-bheinn Gabbro small basic patches (S16500) [NM 5613 3341] similar to the eucrite of Ben Buie. These patches contain large crystals of fresh olivine poecilitically enclosed in crystals of ophitic augite. The felspar, in its larger individuals, is anorthite zoned with bytownite, but there are smaller unzoned crystals, frequently enveloped by olivine, which are presumably anorthite. A little biotite occurs in association with the olivine.

About a quarter of a mile to the north-east of Corra-bheinn, what appears to be the Corra-bheinn Gabbro, sliced by Cone-Sheets, has the character of a quartz-gabbro (S17961) [NM 5772 3280], and is indistinguishable from the later gabbros that form the more basic portions of the Glen More and similar Ring-Dykes (Chapter 29).

Felspathic veins (S16541) [NM 5604 3204], traversing the gabbro and presumably segregated from it, are composed essentially of interlocking rectangular crystals of turbid alkali-felspar with areas of secondary iron-epidote and quartz. The felspars are mostly micro-perthitic or crypto-perthitic in character, but others are distinctly microgranophyric. Microgranophyric matter often fringes the perthitic crystals, and fills interspaces between the larger individuals. Dr. Clough has also recorded acid veins of this type (S16528) [NM 5676 3137] immediately beyond the limits of the gabbro and cut off by the latter.

The older dolerites, where in contact with, and invaded by, the gabbro, have been granulitized in a manner similar to those involved in the Ben Buie Gabbro. They have developed a marked granulitic structure with the production of rhombic pyroxene, and frequently contain large areas of recrystallized felspar (S16528) [NM 5676 3137].

Beinn Bheag Gabbro

The mass, which occupies the slopes of Beinn Bheag to the east of Beinn Talaidh and stretches down into Glen Forsa ((Figure 37), p. 234), is extremely variable in character. It may be separated, but with indefinite division, into a coarse black-and-white gabbro, a fine-textured rock of similar composition, and a dark-grey fine-grained gabbro.

The typical coarse rock (S18657) [NM 632 351], that occurs south-east of the summit of Beinn Bheag and along the western flanks of Allt nan Clàr, is a coarsely ophitic olivine-gabbro composed of occasional large serpentinized olivines, a yellowish brown augite without schiller structures, zoned basic labradorite, and large patches of magnetite—partly primary, partly secondary, in origin.

The finer black-and-white gabbro (S18661) [NM 6451 3419], (S18662) [NM 6501 3443], (S18663) [NM 6468 3490], to the east of Glen Forsa, is also olivine-bearing, and petrographically resembles the coarser rock described above. The augite, however, while retaining its coarsely ophitic structure in a modified degree, has a tendency to assume idiomorphic outlines. In general character, this gabbro is comparable to the normal olivine-gabbro of Corra-bheinn.

We will now consider the series of more acid rocks that occurs intimately associated with the coarse gabbro on either side of the summit of Beinn Bheag (Figure 37). The most striking feature of these rocks, when microscopically examined, is their granophyric (S18660) [NM 631 354] or felsitic matrix, containing abundant free quartz, and strongly charged with apatite (S18659) [NM 631 354]. Among the crystalline constituents enveloped by this matrix, are large elongated crystals of augite (S18660) [NM 631 354], associated with magnetite, and exhibiting salitic striation (S18659) [NM 631 354]. They are usually replaced, either in whole or in part, by green hornblende. Ophitic masses of augite, in association with intensely albitized labradorite, are of local occurrence. In these masses, the labradorite is frequently zoned with oligoclase (S18659) [NM 631 354], but there is the clearest evidence that the basic felspars were unstable in the acid matrix, and were being attacked and eaten up. Further, it is evident that the matrix was to a considerable extent responsible for the intense albitization of the basic plagioclase, for where this mineral has been protected by augite it is unchanged, but where it lies in contact with the matrix considerable albitization has been effected. From appearances in the field, it is probable that these rocks have resulted from the interaction of the coarse black-and-white gabbro, with an acid differentiate provided by some hidden portion of the intrusion. H.H.T.

