Chapter 34 Dykes

Introduction

Dykes of Tertiary age furnish one of the most striking features of West Highland igneous activity, and are characteristically exposed in the shore-sections of Mull, Lorne, and Morven. The basic dykes are lettered M on the one-inch Map (Sheet 44) the acid P; and the intermediates either M or F. As explained in the index, F is also used for certain other acid intrusions besides dykes. A few camptonitic dykes of very doubtful Tertiary date are discussed separately in Chapter 35.

Dykes, as here understood, are roughly vertical seams of igneous rock resulting from underground intrusion. Individual dykes may be traceable for miles along their outcrop; but, often, it would be hopeless to attempt the task of following them in this fashion where many close neighbours are of essentially similar lithological type. The breadth of a dyke is relatively small, and 5 ft. is a very common measurement.

Most of the Mull dykes are of basaltic types; but, whether basic, intermediate, or acid, they have their particular habit of jointing and weathering, controlled, in large measure, by composition. A rude approach to horizontal columnar jointing is often evident; while vertical joints, parallel to dyke-margins, are also well-represented. In many cases, jointing of any kind fails towards the centre of a dyke, where a median vesicular zone may be strongly developed.

Chilled edges, consisting of very compact crystallized rock, are typical, and glassy selvages occasionally occur (p. 47). There is a tendency for faulting and decomposition to follow the edge of a dyke, and this sometimes obscures an original chilled edge. In composite dykes, with more basic margins and more acid interiors (p. 8), it is customary to find marked external chilling of the basic flanking bands, but no chilling at all of basic against acid, or vice-versa, in the interior of the dyke; the explanation, of course, is that the acid followed the basic before this latter had cooled. A good instance of a composite dyke crosses (Figure 52) (p. 308), and others will be cited in the petrological section of this chapter. E.B.B.

Multiple dykes are at least as common as composite ones. In this memoir, the distinction between multiple and composite minor intrusions is based upon the presence or absence of chilling at the contacts of the participants. Coastal roads render the two shores of Loch na Keal (Sheet 44) exceptionally convenient for the examination of a great number of dykes; and anyone walking south-west from Eilean Feòir will find about twenty instances of multiple dykes in a distance of little more than a mile. There may be as many as four or five partners in a multiple dyke.

Only about one dyke in every ten or fifteen is shown. The mainland portion of Sheet 52 of the one-inch Map of Scotland has still to be surveyed.

Minor transgression is the rule, and it is rare to find two partners lying side by side with juxtaposed chilled edges, so that it is generally quite easy to arrive at a fairly complete time-scale for any particular multiple dyke. J.E.R.

Another familar incident of dyke-intrusion, illustrated in Mull, is that of a dyke stepping aside so to continue along some adjacent parallel course. Much the best instance of this is afforded by a basalt-dyke which crosses the coastal road a little east of Kellan Mill, on the north shore of Loch na Keal (Sheet 44). Where lost sight of under the raised beach at the mouth of Allt Mòr, it has a thickness of 10 ft.; inland, this increases locally to 20 ft. The dyke has a characteristic platy cross-jointing, but its main peculiarity is its tendency to expose itself on inland moors. Thus it is easy to make sure of its identity, even when it steps from one course to another. From near Kellan Mill to the first tributary of Allt Mòr, the dyke strikes inland, running without break for three-quarters of a mile. At this tributary, where M is printed on the one-inch Map, it steps south-west 100 yds,, and continues north-west on its new course for a mile. Another Mon the one-inch Map marks a side-step, this time towards the north-east, of 100 yds.; and within a short space two minor steps in the same north-east direction are taken. From here onwards, the dyke is easily traceable for three miles, passing from Sheet 44 to Coire Bàn, in Sheet 43; during this part of its course, it takes only one minor side-step to the south-west, on the north side of Gleann Mhic Caraidh. E.B.B., J.E.R.

Another good example of side-step is afforded by a north-west porphyritic basalt-dyke which runs south-eastwards from the stream west of Upper Druimfin Farm, south of Tobermory Bay (Sheet 52). This dyke, sometimes 20 ft. thick, is traceable at intervals for a mile and a half. A little west of Coire nam Fiadh, it takes a distinct side-step of 100 yds. The main interest, however, of this particular dyke resides in its exceptionally large felspar-phenocrysts, one of which was found measuring 4 by 6 inches. It is quite possible that the phenocrysts represented in Anal. II., p. 34, were collected from its outcrop., G.V.W.

Continuously exposed dykes are a great rarity. A clean-washed shore-section, such as is provided on the south-east side of Mull (Sheet 44), shows dykes to great advantage. They may stand as resistant walls, or shelter at the bottom of miniature chasms, but either way they attract attention. Inland, away from stream-courses, they may become invisible beneath a grassy mantle. It is sometimes, on this account, a matter of great difficulty to form any judgment of the relative abundance of dykes in different localities. E.B.B.

While the Mull dykes generally figure less prominently inland than on the coasts, they are in large measure responsible for a line ated scenery in northern Mull, between Dervaig (Sheet 51) and Tobermory (Sheet 52). A contoured map shows very clearly a belt of country, about six miles across, characterized by a north-westward direction of ridge and hollow. Erosion has been guided to a very large extent by dykes, and to a lesser degree by parallel crush-lines. Loch Frisa may be mentioned as a major element of this north-westwardly directed scenery. G.V.W. Various matters of importance will now be dealt with under separate headings, more particularly, the Mull Swarm of North-West Dykes. Dykes of other Directions, Explosions along Dykes, the Relation of Dykes to the Central Field of Pneumatolysis, and Petrology.

Mull Swarm

We are now in a position to emphasize certain facts regarding the distribution of Mull dykes. The dykes are mostly of northwesterly trend, and are grouped in a swarm, rather more than 10 miles wide. They are known to extend from a centre in Mull, south-eastwards with continually diminishing numbers, across the Firth of Clyde, 50 miles distant, and thence, sorely depleted, into England. In a north-westerly direction, they pass under the sea, after having been traced for about 15 miles. The reality of the Mull swarm will be gathered on inspection of (Figure 60), where a careful generalization of the data supplied by Geological Survey six-inch Maps has been attempted for the whole south-west Highlands. Perhaps the most definite irregularity of the Mull swarm is the northward, or north-north-westward, trend of many dykes west of Seallastle Bay and Loch Aline. A similar tendency is manifested in the Applecross peninsula in regard to the Skye centre (Sheets 71 and 81), and also in Rum. In the latter case, especially, it seems that the northerly trend has a radial significance.<ref>A. Harker, The Geology of the Small Isles of Inverness-shire, Mem. Geol. Surv., 1908, Pl. III., p. 144.</ref>

The north-north-westward, or northward, trending dykes, extending from the north side of the Mull centre, are thoroughly representative of the Mull dyke-assemblage from the point of view of petrology. At any rate, they include typical Plateau and Central Types, as, for instance, crinanite and tholeiite. Accordingly, they are not easily attributable to any single epoch, and this fact, combined with their number, favours their interpretation as a radial offshoot from the main swarm.

The petrological variety of the more or less northward-trending dykes is well illustrated in the Fishnish Peninsula (Sheet 44). The dykes of this peninsula are divisible into two great groups: those running more or less north and south are of various types, and those running more or less east and west are tholeiites. The latter seem to belong to a single relatively late episode, for, in seven exposures, east-and-west tholeiites cut their northwardly trending associates. The details are as follows:

- Talaidh Type of tholeiite (S13898) [NM 6668 4201] cuts porphyritic basalt, like Central Lava, with phenocrysts of felspar and augite (S13897) [NM 6668 4201].
- Brunton Type of tholeiite (S15677) [NM 6477 4219] cuts non-porphyritic olivine-basalt, like a Plateau Lava, with rich purple augite (S15678) [NM 6477 4219].
- Four dykes of Salen Type of tholeiite (S15679) [NM 6477 4233], (S15680) [NM 6476 4244], (S15682) [NM 6475 4250], and (S15683) [NM 6474 4253] cut dyke of unusual type, olivine-basalt approaching mugearite (S15681) [NM

6476 4244].

- Salen Type of tholeiite (S15684) [NM 6498 4266] cuts small-felspar dolerite with purple augite, (S15685) [NM 6498 4266].

Other dykes, belonging to the north-by-west set in Fishnish Point, are represented by (S15675) [NM 6474 4203], of character intermediate between the Plateau Lava and Salen Tholeiite Types, and (S15676) [NM 6475 4205] of strongly marked Plateau Lava Type with very purple augite and interstitial analcite (erinanite). Anyone wishing to make sure of obtaining a crinanite-specimen from among Mull dykes can collect from this dyke.

It is 5 ft. thick, and is the most southerly dyke shown on the one-inch Map on the east shore of Fishnish Bay. An unmapped parallel dyke, a few yards south of it on the shore, may be taken as a landmark, for it is cut through by a 3 ft. dolerite sheet dipping east at 30° E.B.B.

In Morven (Sheet 44), several tholeiites have been encountered running roughly north-north-westwards (S14969) [NM 7091 4342], (S14974) [NM 6977 4509], (S15784) [NM 7667 4572], (S15798) [NM 7471 7048], (S15838) [NM 7517 4502].

It will also be noticed, from inspection of the map, that the main fault-direction in Morven is approximately north and south. G.W.L.

Quite apart from the north-north-west dykes, just alluded to, it is open to anyone to see a radial tendency in the arrangement of Mull dykes, since Tertiary dykes of every dire ction are unusually abundant in Mull (Figure 60). The view accepted here is that the Mull focus has served as a localizes and injector of dykes (p. 10). Most of the dykes it has localized run north-west and south-east; but occasionally a tendency to dyke-formation in other directions has developed, with the result, in the aggregate, of a very ill-defined radial assemblage. Under these circumstances, it seems advisable to lay stress upon the parallelism of the many, and to recognize a Mull Swarm of north-west dykes as the outstanding feature of the district.

Aggregate bulk of dykes in Mull Swarm

The immense bulk of the swarm, as a whole, is brought home by a consideration of the number of dykes which enter into it, as well as of the great area through which these dykes are distributed, far outside the confines of Mull.

