Chapter 10 Tertiary basalt lavas, North-West Mull and Ardnamurchan

The basalt lavas described in the present chapter form a portion, or a continuation, of the Plateau Group of Mull.<ref>E. B. Bailey, in Tertiary Mull Memoir, 1924, chap. v. and pl. iii.</ref> In the case of Mull the area considered falls within Sheet 51, while in Ardnamurchan a portion of Sheet 52 is also included (*see* Memoir-map). Pitchstone lavas, later than the Plateau Group, are found within the Ardnamurchan vents, and their description is reserved for the next chapter.

Over 1000 ft. of lavas are preserved, and most of the flows are olivine-rich basalts without porphyritic felspar — the Plateau Types of Mull. Olivine-poor basalts, of Mull Central Types, with or without porphyritic felspar, occur only as subordinate intercalations. Mugearite and mugearitic basalt are also present.

No evidence has been found to decide whether the Ardnamurchan centre, with its numerous vents and intrusions, functioned during the outpouring of the Plateau Group. The first volcanic event seems to have been the explosion, or series of explosions, that provided material for the widespread basal mudstone described in the previous chapter. The source of these explosions has not been located. The lavas that followed are free from ash intercalations. They may have been poured out from central craters or from fissures. There are many dykes, especially in Mull; but in the latter locality, at any rate, the dykes form part of a swarm that is grouped with reference to an already established focus. They therefore afford no suggestion of fissure eruptions of earlier date than the focus.

As has been known for a long time, the eruptions were subaerial. There are no intercalated water-borne sediments except a few volcanic clays or muds that have been derived from weathering of the lavas, while contemporaneous weathering, resulting in the formation of red clay or bole, is repeatedly observed. This shows that individual flows were often exposed subaerially for a considerable time before being covered up by subsequent lavas. A bole may be resorted by water and penetrate down as veinlets into an underlying slaggy lava-top.

Terrace or trap featuring characterizes North-west Mull and the lava outliers east of Ben Hiant in Ardnamurchan, especially the Ardslignish outlier east of the Loch Mudle Fault. It is due to the general tendency of individual lavas to have solid interiors and slaggy surfaces, more particularly upper surfaces. The lava sequence thus consists of interbanded solid and slag. Rapid waste of each layer of slag leads to undermining of superincumbent solid basalt, and to the consequent formation of an escarpment. On the Mull coast, cliff-sections afford excellent views of lava-flows piled flatly one upon another. At intervals, stream-gullies allow a closer examination showing individual flows with slaggy or amygdaloidal upper portions, more solid interiors, and, sometimes, slaggy bases.

Where trap featuring prevails, the more solid portions of the lavas often retain their olivine in a fresh condition, and they also are apt to weather to a rusty loam, in some cases spheroidally. Another fairly common feature is the development of a pimply surface as a result of weathering.

In the Ardnamurchan outliers north-west of Ben Hiant, trap features are not developed, and olivine is decomposed. These outcrops have been broken by explosions or pierced by intrusions and can scarcely be expected to develop a regular type of scenery. Moreover, they show alteration of their material, partly due to steam and other gases (pneumatolysis) and partly to dry heating. Pneumatolysis has affected to a greater or less degree the lavas in contact with almost all the Ardnamurchan vents excepting those of Ben Hiant, while the rocks actually within the vents are also often altered, and have developed epidote. This alteration is ascribed to vapours derived from the acid magma responsible for the vent explosions. On the other hand, intense contact alteration, accompanied by dehydration, is found in the vicinity of the great gabbro intrusions of Ardnamurchan.

Other points of interest, mentioned in the local descriptions that follow, include: an unconformable contact with an underlying sandstone at Bloody Bay in Mull; segregation veins both in the Mull and Ardslignish outcrops; and an occurrence of pipe amygdales at Ben Hiant.

North-West Mull <ref>This account is rewritten from the description by J. E. Richey, G. V. Wilson, and G. A. Burnett in Tertiary Mull Memoir, 1924, chap. vii.</ref>

A typical development of the Plateau Group occupies the northwestern corner of Mull. Most of the lavas are olivine-rich basalts with fresh olivine and no porphyritic felspar. They generally show a rude approximation to columnar structure; but, in Beinn Bhuidhe, platy jointing is common, and is probably to be correlated with a somewhat mugearitic composition. An individual flow with sparse felspar phenocrysts forms a conspicuous scarp above the Dervaig-Salen road, 2½ miles south-east from Dervaig. Along with a few other examples it shows an approach to the Porphyritic Central Type of Mull. Another exceptional lava (S20949) [NM 383 499] reproduces the compact Non-porphyritic Central Type of Mull. It overlies a bright red bole, or irony clay, 12 ft. in thickness, which renders the exposure conspicuous in the field, though not easy to locate on the map. The following directions may help. Two streams are shown on Sheet 51 between Beinn Bhuidhe and Cam Mr, and the more westerly, 700 yds. north of the map margin, is joined on the west by a tributary (omitted on the one-inch Map). The bole and overlying compact lava occur in a little gorge 300 yds. up this tributary.

On examination, the lower portion of the bole is seen to consist of lava rotted *in situ.*

Lava tops, reddened by contemporaneous weathering, are common in the district. A good succession is seen in a ravined coastal cliff, north of the 200 ft. hill that stands east of Treshnish Point. Other good examples occur in the cliff above the road to Calgary pier, between the plantation and the stream that are shown on the one-inch Map. Another is afforded at the base of Dun Leathan on the coast of Quinish.

Trap or terrace featuring is very general in this lava country, and is well illustrated along the zig-zag road that leads from Dervaig eastwards towards Tobermory. It is due, as already explained, to differential weathering of solid and slag.

The district is scenically divided into two parts by the hollow of Loch a' Chumhainn, on which Dervaig is situated. It can be seen on the one-inch Map that south-west of this line the trap featuring of the lavas is irregular in plan; while north-eastwards it is conspicuously lineated in a north-west and south-east direction. The difference is due to the fact that, north-east of Loch a' Chumhainn, the lavas lie in the course of the great Mull swarm of northwest dykes, and that many of these latter have served as guides to erosion (*see* p. 344).