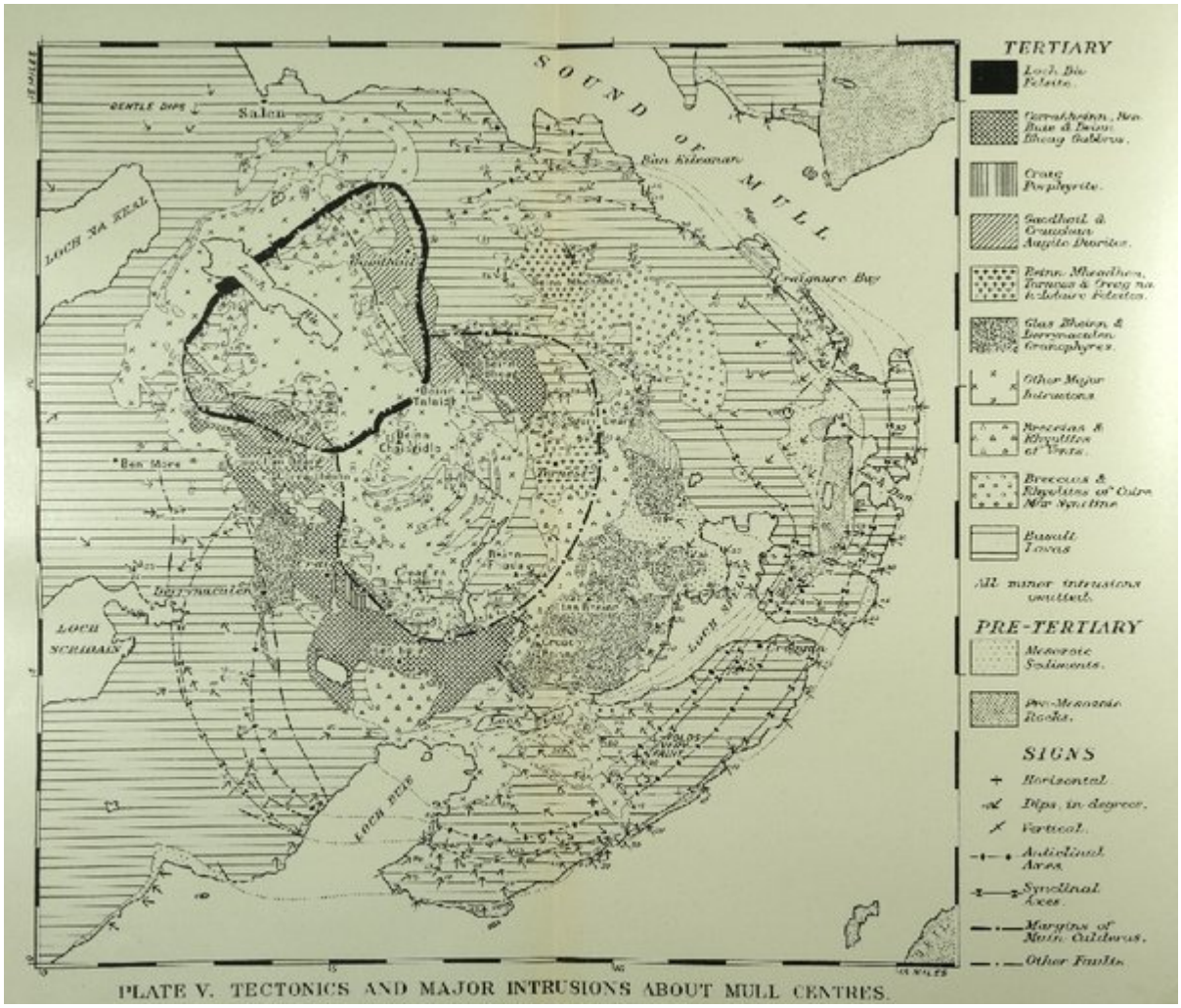

PLATE V. TECTONICS AND MAJOR INTRUSIONS ABOUT MULL CENTRES.