In the 12½ miles, measured in a south-west direction, that separate Duart Point from Frank Lockwood's Island (Sheet 44), 375 more or less north-westerly dykes have been mapped in tolerably complete coastal exposures, only interrupted for 1000 ft. at the mouth of Loch Don. Two of the dykes are of quite exceptional thickness: one, a north-north-west felsite at Duart Point, is about 130 ft. thick; and another, which terminates upwards in the cliff of Rudha Tràigh Gheal, is, at sea level, 200 ft. thick. Of the remainder, 291 dykes have been roughly measured, and give an aggregate thickness of 1698 ft.—or on an average 5.8. If this average holds for the remaining unmeasured 82 dykes, towards the southern end of the swarm, then the total thickness of the northwesterly Mull dykes actually exposed on the south-east coast of the island is: 330 + 1698 + 476 = 2504 ft., or approximately half a mile. E.B.B., G.V.W.

The exposure of the swarm, afforded on the other side of the Mull centre by the south-east shores of Loch na Keal (Sheet 44), is much more partial; but, so far as it goes, it is in wonderfully close agreement with that considered above. Thus, in 1¼ miles, 142 dykes have been counted with an aggregate thickness of 817 ft., which again gives an average of 5.8 ft. per dyke. J.E.R.

Age of the north-west dykes

The north-west dykes of the Mull Swarm constitute a complex, built up during a long period of time. It is certain that many of the north-west dykes of Mull are the latest igneous products of the focus; but it is equally certain that others are of earlier date than associated intrusions of non-dyke habit. It is impossible to decide whether any of them are as early as the lavas still preserved.

Apart from normal dykes, such as furnish the subject-matter of the present chapter, the Loch Bà, Felsite Ring-Dyke is the latest intrusion in Central Mull (Chapter 32). Its, exposures are particularly clear on either side of Loch Bà, and it is there seen traversed by 24 north-west basalt-dykes in a total distance of about four miles. Of course, 24 does not represent quite the full number of dykes, but it is established beyond doubt that there are not nearly so many here as one meets with in the middle of the Mull Swarm on the coast, where the concentration exceeds 100 per mile. The deficiency of dykes, whatever the cause, is particularly marked in the first 700 yds. north-east of the head of Scarrisdale River: here, in virtually complete exposures, not a single basalt-dyke has been observed to cross the Loch Bà Felsite.

A thoroughly representative collection has been made of northwest dykes cutting the Glen Cannel Granophyre, with the following results:

- (S14784) [NM 6034 3420]: felsite.
- (S14778) [NM 5944 3646], (S14782) [NM 5910 3443]–(S14783) [NM 5904 3443]: quartz-dolerite of a rather peculiar type, with affinity to porphyrite.
- (S14779) [NM 5948 3650], (S14826) [NM 5820 3609]–(S14839) [NM 5669 3566]: olivine-basalt, generally with purple augite; (S14833) [NM 5699 3651] and (S14835) [NM 5692 3651] are particularly interesting as they carry a little of the deep brown hornblende often found in camptonites (Chapter 35), and the former also shows ocellar structure.
- Two pairs of composite dykes (S14780) [NM 5996 3600]–(S14781) [NM 5996 3600]: olivine-dolerite with pale augite bounding olivine-quartz-dolerite; and (S14786) [NM 6082 3502]–(S14787) [NM 6082 3502] olivine-tholeiite bounding curious quartz-porphyry.

While it cannot be claimed for certain that all these dykes are of later date than the Loch Bà Felsite, it is unquestionable that most of them are. Accordingly, this microscopic examination demonstrates a reappearance of the Plateau Type of magma (p. 7), in post-Loch-Bà-Felsite times. W.B.W.

It will be pointed out in the section on pneumatolysis (p. 366) that there is reason to suspect that as many as a third of the northwest dykes exposed on the south shore of Loch na Keal may be earlier than the Loch Bà Felsite and the Knock and Beinn a' Ghràig granophyres. In a suite of slices from these supposed early dykes, the Plateau Type is again predominant. J.E.R.

Direct evidence that a north-west dyke of this district is earlier than the Knock and Beinn a' Ghràig granophyres is exposed on the hill face a quarter of a mile south of Knock burial-ground. A 7 ft. north-west basalt-dyke is here seen cut across by a 3 ft. north-east Late Basic Cone-Sheet, itself veined by granophyre. The exposure lies 200 yds. outside the Knock Granophyre. W.B.W.

Another very good example of a pre-granophyre north-west basic dyke can be easily recognized on the one-inch Map, Sheet 44. It is traceable for about two miles from the coast near Dishig almost to the base of the Ben More Mugearite. The dyke consists of dolerite; it is sometimes 40 ft. thick, and is excellently exposed. It is cut by at least four of the pre-granophyre basalt-sills of the district (Chapter 26).

A shore-section showing a similar relationship, with a 2 ft. 6 ink. north-west basalt-dyke cut by a 5 ft. basalt-sill, occurs a mile farther north-east, just beyond the mouth of Abhuinn na h-Uamha. Inland exposures, on much the same line, show a 21-ft. dolerite-dyke cut by a couple of thin sills in, and below, the level of the Ben More Mugearite, north of A'Chioch. J.E.R.

Intersections, comparable with the above, are very rarely seen. An example will now be cited from another part of the island, where the interest is enhanced, since one can deduce a lower as well as an upper time-limit for the dyke. A north-west basalt-dyke crosses some agglomerate-crags, 500 yds. north-east of Dùn da Ghaoithe summit (overlooking Scallastle Bay, Sheet 44), and is itself cut across by a massive Early Basic Cone-Sheet (Chapter 21). In this case, the dyke clearly belongs to some period following that of maximum explosive activity (Chapter 16), and, therefore, considering its composition, is probably a product of Early Basic Cone-Sheet times.

Two additional instances of relatively early north-west dykes are illustrated in (Figure 53) (p. 312). They occur on the east face of Maol nam Fiadh, and are seen traversing lavas of Central Type (Chapters 9 and 10), and cut to pieces by Late Basic Cone-Sheets (Chapter 28). One of them is a felsite, and is named as such on (Figure 53). The other occurs about 60 yds. farther south-west and consists of rhyolite-breccia, apparently indicative of explosion. A north-west basalt-dyke, lettered M on (Figure 53), lies almost immediately on the south-west side of the breccia-dyke, and serves as a landmark; it is of late date, and cuts Late Basic Cone-Sheets as well as lavas. The age of these two dykes, felsite and rhyolitic breccia, cannot be precisely fixed, because the time-interval separating the Central Lavas from the Late Basic Cone-Sheets is a very long one.

Only in one case, can an intersection be pointed to that suggests so early a date for a north-west dyke as that, perhaps, of some of the lavas preserved in the island. For a mile south from the entrance of Loch Don, an Early Acid Cone-Sheet runs more or less along the shore-line. It is seen to be cut by eight north-west non-porphyritic basalt-dykei; but it almost certainly cuts another dyke, which, while it runs north-west, is distinguished from its fellows by porphyritic felspars. The crossing occurs just where *Exogyra*-sandstone is noted on the one-inch Map, Sheet 44, under flint-conglomerate.

E.B.B.

Dykes other than north-west

It has already been pointed out (p. 359) that the north-north-west, and north-and-south dykes of Mull, west of Scallastle Bay, and of Morven, west of Loch Aline, are probably an offshoot from the main north-west swarm; it is thought that they have been intruded intermittently through a very long interval of time.

It has also been shown that in the Fishnish district a set of roughly east-and-west tholeiite-dykes cuts across the more or less north-and-south assemblage (p. 359).

More towards the centre of Mull, two additional examples of east-and-west dykes cutting north-and-south dykes can be cited, and two other cases where this relationship is reversed:

- In Gleann Dubh, near the head of Loch Scridain, just above where a small tributary joins the main stream, 200 yds. south of an east-and-west fault shown on the one-inch Map, an east-and-west dyke cuts a north-and-south dyke.
- So also, on the south shore of Loch Beg, another east-and-west dyke cuts a north-and-south dyke.
- But, where the first stream west of Sròn Daraich crosses the Pre-Glacial coast above Loch Beg, a north-and-south dyke cuts an east-and-west dyke.
- And also, a mile east-south-east of Ben More summit, a north-and-south dyke cuts an east-and-west dyke.

It will be seen, therefore, that, in the Ben More and Loch Beg district, the rule established for the Fishnish district seems to be as often broken as obeyed. It may be added that, while the east-and-west dykes of Ben More and Loch Beg have been observed cutting cone-sheets in three different exposures, the reverse has never been detected. E.M.A

A group of north-north-east and north-and-south dykes on the south-west slopes of Corra-bheinn can be dated fairly accurately. They vary in composition from olivine-dolerite to felsite, but they agree in being cut across by both Early Basic Cone-Sheets (Chapter 21) and Corra-bheinn Gabbro (Chapter 22). Since the basic dykes are seen to cut the Derrynaculen Granophyre (Chapter 12), it is almost certain that they belong to some interval in the earlier part of the Cone-Sheet Cycle of Mull chronology. As might have been expected, these basic dykes show manifest signs of contact-alteration with the production of biotite and hornblende (S16542) [NM 5699 3210], (S16543) [NM 5680 3105], (S16544) [NM 5687 3124]. (C.T.C.)

There are quite a number of north-east dykes in the country overlooking Scallastle Bay on the Sound of Mull. In one case, it is clear that a basalt-dyke of this direction is earlier than the Early Basic Cone-Sheets of its vicinity. It is exposed 800 yds. north-north-east of the summit of Beinn Chreagach Mhòr, just on the east side of a deer-fence. It cuts a post-lava agglomerate-vent, and is distinguished from neighbouring cone-sheets by its baked appearance. However, all the north-east dykes of this district are not similarly altered. The lavas of Beinn nam Meann 1½ miles farther

east-south-east) are greatly affected in proximity to an agglomerate-vent cut through by the Beinn Mheadhon Felsite; but the dykes traversing the lavas, whether running north-east, north and south, or north-north-west, are no more visibly changed than the cone-sheets near by. E.B.B.

That some of the north-east dykes of Mull are comparatively late is shown by a north-east basalt-dyke cutting the Glen Cannel Granophyre south of Lochan nam Ban Uaine. W.B.W.