Only at one place, discovered by the late Prof. Judd, is the base of the lava series exposed. This locality occurs in the cliffs of Bloody Bay, at the eastern margin of the map, 500 yds. east-south-east of Ardmore farm (*see* p. 49). The best exposure is in an old quarry in the cliff face (Figure 9).

The sandstone in the quarry exposure stands up as a knoll, surrounded and overlain by lava with manifest unconformity. In no other instance known in Mull or Ardnamurchan, do the Tertiary lavas exhibit a comparable irregularity of base, though transgression of the Tertiary lavas across the Mesozoic subdivisions and on to the schists is of course a leading feature of the district. A thin basic intrusive sheet locally occurs at the contact, but in the main the overlying discordant material is lava, not intrusion, for it is associated with slag and shows no trace of marginal chilling.

Three other features of interest may be noted in conclusion. (1) Some of the solid basalts weather with pimply excrescences. A good example may be examined below the Calgary road, at the foot of the cliff above the south end of the rocky foreshore, half a mile south of Lainne Sgeir. Here, solid pimply-weathering basalt may be seen passing laterally into vesicular basalt with conspicuous analcite crystals contained in druses. (2) An interbanding of slaggy and solid basalt within the limits of a single flow is exposed just on the margin of the map, south from Treshnish Point. (3) A few of the lavas carry contemporaneous pegmatitic segregations of felspar and idiomorphic augite that can be easily distinguished with the naked eye. These crystal growths form little felspathic patches or, in some cases, the outer lining of amygdales. Examples have been noted on the northern ridge of Beinn na Cille, about three quarters of a mile from the summit; others again occur in the amygdaloidal portion of a banded lava exposed in a gorge of Allt Mòr, due east of Calgary Castle. E.B.B.

Ardnamurchan

Ben Hiant and Ardslignish

Two outliers of basalt lavas occur east of Ben Hiant; the one forms part of the wall of the Ben Hiant vent, the other extends north-west from the Ardslignish peninsula almost to Loch Mudle. The two are separated by the Loch Mudle Fault, the displacement of which is roughly 250 ft. down to the north-east. The total thickness of lavas preserved in the Ben Hiant and Ardslignish outliers is only about 100 and 300 ft. respectively. In both outliers, the lavas are practically free from pneumatolytic and contact alteration, and they weather spheroidally with characteristic reddish-brown hues.

On the south and east sides of Ben Hiant, good lava exposures may be seen along escarpments, up to 100 ft. high. Each flow is often not more than about 12 ft. thick and consists of slag above and solid basalt below. On the north-east face of the hill, a dark cliff consists of lavas greatly brecciated as a result of the vent explosions.

In a stream half a mile directly south-east of Ben Hiant summit, the slag overlying the solid lower portion of the basal flow is banded. In a sense, each band represents a miniature lava-flow, 2 or 3 inches thick, with its base marked by a striking development of pipe amygdales, in contrast to small round vesicles that occur in its top. These pipe amygdales are inclined in one direction,<ref>Sir A. Geikie illustrates a similar case from Skye: Ancient Volcanoes of Great Britain, vol. ii., 1897, p. 191.</ref> perhaps indicating flow of the basalt after a development of originally vertical pipes. The individual bands are clearly distinguishable and are interpreted as due to the repeated overflow of still-liquid lava on to a previously consolidated crust. This explanation has already been given for similar occurrences in Mull.<ref>J. E. Richey in Tertiary Mull Memoir, 1924, p. 134.</ref>

Non-porphyritic olivine-basalt of coarse or medium grain is the common type of rock, but porphyritic basalt has been noted in the Ben Hiant district and elsewhere in Ardnamurchan at or near the base of the group. For example, the basal flow referred to in the preceding paragraph is porphyritic, with numerous felspar phenocrysts. A compact type occurs on the east face of Ben Hiant at the north end, and also on the north side of the hill, next to the Ben Hiant intrusion. In this case, no typical slag is seen, though some exposures are amygdaloidal. Under the microscope this rock is a microlithic olivine-basalt (S21445) [NM 5483 6402]. J.E.R.

The Ardslignish outlier, east of the Loch Mudle Fault, is crossed at the road north of Ardslignish by another fault. The throw is 200 ft. and brings the base of the lava series approximately down to sea-level in the peninsula. The outlier as a whole furnishes an excellent example of plateau-lava country. There are at least twenty flows preserved. All appear from their field-character to be olivine-rich basalts, or fine-grained dolerite, of Mull Plateau Types. Trap featuring is pronounced and shows a gentle dip which is usually a little to the north or south of west Escarpments exhibit a rude approach to a blocky columnar structure. Segregation veins have been noted at intervals along the west coast of Ardslignish, and pipe amygdales occur 500 yds. south-west of Beinn Bhuidhe summit, just beyond the limit of the Memoir-map. J.B.S.

An unusual feature is presented by the basal flow near the north end of the Ardslignish outlier at a point just east of the Loch Mudle Fault, half a mile south-east of Loch Mudle. There, just north of a stream-gully cut in the basal lava-escarpment, the lowest lava-flow is brecciated from top to base. The amygdaloidal upper portion is affected almost as much as the solid lower part of the flow. The brecciation, however, does not extend far laterally, for the basal lava in the adjoining stream-gully is quite sound throughout. The angular fragments are of various sizes and are separated by dark, compact material. Under the microscope, Dr. Thomas finds that this' matrix consists of comminuted basalt and felspar, together with numerous grains of angular quartz (S22438) [NM 5495 6503], and that the basalt itself is similar in type to the pillow-lavas of Central Mull <ref>Tertiary Mull Memoir, 1924, fig. 21, p. 151.</ref> (S22289) [NM 5495 6503], (S22290) [NM 5495 6503]. Possibly the lava flowed into a pool or lake, and by its sudden cooling became brecciated. Similar brecciation of lava-flows is commonly met with in the case of the Lower Old Red Sandstone lavas of the Lorne Plateau, of which the general subaqueous origin is beyond doubt.<ref>E. B. Bailey in The Pre-Tertiary Geology of Mull, Loch Mine, and Oban, Mem. Geol. Surv., 1925, pp. 23, 24.</ref> It seems perhaps less likely that the brecciation of the Ardslignish lava was due to volcanic explosion, and that the material infilling the interstices is tuff.

