Chapter 16 The Paleozoic intrusions

Introductory

The formations described in the foregoing chapters are traversed by a great number of igneous intrusions, in the form of both dykes and sills. They have, moreover, a wide range of chemical composition, from the very basic to the very acid. There are basic, intermediate and acid dykes and sills, and also some lainprophyres. By far the most numerous are the basic dykes. With regard to distribution: dykes are found over the whole width of the Island, but sills are almost confined to a curved belt concave to the north, whose southern point is at Llanerchymedd. Very few dykes are found outside, very few sills inside the present limits of the Mona Complex, and the dykes are much the more numerous as a whole. Their average trend is about north-west and south-east, and they occur sometimes in crowded plexi, recalling those of the West of Scotland. In the Mynydd Mechell plexus, less than four square miles in area, 292 dykes have been plotted on the six-inch maps.

Petrology

Under this head<ref>Dr. H. H. Thomas kindly looked over nearly all the slides, giving highly valued aid on a number of obscure and difficult points, especially upon certain very delicate intergrowths of different felspars in some of the acid dykes.</ref> will be described the characters of the rocks themselves, their veins and selvages, and their contact metamorphism. The arrangement will be according to chemical composition.

The Basic Dykes

There are two sub-types, which may be called the Normal and the Coarse.

The normal dolerites

These are heavy, dark, and indeed almost black when fresh. The rock from the cores is usually of medium grain, its felspar and augite being easily distinguished with, sometimes without, the hand-lens. They weather with a brown crust, but the material is both chemically and mechanically durable, so that they are very seldom decomposed to any depth. The jointing is irregular, and spheroidal structure is extremely rare. Hardly any can be called amygdaloidal, but a few small round amygdules may sometimes be seen. Some are porphyritic, with large tabular felspars; the body of such dykes being usually lighter in tint and more felspathic than the others, but of about the same degree of texture.

The minerals of original consolidation are felspars, pyroxenes, hornblende, magnetite, ilmenite, pyrite, biotite, apatite, and quartz. The porphyritic felspars, which may attain three-quarters of an inch in length, have proved, where determined, to be labradorite with an inclination to andesine. The felspars of the body are lath-shaped and usually rather slender. They seldom exceed 1 millimetre in length, a frequent length being about 0.5 millimetres, but are often smaller, even in the cores of the dykes. They also are labradorite, often, however, zoned with material that may range to oligoclase. All these felspars are, in varying degrees, albitised, and albite is often the only felspar present. Labradorite, however, is to be regarded as the typical original felspar of these rocks, though in some cases the albite may be, as in the skomerites,<ref>H. H. Thomas, *Quart. Journ. Geol. Soc.,* 1911, p. 175.</ref> nearly if not quite original.

The pyroxene is a pale brown augite, of the kind that is usual in dolerites; but in a few cases has the deeper tint that is met with in the teschenites. In a few dykes it is hypidioniorphic, and in some, especially the smaller ones, has a granular habit, groups of rather small allotriomorphic crystals lying between the felspars. For the most part, however, it is in irregular ophitic plates. A rhombic pyroxene has been observed in one case only, and that in the state of pseudomorphs. Olivine is unknown<ref>For a probable exception, see Chapter 17 ('Northern Region'.)</ref> in any dyke that has been demonstrated to belong to this series.

Hornblende, brown and strongly pleochroic, with green and colourless enlargements, is occasionally found, and may be abundant. Granules of augite are embedded in it, but its habit is that of an original mineral, being broad rather than fibrous, with well-defined pairs of cleavages, and the faces of the prism and the pinacoid, moreover, well developed. Biotite is frequent, but not abundant, in little flakes that are often allotriomorphic though not ragged; the pleochroism being light straw to deep brown. It is generally associated with the iron-ores.

Magnetite is almost always present, sometimes in great quantity. Faces of the cube and octahedron are often to be seen; but many of the crystals are skeletal, and sometimes their ribs are prolonged into rods. Ilmenite can generally be distinguished by its leucoxeni-sation along planes parallel to a face of the rhombohedron, besides which it has been converted locally into sphene, and where unaltered has a tabular habit unlike that of the magnetite. It is often skeletal. In many dykes it is the most abundant of the iron-ores.

