Chapter 22 Tertiary dykes, Ardnamurchan and North-West Mull

Basic dykes are widely distributed throughout the British Tertiary igneous province, and extend far beyond the limits of the plateau lavas. They are found from the Outer Hebrides, where they traverse the Lewisian gneiss, to as far south at least as North Wales and the English Midlands, where the Trias is the youngest formation cut by them. They are especially prevalent in the neighbourhood of the plutonic centres where they traverse other Tertiary igneous rocks, as well as Cretaceous, Jurassic, and Triassic sediments. Their identification as Tertiary in areas of Paleozoic and pre-Cambrian rocks depends in large measure on the peculiarity of their rock-types coupled with the fact that the prevalent direction of Tertiary dykes in Britain is north-west.

The detailed mapping of the British Tertiary dykes has demonstrated that they are concentrated in north-westerly directed swarms, and that each swarm is coincident with one of the plutonic complexes. Further, the number and aggregate thickness of the dykes composing a swarm increases markedly in the vicinity of the plutonic complex concerned. These remarkable features of dyke-distribution seem to have been first clearly recognized by Mr. H. B. Maufe<ref>*Cf.* E. B. Bailey *in* Tertiary Mull Memoir, 1924, p. 10.</ref> in the case of the Mull Swarm, largely on account of his work on the mainland south-east of Mull (Sheet 36). The localization of dyke-swarms at plutonic centres was attributed by Mr. E. B. Bailey<ref>The Cauldron-Subsidence of Glen Coe, *Quart. Journ. Geol. Soc., vol.* lxv., 1909, pp. 674–675.</ref> to the local weakening of the crust where traversed by pipes filled to a large extent with unconsolidated magma. In the British Tertiary province, well-marked dyke-swarms are associated with the central intrusive districts of Skye, Rum, Mull, and Arran in Scotland, and with the Mourne and Carlingford districts in Ireland (see (Figure 4), p. 53).

In Ardnamurchan, the dykes are considered to be in part referable to the Mull Swarm, in part to belong to the Ardnamurchan district itself. The majority are basic in composition, but a number of acid dykes have also been mapped. They usually have a northwesterly trend, though many dykes, both basic and acid, follow other directions. In North-west Mull, only basic north-west dykes are met with, and are a continuation of the Mull Swarm (Figure 49).

In both North-west Mull and Ardnamurchan, the dykes are, with rare exceptions, single individuals. In Ardnamurchan, only a few instances of double basic dykes, and only two of composite habit, have been noted. In this respect these districts differ from Central Skye and Central Mull, where double and multiple dykes are frequent.

The dykes of North-west Mull, as described by Mr. G. V. Wilson in the Tertiary Mull Memoir (p. 358), are in large measure re sponsible for a lineated scenery in the district eastwards of Dervaig. This belt of country is characterized by a north-westward direction of ridge and hollow, erosion having been controlled to a very large extent by dykes, and to a lesser degree by parallel crush-lines. In Ardnamurchan, dykes play a small part in guiding erosion, but north-westerly or northerly crush-lines, sometimes accompanied by dykes, have often determined the positions of streams and valleys, more especially in the western part of the peninsula.

(Table 8) Data concerning mull dyke-swarm

Locality	Breadth of swarm or portion of swarm examined	Number of dykes	Total aggregate thickness of dykes	Average individual thickness	Average number per mile	Average Aggregate thickness per mile	Amount Of crustal stretch due to dyke-intrusion
S.-Central Mull *	12½ miles	375	2504 ft.	5.8 ft.	30	200 ft.	1 in 25
N.-Central Mull*	1¼ miles	142	817 ft.	5.8 ft.	114	654 ft.	1 in 8
North-west Mull	5 miles	62	480 ft.	7.7 ft.	12	96 ft.	1 in 55
South-west Ardnamurchan	1½ miles	36	272 ft.	7.5 ft.	24	180 ft.	1 in 30

* Data from Tertiary Mull Memoir, p. 360.

Distribution

As mentioned above, the Mull Swarm traverses North-west Mull, and a portion of it may be presumed to extend to the western part of the Ardnamurchan peninsula. On (Table 8), the numbers and aggregate thicknesses of dykes belonging to the swarm are shown for Central and North-west Mull and for the south-west part of Ardnamurchan. It will be seen that these values decrease greatly in North-west Mull as compared with Central Mull, but that in south-western Ardnamurchan there is a renewed increase. While it must be remembered that we are only dealing here with a portion of the Mull Swarm, the increase seems too large to be merely a matter of chance; it is certainly in part due to the occurrence of a few local acid dykes, but may be in part attributed to the presence of basic dykes belonging to an Ardnamurchan suite. In the more easterly parts of the Ardnamurchan area here described, a number of north-west dykes have been mapped which lie too far to the east to be referred to the Mull Swarm. Yet farther east, beyond the eastern boundary of the area, Tertiary dykes become very scarce. There thus seems to be a local concentration of dykes belonging to the intrusive district of Ardnamurchan, though the dykes are nowhere as numerous as in the case of Central Mull.

As will be seen on (Figure 50), a number of the Ardnamurchan dykes on the northern coast between Rudha Groulin and Faskadale Bay trend west of north and north. Similar deviations from the usual north-west direction are also met with in the northern parts of other intrusive districts, northwards of Central Mull, Rum, Central Skye, and Arran, as shown on (Figure 4), p. 53. In Ardnamurchan there are also a number of what may be termed transverse dykes, of both basic and acid composition, which run north-east or east-northeast at approximately right angles to the prevailing north-west or north-north-west directions. Since the transverse dykes are found across the whole breadth of the peninsula from the northern coast near Achateny southwards to the Ben Hiant district, they cannot well belong to a radial set such as is found in Rum<ref>A. Harker, The Geology of the Small Isles of Inverness-shire, Explanation Sheet 60, Mem. Geol. Surv., 1908, Plate III, p. 144.</ref> and in the Cuillins of Skye.<ref>A. Harker, The Tertiary Igneous Rocks of Skye, Mem. Geol. Surv.,1904, p. 364.

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Age relations

In North-west Mull basic dykes are frequently seen traversing the coastal cliffs that are formed of the plateau lavas. No instance has been noted there or elsewhere in the Inner Hebrides of a dyke of earlier date than any of the lavas exposed, and the majority at least of the dykes are presumably later than the plateau lava period. They were probably injected at various subsequent times, and do not belong to one epoch of intrusion. Such is certainly the case in Central Mull, where individual dykes can be dated relatively to various other intrusive rocks.<ref>E. B. Bailey, W. B. Wright, and J. E. Richey in Tertiary Mull Memoir, 1924, pp. 360–362.</ref> In Ardnamurchan, the dykes, both basic and acid, are also of various dates, as will appear from the following instances, in which it has been possible to determine age relations in regard to other intrusions.

An east–west composite dyke with central portion of bostonitic granophyre (S22259) [NM 4731 6897], cutting basalt lavas that form the eastern wall of the North-east Vent of Ben Hiant, is truncated at the vent-margin, and is clearly earlier than the vent ((Figure 11), p. 123). Two trachyte dykes (S26675) [NM 5458 6404] may here be mentioned which traverse the brecciated lava-wall of the same vent on the north-east side of Ben Hiant, and which probably belong to the Ben Hiant vent-period.