Kilmory and Braehouse

An irregularly bounded set of lava outcrops roughly follows the course of the road from Camphouse, by Braehouse, north to Kilmory. The lavas are separated from the older rocks of the district by vent-agglomerates, and are often so shattered' that no two observers would agree as to where broken lava ends and vent-agglomerate begins. It is quite possible that the lavas as a whole have dropped down to some extent with reference to the older rocks that lie to the south and east. Though probably as much as 1000 ft. of these lavas are exposed, there is no trace of trap featuring, and it is impossible to follow details of structure. There can, however, be no doubt of the identification of the lavas, for they repeatedly show characteristic passages from solid into slag.

Most of the exposures suggest commonplace Plateau Basalt Types. The following exceptions may be noted. Basalt with big-felspar phenocrysts occurs in the point north of Kilmory. Mugearite has been noted 500 yds. east of the hamlet of Branault, a third of a mile south-south-east of Kilmory. Basalts with small felspar phenocrysts are common towards the southern extremity of the Braehouse outcrop. For instance, a small quarry has been opened in basalt of this type by the main road west of Loch Mudle, 150 yds. east from its junction with the Braehouse road.

Everywhere olivine has been decomposed, presumably by the gases that issued from the volcanic vents. E.B.B., J.E.R.

Kilchoan

Various isolated outcrops of the basalt lavas occur in this district, the most extensive of which forms the Glebe Hill, north-west of Kilchoan. They are all altered to a greater or less degree, and no fresh olivine is found. Where they border the Ring-dyke Complex they become highly granulitized. Near Kilchoan the lavas are in fault-contact with Mesozoic sediments and Moine Schists, but their base is well exposed beyond the west side of Kilchoan Bay, in sea-cliffs forming the headland of Sròn Bheag..

The lavas on the Glebe Hill are greatly baked by the adjoining Ring-dyke Complex, and appear to form a capping to the outermost intrusion (Hypersthene-gabbro). They apparently are near to the base of the lava group (p. 104). Along the summit, porphyritic basalt forms a considerable outcrop, and though there are no associated slags, the rocks are presumably extrusive.

Less altered amygdaloidal lavas are exposed alongside the main coast-road, south-west and south-east of the Established Church Manse. Two successive lava-flows may be seen at low tide between the mainland and the island of Glas Eilean, on the east side of Kilchoan Bay, where the lavas are dipping to the west ((Figure 13), p. 132). Epidote often occurs in this vicinity as greenish streaks and in vesicles, and was perhaps formed by vapours emanating from the adjacent Glas Eilean Vent.

Basalt lavas involved in the Ring-dyke Complex

These outcrops are considered under a separate heading, since they are so completely isolated from all others.

On the south-west side of Meall an Tarmachain, basalt and agglomerate form a complicated highly baked mass of considerable size, which serves partly as capping and partly as wall to gabbrointrusions. The basalt, which is frequently amygdaloidal and certainly lava, is fine-textured, dark in colour, and in many places brecciated. Smaller outcrops of compact basalt associated with agglomerate have been mapped to the south of this large mass.

Another mass of compact basalt is shown much farther within the Ring-dyke Complex, between Beinn na Seilg and Aodann. It also is associated with agglomerate, which contains fragments of a similar basalt. The baking of these rocks is so intense that amygdaloidal structure is detected with difficulty. On fractured surfaces, amygdales can be made out in outline, but they are mere ghosts. On exposure to weather, however, they sometimes stand up fairly prominently, and their diagnosis is then easier.

Still more intense alteration is met with on Meall nan Con, and equally affects the basalt lavas and vent-materials (agglomerate and tuff) there mapped. Indeed, so highly granulitized are these rocks that it is often impossible to make out any original structure in the hand-specimen, and the boundary line on the Memoir-map is only approximate. Under the microscope, however, the fragmental nature of the vent-materials is apparent, while even-textured granulites are

probably basalt lavas. J.E.R.

Petrology

North-west Mull

The plateau types of basalt as represented in this district have received full attention in the Memoir descriptive of the Tertiary rocks of Mull, and the reader is referred there for a detailed account of their petrography.<ref>H. H. Thomas and E. B. Bailey in Tertiary Mull Memoir,<ref>H. H. Thomas and E. B. Bailey in Tertiary Mull Memoir, 1924, p. 136, et seq.</ref> It was there pointed out that microporphyritic olivine-basalts, characterized by titaniferous augite with ophitic to hypidiomorphic granular structures, were representative of the greater proportion of the lava-flows, more especially of those of the earlier part of the lava-sequence.

Ardnamurchan

As has been indicated in the foregoing account of their distribution, the plateau lavas do not occupy very extensive tracts of country but are mainly encountered in relatively small isolated areas. They may occur either as outliers of the main basalt plateau, may be preserved in the volcanic vents, or may exist as integral parts of screens bounded by plutonic rocks of later date. In the vents and screens the lavas have been, to a considerable extent, robbed of their original characters and have suffered thermal and other alteration of varying degree. These altered and metamorphosed lavas will, for the most part, be referred to later under the heading of the rocks with which they are associated or those to which their metamorphosed condition is due. In the present instance we shall confine ourselves chiefly to a description of the rocks in their normal state.

The two main areas of unaltered plateau lavas lie respectively to the south-east of Ben Hiant (S22435) [NM 5437 6267], (S22436) [NM 5436 6278], (S22437) [NM 5402 6204] and in the outlier of Ardslignish (S24462) [NM 5617 6016], (S24463) [NM 5743 6321], (S24464) [NM 5638 6226], the latter marking the most easterly occurrence of such lavas on the north side of Loch Sunart.