A little pyrite is generally present, sometimes in skeleton-crystals like the other iron-ores, and apt to occur, like them, in groups. Apatite, in very slender. prisms which may be more than two millimetres long, is often quite an important constituent. Quartz is frequent, but much of it is secondary. Some, however, is original, for aggregates of micropegmatite are found.

With regard to structure: the porphyritic dykes, though numerous, are in a minority. Most are ophitic, but in varying degrees, and in many the granular augites between the felspar-laths, are optically independent. Residual interstitial matter is present in some cases, and these rocks have affinities to the tholeiites. Some display an approach to intersertal structure. A few of the quartz-dolerites have affinities to the Talaidh type of Mull.<ref>*Sum.,Prog. Geol. Survey,* 1914.</ref>

That they vary a good deal in composition will be seen from the following specific gravities:

Mynydd Mechell	3.029
Pont Dic	2.987
Castellior	2.985
Yr-allt, near Cadnant	2.979
Mynydd Mechell	2.954
Wood north of Gaer-wen Church	2.948
Roadside north-east of Garth Ferry	2.785

One has been partly analysed, an ophitic dolerite not much albitised, but rich in secondary hornblende.

SiO_2	50.92
Fe_2O_3	14.74
CaO	8.51

Cliff east of Trwyn Ffynnon-y-sais, Llanddwyn Island (E10121) [SH 389 633]. Anal. Miss Reyner, under supervision of J. O. Hughes.

With regard to their state of preservation: secondary quartz is frequent, and all the rocks have been chloritised and albitised, often in very high degrees. The albitisation Dr. Thomas considers to have been an early process, following quickly upon the consolidation. It will presently be seen that much of the chloritisation is also ancient. The labradorite is generally more or less turbid. None of the rocks, indeed, are fresh. Yet they were brought long ago into a state of comparative chemical stability, for only in rare cases has decomposition resulted in general disintegration.

To sum up, these dykes may be described as augite-labradorite-dolerites of medium texture (Plate 28), Fig. 3, often rich in apatite. They may be divided into dolerites, quartz-dolerites, and hornblende-dolerites, the dolerites being the majority. Most of them are ophitic, many granular, some have an isotropic matrix, some again an approach to intersertal structure. But as these distinctions cannot be made in the field they cannot be expressed upon the maps.

Selvages — Where the exposures are good, a well-developed chilled margin is to be seen. The material of these is a compact grey basalt, in which little white felspars are generally scattered. There are also very small green pseudomorphs after porphyritic augite. The porphyritic felspars are tabular and often slender, and where fresh are found to be labradorite. Close to the edge of the dyke they come to lie parallel to the margin, but this fluxion-zone is usually not more than a few millimetres wide. The matrix is composed, so far as can be seen, of a very fine mesh-work of felspar microliths, with granular augite and iron-ores. Isotropic matter seems to be present, but is obscured by chloritisation of minute pyroxene. Thin sections of these selvages differ so strikingly from sections of the cores of the dykes that they would hardly be supposed to be from the same magma (Plate 28), Fig 4.

The coarse dolerites

Though the special (sometimes almost gabbro-like) texture of these is a consequence of their size, they present other characters as well that call for separate treatment. The usual mineral components are the same, but no porphyritic felspar has been observed, and no quartz. Apatite is rather abundant in some, and is followed by the iron-ores. The conspicuous felspars, often half an inch in length, whose twinning is visible to the naked eye, are for the most part labradorite, with zones and veinlets of albite. In the Rhoscolyn dyke albite only has been recognised. The augite, pale-brown, usually occurs in very large ophitic plates, but sometimes presents crystal-faces to the felspar. In the Holyhead dyke are some bastite pseudomorphs after a rhombic pyroxene; while the Rhoscolyn dyke was rich in olivine, all now serpentinised, and may be characterised as pene-picritic.