North-east dykes are rather common in the south-east part of Mull, though far out-numbered by their north-west fellows. The north-east dykes have a tendency to incline steeply north-west. They are, on the whole, earlier than the north-west dykes; for the latter have been seen to cut them fifteen times, whereas the reverse relation has only been noticed four times,

Explosions along dykes

Much the best example of blow-holes along the course of Tertiary dykes, belonging to the Mull Swarm, falls a mile outside the east margin of Sheet 44 (Figure 61), and has been described by Messrs. Peach, Symes, and Kynaston.<ref>The Geology of the Country near Oban and Dalmally (Sheet 45), *Mem. Surv,* 1908, pp. 135–137</ref> In this case, vents occur along a line of multiple dyke-intrusion in which both basalt and rhyolite play a part. Often, the dyke-rocks cut and include the agglomerate, but, in some exposures, this relationship is reversed. The agglomerate consists of fragments of basalt, rhyolite, and country-rock—the latter mostly lava of Old Red Sandstone age,

The neighbouring south shore of Loch Feochan affords an exposure of a similar and parallel multiple dyke, still half-a-mile outside Sheet 44. Here, basalt is cut by dolerite, and both of them are traversed by fissures filled in with agglomerate; which in its turn is cut by rhyolite. Dr. Kynaston has described this example in the Memoir just referred to, and has illustrated it with a sketch-map drawn by Dr. Peach.<ref>Op. cit., Fig. 2.</ref>

The next instance of the sort to be noted lies half-a-dozen miles farther south-west. It is best exposed on an islet, north of Eilean Buidhe, to which a note on the one-inch Map (Sheet 44) directs attention. It consists of a basalt-, or dolerite-dyke, about 8 ft. thick, though irregular. The basalt veins and surrounds lenticles of breccia made up of the country-rock (black slate) along with a subordinate proportion of basalt, some of which is vesicular. Half-a-mile farther south-east, the same dyke is seen again, retaining its characters, in a small quarry in the face of the bluff behind the raised beach north-west of Clachan Bridge.

Perhaps, the Clachan Bridge dyke turns from its south-east course at the bridge. At any rate, showing through the raised beach, half-a-mile south-south-east of the bridge, there- is exposed a north-north-west dyke of agglomerate some 12 ft. wide, separated from the slates on either side by a narrow basaltic border. The agglomerate consists of various types of basalt, and its junction with the marginal basalt is rather vague. E.B.B.

Three explosion-vents, which are interpreted with some hesitation as belonging to north-west dykes, are exposed on the south-east coast of Mull near Port a' Ghlinne; and two of them are noted on the one-inch Map (Sheet 44). The first lies about 200 yds. east of Port of Ghlinne. As seen on the shore, it is a broad irregular northwesterly dyke, consisting of porphyritic basalt of Central. Type (S17374) [NM 6693 2210]—a coarser specimen is a good example of small-felspar dolerite (S17378) [NM 6693 2210]. It is crowded with an assortment of basaltic and felsitic xenoliths (S17368) [NM 6693 2210], (S17377) [NM 6693 2210], (S17381) [NM 6693 2210], and surrounds a central patch of agglomerate, full of fragments of variolites (S17367) [NM 6693 2210], (S17369) [NM 6693 2210], (S17379) [NM 6693 2210], (S17380) [NM 6693 2210]. This complex dyke-vent is seen cutting an east-and-west dyke, and also a later acid intrusion.

Eleven hundred yards farther north-east, a small patch of agglomerate has been found on a north-west basalt-dyke, though not indicated on the one-inch Map. G.V.W.

Two hundred yards beyond this, at the second point noted on the one-inch Map, there is a good exposure of breccia belonging, perhaps, to a dyke-vent. The fragments include both igneous and sedimentary types (S15859) [NM 6803 2769], (S15860) [NM 6803 2769], (S15861) [NM 6803 2769], (S15862) [NM 6803 2769], (S15863) [NM 6803 2769],

(S15864) [NM 6803 2769], (S15865) [NM 6803 2769], and some of the latter are intensely altered. E.B,B.

- The sedimentary fragments appear to be mainly quartzites or sandstones, and have suffered various degrees of alteration and magmatic digestion. A moderately large siliceous fragment (S15862) [NM 6803 2769] shows, beautifully, the effect of continued heating. The original quartz has undergone almost complete digestion, accompanied by the separation of large plates and wedge-shaped twins of tridymite, giving rise to a structure similar to, and as coarse as, that observed in silica-bricks after continued use in a steel-furnace. The tridymite, as is usual in these rocks, has reverted to a granular mosaic of quartz, but its external form is sharply preserved. *Lacunae* of melt throughout the rock have developed crystals of yellowish to greenish augite which appear to be in eutectic relationship to the silica. The eutectic structure is in some instances of extremely delicate nature. The crystals of augite are relatively homogeneous at their centres, but towards their peripheries give evidence of rapid growth in the cooling magma, resulting in a fibrous or acicular type of crystallization.
- The residual glass contains abundant minute crystals and skeletal growths of magnetite. The chief interest in the rock lies in its original richness in tridymite, for this mineral constituted the greater part of its mass.

If, instead of going along the coast from Port a' Ghlinne, one turns up Glen Libidil, another dyke-vent is encountered. It traverses the lavas on the steep western face of the glen, a little north of the second fault marked on the one-inch Map. In this case, the vent shows as a narrow belt of fine breccia, or tuff, traceable in an east-north-east direction. Acid fragments are a feature of its constitution (S17371) [NM 6612 2272]–(S17372) [NM 6605 2264]. G.V.W.

The only other example of the kind in Mull is an early northwest dyke of rhyolite-breccia on the east face of Maol nam Fiadh. Attention has already been directed to this dyke on p. 362. Possibly it is a fluxion-breccia, and not a product of explosion.

Relation of dykes to the central field of pneumatolysis

A considerable proportion of the Tertiary dykes of the region carry fresh olivine, where they have been collected outside the Limit of Pneumatolysis recognized for the Mull lavas of Chapters 5–10 ((Plate 3), p. 91). A little distance inside this limit, fresh olivine seems to fail altogether. On the north-west side of the Pneumatolysis Field, the boundary, at which the fresh olivine of the dykes gives place to pseudomorphs, agrees approximately with the limit traced on (Plate 3); on the south-east side, however, the limit for the dykes lies materially farther in than for the lavas, and fifteen examples retaining fresh olivine have been sliced from the south-east shores of Mull, on the two sides of the entrance to Loch Spelve. A dyke with fresh olivine has also been sliced from near Kinloch Inn at the head of Loch Scridain.

The dykes which traverse the plexus of intrusions characteristic of Central Mull are manifestly of very much later date than the lavas; and their comparatively unaltered appearance might in some cases lead one to expect a certain proportion of fresh olivine. The dykes cutting the Glen Cannel Granophyre have been carefully examined from this point of view. Sixteen among the sliced specimens show olivine-pseudomorphs, and not one shows the mineral fresh. Moreover, as in many cases there is a fairly free development of fibrous hornblende in amygdales, etc. (S14779) [NM 5948 3650], (S14786) [NM 6082 3502], (S14827) [NM 5818 3603], (S14831) [NM 5704 3651], it does not seem possible to account for this decomposition of olivine as a result of mere weathering; in fact, their condition is on the border-line where pneumatolysis gives place to contact-metamorphism.

It is established, therefore, that all, or almost all, the dykes cutting the Glen Cannel Granophyre have suffered some degree of pneumatolysis. The majority, at any rate, of these dykes are later than the adjacent Loch Bà Ring-Dyke—that is, they are the latest of Mull's igneous products. Accordingly, the phenomenon of central pneumatolysis continued to find expression in Mull until the very close of igneous activity. This is in keeping with the view that the concentration of a swarm of dykes, in itself, bespeaks the underground existence of a pipe filled with molten magma (p. 10). E.B.B.

We may note two further examples of definitely late, and yet much altered, dykes (S16633) [NM 5347 3607]–(S16634) [NM 5362 3684], both of them cutting the Beinn a' Ghràig Granophyre. The first is a north-and-south dyke in Allt Coire nan Gabhar in the middle of the granophyre-outcrop. The other is the second north-west dyke shown on the one-inch Map in the Scarisdale River above the west margin of the granophyre. Both are tholeiites with an abundant development

of fibrous hornblende. E.B.B., J.E.R.

It must not be supposed that the dykes of Mull have, as an assemblage, been uniformly affected. There is no place where this point can be better appreciated than within the Pneumatolysis Limit of (Plate 3) (p. 91) on the south shore of Loch na Keal. About 30 per cent. of the dykes here seem to have reached the same condition as the lavas which they traverse, while the rest are notably fresher; so much so, that one is justified in regarding the intrusion-periods of the two sets of dykes as separated by an interval of intense pneumatolysis, connected possibly with the introduction of Knock and Beinn a' Ghràig Granophyres. J.E.R.

Mr. Richey has collected a series of specimens (S17064) [NM 5190 3772], (S17065) [NM 5190 3775], (S17066) [NM 5197 3777], (S17067) [NM 5207 3777], (S17068) [NM 5207 3777], (S17069) [NM 5208 3777], (S17070) [NM 5269 3802], (S17071) [NM 5269 3802], (S17072) [NM 5299 3846], (S17073) [NM 5299 3846], (S17074) [NM 5309 3854], (S17075) [NM 5311 3858] to illustrate the marked alteration of some of the dykes referred to above. Occasionally, their condition renders it difficult to assign them to their proper place in the petrological classification proposed in the succeeding section; but certainly most of them are Plateau Types, often with rich-purple augite, while one (S17072) [NM 5299 3846]–(S17073) [NM 5299 3846] is an olivine-tholeiite (Salen Type). The alteration of these rocks is exactly on a par with that of neighbouring lavas. There has been a complete decomposition of olivine, and a considerable change in the felspars, and sometimes also in the augite. The resulting secondary minerals, mainly chlorite, albite, and epidote, with subordinate calcite, occupy vesicles and also veins (S17065) [NM 5190 3775],(S17074) [NM 5309 3854]. The alteration is sufficiently intense to lead to the development of fibrous hornblende in many of the vesicles (S17066) [NM 5197 3777], (S17067) [NM 5207 3777], (S17071) [NM 5269 3802]. Occasionally, somewhat fibrous hornblende completely replaces the augite of the groundmass; and, in the two cases where this has been observed, garnet occurs in the vesicles (S17068) [NM 5207 3777], (S17070) [NM 5269 3802].

Petrology

Examples of the Tertiary dykes of Mull, and the surrounding district, are well-represented in the Survey collections, and abundant material is available for safe generalizations.