These lavas are dark-grey to black microporphyritic rocks which may for the most part be described as normal olivine-rich basalts, and which are comparable in every respect with those of the plateau region of Mull </ref>H. H. Thomas and E. B. Bailey in Tertiary Mull Memoir, 1924, p. 136, et seq.</ref>. Their texture is moderately coarse but naturally varies somewhat in accordance with the thickness of individual flows. Structurally they are microporphyritic with dominant olivine and quite subordinate felspar (S22436) [NM 5436 6278] as the porphyritic constituents. As in the plateau basalts beyond the pneumatolytic limit of Central Mull, the olivine of these rocks is mainly in a fresh condition, and it is only on occasions that it is partially serpentinized or pseudomorphed by carbonates. The augite is characteristically titaniferous, it exhibits the lavender tint generally associated with such a composition, and occurs in ophitic relationship to the lath-shaped crystals of labradorite. The felspar laths, usually twinned and zoned, form an interlacing network that encloses granules of olivine, granular augite, moderately abundant crystals and patches of titanomagnetite and a variable amount of residual base. The original character of the ultimate product of consolidation is frequently masked by more or less complete analcitization and zeolitization, which give rise to patches of turbid analcite, radial growths of natrolite, and other zeolites. Frequently the analcitization extends to the felspar (S22435) [NM 5437 6267], and may completely obliterate all original characters other than external form, It is this type of plateau basalt which in the thicker flows shows a tendency to segregate contemporaneously certain of its constituents into ill-defined veins of coarser texture. These segregations consist mainly of titaniferous augite and zoned basic plagioclase in a distinctly alkaline residuum composed of alkali-felspar and analcite. In such veins the augite crystals are usually idiomorphic and frequently exhibit hour-glass structure. Moreover they often demonstrate the introduction of the aegirine molecule by presenting a green peripheral layer of aegirine-augite to the alkaline matrix in which they are embedded. As pointed out in the case of similar occurrences in Mull 138<ref>Ibid, p. 138</ref> these veins are of special interest, as they afford evidence of the segregation of a rock of definitely alkaline affinities from a magma of plateau basalt composition.

Although the microporphyritic types are by far the more prevalent, non-porphyritic types are occasionally encountered and amongst these we may mention a micro-ophitic type that quite commonly occurs in the Mull sequence. It is a type that exhibits a mottled structure due to elliptical or rounded patches of augite ophitically enclosing felspar and separated from each other by a matrix of felspar laths, granular olivine, and magnetite. It is a feature of these rocks that olivine, instead of being evenly distributed, is frequently concentrated in the interspaces beyond the limits of the ophitic augite. This presumably points to a late crystallization of olivine or, conversely, to an early separation of augite. A flow of this type occurs to the north of Ardslignish farm (2–4464), in association with the normal microporphyritic types of plateau basalts.

Another type associated with the normal plateau basalts of Ardslignish is a compact basalt (S24465) [NM 5631 6119] with microporphyritic labradorite in a matrix of small irregular crystals of labradoriteandesine, hypidiomorphic granular augite, magnetite, apatite, and a small amount of devitrified and altered residual glass. The presence of felspar as the only phenocrysts, the hypidiomorphic granular structure of the matrix, and the sparsity of olivine, are features commonly exemplified by lavas of the Central Type as developed in Mull.

An interesting lava that shows signs of brecciation forms the lowest member of the Ardslignish outcrop (S22289) [NM 5495 6503], (S22290) [NM 5495 6503]. It is much decomposed but it can be recognized as a highly vesicular olivine-basalt. Olivine, as microporphyritic individuals, is represented by calcite pseudomorphs. The bulk of the rock, however, is composed of irregularly terminated small laths and skeletal crystals of plagioclase set in a dark basic residuum that has solidified with a microvariolitic structure. This basic residuum has invariably invaded the abundantly occurring vesicular cavities, giving these a continuous lining of varying thickness. The ultimate infilling of the vesicles belongs to a later period and is composed of calcite and secondary silica. The rock presents characters that suggest more rapid chilling than that usually met with in lavas of this type. The lining of the vesicles by glassy residual matter and the subvariolitic crystallization of the base recall in some measure structures presented by the rapidly chilled pillow lavas of Mull.<ref>H. H. Thomas and E, B. Bailey in Tertiary Mull Memoir, 1924, pp. 150, 151.</ref> In the lavas preserved in the neighbourhood of Camphouse we have a group of flows, in part at any rate, referable to the plateau types of olivine-basalt, but of a somewhat finer texture. Although great alteration of the nature of serpentinization, chloritization, and albitization, has affected their original constituents, the survival of their original structures enables their types to be determined. An olivine-rich type is present (S22693) [NM 5092 6499], while more compact rocks less rich in olivine are also represented (S26099) [NM 5133 6463]. The changes these rocks have suffered are similar to those which affected the plateau basalts of Central Mull within the pneumatolytic limit of that region. A compact olivine-free type (S22691) [NM 5105 6460] has amygdales that are composed of yellow garnet, pale-green actinolite, yellow epidote, calcite, and what appears to be chabazite. The garnet and epidote are peripheral while the zeolite occupies a more central position. The garnet occurs as small grains that occasionally have idiomorphic outlines, the epidote as small prisms, and the actinolite as needles and fibrous patches. The zeolite furnishes rhomboidal and trigonal sections, and has the low birefringence and refractive index of chabazite. This mineral assemblage recalls that met with in the pneumatolysed and metamorphosed lavas of An Gearna in Mull, which were made the subject of special study by Dr. McLintock.<ref>W. F. P. McLintock, On the Zeolites and Associated Minerals from the Tertiary Lavas around Ben More, Mull, Trans. Roy. Soc. Edinburgh, vol. li., 1915, p. 4</ref>H.H.T.

Folding and faulting, Ardnamurchan

It seems convenient to describe in the present chapter the main folds and faults of Ardnamurchan, although many of the faults and crush-lines affect not only the bedded rocks heretofore dealt with, but also the succeeding intrusive rocks such as the ring-dykes. These structures are chiefly demonstrated with reference to the Mesozoic strata, as being more extensively developed than the Tertiary basalt lavas, but are for the most part, if not altogether, of post-basalt-lava date.