A number of dykes of basalt with large felspar phenocrysts are also to be assigned to this period, since they are identical in rock-type with blocks in the Ben Hiant agglomerates (p. 136). These dykes (lettered fM on the Memoir-map and on (Figure 50)) are sparsely distributed, and all trend north-west with the exception of one individual directed north and south on the northern coast, a mile west of Faskadale Bay. An example on the shore, south of Kilchoan, 200 yds. east of Mingary Pier ((Figure 23), p. 174), and two others on the northern coast between Rudha Carrach and Faskadale Bay one of which is the north–south dyke just mentioned, are cut by the Outer Cone-sheets of Centre 2. Sheet-like or elongate

masses of the same rock-type are also met with. A sheet cut by the Outer Cone-sheets has been mapped inland from the northern coast south of the more easterly of the two dykes quoted above from this district. Two elongate masses, perhaps short thick dykes, occur one to the south of the summit of Beinn nan Losgann, the other north of Loch Mudle.

Numerous instances of dykes of the usual basic types cut by cone-sheets of the Outer Set of Centre 2 have been noted. Many of these are shown on the (Figure 3), (Figure 23), (Figure 25). In some cases it is found that the same dyke cuts some cone-sheets and is cut by others, and thus demonstrably belongs to the period of injection of the Outer Cone-sheets (*see* p. 176). Two examples of dykes in continuity with a cone-sheet in one case and with sills in the other have been examined. On the west shore of Kilchoan Bay, two thirds of a mile south-west of the Landing Jetty, a north-west porphyritic basic dyke is in visible continuity with a cone-sheet, which is cut by a pitchstone dyke ((Figure 3), p. 34). Again, on the east side of Mingary Castle, two basic sills are connected by a short dyke ((Figure 25), p. 177). In the latter case it would seem as if the sills acted as feeders for the dyke.

Various acid dykes cut by the Outer Cone-sheets have also been mapped. Instances are a north-west dyke of bostonite, 7 ft. in width, the more northerly of the acid dykes mapped on the west shore of Kilchoan Bay, and an unusually thick north-west composite dyke, west of Sròn Bheag , 80 ft. wide, with a central portion of felsite with fluxioned edges 27 ft. in width ((Figure 3), p. 34).

Interesting age relations between dykes and cone-sheets belonging to the Outer Set on the shore west of Sròn Bheag are illustrated in (Figure 51). A north-northeast porphyritic basalt dyke (lettered pM on (Figure 51)) is cut by quartz-dolerite cone-sheets (I). Both the dyke and the cone-sheets are in turn traversed by a north–south non-porphyritic quartz-dolerite dyke (M), in part xenolithic (xM). Chilled margins in all cases mark the contacts of the younger against the older intrusions, except where the xenolithic portion of the north–south dyke is in contact with the porphyritic dyke. The contact at this point is seen as a sharp wavy line along which the north–south dyke is apparently unchilled.

The north–south dyke only contains xenoliths north of where it crosses the porphyritic dyke. The xenoliths appear in profusion just where the chilled margin of the north–south dyke against the porphyritic dyke gives place to the unchilled margin. They are equally abundant throughout the northern portion of the dyke, and occur even on the chilled margins. They are angular masses or fragments, usually narrow in comparison with their length which ranges up to 3 ft. Petrologically the xenoliths, though porphyritic (S21834) [NM 4614 6228], do not closely resemble the material of the porphyritic dyke pM (S21832) [NM 4614 6228]. On the other hand, apart from their conspicuous felspar phenocrysts, they are quartz-dolerite of Talaidh type similar to the enclosing matrix. This matrix seems to be continuous with the dyke M (S21833) [NM 4614 6228].

The xenoliths, notwithstanding their slight marginal corrosion, would seem from their arrangement to have originally fitted into one another. It is not unlikely that they originally constituted a dyke which failed to extend across the porphyritic dyke (pM) and which was subsequently brecciated and injected by the nonporphyritic magma (M) intruded along the same line of fissure, with little displacement of the brecciated material. No definite reason can, however, be advanced for the curiously local, unchilled contact of xM with pM.

Porphyritic xenoliths similar to those found in the xenolithic dyke above described have been noted in a cone-sheet about 150 yds. west of the xenolithic dyke. The occurrence suggests that there are cone-sheets of the same age as the xenolithic dyke, especially since the Talaidh type of quartz-dolerite, typical of the cone-sheets generally, is the rock-type of which the xenolithic dyke is composed.

It is, indeed, not improbable that many at least of the basic dykes of types similar to the Outer Cone-sheets were injected during this cone-sheet period, even in cases where they are seen to cut adjacent cone-sheets. A later date may, however, be assigned to a number of dykes composed of olivine-dolerite that traverse the Outer Cone-sheet Complex and are sometimes traceable for considerable distances.

The age relations between such comparatively late dykes traversing the cone-sheet area that surrounds the plutonic complex and the plutonic rocks themselves can rarely be determined. An instance is supplied by a north-west olivine-dolerite dyke, 24 ft. in width, which cuts the cone-sheet complex on the lower, western slopes of Glas Bheinn

north of Kilchoan. The dyke has been traced close up to the margin of the Hypersthene-gabbro Ring-dyke (a), but does not penetrate the gabbro. Close to the gabbro the dyke is cut by acid veins such as are often seen to traverse the country rocks along the gabbro margin. The dyke itself is slightly contact altered as shown by a development of biotite in connexion with decomposed olivine (S21431) [NM 485 644]. This dyke is therefore considered to be earlier than the Hypersthene-gabbro.

Comparatively few dykes cut the ring-dykes themselves. The sparseness of such dykes in the western part of the Ardnamurchan peninsula is especially marked. Since this area lies directly astride the course of the Mull Swarm, it would seem as if the great majority of the dykes of this swarm must be earlier than the Ardnamurchan ring-dykes. On the other hand, failure of dykes to penetrate the plutonic masses does not necessarily imply that these masses are of later date. Suggestive evidence is afforded by certain dykes that are intruded along crush-lines in the country rocks bordering the plutonics. For example, midway between Sròn Bheag and Beinn nan Codhan, two crush-lines marked by stream-hollows are followed by dykes of olivine-dolerite. The crush-lines, but not the dykes, extend northwards to traverse the adjoining ring-dyke complex of Centre 2. It would seem as if the supply of magma available for dyke-intrusion was in some way cut off near to the margin of the ring-dyke complex. In this connexion it is perhaps noteworthy that the numerous crush-lines traversing the ring-dykes are in no known instance accompanied by dyke-intrusion. J.E.R.

Petrology

Although the majority of the dykes that occur within the Ardnamurchan peninsula are of generally basic character, there is considerable variation both in texture and composition, while intermediate and acid types are by no means rare. It is noteworthy that dykes of plateau-basalt composition, although well represented among the north-westerly directed examples, are not so prevalent as might be expected, and that the greater number of the basic dykes appear to have a quartz-dolerite or tholeiitic composition. For purposes of description the various dykes will be considered under the following headings, and reference will be made where possible to the extension in time of each class: Plateau Basalt Type, Porphyritic Central Type, Tholeiites and Quartz-dolerites, Intermediate and Sub-acid Dykes, Acid Dykes, and Composite Dykes:

Dykes of Plateau Basalt type

As in Mull and other parts of the Tertiary Province there are a number of dykes that are directly comparable with the Plateau Basalt Lavas both as regards texture and composition, and are best described as being of Plateau Basalt Type. They are moderately fine-grained non-porphyritic, dark-grey to black crystalline rocks, characterized by fairly abundant olivine, an ophitic lilac-tinted titaniferous augite, lath-shaped zoned labradorite felspar of normal composition, fairly abundant titanomagnetite and apatite, and a variable amount of base that may be either glassy or analcitic. They are of all ages, and point to the availability of the normal plateau basalt magma at all stages of the igneous activity. One of these dykes (S21473) [NM 4730 6863] in Ardnamurchan is of the latest demonstrable age, for it cuts the Tonalite of Centre 3. In composition it approaches the crinanites or analcite-dolerites, as it contains a fair amount of analcite in its base, together with many small flakes of deep-brown biotite. Where this alkaline mesostasis is brought into contact with the normal augite the pyroxene is edged with green aegirine-augite.