In the following account of the petrography of these rocks, only such dykes as cut Mesozoic sediments or Tertiary lavas are made use of, *except where slide-numbers are quoted in square brackets.* Camptonites and allied types, of doubtful age, are dealt with in Chapter 34.

As has already been indicated, the majority of the dykes are of more or less basaltic character, but they exhibit considerable variety. They are dealt with in the sequel under the headings Plateau Basalt Type, Porphyritic Central Lava Types, Tholeiites, Leidleites, Felsites, and Composite Dykes.

Dykes of Plateau Basalt Type

A very large proportion of the basaltic dykes are directly comparable, both as regards texture and composition, with the Plateau Basalt Lavas (Chapter 10), and it will be convenient to refer to them as dykes of Plateau Basalt Type. Olivine-rich varieties, of basaltic and doleritic character, are extremely common, often with an appreciable amount of analcite in the base—crinanites of Dr. Flett (p. 16), Rocks with mugearitic affinities (S16270) [NM 5443 3828] occur very sparingly.

The dykes of Plateau Basalt Type, as a class, are characterized by a highly titaniferous augite of purplish tinge and distinct pleochroic character. Texturally, they range from coarsely to finely ophitic varieties, and porphyritic constituents, other than olivine, are usually wanting. The ultimate residual products of consolidation of these rocks consist mainly of analcite, which occurs together with a certain amount of alkali-felspar. Olivine is always present, frequently in an undecomposed condition (p. 366), and may occasionally be more abundant than augite (S14870) [NM 5420 2216]. Porphyritic constituents, other than olivine, are usually wanting, but types are met with which have a multitude of small tabular sub-porphyritic felspars (S14990) [NM 6405 4722] that may take on a linear arrangement according to the direction of flow. In rarer instances, large porphyritic felspars, ranging up to half-an-inch in length, may be noticed (S15781) [NM 7231 4187] as a minor feature of a rock that otherwise is of normal Plateau Type.

A coarse type, forming a six-foot dyke in a stream on the western side of Clachaig (S14836) [NM 5681 3644], is more than usually rich in analcite. For the most part the augite is ophitic, but when in contact with the analcitic areas it assumes a hypidiomorphic habit (p. 137). In this rock, olivine is entirely decomposed (p. 366), and areas, originally occupied by residual material, are frequently replaced by chlorite of a late secondary character.

A beautiful fine-grained crinanite, with abundant analcite, occurs as a north-and-south dyke, 500 yds. to the south of Fishnish Point (S15676) [NM 6475 4205]. *See* also p. 359).

A few somewhat unusual types are worthy of individual mention. In a dyke south-west of Beinn Chàisgidle (S17942) [NM 5996 3248], there is a considerable falling off in the amount of felspar, and the principal minerals present are hypidiomorphic titaniferous augite and olivine (decomposed, p. 366). The whole rock shows a tendency to assume the characteristic panidiomorphic structure of the lamprophyres (camptonites, etc). A neighbouring dyke, north-north-west of Sgulan Mòr, shows segregation of titaniferous augite around the vesicular cavities, with the augite-crystals sometimes interrupted at the surface of the vesicle (S17943) [NM 6162 3332]. In specimens from Loch na Keal, titaniferous augite may be seen to project, in a position of growth, into the vesicular cavities (S17065) [NM 5190 3775]—a feature not uncommon in Mull lavas, as was first described by Dr. M'Lintock (p. 141).

In many instances, we may detect an approach of the Plateau Basalt magma to that of the camptonite-branch of the lamprophyres. One case (S17942) [NM 5996 3248] has been cited above, but others may be noted in which biotite or hornblende makes an appearance (S14217a) and (S14217b), (S14833) [NM 5699 3651], (S14835) [NM 5692 3651] and a definite ocellar structure is discernible. The last two slides have already been dealt with (p. 361). The first two come from an easily located 10 ft. dyke, at a wall south of Port na Tairbeirt, on the east coast of Mull. Its amygdales, with ocellar linings, can be recognized in the field. In petrological character, the rock appears to stand about half-way between the basalts and the camptonites, and for this reason is of special interest. The ocelli (S14217) [NM 7417 2942] [NM 7417 2942] [NM 7417 2942] a and b) are moderately coarse-grained, and are composed of somewhat tabular orthoclase in association with a deep red-brown intensely pleochroic biotite. The microscopic structure recalls vividly that of the Carsaig Alkaline Syenite (Chapter 14).

'Cognate' xenoliths

A particularly interesting dyke occurs on the north side of Loch na Keal, a third of a, mile west by north of the cairn (769 ft) on Cnoc na Dì-chuimhne (inside the angle of the stream shown on the one-inch Map, Sheet 44). It is only partially exposed, but is seen to consist of two lateral bands, each 1½ ft. wide, marked by a great abundance of 'cognate' xenoliths, and separated by a two-foot central portion of olivine-basalt of Plateau Type (S17031) [NM 4812 4043]. The rock, as a whole, is exceedingly fresh, with its olivine showing little or no sign of decomposition. The xenoliths are gabbroic or peridotic in character; some consist of moderately coarse aggregates of bytownite and olivine with the local ocurrence of large (2–3 mm) ill-formed crystals of sage-green spinel (S17030) [NM 4812 4043]; others of bytownite and bottle-green augite (S17033) [NM 4812 4043], and others again of similar augite poecilitically enclosing olivine (S17032) [NM 4812 4043]. The augite shows evidence of re-heating and resorption. It is difficult to draw a valid distinction between these xenoliths and the well-known olivine-nodules, so conspicuously absent, as a rule, from the British Tertiary rocks.

Dykes of Porphyritic Central Lava Type

Porphyritic rocks with phenocrysts of felspar are well-represented amongst the dykes, and approximate in character to lavas of Porphyritic Central Type (Chapter 10). The felspar is usually a moderately basic labradorite, frequently of surprisingly uniform composition, as is indicated by its insignificant zoning. The porphyritic individuals exhibit considerable variation in size, commonly from a few millimetres to a centimetre in greatest dimension (S15745) [NM 5595 4672], and in one case ranging up to 6x4 inches across (p. 358); the average size may be taken as 4 to 5 mm. The matrix shows variation comparable to that exhibited by the corresponding lavas. It may be granular (S14207) [NM 7473 3075] [(S19040) [NM 8012 2263]], micro-ophitic (S16666) [NM 5131 4735], or fluidal (S17374) [NM 6693 2210], or show a tendency to intersertal structure (S14954) [NM 7084 4523]. Olivine may occur as additional phenocrysts (S16666) [NM 5131 4735], (S17374) [NM 6693 2210], but is more commonly restricted to the matrix in the form of small crystals and grains.

Augite is not particularly common as a porphyritic constituent, but a dyke from near the summit of Ben Buie contains a few badly formed crystals, comparable in size to the porphyritic felspar.

A highly porphyritic type, in which the phenocrysts of felspar are extremely abundant—so abundant that they practically touch each other—furnishes another example of the 'small-felspar dolerite' (pp. 163, 286). This type of rock was previously met with by Dr. Harker<ref>A. Harker, Tertiary Igneous Rocks of Skye, Mem. Geol. Surv., 1904, pp. 329, 330.</ref> in Skye, and referred to by him as an olivine-dolerite of Gheal Gillean Type (S7366) [NG 595 038]–(S7367) [NG 580 096].

The dominant felspar is basic labradorite, much twinned and usually zoned. It commonly contains inclusions of the matrix which show a rudimentary type of crystallization (S14956) [NM 7031 4556].

The ground-mass, which in many cases is reduced to a minimum, is invariably rich in augite relatively to felspar, and frequently contains granular olivine (S14956) [NM 7031 4556], (S14975) [NM 7011 4487]. The augite usually has an ophitic development, and is commonly of a somewhat deeply coloured titaniferous variety. The ophitic structure varies in coarseness in different dykes, giving in some instances a normal basaltic character to the ground-mass (S14537) [NM 5395 2157], (S14889) [NM 5323 2099], but in others a much coarser, almost gabbroic texture (S16312) [NM 7194 2622], (S16332) [NM 7061 2462]. The type is 'very definite, and, although not particularly prevalent, is widely distributed.

Olivine most commonly occurs in the ground-mass; but in the more coarsely crystalline rocks, in which the proportion of matrix is small, olivine builds large porphyritic individuals associated with the felspar (S16662) [NM 4834 4457] [(S17451) [NM 7789 2675]], and thus emphasizes the gabbroic character.

'Cognate' xenoliths

Cognate ' xenoliths are occasionally met with in the porphyritic dykes; and a good example may be cited in the case of a dyke that occurs on the shore of Loch Spelve, at the first point south of Seanvaile. The xenolith-bearing rock is somewhat different to the common type, in that the augite tends to assume an idiomorphic, rather than an ophitic, form (S15066) [NM 6836 2847].

The xenoliths are large masses of greenish augite, ophitically enclosing somewhat tabular crystals of bytownite (S15065) [NM 6836 2847]. Against the enclosing rock, the augite shows signs of corrosion, as also do isolated xenocrysts of augite which occur scattered throughout the ground-mass.

A similar dolerite, with xenocrystal development, occurs at Loch na Keal, 530 yds. S. 13° W. of Eilean Feeir (S16235) [NM 5296 3842].

Tholelite dykes

(Anals. I., VI., and VII.; (Table 2), p. 17).

Tholeiites have already been defined (Chapter 25), and it has been pointed out that, in Mull, they group themselves conveniently under three headings: (a) olivine-tholeiites of Salen Type; (b) tholeiites of Brunton Type; and (c) tholeiites of Talaidh Type. The Brunton and Talaidh Types agree in having little or no olivine, but are distinguishable on structural grounds.

Olivine-tholeiite of Salen Type

(Anal. I.; (Table 2), p. 17).