Away from the vicinity of the plutonic complex, in the more easterly parts of the area, the Mesozoic strata and Tertiary basalt lavas are horizontal or gently inclined in various directions. Around the plutonic complex, however, the Mesozoics are everywhere tilted at angles of about 30 degrees outwards from the plutonic masses. As will be seen on (Plate 2), p. 71, the dips are for the most part directed away from Centre 2, as though the dome which they indicate had been developed in relation to this centre. The Mesozoic outcrops are discontinuous, but the dome-structure is sufficiently

demonstrable from the vicinity of Kilchoan westwards around the nose of the peninsula almost to Ardnamurchan Point, that is, around a quarter of a circle about Centre 2. On the northern coast, west of Faskadale. Bay, where the Mesozoics are once more exposed, the dome-structure is again evident, though here the strata appear to be inclined away from Centre 3, rather than from Centre 2.

From the evidence west of Kilchoan it would seem that the doming is not only earlier than the ring-dyke intrusions of Centre 2, but must have been effected prior to the injection of the Outer Cone-sheets belonging to this centre, which preceded the ring-dykes in time. In the first place, the contact-surface of the outermost ring-dyke of Centre 2 (the Hypersthene-gabbro) with the domed Mesozoics westwards of Kilchoan is much steeper than the dip of the Mesozoics, though inclined in the same direction. The transgressive gabbro-junction. thus indicated is perhaps most marked immediately to the north-west of An Acarseid, 3 miles west of the head of Kilchoan Bay. At this point the contact-surface of the gabbro is practically vertical against the tilted Mesozoic shales and Tertiary basalt lavas (*see* p. 220 and (Figure 27), p. 205). Further, on the hill slopes west of Kilchoan Bay, the cone-sheets cutting the domed Mesozoics are inclined towards Centre 2 at no less an angle than others farther to the east outside the limits of the dome. If the doming were later than the injection of the cone-sheets, an original inclination of, say, 40 degrees for the cone-sheets should be no more than to degrees within the area of the dome.

As suggested in Chap. 14, p. 178, the doming may be due to an increase of pressure in the magma-reservoir, which subsequently found relief in the intrusion of the Outer Cone-sheets. A detailed study of the domed rocks west of Kilchoan Bay shows, however, that the structure is by no means a simple one, but is complicated by faults (proved by mapping) and reversals of dip. It is noticeable that variations in the prevalent dip are most marked in the neighbourhood of the faults, as though due to fault-movement. For example, in the vicinity of the north-east fault that brings down basalt lavas and underlying fine-grained white sandstone against Lower Lias shales, a mile south-east of Beinn na Seilg, the dip of the Lower Lias shales changes from the normal 25–30 degrees to ro-15 degrees (*see* (Figure 28), p. 219), while close to or at the fault itself the dip becomes reversed in direction and is very steep.

The fault-planes are never well seen, partly owing to lack of exposure, partly on account of the subsequent metamorphism of the rocks by the ring-dykes. Consequently, the relations between the faulting and the Outer Cone-sheets have not been determined by means of actual contacts. Sometimes, however, as in the case of the important east-west fault that crosses the Sran Bheag headland, it is fairly evident in the field that the cone-sheets continue without interruption across the line of fault (*see* (Figure 3), p. 34).

The fault last mentioned, just before it reaches the coast to the west, crosses a hollow eroded along a later north-south crush-line. On the rock-face bounding the hollow to the west, Lower Lias shale overrides Middle Lias sandstone, §o that this fault is evidently reversed. Owing to the intense baking of the rocks the position of the actual fault-plane is difficult to determine to within a few inches.

Outside the area of doming, eastwards of Kilchoan, the Mesozoic rocks form a fringe along the south coast as far east as the mouth of the river that flows past Camphouse. A short distance east of this point, the base of the Mesozoics (Trias on Moine Schists) rises abruptly, for it is met with at a height of about 300 ft. above sea-level on the west side of Ben Hiant. Around the south-eastern slopes of this mountain it extends up to higher and higher levels till, on the east face, it approaches the 800-foot contour. This rise of the Mesozoic base eastwards in Ardnamurchan was first noted by Sir Archibald Geikie,<ref>Sir A. Geikie, The Ancient Volcanoes of Great Britain, vol. ii., 1897, pp. 279–280, footnote</ref> and is to be correlated with a similar rise demonstrated by Prof. Judd<ref>J. W. Judd, The Secondary Rocks of Scotland. Third Paper. The Strata of the Western Coast and Islands, Quart. Journ. Geol. Soc., vol. xxxiv., 1878, Plate xxxi., p. 660.</ref> in Morven, south of Loch Sunart. It is not at present known whether the tilting of the Mesozoic floor is earlier or later than the Tertiary basalt lavas. Possibly, when Morven is mapped in detail, evidence of an easterly overlap of the lavas against a rising floor of the Mesozoic rocks may be obtained, indicating a pre-Tertiary date for the uplift. However this may be, it is certain that there is post-lava faulting on the Ardnamurchan side of Loch Sunart. For example, the Loch Mudle Fault extends north-north-west across the Ardnamurchan peninsula from a point east of Ben Hiant, and downthrows the lava-base to the north-north-east about 250 ft. (*see* p. 110). The fault also shifts the outcrops of cone-sheets and a tongue-like extension of the Ben Hiant Intrusion, which lie south-east of Loch Mudle, and is certainly a late structure.

Numbers of similarly late faults and lines of crush traverse the Ardnamurchan district, and affect all the intrusive rocks, including the latest of the ring-dykes. The majority are simply lines of crush unaccompanied by any appreciable movement. Some are demonstrably tear-faults, and shift laterally the outcrops of the ring-dykes. As examples may be cited the two crush-lines that extend approximately north and south to the west of Beinn na Seilg and effect lateral displacement, not only of ring-dyke margins, but also of the Inner Cone-sheets of Centre 2.

The faults and crush-lines of late date vary in direction from north-west to east of north. The majority, however, would appear to be directed north-north-west. Though only those that shift outcrops are shown on the Memoir-map, the presence of many others is indicated by the north-westerly and north-north-westerly direction of much of the river system of Ardnamurchan. Many more have left their impress on the scenery in numerous straight-running hollows crossing hillsides. Crush-lines have indeed considerably affected the landscape in Ardnamurchan as in other Tertiary igneous districts of Britain. J.E.R.