A 60 ft. dyke of similar type (S24475) [NM 5682 6251] cuts the basalt lavas of Ardslignish, It is rich in fresh olivine and titaniferous augite, and has a little biotite developed in association with both olivine and iron-ore; apart from the fact that it is later than the plateau basalts there is no further evidence of its age.

A group of north-westerly dykes that cut the agglomerates and associated rocks in the neighbourhood of Rudha Carrach on the north coast are typical olivine-dolerites of plateau type (S22424) [NM 4610 7078], with fresh olivine and ophitic highly coloured titaniferous augite. On the other side of the peninsula similar north-west dykes cut the older rocks in the neighbourhood of Kilchoan (S21842) [NM 4767 6337].

A dyke of ophitic dolerite 36 ft. in thickness which cuts the older Mesozoic sediments on the west side of Kilchoan Bay is interesting on account of its local pegmatitic development and geodal character. The rock (S22425) [NM 4721 6297] consists of large ophitic augites, pseudomorphs after olivine, and large leucoxenic crystals of ilmenite associated with

felspars that show both albitization and silicification. The main peculiarity of the rock is the occurrence of large amygdaloidal patches and streaks of fine-grained acid material. The amygdaloids are occupied at their centres by highly birefringent colourless prehnite and lined with a mosaic of small interlocking crystals of albite-perthite ((Figure 52) B, p. 354). The prehnite of the central infilling carries near its outer boundary an abundance of small idiomorphic colourless garnets that measure up to 0.2 mm. in diameter, but are usually smaller. The rock is chloritized, and within the chlorite as well as in the serpentine-pseudomorphs occur strings of minute badly-formed garnets of pale pinkish-brown colour, as well as bunches of acicular actinolite. Garnet, however, is more particularly abundant in association with the prehnite. These patches within the dolerite recall the garnetiferous amygdales contained in some of the Mull lavas, for which a metamorphic origin has been claimed. It was found in Mull that the association of prehnite and garnet was consequent on the metamorphism of scolesite, etc., that frequently formed normal amygdaloidal infillings. As the doleritic portion of this dyke is in an unmetamorphosed condition, we must regard the peculiar mineral assemblage as belonging to the pegmatitic facies of the dyke.

Dykes of Porphyritic Central type

A group of conspicuously porphyritic basic dykes (lettered fM on (Figure 50)), sparsely distributed, appears to be an early phase of dyke-intrusion in Ardnamurchan, as many examples are cut by the Outer Cone-sheets of Centre 2.

In general type these rocks are similar to those met with as blocks in the agglomerates, and as intrusions, in the Ben Hiant vent. They are linked together by the common feature of an abundance of porphyritic basic plagioclase felspar, individual crystals ranging from a few millimetres to 4 or 5 inches in length. These felspars show some range in composition although they seldom exhibit strong zoning; generally they consist of a basic labradorite or bytownite with a thin outer layer of oligoclase (S21433) [NM 4659 6395], but are often extensively albitized (S22426) [NM 4709 7093]. The very large felspars from a somewhat narrow big-felspar basalt dyke exposed on the shore south of Kilchoan, 200 yds. east of Mingary Pier, proved to be a labradorite of more or less normal composition. They had a specific gravity of 2.71, were optically positive, and by the immersion method gave α=1.557 and γ=1–565. Such values suggest a composition of approximately $Ab_{43}An_{57}$, a composition quite commonly assumed by porphyritic plagioclase in rocks of basaltic nature.

Both olivine and augite (S24406) [NM 4750 7107] may occur as subordinate and relatively insignificant porphyritic individuals, but generally they are confined to the matrix. Olivine is seldom encountered in a fresh condition, and the augite, unlike that of the plateau basalts and dykes of plateau type, is a yellowish to greenish-brown variety. The matrix is somewhat variable in character. In some dykes it is basaltic with narrow laths of felspar, hypidiomorphic to granular augite, and fairly abundant magnetite (S21832) [NM 4614 6228]. In other examples, the matrix has the character of the olivine-tholeiites. It then consists of fairly abundant small olivines, lath-shaped felspar, and an augite that exhibits an ophitic structure frequently associated with a stellate grouping of the felspar-laths (S21433) [NM 4659 6395], (S22426) [NM 4709 7093].

On account of their age many of these dykes show the effect of thermal alteration, which usually takes the form of conversion of augite into uralitic hornblende and the development of minute scales of deep-brown biotite throughout the rock (S22235) [NM 4915 6268].

Tholeiite and quartz-dolerite dykes

A considerable number of the north-westerly dykes, as well as the majority of those which depart from the normal direction, are dolerites of somewhat different type to those which have a plateau basalt composition. They differ primarily in the colour of their augite, but they also develop an acid mesostasis of variable amount, and pass by insensible gradations through various types of quartz-dolerites and tholeiites. The change in composition is generally accompanied by a change in the type of crystallization. There is a gradual suppression of the coarse ophitic structure of the dolerites in favour of a more localized separation of augite, and a tendency for this mineral to assume a columnar habit The dominant types represented among these dykes appear to be olivine-bearing quartz-dolerites, and tholeiites of Salen and Talaidh types.<ref>H. H. Thomas and E. B. Bailey *in* Tertiary Mull Memoir, 1924, p. 370.</ref>

Of the more definitely doleritic and ophitic types some are of cluite late intrusion, and cut members of the ring-dyke complex (S22427) [NM 4687 6766], (S22428) [NM 4586 6772]. They have, however, an east and west, or west-northwesterly trend. They are dolerites with a tholeiitic type of crystallization, but are frequently much albitized and chloritized.

Olivine-bearing quartz-dolerites, comparable in type to those forming the Ben Hiant intrusion (p. 169), occur as dykes in the south and south-east of the peninsula. Many are of fairly early date, being cut by cone-sheets, and mainly of north-westerly direction (S21431) [NM 485 644], (S21432) [NM 5265 6479]. Olivine was present as a porphyritic constituent, and the matrix is either doleritic or tholeiitic with the inclusion of some acid mesostasis. A dyke that cuts the craignurite sill of Mingary Castle is an olivine-bearing rock (S22423) [NM 5104 6317], not quite so like the Ben Hiant type as some of the others, but obviously belonging to the same type of magma.

Closely related are the tholeiites of Salen type with their fairly prevalent olivine. One such dyke (S22297) [NM 5311 6279], 10 ft. in width, and with a well-developed platy structure cuts the Ben Hiant intrusion in a north-westerly direction. This type is also represented amongst the early cone-sheets (S24396) [NM 5017 6627].