Rocks of this type are abundantly represented among the tholeiite-dykes of Mull. They are even-grained, finely crystalline dark-grey rocks, usually without any trace of porphyritic constituents. Microscopically, they are seen to be composed mainly of augite and labradorite felspar, with subordinate olivine, iron-ore, and a variable quantity of residual glassy matter ((Figure 62)A) of relatively late consolidation (S14218) [NM 7413 2930], (S16807) [NM 5601 4705], (S16808) [NM

5593 4670] [(S19035) [NM 7963 2206]]. The augite is, usually, at least as prevalent as the felspar. it has a pale yellowish-brown colour, is sometimes pleochroic (S15744) [NM 5593 4670], and occasionally somewhat titaniferous; it forms somewhat small crystals, that, while behaving ophitically towards the felspar (S19034) [NM 7942 2180], show a distinct tendency towards idiomorphism, when in contact with later products of consolidation. Occasionally, acicular augite is present as a consolidation-product of the residual matter (S14209) [NM 7466 3051]; and, now and again, this mineral may assume to a limited extent that cervicorn structure (S14853) [NM 5333 2232] [(S15792) [NM 7553 4260]], so characteristically developed in some of the sub-basic sheets (Chapter 28).

Olivine appears to be the earliest silicate to have separated; but it seldom reaches any considerable importance as a constituent. It builds small somewhat badly formed crystals, or ellipsoidal grains, on which both felspar and augite are moulded.

The felspar is usually a much-twinned and zoned labradorite, that occurs in somewhat irregular, and probably rapidly grown, lath-shaped crystals. The individuals frequently show a tendency to crystallize from common initial points, a fact that leads to a roughly radiate or stellate grouping (S14853) [NM 5333 2232], such as is often found in rocks of the Brunton Type.

Iron-ore, comparable in size to the olivine, has the magnetite-habit, and commonly clings tenaciously to the augite, or is concentrated in the areas occupied by residual material. Less frequently, it builds large plates with narrow cross-sections (S14209) [NM 7466 3051].

The residual matter shows a tendency to collect into definite areas; giving rise to intersertal structure. It is usually chloritized and full of skeletal growths of magnetite; but its devitrification-products, and the increased alkalinity of the felspars in its immediate neighbourhood, suggest that it is much more siliceous and alkaline than the bulk of the rock.

Coarse-grained representatives of the Salen Type of tholeiite pass over to the quartz-dolerites [(S19017) [NM 7558 1972], (S19021) [NM 7561 1973], (S19037) [NM 7990 2239], from Lorne], and connect with somewhat similar rocks on the border-line of the Plateau Type (S15068) [NM 6669 2414], (S15866) [NM 6862 2295], (S16252) [NM 5131 3758], (S16348) [NM 6862 2293]. In the more acid direction, we find the incoming of more definitely siliceous mesostatic material, with a marked acicular type of crystallization, such as is a feature of the quartz-dolerites of Talaidh Type (p. 303).

Tholeiites of Brunton Type

Anals. IV and VII.; (Table 2), p. 17).

The tholeiites of Brunton Type are olivine-free, or are, at any rate, definitely poorer in this mineral than those of the Salen Type. They differ from tholeiites of Talaidh Type in an absence of acicular or columnar crystallization of the augite. The general texture is finer, with a considerable proportion of residual glassy matter, and there is marked aggregation of the crystalline elements, other than iron-ore. The type, as developed in Mull, is identical with the rock described by Sir Jethro Teall<ref>J. J. H. Teall, Petrological Notes on some North of England Dykes, Quart. Journ. Geol. Soc., vol. al., 1884, pp. 236–7, Pl. xii., Fig. 6; *see also* A. Barker, Petrology for Students, 5th ed., 1919, (Figure 62), p. 180.</ref> from the Brunton Dyke in the North of England, and we have therefore adopted this name as the type-designation.

There is little to add to Sir Jethro Teall's description. The rocks are usually devoid of phenocrysts, and are composed essentially of augite, labradorite, iron-ore, and glass: the iron-ore shows a definite tendency to restriction within the areas occupied by residual material (S15724) [NM 5594 4766]. The well-marked intersertal structure produced by the arrangement of the crystalline elements with reference to the glassy residuum is a constant and characteristic feature, and is illustrated in the appended figure (Figure 62)B. The type is uniform, because a little variation introduces the characters either of the Salen or Talaidh Type. The analysed rocks (S16809) [NM 5592 4755], (S16810) [NM 5541 4837] may be regarded as typical.

Tholeiites of Talaidh Type

When dealing with the petrology of the Late Basic Cone-Sheets (Chapter 28), we described numerous examples, with quartz-dolerite affinities, as belonging to the Talaidh Type, on account of the prevalence of such rocks in the region of Beinn Talaidh. The more finely crystallized varieties of the type are tholeiites, as already pointed out in Chapter 25.

The Talaidh Types of tholeiite and quartz-dolerite, as represented by dykes, are olivine-free rocks, for the most part of moderately fine grain and dark colour. They vary more in their textural characters, than in the relative proportions of their constituent minerals. They carry augite, moderately basic, but much-zoned, plagioclase, and abundant magnetite, in an acid base, partially devitrified to quartz and alkali-felspar, with or without ferro-magnesian constituents. This acid base, of a mesostatic character, is occasionally more or less evenly distributed as a discontinuous matrix to the larger crystalline elements (S14353) [NM 5759 3930], but usually is collected into fairly definite irregularly-shaped areas (S13898) [NM 6668 4201], (S14341) [NM 6138 4327].

The augite of these rocks shows great variation in its manner of crystallization. Frequently, it is coarsely ophitic, though with a tendency to idiomorphism towards the mesostatic material [(S15841) [NM 8083 4693]]; and, in this form, it is common to encounter a curving of the cleavage-planes [(S15793) [NM 7749 4323]], as remarked upon in the case of the cone-sheets (p. 303). More frequently, the augite tends to assume a stoutly columnar habit [(S15838) [NM 7517 4502]] (S17614) [NM 4877 4311], with an incipient development of salitic striation [(S15840) [NM 8222 4644]], a common habit of augite in fairly acid quartz-dolerites. We also notice those curious cervicorn growths of this mineral (S14206) [NM 7480 3087], (S14854) [NM 5271 2708], so characteristic of many of the cone-sheets of Bheinn Talaidh ((Figure 50)B, p. 302); and all stages exist between this structure and a micro-ophitic development [(S15802) [NM 738 407]]. The examples cited in square brackets in this paragraph cut Pre-Mesozoic rocks in Morven.

The mesostatic matter of late consolidation is a finely crystalline mass, in which practically all the quartz is segregated, along with most of the alkali-felspar, other than that which may fringe zonally the larger crystals of plagioclase. It is characterized by a marked acicular type of crystallization (S16658) [NM 5132 4526], such as is the dominant feature of the mesostasis of the differentiated rocks of Glen More (Chapter 30), and the matrix of the craignurites.

Intermediate and sub-acid dykes

Leidleite

A comparatively small proportion of the Mull dykes belong to the leidleite type as already defined (p. 281). They are dark grey in colour, with a variation in texture corresponding to their degree of devitrification (S14534) [NM 5346 2133], (S16663) [NM 5084 4696]. They are composed of plagioclase, augite, and magnetite, with glass, or the products of its divitrification, in varying amounts. In those which approach to pitchstone, the glassy matter is abundant and the crystalline constituents are of small dimensions (S14588) [NM 5346 2133] [(S19003) [NM 7506 1930], (S19018) [NM 7560 1973], from Lorne], while, in the more stony varieties (S14974) [NM 6977 4509] [(S15794) [NM 7680 4590]], the glass is reduced to a minimum, with the development of very fine-grained devitrification-products, and the crystalline elements are of relatively greater size.

The felspars build narrow, somewhat ill-formed laths or skeletal growths, and have the composition of acid labradorite or andesine. The augite is a normal aluminous variety, that occurs commonly as blade-like crystals, frequently with stellate grouping. Magnetite exists as strings or rods, formed by adherent octahedra, and it is either closely associated with the augite or more or less restricted to the residual material. By the presence of uniaxial augite as small rounded phenocrysts, the rocks [(S15301) [HY 382 285]] occasionally may show a leaning towards the ininmorites (p. 282); and, by the occurrence of an acid residuum with clearly individualized quartz, they connect with the craignurites of Chapter 19 [(S19001) [NM 7500 1923]]. Certain other varieties with a variolitic structure, on a microscopic scale (S16317) [NM 7132 2519], (S17379) [NM 6693 2210], recall in a measure the variolites of Cruachan Dearg (p. 304).

A dyke (S16659) [NM 5051 4410], that occurs three-quarters of a mile to the east of Meall an Fhìar Mhàim, north of Loch na Keal, is a rather more exceptional variety. It is a fine-grained, compact, somewhat glassy rock, built up of hypidiomorphic columnar augite-crystals that are intimately associated with regular crystals and plates of magnetite. The felspar is andesine-labradorite, and forms irregularly bounded lath-shaped crystals. The larger crystalline elements are

spaced without crowding in a micro-variolitic glassy base that is full of skeletal growths of augite and magnetite.

Inninmorite

A few inninmorite dykes occur associated with sheets in the Inninmore district of Morven (p. 293).

Acid dykes

The acid dykes of Mull are in a minority. They present, however, considerable variety amongst themselves, both in macroscopic and microscopic characters. Judged by the phenocrysts that are usually present, the composition, too, should vary within wide limits, but by reason, of the fine texture of the matrix of most of these rocks, compositional differences are difficult to gauge without ultimate chemical analyses.

A microscopical examination shows that these dykes are mostly microporphyritic, and have frequently, in addition, some definite structure that enables us to describe them as granophyric, spherulitic, or trachytic. The greater number of the dykes are felsites, amongst which a few with quartz-phenocrysts may be distinguished as quartz-felsites. They are almost invariably micro-porphyritic, with phenocrysts of albite (S13907) [NM 5971 3689], orthoclase (S14773) [NM 5992 3793], (S14789) [NM 5684 3518], or quartz (S16622) [NM 5279 3452], (S17269) [NM 5238 3156], in a microcrystalline base.

True granophyres are not well-represented, but, in a certain number of dykes, the base has a granophyric structure, either fairly coarse (S14375) [NM 6147 3444], or more commonly of a micrographic character produced by the very fine and intimate intergrowth of alkali-felspar and quartz (S14735) [NM 6032 3959], (S18525) [NM 5113 3215].

The spherulitic rocks are mainly referable to the quartz-felsites, and two beautiful rocks may be cited. One is a dyke having a west-north-west direction and exposed 600 yds . to the south-west of Killbeg, Glen Forsa (S14768) [NM 5978 4121]; while the other is a six-foot north-north-west dyke that occurs 1580 yards S. 35 W. of Eilean Feoir, Loch na Keal (S16244) [NM 5232 3778]. In both cases, the quartzo-felspathic spherulitic and radiate growths have small quartz-phenocrysts as nuclei, and occur in a microcrystalline, presumably divitrified, matrix. The spherulites reach a few millimetres in. diameter. In the second named example, small phenocrysts of alkali-felspar are present in addition to those of quartz.