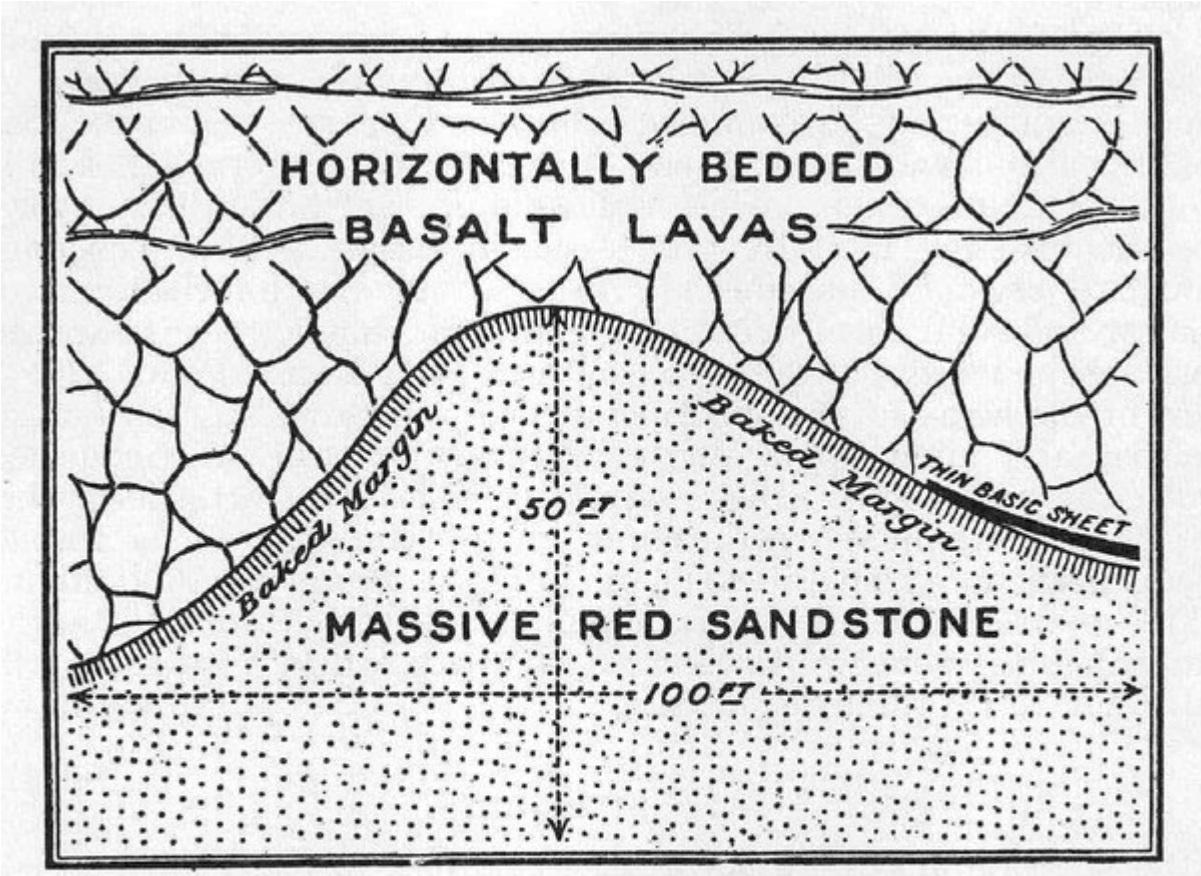


FIG. 9.—*Tertiary basalt lavas overlying a knob of sandstone at Bloody Bay, Northern Mull.*

Quoted from ' Summary of Progress for 1920,' p. 37.

(Figure 9) Tertiary basalt lavas overlying a knob of sandstone at Bloody Bay, Northern Mull. Quoted from Summary of Progress for two, p. 37.