The Talaidh type of tholeiite, so prevalent as cone-sheets, is also responsible for many dykes. One of these (S21833) [NM 4614 6228], with a north and south direction, occurs on the shore west of Sran Bheag (Figure 51). It contains the usual columnar augite with salitic striations, and albitized felspar, and has a tendency towards a stellate grouping of its primary constituents. Cognate xenoliths carried by this dyke are of a more basic variety of the same rock-type, but distinguished by the presence of felspar phenocrysts (S21834) [NM 4614 6228]. Another dyke (S21810) [NM 4706 6762] with an east-north-east direction and cutting the Quartzbiotite-gabbro of Centre 3, to the north of Sìthean Mòr, is of the same class.

Certain sub-variolitic dykes may be considered here. They are generally thin and may depart from the general north-westerly direction. A 2-ft. dyke on the shore 650 yds. north-west of Faskadale (S24015) [NM 4956 7119] has a north-easterly trend, and exhibits characters that recall the variolitic types of Ben Hiant, and also those of Ben Talaidh in Mull. Related types reminiscent of the variolitic rocks of Ben Hiant have also been encountered to the south-east (S21841) [NM 4774 6338].

Intermediate and sub-acid dykes

Intermediate and sub-acid types in Mull were most freely represented amongst the sills and composite intrusions, but formed only a small proportion of the dykes, and the same is true for. Ardnamurchan. In Mull the types most frequently represented were leidleites and inninmorites.<ref>H. H. Thomas and E. B. Bailey *in* Tertiary Mull Memoir, 1924, pp. 373–374</ref>

A dyke that occurs 200 yds. to the south-east of Beinn Bhuidhe, a mile northwards of Ardslignish farm and beyond the east margin of the Memoir-map (S24473) [NM 5704 6301], (S24474) [NM 5704 6301], is interesting on account of its being a typical mugearite, and the only example noted in Ardnamurchan. The dyke has a good platy jointing parallel to its margins near its edges, but a transverse structure in its interior. Microscopic sections show that this structure is determined in both cases by the parallel orientation of thin felspar plates which in cross section look like microlites, and also of minute scales of biotite. Sections transverse to the platy structure (S24474) [NM 5704 6301], (S24473A) [NM 5704 6301] show a fluxionally arranged mass of oligoclase felspars with rectangular cross section and length many times their thickness, granules of augite, and abundant finely distributed magnetite. In sections parallel to the platy structure (S24473) [NM 5704 6301] all traces of fluxion is lost and the felspars appear as small, more or less equi-dimensional crystals (0.05 mm.) with an approach to rectangular outline. In these sections, also, biotite is easily visible as small hexagonal plates, which, owing to their extreme thinness, are not easily detected in sections cut across the foliation.

A very beautiful black glassy pitchstone forms a 4-ft. dyke on the shore west of Ardslignish (S24472) [NM 5605 6101], (Figure 52) A). It carries small glomero-porphyritic groups of labradorite and moderately pleochroic hypersthene, the felspar being much twinned and but little zoned. Hypersthene and augite also occur as small idiomorphic crystals. Isolated porphyritic crystals of plagioclase have an intensely honeycombed structure that recalls the felspars of the Sgùrr

of Eigg and other pitchstones from the Small Isles. The ground-mass is a partly devitrified colourless glass rendered almost opaque by a close network of skeletal growths of pyroxene, forming an interlacing rectangular pattern, and plates and minute octahedra of magnetite. A few apatites occur and the rock is minutely vesicular — the vesicles being filled with a highly birefringent chlorite. There is little doubt that this rock is related to the inninmorites of Mull and the pitchstone lavas of Ben Hiant, but a rhombic pyroxene has more or less replaced the usual enstatite-augite of these types; a rhombic pyroxene, however, was an occasional constituent of the Ben Hiant lavas (p. 139).

Dykes referable to the stony devitrified variety of leidleite are represented by certain non-porphyritic fine-textured rocks. The coarser of these (S22429) [NM 5088 6599] are composed of narrow laths of oligoclase-andesine felspar, elongated small crystals of augite with here and there a cervicorn habit, and abundant plates and adherent octahedra of magnetite. Some even finer-grained rocks (S22324) [NM 4539 6653], in which the augite is less definitely prismatic, must be referred to the same type. Hybrid rocks are, as a rule, rare in the dyke-form, but a dyke that appears hybrid in nature occurs on the shore of Sanna Bay and cuts the Great Eucrite (E). It has a granophyric base of perthitic orthoclase and quartz, but appears to contain xenocrystal material in the form of relatively large individuals of resorbed or albitized labradorite, and granules and imperfect crystals of brownish augite. There has been a development of biotite, now chloritized, and a crystallization of oligoclase as narrow individuals that carry perthitic fringes. The rock appears to be a basified granophyre.

Acid dykes

Acid dykes are sporadically developed over the Ardnamurchan area. They vary in composition, follow various directions, and do not lend themselves to any satisfactory grouping. Individual dykes of quartz-porphyry, for example (lettered qF on (Figure 50)), are met with which run north-west, north-north-east, and east-north-east. Many of them are of late date, since they cut members of the ring-dyke complexes. Others of bostonitic or trachytic nature are probably of early date and related to the main vent-period.

Dykes of acid pitchstone and spherulitic felsite (lettered sF on (Figure 50)) are fairly numerous. One of the best examples is a 5-ft. north-west dyke of glassy pitchstone (obsidian) exposed on the western shore of Kilchoan Bay, and which has been traced for more than a mile inland where it is seen to cut the Hypersthene-gabbro Ring-dyke (a) On the shore it is mainly a beautifully banded spherulitic glass, with glassy margins from which spherulites are wanting.

Of the early dykes, a fine-textured microporphyritic rock is referable to the trachytes (S26675) [NM 5458 6404], and is similar in many respects to the trachyte that occurs as blocks in the vent-agglomerates (p. 133). It has suffered some silicification so that the original nature of its phenocrysts cannot be determined, and a good deal of microscopic quartz has developed in the ground-mass. The bulk of the rock, however, is a plexus of microlithic alkali-felspar crystals that occasionally embrace small idiomorphic pseudomorphs after augite. Another dyke cut by the Outer Cone-sheets of Centre 2, 7 ft. in width, occurs 300 yds. south-west of the Landing Jetty, Kilchoan Bay, and is a moderately coarse-textured bostonite (S21839) [NM 4777 6339]. It is composed of an interlocking network of elongated crystals of turbid alkali-felspar that, for the most part, appears to be an albite-perthite. A feature of the rock is its extraordinary richness in apatite, which, as slender needles, penetrates the felspars in all directions. It contains a moderate amount of iron-ore and a little interstitial chlorite.

Of the quartz-porphyry dykes, one cutting the Glendrian Fluxion Gabbro occurs 500 yds. north-east of Achnaha (S21523) [NM 4661 6854]. It is a pale rock in which the porphyritic individuals reach a millimetre or so in diameter. These consist mainly of quartz, but perthitic orthoclase is also represented. The matrix is a devitrified glass, now intensely turbid, but showing signs of having an originally perlitic structure. A somewhat similar acid dyke 400 yds. to the south-east of Achnaha is devoid of phenocrysts, and is best described as a devitrified felsite (S21525) [NM 4573 6783].