(Plate 5) Map showing calderas, major intrusions, and folds

FIG. 29.—Distribution of Gneiss-Fragments in Mull Agglomerates.

(Figure 29) Distribution of gneiss-fragments in Mull Agglomerates.

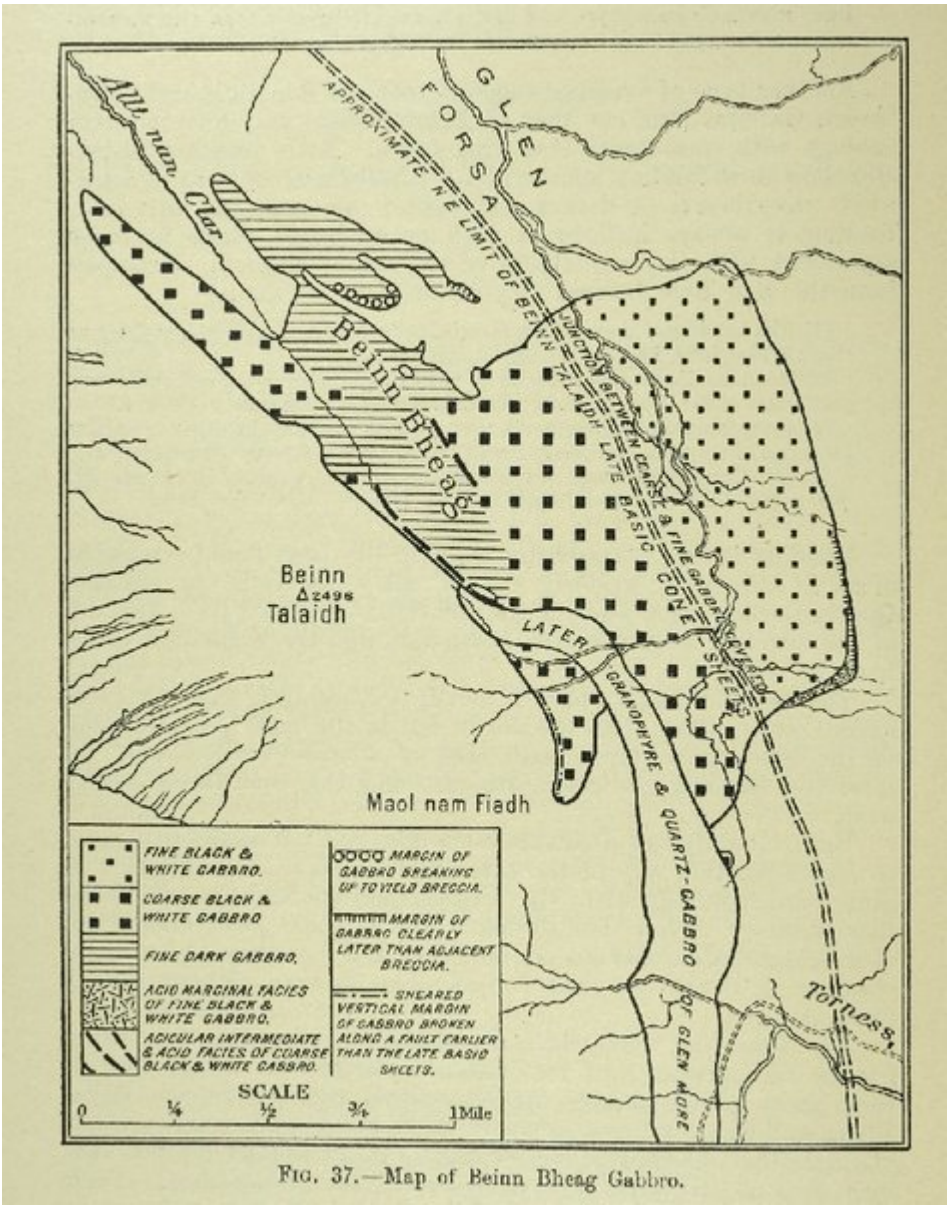

FIG. 37.—Map of Beinn Bheag Gabbro.