Biotite, rare, is associated with the iron-ores. Hornblende is always present: the deep-brown variety, with absorption-formula $Z > Y > X$, in broad-bladed crystals, which often develop the faces of the prism and the pinacoid, and even the base. Yet it is closely related to the augite, the two minerals having frequently the orthodiagonal axis in common. When bordering the augite, the border may have crystal form, and this is then the form of hornblende. Irregular grains of augite are also included in it. It must therefore be regarded, not as paramorphic, but as complementary. Green enlargements are also common, in crystalline continuity with the brown. There is also a third hornblende, but it is certainly of secondary origin.

These great dykes may therefore be described as hornblende-dolerites, with occasional affinities to the hornblende-picrites.

A partial analysis was made of the Holyhead dyke:

SiO_2	48.03
Al_2O_3	11.59
Fe_2O_3	7.31
CaO	8.51
MgO	3.39

Hornblende dolerite (E10124) [SH 233 826], Llain-goch. Anal. W. C. Evans, under supervision of J. O. Hughes.

Selvages — Within about four or five feet of the margins, these rocks graduate into an ophitic dolerite of medium texture, like that of the ordinary dykes, except that there is still abundant brown hornblende complementary to the augite. The outer selvages are compact grey basalt with slender lath-felspar and augite phenocrysts, and like the selvages of the ordinary dykes, would hardly be supposed to be from the same magma as the cores.

Acid veins

In the Rhoscolyn dyke, a few yards north of the parish boundary, there is an acid segregation-vein about an inch and a half wide, composed of hypidiomorphic albite, beautifully twinned, the triangular interspaces being filled with strongly pleochroic epidote, which has the aspect of being original. Acid veins are also seen in the same dyke about 250 yards north-north-west of Bronddel. In a dyke at Bodorgan are some curious thin veins, lying at low angles. On one side they are composed of a fine darkish matter, rather sharply edged, on the other side being about a quarter of an inch of sub-acid material, rather coarse, which graduates into the body of the rock.

Veins of second injection

In the same dyke is also an 8-inch to 12-inch vein of second injection, traceable for several yards, and approximately parallel to the margin. Its core is composed of dolerite which differs from that of the normal dykes only in being rather finer. Its selvage is compact, with what seems to be a glassy base, 'chilled' against the coarse dolerite of the large dyke in which it is enclosed. In this fine selvage are little slender felspars (now silicified) having, like those of the selvages of the ordinary dykes, a fluidal arrangement parallel to the junction, which is quite sharp. This little dyke must therefore have been injected after the large one had not only consolidated throughout, but had become sufficiently cool to 'chill' the margins of the new one. Similar veins occur in the large dyke on the north shore of Tre-Arddur Bay, and in a dyke on the Menai Strait, where they are very irregular (Figure 225).

Persistence in mineral character

The ordinary dykes are seldom long enough to afford much evidence on this point. Differences of structure have been observed at successive points along the large dyke of Holyhead. At Porth Namarch its augite presents idiomorphic outlines to the felspar. At Llain-goch and at the crossing of the Porth Dafarch road, as well as that relationship, the felspar penetrates the augite.

Contact-metamorphism

The ordinary dykes do not often produce more alteration than a slight porcellanising of the schist for an inch or two. Probably this is due, not only to their moderate size, but to the relative stability of the minerals of schists as compared with those of unaltered sediments. In the Mynydd Mechell, where there are many dykes near together, a more extensive, but still slight, porcellanising of the crystalline Coeden beds may be seen. A 75-foot dyke in the railway cutting north-west of Llyn Coron has altered the Penmynydd mica-schist for about three yards. The fissility has vanished, and faint dark spots appear. The altered rock is an irregular mosaic, with strings of chlorite running in all directions, the spots being also of chlorite. By the roadside at Bryn-yr-odyn, about two miles to the north-east, a 50-foot dyke has produced rather more effect, the Gwna Green-schist being converted for several yards into a grey porcellanite with faint spots. The original foliated mica has nearly disappeared, and the spots consist of new white mica, generally with a nucleus of finely granular epidote. There are many thin rods of rutile. All these rocks contain allotriomorphic albite, probably reconstructed from the albite of the schist.