Of the rocks that assume a trachytic, or orthophyric, structure we may mention the acid margin of a multiple dyke occurring on Speinne Beag, on the junction of Sheets 44 and 62 (S15765) [NM 5138 4799]. It is built up of narrow, elongated, indefinitely terminated crystals of orthoclase, having a sub-parallel arrangement.

A beautifully banded rhyolite (S14789) [NM 5684 3518], reminiscent of the Loch Bà, Felsite ((Figure 59)B), occurs as a north-and-south dyke that cuts the Glen Cannel Granophyre, three-quarters of a mile south of Clachaig. It has small phenocrysts of albite in a micro-crystalline divitrified matrix, that has a somewhat patchy appearance and has undergone some secondary silicification. Occasionally, rocks, similar in other respects, may develop a spherulitic structure, together with an acicular type of crystallization of the ground mass (S17034) [NM 5151 4069].

From these acid rocks, there is a gradation into several subacid and intermediate types that have been already discussed when dealing with the Cone-Sheets (Chapter 19).

Two exceptional acid dykes of alkaline character are worthy of mention, although their Tertiary age is not quite- established, since they have only been found cutting Pre-Mesozoic Rocks. Both run north-west and south-east. One of them, a pale micro-porphyritic dyke, has been collected from the north-east of Rudh' an Fheurain, Sound of Kerrera [(S18722) [NM 8250 2673]], Dùm Ormidale [(S18723) [NM 8279 2632]], and Lerags House (S18724) [NM 8423 2458]. It consists almost entirely of alkali-felspar with subordinate quartz The felspar occurs as two generations, seemingly of approximately the same composition: the first is represented by porphyritic crystals of anorthoclase, somewhat rounded in form and edged with orthoclase; and the second, by small rectangular, often equilateral, crystals that have fairly uniform extinction, and are closely packed together to constitute the matrix in which the porphyritic crystals lie. Quartz occurs sparingly between the felspars of the matrix, but there is no attempt at micrographic

intergrowth on the part of the two minerals. Apatite is present in small quantity only. A striking and unusual feature of the rock is the occurrence throughout the matrix of minute, but abundant, crystals and patches of chalybite. The origin of this carbonate is obscure, but there is some evidence that it occupies pseudomorphously the place of a mineral, now completely removed, possibly of some alkaline pyroxene or amphibole.

The other dyke [(S18721) [NM 8364 2838]] was collected from the mainland shore, 200 yds. north-east of Kerrera Ferry. The matrix takes on a more bostonitic character with frequent radial grouping of the elongated felspars. As a whole, the rock presents many points of similarity to the bostonites of Rossal Type, and might well be regarded as the dyke-equivalent of such sills (Chapter 14).

Composite dykes

An enumeration of a few sliced examples of composite dykes is all that is necessary in this connexion:

1. At Allt Molach, a conspicuous composite dyke, shown on the Map ((Figure 52), p. 308), has a margin (S17427) [NM 6294 3133] of quartz-dolerite with columnar augite and acid mesostasis; the interior (S17426) [NM 6294 3133] is a fine-grained soda-felsite.

2. An east-north-east dyke, not shown on the one-inch Map, Sheet 44, 100 yds. north of the top tributary of Allt na Coille Mbire, north of Loch Scridain, has a margin (S17274) [NM 5057 3124] of Salen Type of tholeiite, and an interior (S17273) [NM 5057 3124] of felsite with small perthitic phenocrysts.

3. A west-north-west dyke, traced for half a mile on the one-inch Map, Sheet 44, three-quarters of a mile west-south-west of Beinn Talaidh summit, has a margin (S14372) [NM 6147 3444] of micro-ophitic basalt. Farther in (S14373) [NM 6147 3444]–(S14374) [NM 6147 3444], it is more acid; while its interior (S14375) [NM 6147 3444] is a felsite with quartz- and perthite-phenocrysts, the quartz showing micrographic fringes. The matrix of the felsite is an intricate intergrowth of quartz and alkali-felspar, often in the form of sub-radial sheaves. H.H.T. , E.B.B.

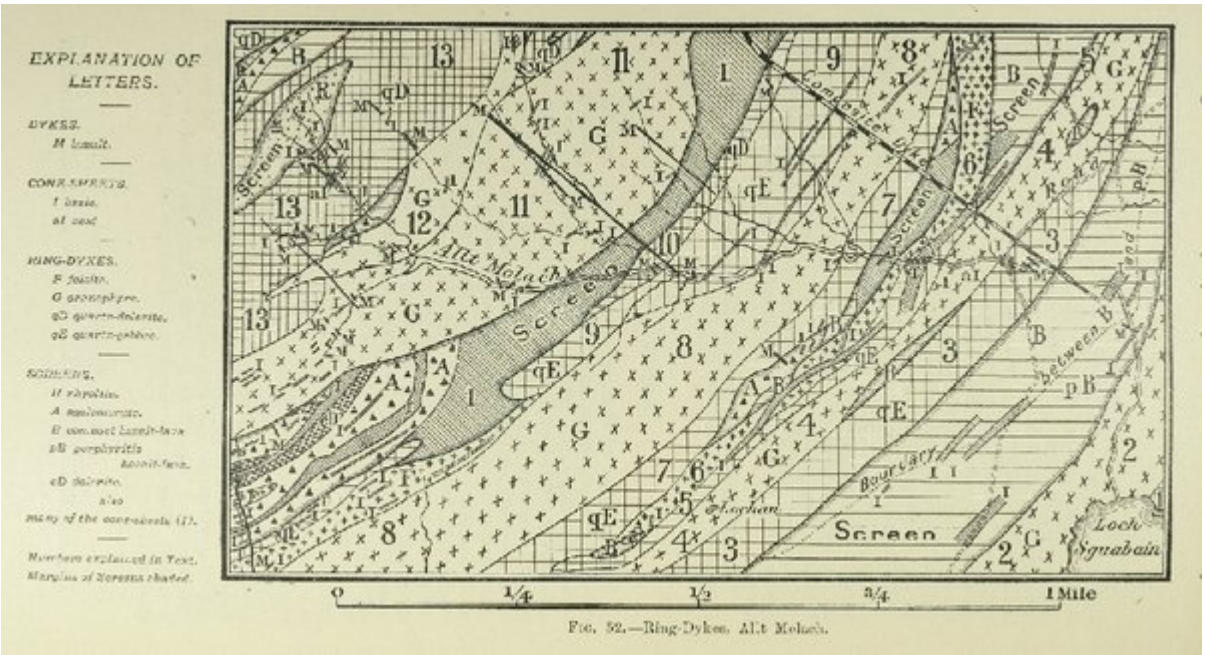


FIG. 52.—Ring-Dykes, Allt Molach.

(Figure 52) Ring Dykes, Allt Melach.

Fig. 60.—Tertiary Dykes of the South-West Highlands.
Only about one dyke in every ten or fifteen is shown. The mainland portion of Sheet 52 of the one-inch Map of Scotland has still to be surveyed.

(Figure 60) Tertiary Dykes of the South-West Highlands.

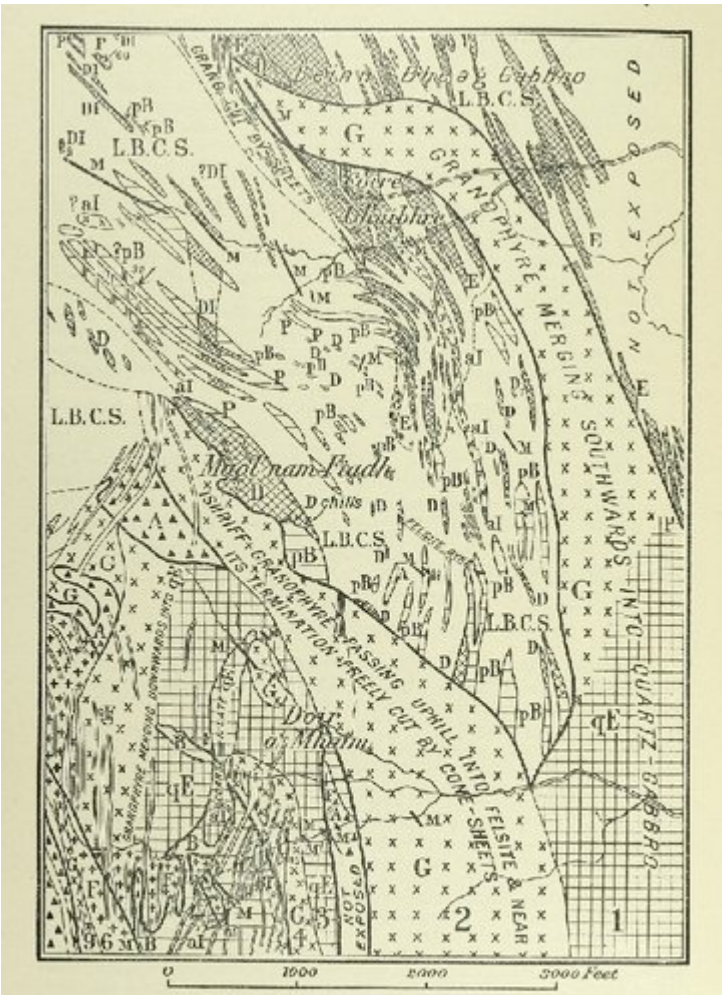


FIG. 53.—Ring-Dykes, Maol nam Fiadh.

Dykes: M basalt,

Cone-Sheets: DI dolerite; aI acid; L.B.C.S. Late Basic Cone-Sheets (shown without ornament).

Ring-Dykes: F felsite; G granophyre; qE quartz-gabbro.

Screens: A agglomerate; B compact basalt-lava; pB porphyritic basalt-lava; P pillow-lava; D dolerite; E gabbro; also many of the cone-sheets.

Numbers as in Fig. 52, *see* Text.

(Figure 53) Ring-Dykes, Maol nam. Fiadh. Dykes: M basalt, Cone-Sheets: DI dolerite; aI acid; L.B.C.S. Late Basic Cone-Sheets (shown without ornament). Ring-Dykes: F felsite; G granophyre; qE quartz-gabbro. Screens: A agglomerate; B compact basalt-lava; pB porphyritic basalt-lava; P pillow-lava; D dolerite; E gabbro; also many of the cone-sheets. Numbers as in Figure 52, see Text.