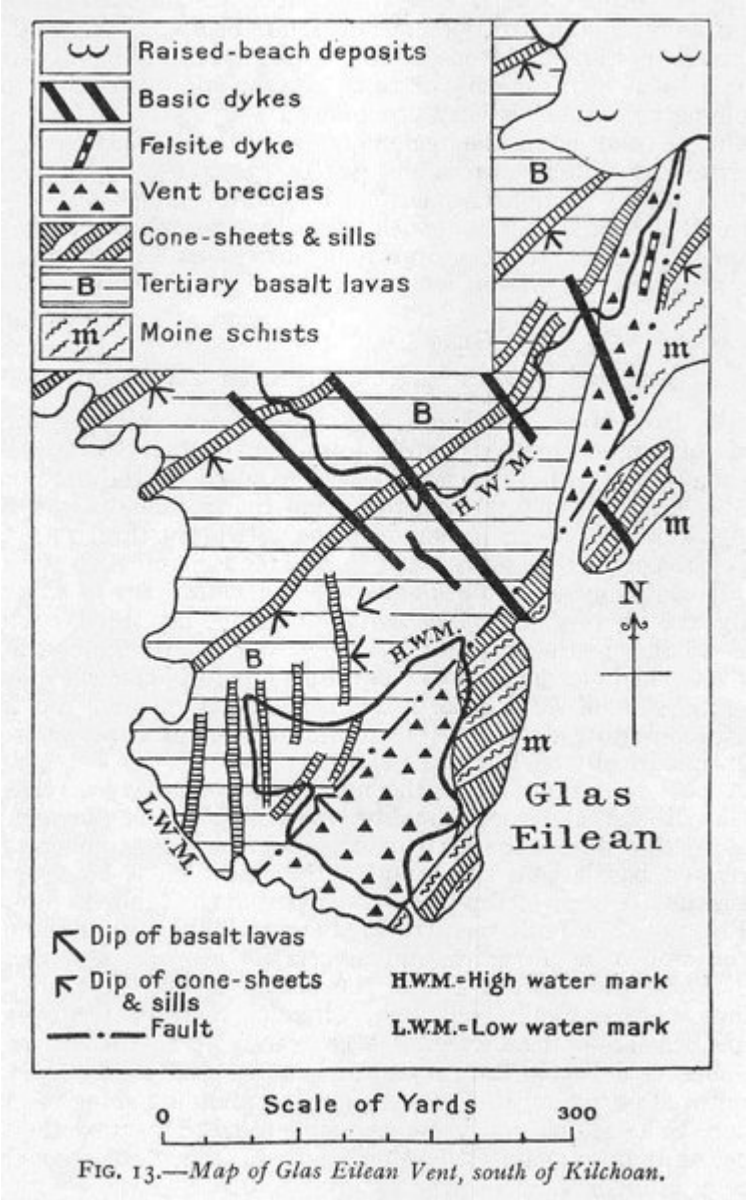
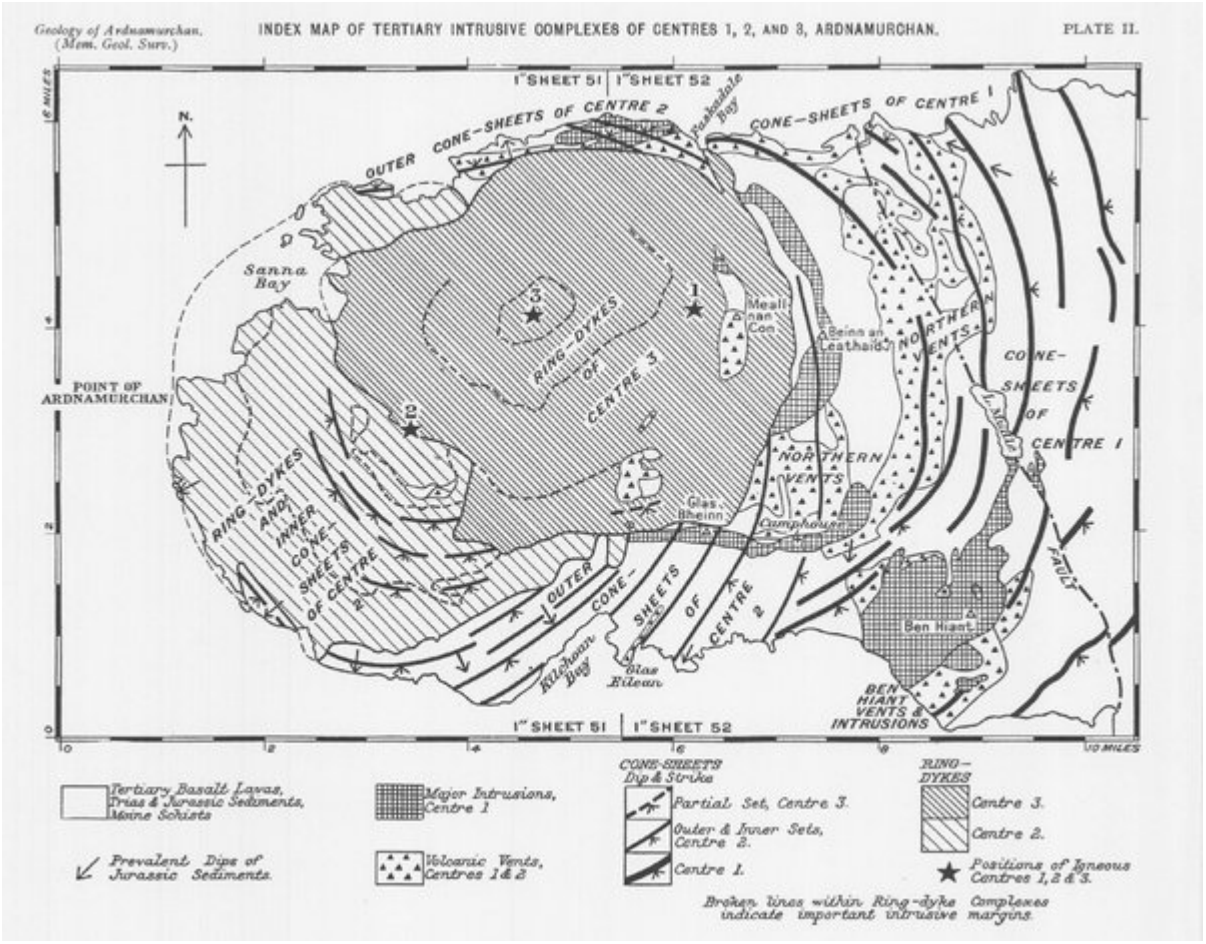


FIG. 13.—*Map of Glas Eilean Vent, south of Kilchoan.*

(Figure 13) Map of Glas Eilean Vent, south of Kilchoan.



(Plate 2) Index map of Teriary intrusive complexes of Centre 1, 2, and 3 Ardnamurchan.

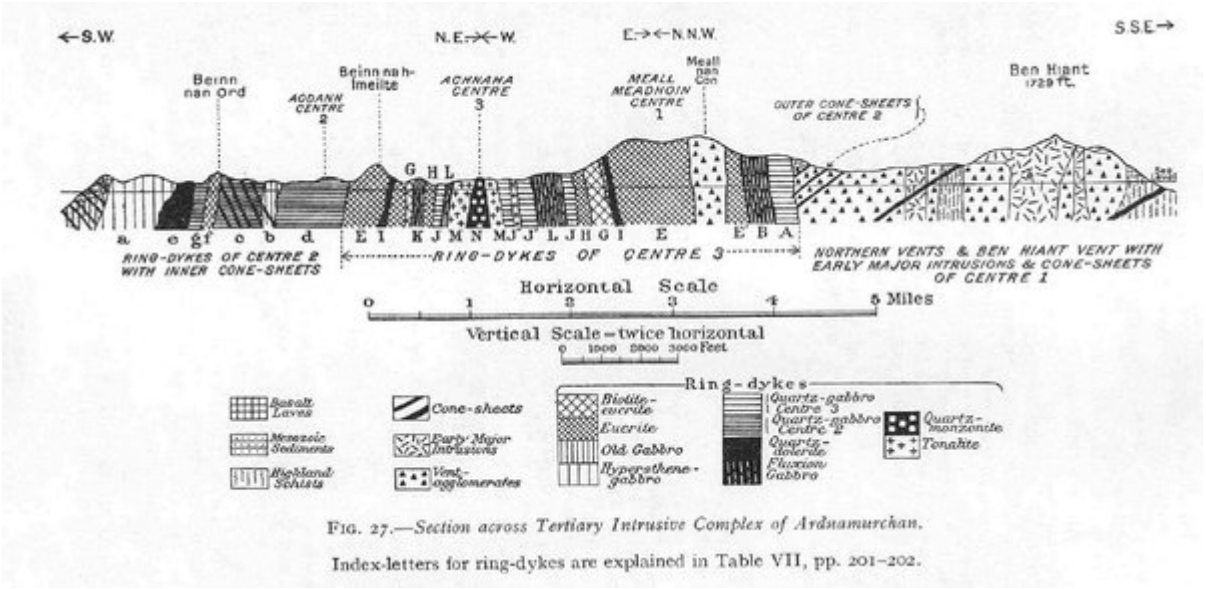


FIG. 27.—*Section across Tertiary Intrusive Complex of Ardnamurchan.*

Index-letters for ring-dykes are explained in Table VII, pp. 201–202.