The strongest alteration observed anywhere is at a knob 333 yards north-west of Penmynydd, Caergeiliog, where a 100-foot dyke traverses green-mica-schist of the New Harbour group, producing spilosite. (E10285) [SH 31 78] in which dark-green spots, about 5 millimetres in diameter, have been developed along what were once the micaceous seams, the minerals of the foliation having been destroyed. The spots are composed of a new mica, but are coloured by chlorite. Iron-ore dust marks out the old banding. Reticulated chains of chlorite, with a little pale actinolite, run in all directions through the siliceous seams. But the most interesting feature is the production, in those seams, of abundance of beautiful, fine, micro-pegmatite. There can be no doubt, therefore, in this case, of the production of micro-pegmatite in a solid rock.

The basic sills

These are chiefly of diabase, but include the remarkable rocks known as hornblende-picrite.

The diabases

In general appearance these (with a few exceptions) differ a good deal from the basic dykes, a difference due more to structure than to composition. The definite lath-mesh-work of the dolerites is rarely to be seen, and instead of it is the somewhat confusedly mottled texture characteristic of greenstones! They are usually a little coarser than the ordinary dykes, greener, often rather light in tint, and altogether, recall decidedly the types prevalent among the sills of the adjacent mountain land.

The minerals of original consolidation are felspars, pyroxene, hornblende, biotite, iron-ores, apatite, and quartz. The felspars are for the most part rather broad, and not very well formed; but smaller ones, lath-shaped,-occur sometimes as a second generation in the interspaces of the broad ones. None are porphyritic. Those of the first generation are much decayed. Some are labradorite, with zones that may range to oligoclase, and are often albitised. In some sills the felspar is wholly albite, in others the albite has narrow outer zones of orthoclase, with fringes of micropegmatite. The pyroxene was abundant, but very little of it survives. It was in large irregular ophitic plates, and seems to have been a pale augite. Of the hornblende, which is frequently present, the pale-green varieties are probably all secondary; but there is also sometimes a pale-brown hornblende that is evidently original. Biotite is rare, but in the sill at Ogo-fawr, a nearly colourless chlorite, in large glistening flakes, is quite abundant, probably pseudomorphing a white biotite such as is found in the scyelites. Iron-ores are scanty, often absent, and seem to be wholly ilmenite, now leucoxenised. Quartz is common, but save in the micro-pegmatite aggregates, which are sometimes numerous, is probably not original. Apatite in long hexagonal prisms is abundant in such sills as resemble the dyke-dolerites. The specific gravity of the sill at Llyn Penrhyn is 2.894.

These sills are therefore, for the most part, albitised diabases, some being albite-diabases, others albitised hornblende-diabases, others quartz-albite-diabases. Some have a tendency to intersertal structure.

Veins and selvages — Acid veins are rare. The chilled edges are of two kinds. In one, the diabasic texture continues unaltered, simply getting finer. In the other, we have a compact grey basalt with little porphyritic lath-felspars, like the selvage of the dyke-dolerites.

The hornblende-picrites

are heavy, dark rocks, gabbroid in aspect, very coarse, and of great beauty, on account of the size of the brilliant lustre-mottled black hornblendes, which are often two-thirds of an inch across. The size of these crystals is indeed quite surprising, and seems out of proportion to the comparatively small dimensions of most of the intrusions. In a green granular matter between them a little felspar may sometimes be seen, but the composition varies a good deal, even in one and the same sill. The fresh rock is extremely tough. It weathers to a russet-brown, with the black hornblende standing out.

The minerals of original consolidation are apatite, magnetite, ilmenite, pyrite, olivine, augite, hornblende, biotite, and felspar; but secondary products are abundant, including serpentine, leucoxene, actinolite, chlorite, epidote, calcite, and quartz. Apatite in slender needles is sometimes abundant: Iron-ores, though always present, are not so plentiful as they often are in less basic rocks. The ilmenite is generally leucoxenised, with skeletons of unaltered bars. Some grains with a faint brown translucency may be picotite. Fresh olivine is rare, and the mineral does not appear to have been abundant, for not much of the serpentinous matter shows the mesh-work structure. An almost colourless greenish augite is generally present, but in very variable quantity. When in the felspar it is idiomorphic, but when in the hornblende is in irregular plates or groups of small granules, and is often beautifully fresh, with well-developed prism-cleavages.