(Figure 37) Map of Beinn Bheag Gabbro.

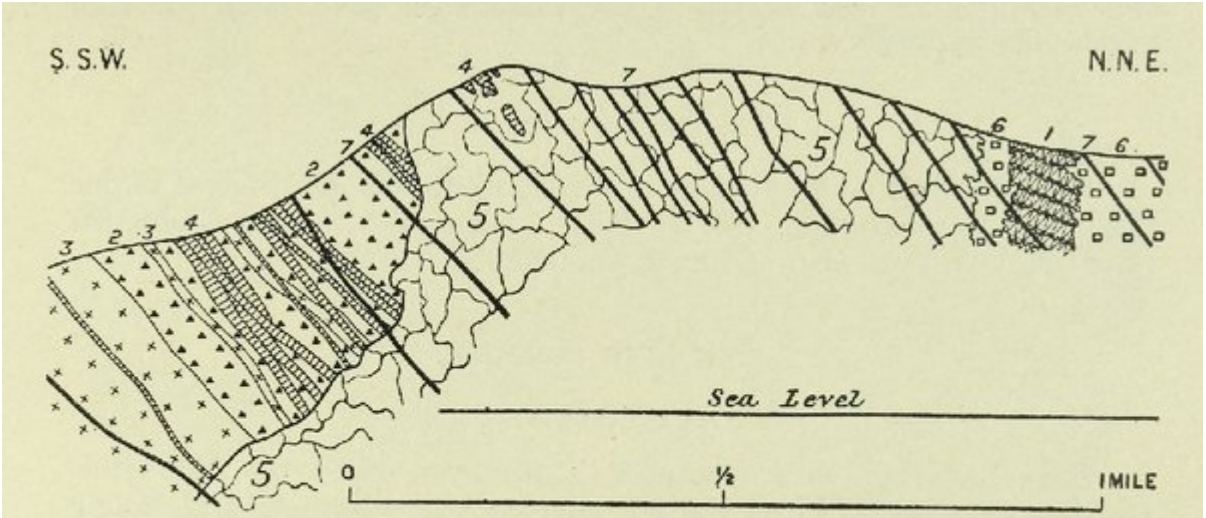

FIG. 38.—Section across Ben Buie.

1. Basalt-Lavas with pillow-structure. 2. Vent-Agglomerate of Early Paroxism.
3. Early Acid Cone-Sheets. 4. Pre-Ben-Buie Early Basic Cone-Sheets.
5. Ben Buie Gabbro. 6. Vent-Agglomerate of Post-Ben-Buie Date.
7. Post-Ben-Buie Early Basic Cone-Sheets and Late Basic Cone-Sheets.

(Figure 38) Section across Ben Buie. 1. Basalt-Lavas with pillow-structure. 2. Vent-Agglomerate of Early Paroxism. 3. Early Acid Cone-Sheets. 4. Pre-Ben-Buie Early Basic Cone-Sheets. 5. Ben Buie Gabbro. 6. Vent-Agglomerate of Post-Ben-Buie Date. 7. Post-Ben-Buie Early Basic Cone-Sheets and Late Basic Cone-Sheets.

TABLE V.—ALLIVALITE—EUCRITE MAGMA SERIES OF FIG. 3.