(Figure 27) Section across Tertiary Intrusive Complex of Ardnamurchan. Index-letters for ring-dykes are explained in (Table 7), pp. 201–202.

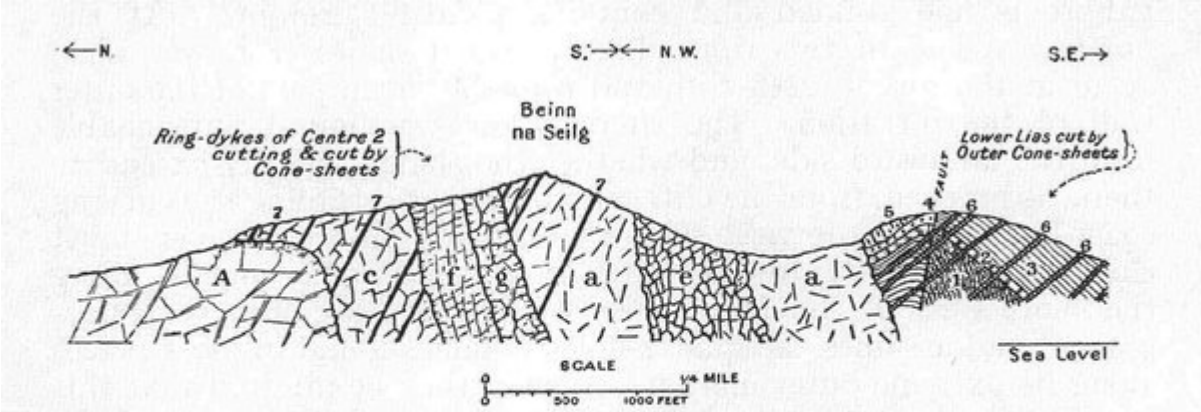


FIG. 28.—*Section across south-west part of Ardnamurchan Igneous Complex.*
1, *Highland Schists.* 2, *Trias.* 3, *Lias.* 4, *Inferior Oolite (limestone and sandstone).* 5, *Tertiary basalt lavas.* 6, *Outer, and* 7, *Inner, Cone-sheets of Centre* 2. *Ring-dykes* a, c, e, f, g, and A *as lettered on Plate V., p.* 201.

(Figure 28) Section across south-west part of Ardnamurchan Igneous Complex. 1, Highland Schists. 2, Trias. 3, Lias. 4, Inferior Oolite (limestone and sandstone). 5, Tertiary basalt lavas. 6, Outer, and 7, Inner, Cone-sheets of Centre 2. Ring-dykes a, c, e, f, g, and A as lettered on (Plate 5)., p. 201.

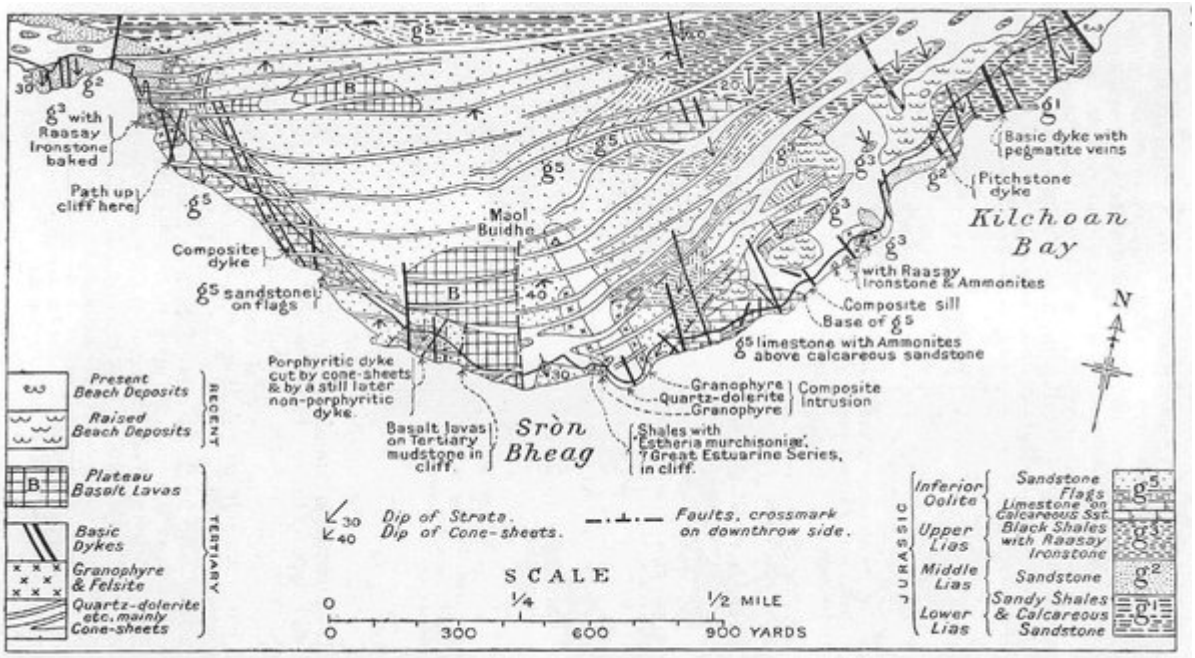


FIG. 3.—*Map of Mesozoic strata and Tertiary basalt lavas cut by Tertiary minor intrusions, west of Kilchoan Bay.*
NOTE.—Tertiary cone-sheets are mainly represented diagrammatically.

(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.