Hornblende, which is the dominant component, occurs in four conditions or varieties. The large crystals which impart such a striking appearance to the rock are hypidiomorphic, the prism-faces being not infrequently, and others occasionally, developed. The normal and original colour is the 'basaltic' brown, with strong pleochroism: Z deep greenish-brown, Y a less deep brown, X pale-brown, and the absorption $Z => Y > X$. This type is often zoned with a pale-green and sometimes with a colourless variety, which has a higher bi-refringence, a single zone sometimes enveloping several brown cores, with one of which it may be in optical continuity and not with another. Finally, needles of actinolite may be abundant, but they will be considered in connexion with the secondary modifications. Biotite is rare, except in a rock at Llandyfrydog. It is brown, but often pale, and seems to be allied to the white variety found in certain peridotites. Felspar is absent from some of these rocks, but there is usually a little, and where fresh it is invariably albite.

The complex enlargements and alterations of the minerals make it rather difficult to ascertain the order of their separation. The apatite and some of the iron-ores are early. The olivine and augite, which, enclosed in the large hornblendes, impart to them the lustre-mottling, must be relatively early, and yet the hornblende is hypidiomorphic. The felspar, though generally late, sometimes penetrates the hornblende. The texture is unlike that of any dolerite, it is gabbroid or hypogranitoid.

The following analysis is given by Prof. Bonney as from a hornblende-picrite of normal type. It is a mean of the duplicates published by him (*Quart. Journ. Geol. Soc.,* 1883, p. 256):

SiO_2	42.865
Al_2O_3	10.925
Fe_2O_3	3.435
FeO	10.135
CaO	9.110
MgO	16.270
K_2O	0.125
Na_2O	0.915
H_2O combined	2.870
H_2O hygr.	0.565
CO_2	2.705
	99.920
Sp. gr.	2.88

Traces of MnO, TiO_2, P_2O_5. Ni and Cr sought for but not found. Boulder on the Llangwyfan road near Bod-elwa, about a mile from Ty-croes Station. Anal. J. A. Phillips.

The variations are quite irregular, and graduate into the normal rock. A specimen from Capel-coch (Llangwyllog area) is quite light in tint between the large black hornblendes. Well-defined acid veins are rare, but some have been observed, about two inches wide, with long crystals of hornblende set across them. More common is a rude banding, dipping in the same direction as the axial plane of the sill, sometimes of a coarse light-grey rock with elongated hornblendes, sometimes of a rather fine dark grey type with porphyritic (though rounded) hornblendes.

Drusy cavities, about an inch across, with beautifully formed crystals of black hornblende, almost half an inch in length, and rather thick and broad, have been found in the sill at Pandy alluvium.

In the sill at Capel-goch is a variety (E10564) [SH 445 813] with large poicilitic albites, full of idiomorphic augite and hornblende, which is (though poor in apatite) allied to the minverites of Cornwall that have been described in the Geological Survey memoir on the country around Padstow and Camelford (p. 46); and this passes outwards into a finer albite-hornblende rock that has affinities to the camptonites.

Margins — The picrites have two quite different kinds of margin.