	Allivalite	Eucrite		
	A	I.	B	
SiO_2	42·20	46·66	48·05	SiO_2
TiO_2	0·09	0·47	0·49	TiO_2
Al_2O_3	17·56	16·71	15·35	Al_2O_3
Cr_2O_3	0·06	...	0·14	Cr_2O_3
Fe_2O_3	1·20	2·69	1·86	Fe_2O_3
FeO	6·33	5·87	7·53	FeO
MnO	0·18	0·12	0·28	MnO
(Co,Ni)O	0·13	...	0·11	(Co,Ni)O
CuO	0·04	...	0·05	CuO
MgO	20·38	12·36	12·53	MgO
CaO	9·61	12·57	11·02	CaO
Na_2O	1·11	1·16	1·26	Na_2O
K_2O	0·11	0·27	0·19	K_2O
Li_2O	...	nt. fd.	...	Li_2O
$H_2O+105°$	1·13	1·24	0·45	$H_2O+105°$
H_2O at 105°	0·06	0·13	0·15	H_2O at 105°
P_2O_5	...	0·13	...	P_2O_5
CO_2	tr.	0·18	0·44	CO_2
S	0·02	nt. fd.	0·20	S
	100·21	100·56	100·10	
Spec. grav.	2·96	2·97	2·95	