One of the spherulitic pitchstones of acid composition, from the west shore of Kilchoan Bay is a 5-ft. dyke (S21457) [NM 4675 6316]. It contains perthite phenocrysts in a yellowish-brown glassy matrix that has devitrified locally with the formation of spherulites of considerable size. The spherulites are arranged in coalescing groups and strings, and are composed of alkali-felspar–both spherulites and glassy base having a refractive index lower than that of canada balsam.

Another pitchstone on the eastern shore of Camas nan Geall west of Ardslignish is remarkable in containing small phenocrysts of biotite as the only porphyritic constituent. The ground-mass is a colourless glass crowded with tufts and radiating crystallites of alkali-felspar, and rendered turbid by finely divided iron-ore.

A few dykes are difficult to place under any known heading. These are keratophyric in character, but cannot be said to constitute a type. One such dyke (S21848) [NM 5130 6824], cutting members of the ring-dyke complex, is a fine-textured rock carrying small porphyritic individuals of albite-oligoclase. The matrix is a plexus of ill-formed laths of the same felspar with finely divided iron-ore and interstitial carbonates and chlorite. There appear to be small pseudomorphs in calcite after augite. H.H.T.

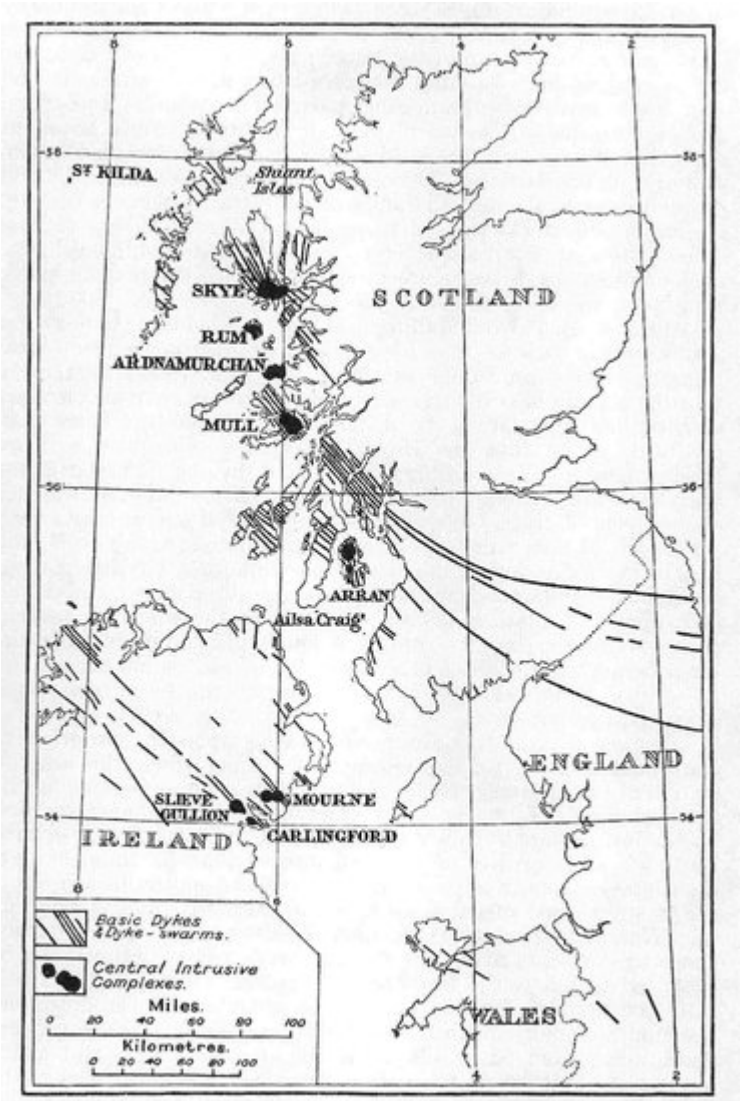

FIG. 4.—*Map showing distribution of Tertiary north-west basic dykes in relation to Tertiary central intrusive complexes of the British Isles.*
NOTE: number of dykes is greatly reduced.

(Figure 4) Map showing distribution of Tertiary north-west basic dykes in relation to Tertiary central intrusive complexes of the British Isles. Note: number of dykes is greatly reduced.

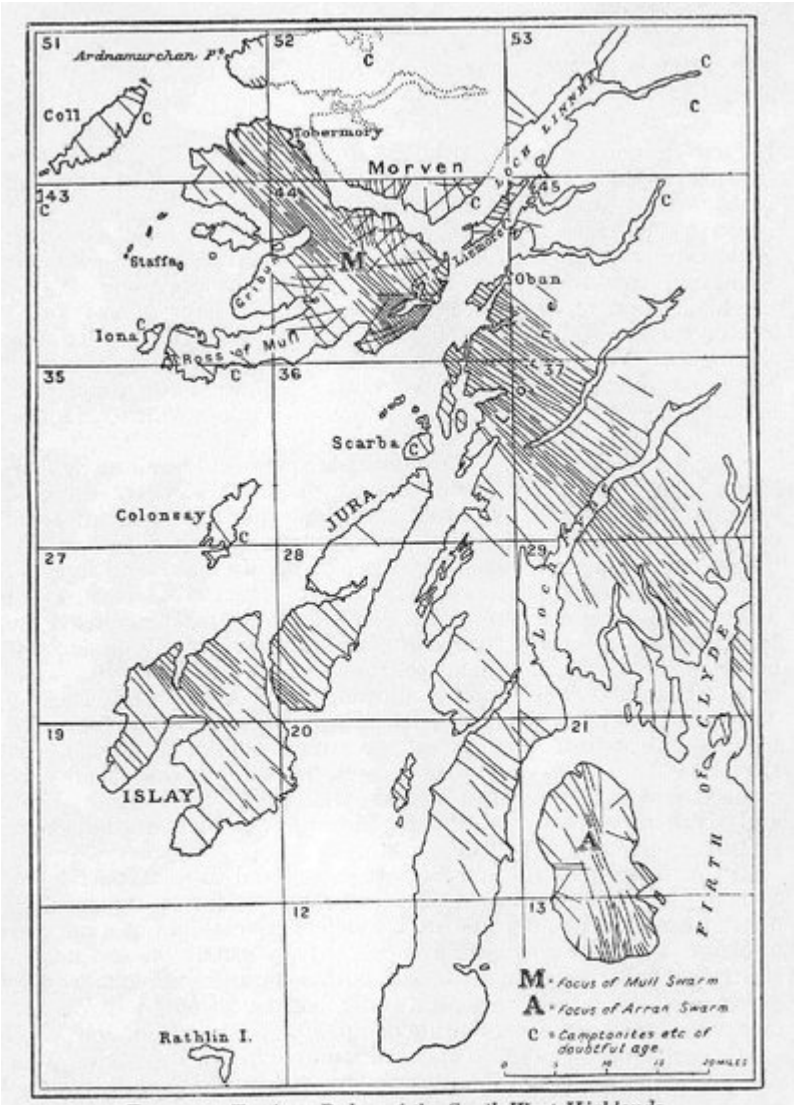

FIG. 49.—*Tertiary Dykes of the South-West Highlands.*
Only about one dyke in every ten or fifteen in shown.
Quoted from 'Tertiary Mull Memoir,' 1924, *Fig.* 60, *p.* 357.

(Figure 49) Tertiary Dykes of the South-West Highlands. Only about one dyke in every ten or fifteen in shown. Quoted from Tertiary Mull Memoir, 1924, (Figure 60), p357.