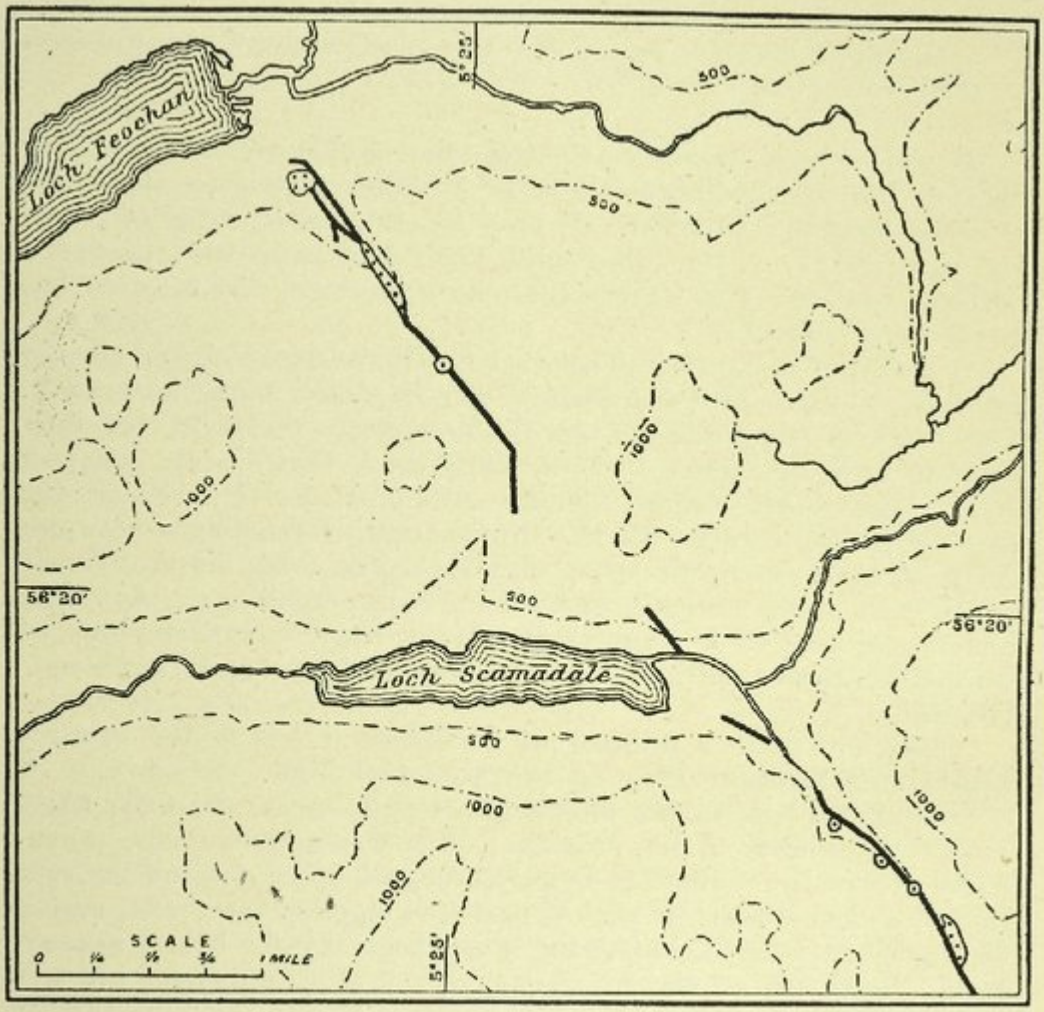
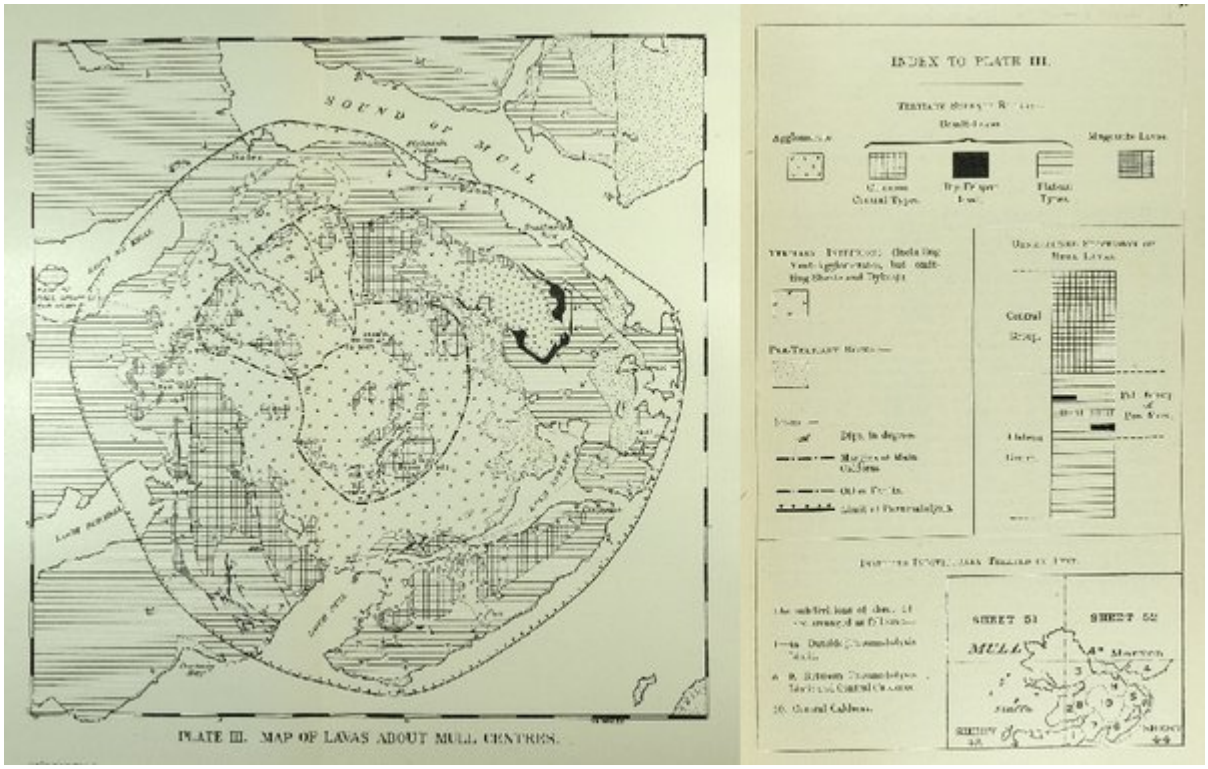


FIG. 61.
Agglomerate-Vents along multiple dyke (basalt and rhyolite) south-west from head of Loch Feochan (after B. N. Peach, R. G. Symes, and H. Kynaston).

(Figure 61) Agglomerate-Vents along multiple dyke (basalt and rhyolite) south-west from head of Loch Feochan (after B. N. Peach, R. G. Symes, and H. Kynaston).



(Plate 3) Map showing the distribution of lava-types and the limit of pneumatolysis

TABLE II.—NON-PORPHYRITIC CENTRAL MAGMA-TYPE OF FIG. 2.

	Tholeiite Salen Type	Basalt Staffa Type			Basalt Compact Central Type		Tholeiite Brunton Type		Quartz-Dolerite and Tholeiite Talaidh Type		
	I.	II.	III.	A	IV.	V.	VI.	VII.	VIII.	IX.	
SiO_2	47·35	47·80	49·76	52·13	50·54	53·78	51·53	51·63	52·16	53·97	SiO_2
TiO_2	1·75	....	0·94	....	2·80	2·28	1·57	2·00	3·25	1·24	TiO_2
Al_2O_3	13·90	14·80	14·42	14·87	12·86	12·69	11·05	11·77	11·95	14·65	Al_2O_3
Fe_2O_3	5·87	....	3·95	....	4·13	3·44	2·73	3·23	4·86	3·62	Fe_2O_3
FeO	8·96	13·08	7·77	11·40	8·75	8·94	10·98	10·47	9·92	6·32	FeO
MnO	0·23	0·09	0·20	0·32	0·32	0·53	0·45	0·35	0·18	0·30	MnO
(Co, Ni)O	nt. fd.	....	nt. fd.	....	0·06	nt. fd.	nt. fd.	0·04	....	nt. fd.	(Co, Ni)O
MgO	5·97	6·84	5·30	6·46	4·63	2·58	5·21	5·02	3·77	4·49	MgO
CaO	10·65	12·89	10·22	10·56	8·74	6·36	9·68	9·34	7·14	7·98	CaO
BaO	....	....	0·04	....	nt. fd.	0·09	nt. fd.	0·03	....	0·04	BaO
Na_2O	2·73	2·48	2·49	2·60	2·89	2·74	3·48	2·90	2·36	2·54	Na_2O
K_2O	0·54	0·86	1·83	0·69	1·43	2·27	0·86	0·91	1·74	1·52	K_2O
Li_2O	....	....	tr.	....	nt. fd.	nt. fd.	tr.	nt. fd.	....	tr.	Li_2O
$H_2O - 105°$	1·16	1·41	1·03	1·19	2·25	2·19	1·26	1·40	1·95	0·94	$H_2O - 105°$
H_2O at 105°	1·04		2·04		0·17	1·19	0·71	0·68	0·56	1·92	H_2O at 105°
P_2O_5	0·24	....	0·21	....	0·34	0·55	0·22	0·29	0·24	0·27	P_2O_5
CO_2	0·32	....	0·06	....	0·33	0·08	0·08	0·11	0·18	0·51	CO_2
FeS_2	....	....	0·04	....	nt. fd.	0·42	0·26	0·08	....	0·09	FeS_2
S	0·23	....	....	....	....	....	....	....	0·18	....	S
	100·94	100·25	100·30	100.22	100·24	100·13	100·07	100·27	100·44	100·40	
Spec. grav.	2·96	....	2·72	....	2·90	2·68	2·93	2·95	2·91	2·83	