(Table 5) Allivalite-Eucrite Magma Series of Figure 3

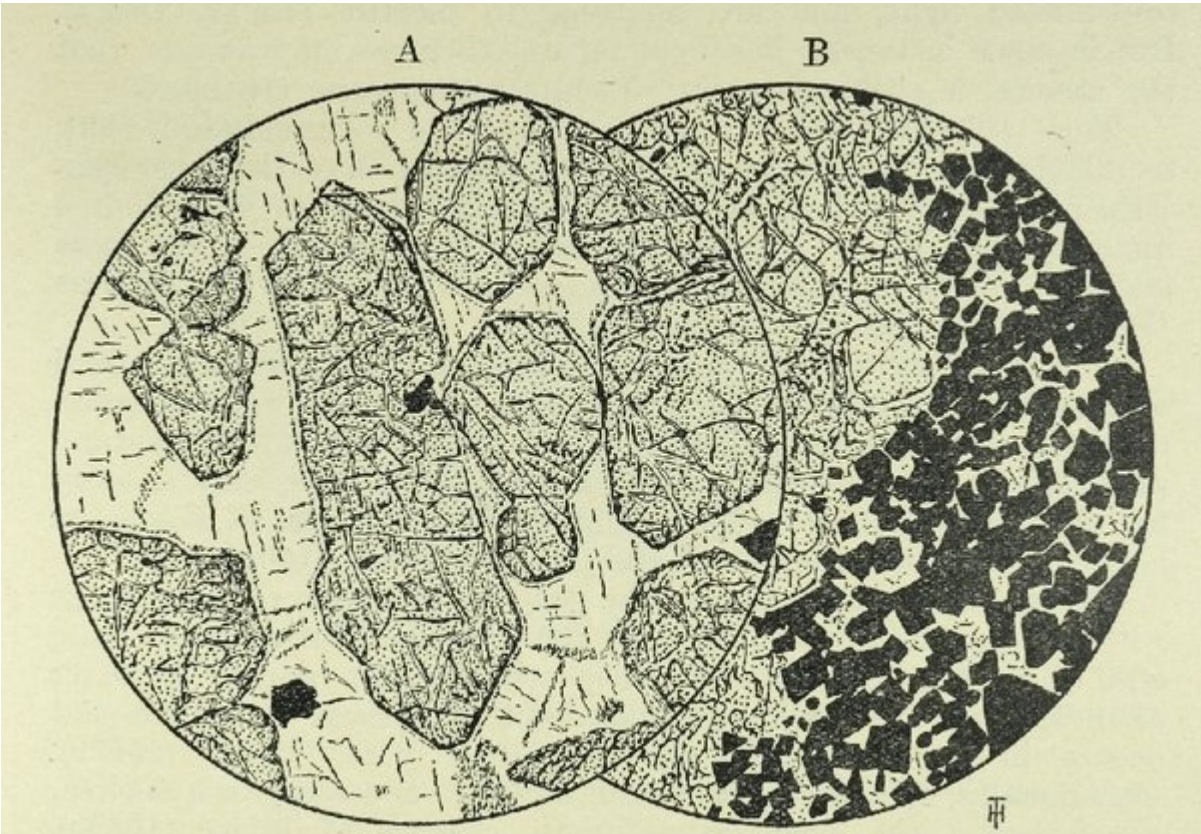

FIG. 39.

(Figure 39) A. [(S18452) [NM 5763 2998]] ×20. Allivalite of the Ben Buie Complex. Hypidiomorphic olivine in a matrix of basic plagioclase felspar that approximates to anorthite in composition. B. [(S16531) [NM 5660 3233]] ×20. Band of picotite in an olivine-rich allivalite of the Ben Buie Complex.

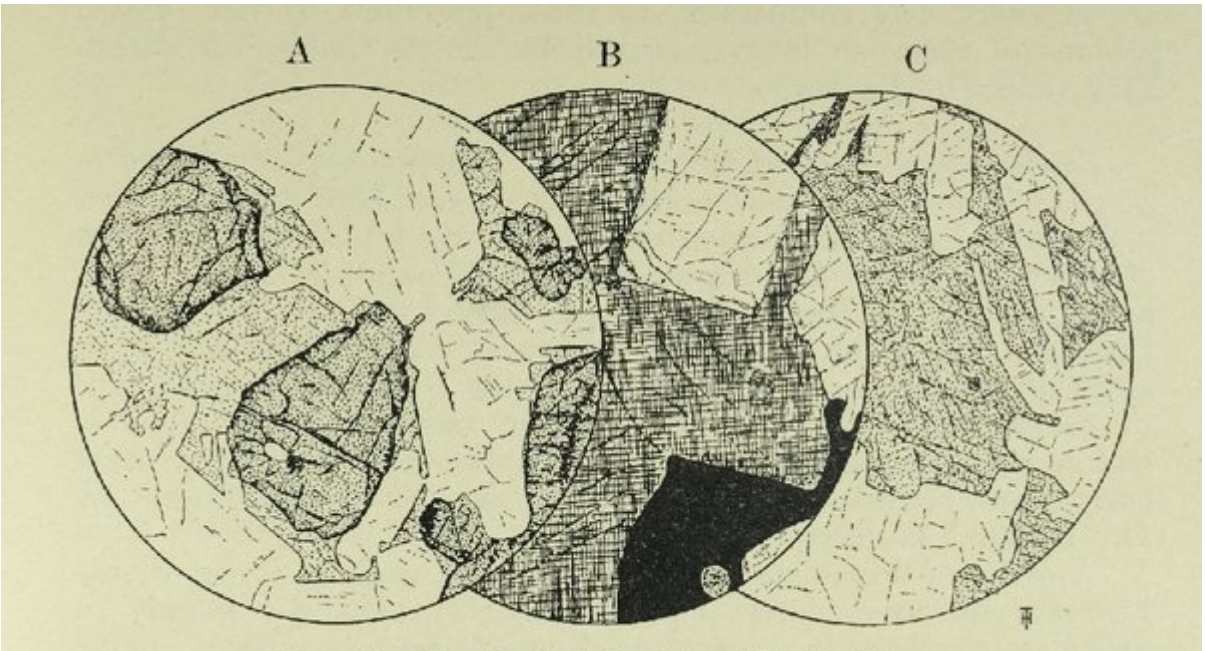

FIG. 40.—The Ben Buie Eucrite and its Varieties.