TABLE VIII

DATA CONCERNING MULL DYKE-SWARM

Locality.	Breadth of Swarm or Portion of Swarm Examined.	Number of Dykes.	Total Aggregate Thickness of Dykes.	Average Individual Thickness.	Average Number per mile.	Average Aggregate Thickness per mile.	Amount of Crustal Stretch due to Dyke-Intrusion.
S.-Central * Mull.	12½ mls.	375	2504 ft.	5·8 ft.	30	200 ft.	1 in 25
N.-Central * Mull.	1¼ mls.	142	817 ft.	5·8 ft.	114	654 ft.	1 in 8
North-west Mull.	5 mls.	62	480 ft.	7·7 ft.	12	96 ft.	1 in 55
South-west Ardnamurchan.	1½ mls.	36	272 ft.	7·5 ft.	24	180 ft.	1 in 30

* Data from 'Tertiary Mull Memoir,' p. 360.

(Table 8) Data concerning Mull Dyke-swarm.

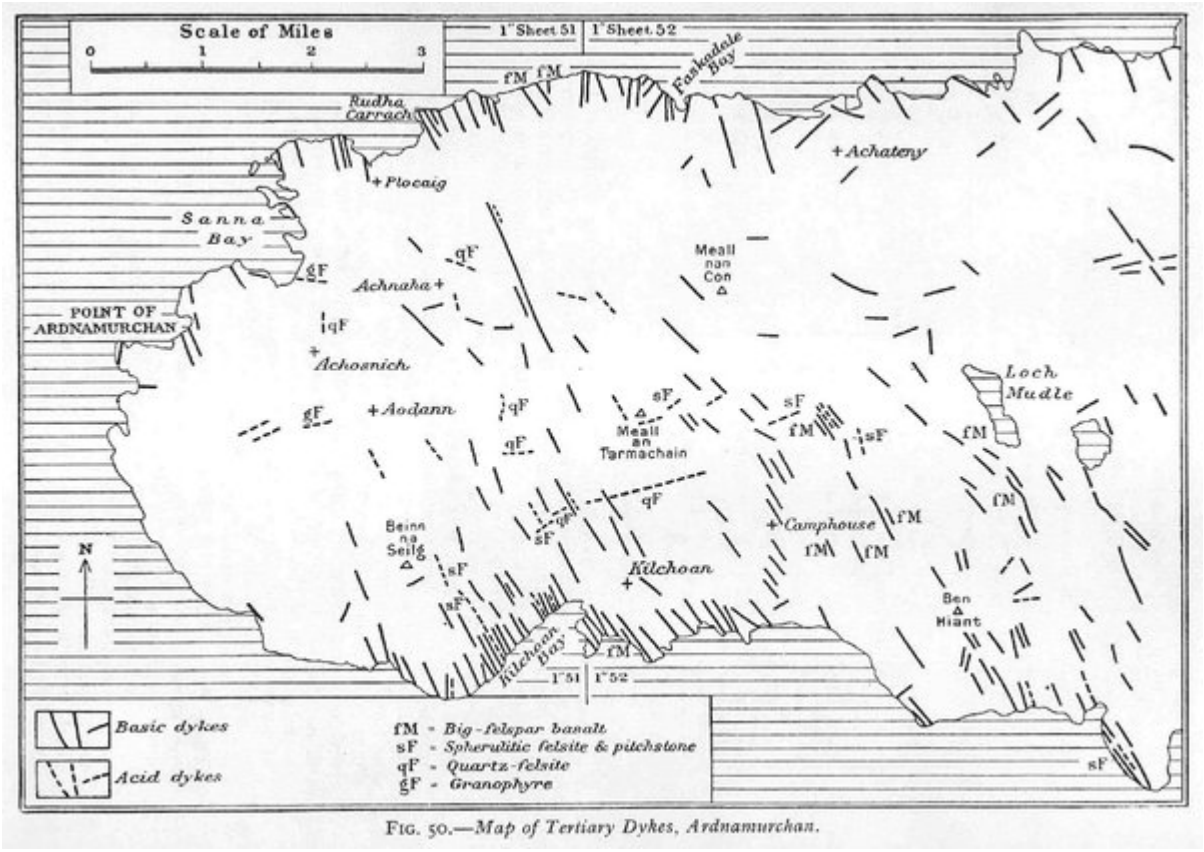

FIG. 50.—*Map of Tertiary Dykes, Ardnamurchan.*

(Figure 50) Map of Tertiary Dykes, Ardnamurchan.

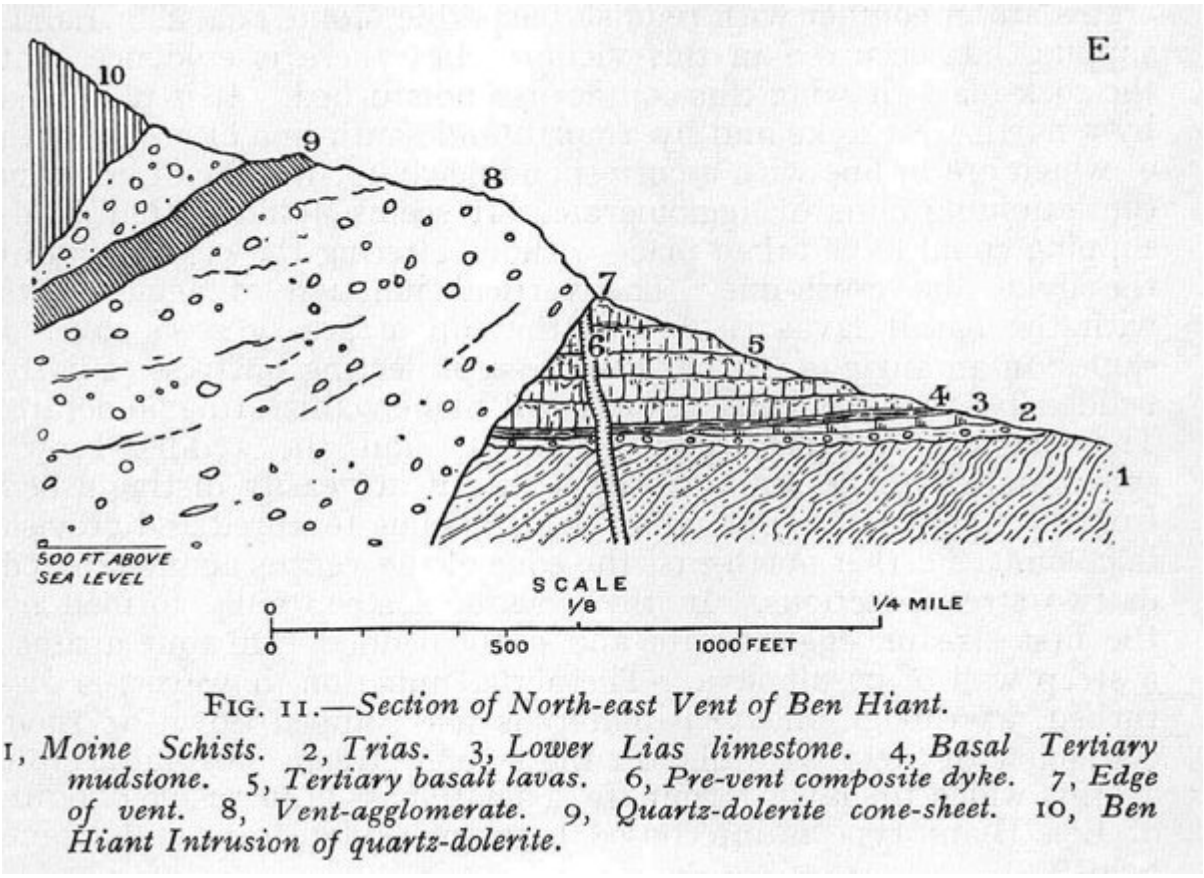

FIG. 11.—*Section of North-east Vent of Ben Hiant.*

1, Moine Schists. 2, Trias. 3, Lower Lias limestone. 4, Basal Tertiary mudstone. 5, Tertiary basalt lavas. 6, Pre-vent composite dyke. 7, Edge of vent. 8, Vent-agglomerate. 9, Quartz-dolerite cone-sheet. 10, Ben Hiant Intrusion of quartz-dolerite.