(Table 2) Non-Porphyritic Central Magma-Type of Figure 2

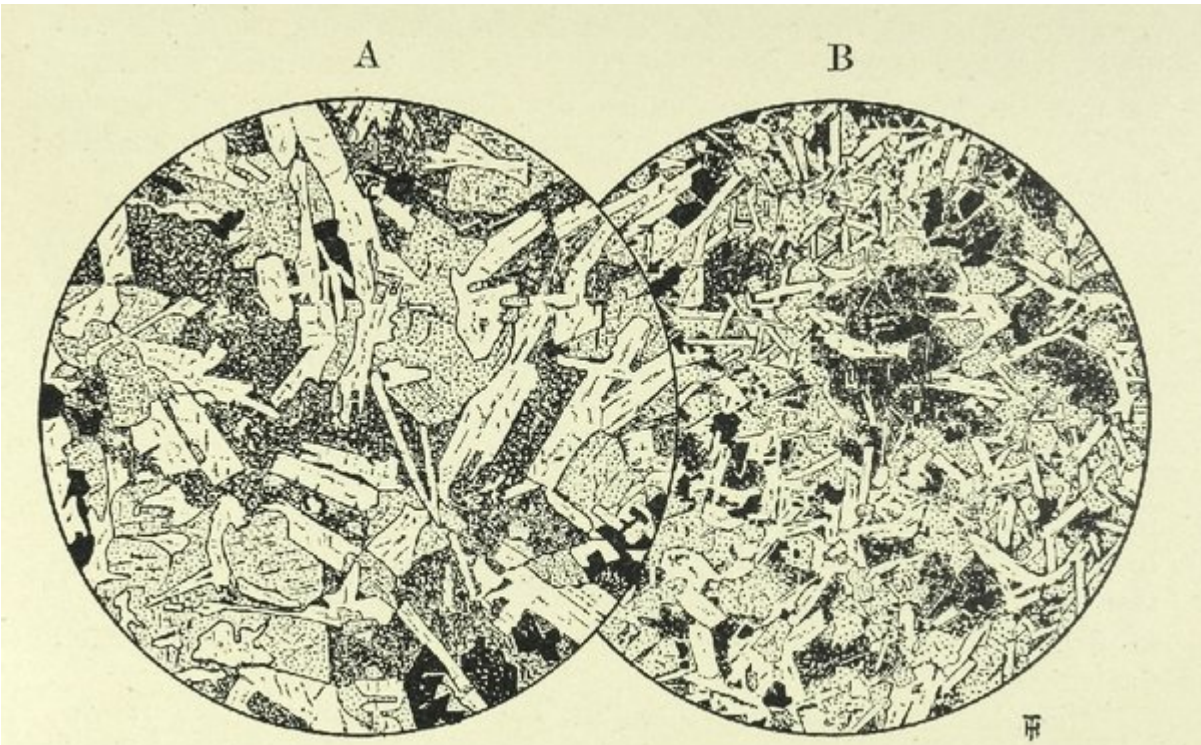


Fig. 62.—Tholeiites.

(Figure 62) Tholeiites. A. [(S16807) [NM 5601 4705]] ×17. Tholeiite of Salen Type. Composed of augite, labradorite-felspar, subordinate olivine and iron-ore, and a variable quantity of residual glass. B. [(S16809) [NM 5592 4755]] x 90. Tholeiite of Brunton Type. Augite, labradorite, magnetite and glass. The well-marked intersertal structure, produced by the arrangement of the crystalline elements with regard to the glassy base, is a constant and characteristic feature.

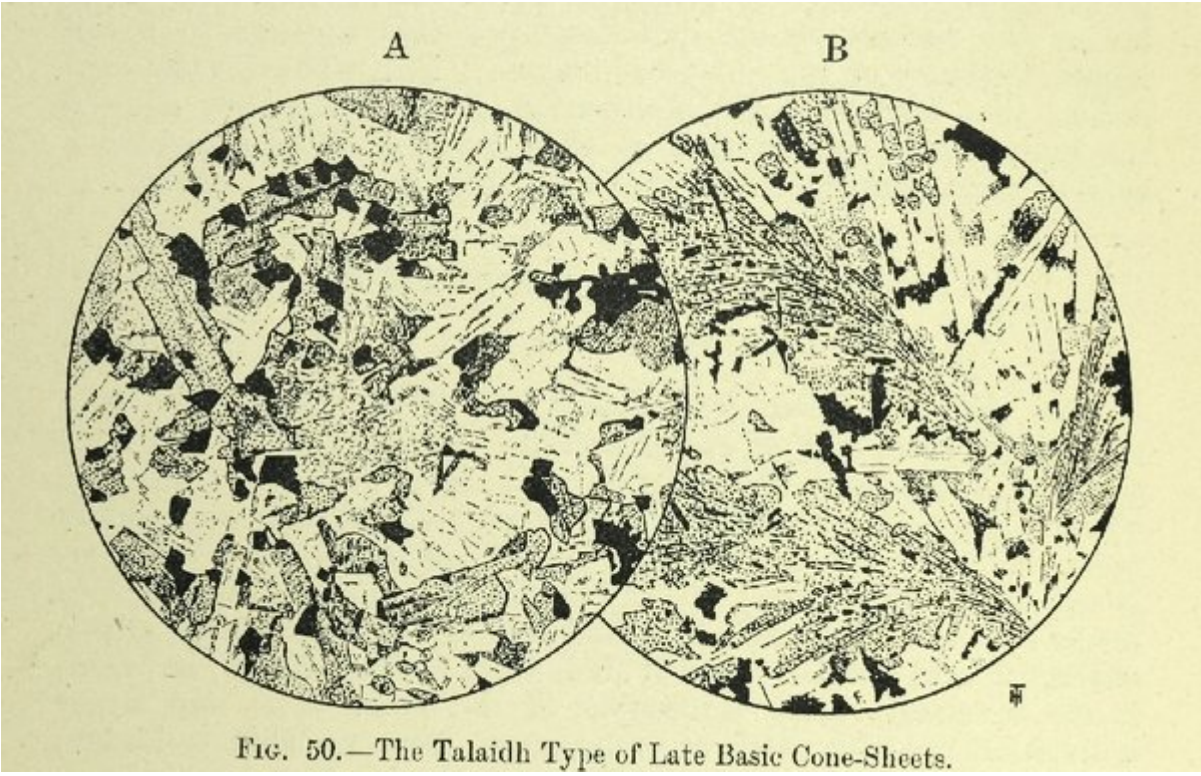


Fig. 50.—The Talaidh Type of Late Basic Cone-Sheets.

(Figure 50) The Talaidh Type of Late Basic Cone-Sheets. A. [(S14867) [NM 5354 2242]] x 17. Quartz-doleiite. The section shows columnar augite associated with titaniferous magnetite, a colourless moderately basic and albitized plagioclase, and a mesostasis of alkali-felspar and quartz. B. [(S14810) [NM 6060 3814]] x 17. Quartz-dolerite. Mineralogically similar to the above, but with a highly characteristic cervicorn development of its augite (p. 303).

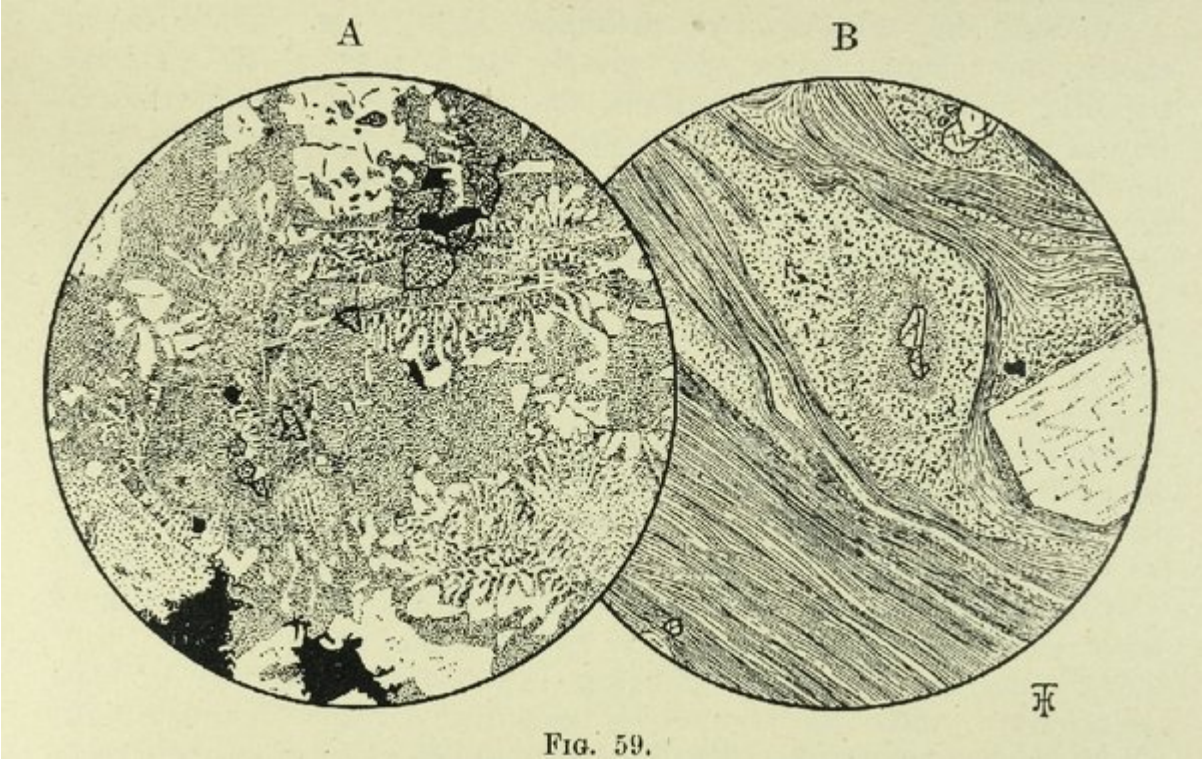


Fig. 59.

(Figure 59) A. [(S14841) [NM 5427 3847]] ×17. Knock Granophyre. Brownish-green augite and crystals of oligoclase edged with perthite, enveloped in a typically granophyric matrix of which the structure is emphasized by the turbidity of the alkali-felspar. B. [(S14825) [NM 5551 3738]]×17. Felsite of Loch Bà. Rhyolitic type with well-developed fluxion-structure. The phenocrysts are of yellowish augite and albite. Areas devoid of banding have suffered a more pronounced devitrification.