(Figure 40) The Ben Buie Eucrite and its varieties. A. [(S16711) [NM 5811 2665]] ×15. Basic variety showing large crystals of olivine in association with ophitic augite. The colourless component, is a zoned felspar with the average composition of bytownite. B [(S17903) [NM 5908 2972]] ×15. Gabbro. Coarse olivine-free rock composed of diallagic augite, basic labradorite and iron-ore. C. [(S16720) [NM 5893 2613]]. Olivine-free coarse ophitic dolerite. The augite in this case is devoid of schiller-structures.

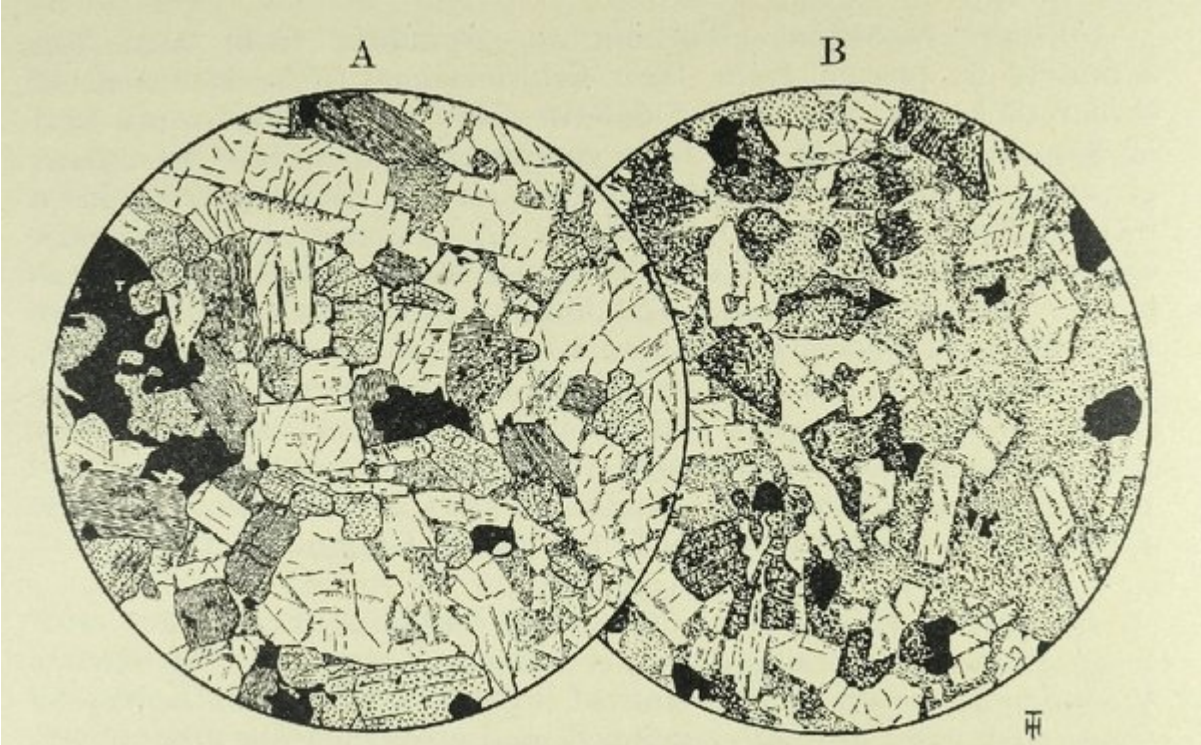

Fig. 41.—Craig Porphyrite.

(Figure 41) Craig Porphyrite. A. [(S16525) [NM 5851 2874]] ×17. Porphyrite, showing the normal development of porphyritic crystals of rhombic pyroxene, augite, and labradorite, with accessory magnetite, in a subordinate fine grained felspathic matrix. B. [(S16523) [NM 5820 3012]] ×17. Porphyrite of variable type, showing clots of relatively basic material similar to that figured in A, with a greatly increased amount of fine-grained acid matrix that has the characters of a soda-granophyre.