(Figure 11) Section of North-east Vent of Ben Hiant.1, Moine Schists. 2, Trims. 3, Lower Lias limestone. 4, Basal Tertiary mudstone. 5, Tertiary basalt lavas. 6, Pre-vent composite dyke. 7, Edge of vent. 8, Vent-agglomerate. 9, Quartz-dolerite cone-sheet. 10, Ben Hiant Intrusion of quartz-dolerite.

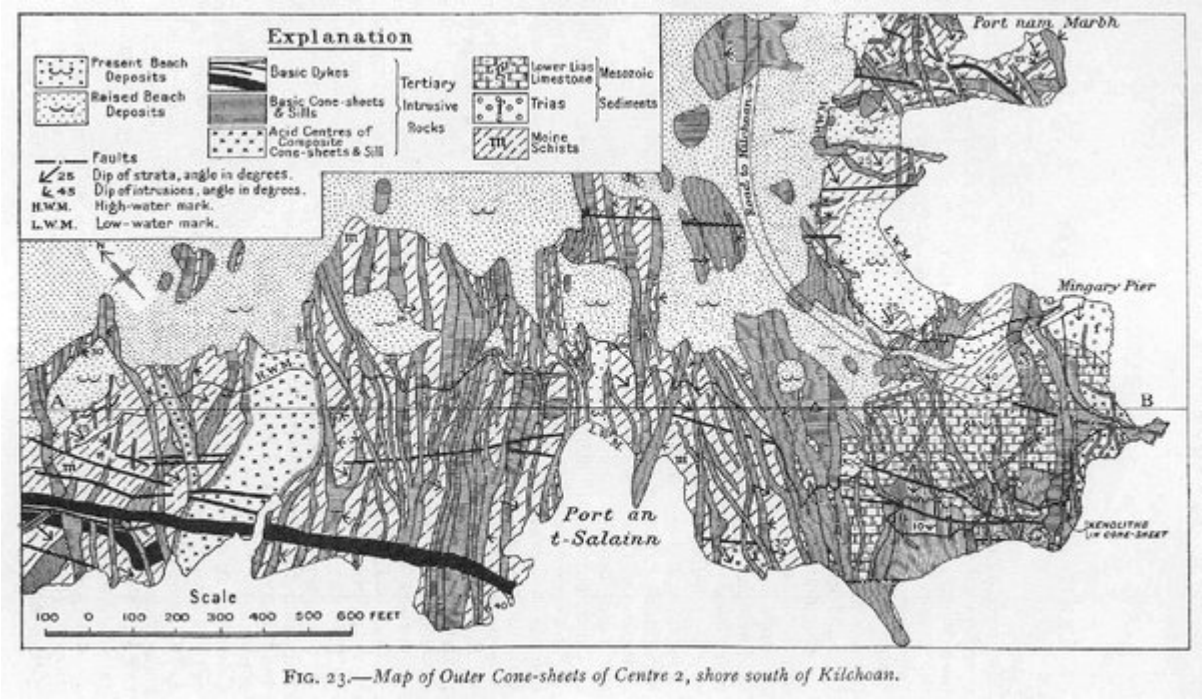

FIG. 23.—*Map of Outer Cone-sheets of Centre 2, shore south of Kilchoan.*

(Figure 23) Map of Outer Cone-sheets of Centre 2, shore south of Kilchoan.

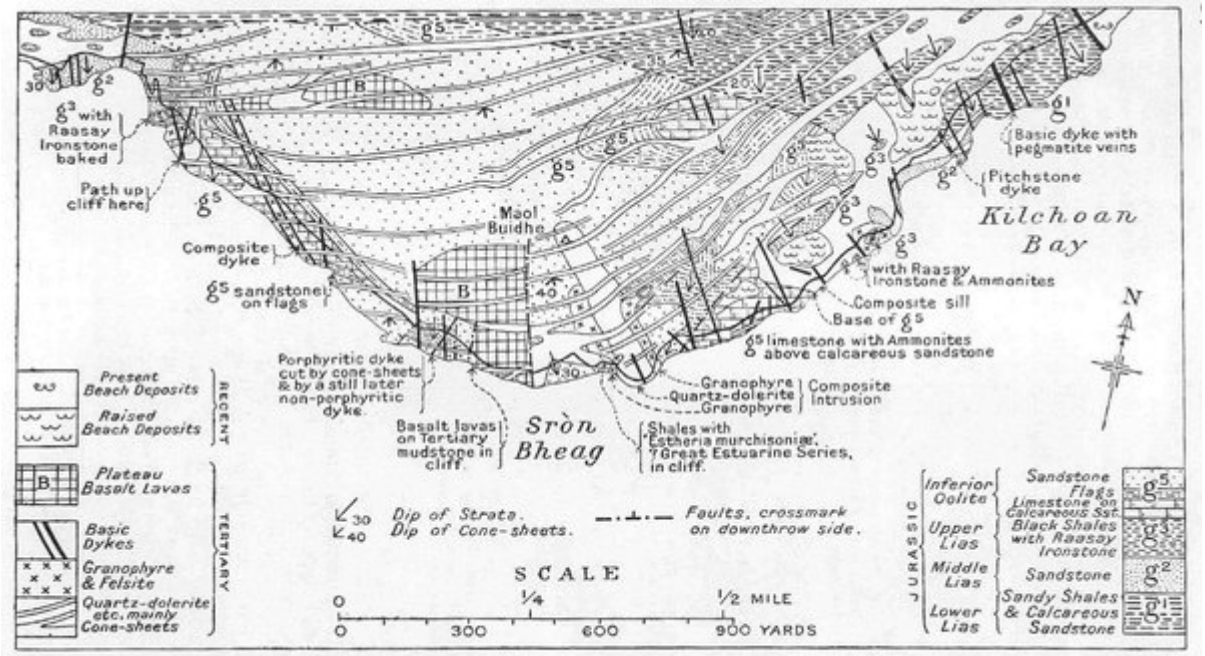

FIG. 3.—*Map of Mesozoic strata and Tertiary basalt lavas cut by Tertiary minor intrusions, west of Kilchoan Bay.*
NOTE.—Tertiary cone-sheets are mainly represented diagrammatically.

(Figure 3) Map of Mesozoic strata and Tertiary basalt lavas cut by Tertiary minor intrusions, west of Kilchoan Bay. Note. Tertiary cone-sheets are mainly represented diagrammatically.

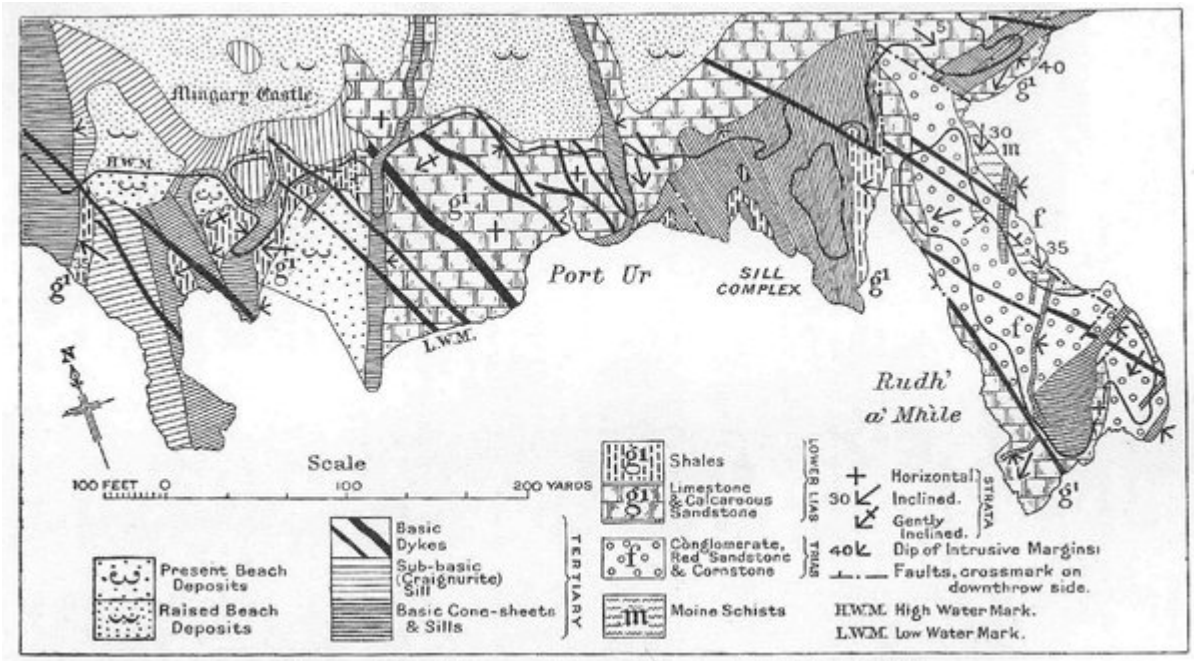

FIG. 25.—*Map of shore near Mingary Castle, east-south-east of Kilchoan.*

(Figure 25) Map of shore near Mingary Castle, east-south-east of Kilchoan.

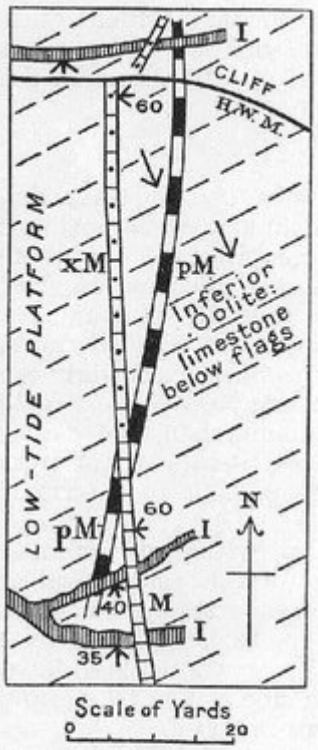

FIG. 51.—*Map showing relations of dykes and cone-sheets, on shore west of Sròn Bheag.*

pM, *4-ft. porphyritic basalt dyke.* I, *cone-sheets of quartz-dolerite (Talaidh type).* M, *5-ft. non-porphyritic dyke of quartz-dolerite (Talaidh type).* xM, *xenolithic portion of* M. H.W.M., *high-water mark.*

(Figure 51) Map showing relations of dykes and cone-sheets, on shore west of Sròn Bheag. pM, 4-ft. porphyritic basalt dyke. I, cone-sheets of quartz-dolerite (Talaidh type). M, 5-ft. Non-porphyritic dyke of quartz-dolerite (Talaidh type). xM, xenolithic portion of M. H.W.M., high-water mark.

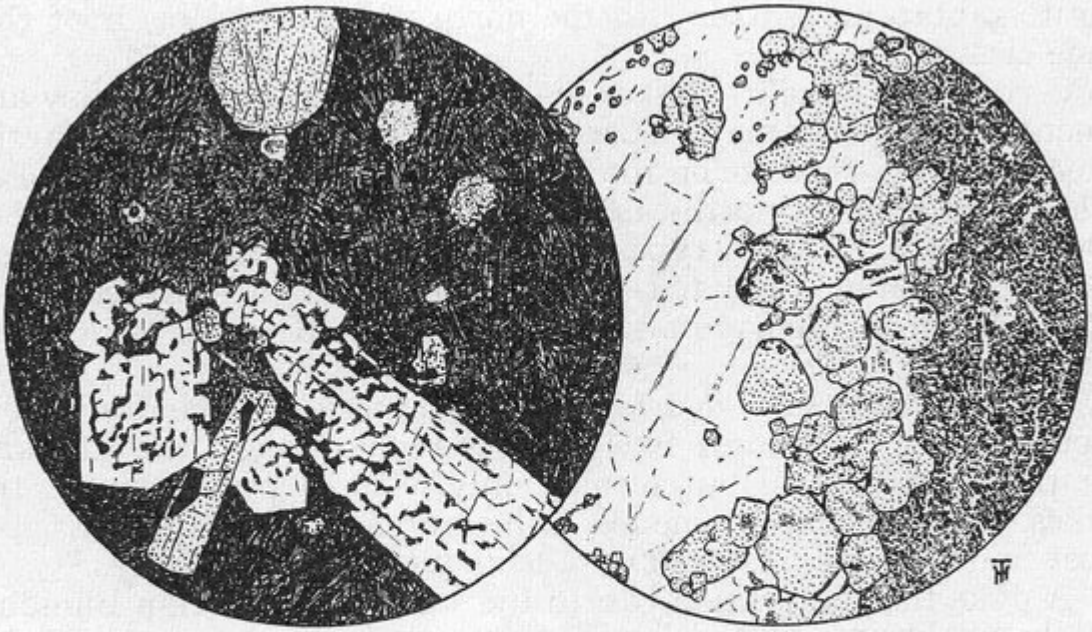

FIG. 52.—*Dyke Rocks.*

A. (24472) × 20. *Pitchstone with porphyritic felspars and pyroxene in a glassy base rendered almost opaque by skeletal growths of magnetite. The porphyritic felspars exhibit a highly characteristic spongy development and are penetrated by the ground-mass.*

B. (22425) × 63. *Amygdale from dolerite dyke showing zone of small idiomorphic garnets between turbid perthite and colourless prehnite.*

(Figure 52) Dyke rocks. A. (S24472) [NM 5605 6101] × 20. Pitchstone with porphyritic felspars and pyroxene in a glassy base rendered almost opaque by skeletal growths of magnetite. The porphyritic felspars exhibit a highly characteristic spongy development and are penetrated by the ground-mass. B. (S22425) [NM 4721 6297] × 63. Amygdale from dolerite dyke showing zone of small idiomorphic garnets between turbid perthite and colourless prehnite.