(1) In the one, there is an interrupted border of grey or whitish-grey rock, of medium grain. It is a proterobase, composed of albite, green hornblende much decomposed, pseudomorphs after olivine about which a brown mica clusters, a little apatite, sphene, and much epidote. Stars of prehnite are sometimes numerous. The following silica-percentages were obtained:

Proterobase, Bodneithior (E10210) [SH 446 860]—SiO_2	45.17
Proterobase, Mynydd Eilian (E10453) [SH 470 918]—SiO_2	48.81

Anal. J. O. Hughes.

which should be compared with the picrite itself. On the sills of Mynydd Eilian, Bodneithior, Llyseinion, and Pandy alluvium, this border is wide and definite enough to be shown upon the maps, but thinner and less definite borders can be detected on other sills. At Bodneithior it attains a width of 120 yards. Its arrangement on Mynydd Eilian is shown in (Figure 245). At the south end of the Bodneithior sill west of the road, and at Graig-lwyd on the north edge of the Mynydd Eilian, sill, there is clear evidence that the picrite and proterobase are in continuity. At Graig-lwyd the border contains large dark hornblendes like those of the picrite. The latter becomes a little less coarse towards its junctions with the proterobase, which in its turn is seen, at Bodneithior and Graig-lwyd, to be chilled against the outer rocks. These compound sills are therefore miniature igneous complexes', produced by separation in a magma that must have been somewhat less basic than the picrite itself.

(2) Along most of the margins where no border of proterobase has been detected there is a lack of evidence as to the nature of the junction; but at two exposures on Mynydd Eilian (see Chapter 17 and (Figure 245)) the real outer selvage of the picrite itself can be seen. Growing rapidly finer, it graduates at last into a yard or two of a compact, heavy material, dark-green, and easily scratched with a knife. One of the selvage-rocks is full of dark amygdules about a tenth of an inch in diameter. Both are composed chiefly of chlorite in broad sheets, which enwrap iron-ore skeletons and irregular albite. The chlorite is probably in part after isotropic matter, but no glass can be identified.

Contact-metamorphism

The basic sills producd a stronger and a much more extensive alteration than do the basic dykes. No doubt this is due in part to their greater mass and to their different position among the beds, but much more to the comparative absence of stable secondary minerals in the Palinozoic sediments. The shales and fine gritty mudslones of the Ordovician series are converted into grey or greenish grey spotted 'spilosite' like that produced by the basic sills of the North Welsh mountain land, which has been described by Dr. Teall.<ref>*Brit. Petr.,* pp. 217–221.</ref> The spots consist of chlorite, but the whole body of the rock is permeated by fine white mica developed without reference to any pre-existing planes. On the north side of the largest of the Llandyfrydog sills, this mica is in much larger flakes, which reach 0.25 millimetres in length.

There seems to be no difference between the spilosite produced by the diabases and that produced by the hornblende-picrites, but the latter is, on the whole, the more highly altered and the more extensive of the two. Excellent examples are to be seen at the margins of the diabases around Mynydd-y-garn, and at other localities. Among the Llandyfrydog picrites a square mile of the Bifidus shales has been converted into spilosite, the beautifully preserved graptolites described on pp. 449–50 having been found only 100 yards from the highly micaceous variety just described. The green shales of the upper parts of Mynydd Eilian are almost as extensively altered, from which it seems likely that buried sills exist within the hill (or, perhaps, once existed higher up and have been removed by denudation). Excellent spotted spilosite full of mica has been produced between the tongues of the great picrite sill, on the north side of the summit.

Dykes of intermediate composition

Though not numerous, these are of interest as links between the basic and the acid dykes. They vary somewhat, both in composition and in texture, but Dr. H. H. Thomas considers that, for the present at any rate, they may be included under the general designation of Quartz-porphyrites. Their minerals include quartz, oligoclase, biotite, and hornblende. In one type, the base is felsitic, the phenocrysts large, and the rock may be termed a quartz-biotite-porphyrite. Another type contains, hornblende as well, and this may perhaps be called a quartz-biotite-hornblende-porphyrite. But quartz (though present in the matrix) is now rare as a phenocryst, and hornblende is in excess over biotite. The rock is decidedly less acid, and it is interesting, therefore, to note that its matrix, though still felsitic, is beginning to assume the panidiomorphic texture of the porphyrites. There are also some very pale green rocks that are evidently much less basic than the dolerites, but unfortunately they are all schistose, and are at present but imperfectly known. They have been observed only in the north, while porphyrites in fair preservation are as yet hardly known outside the middle of the Island. All these intermediate types of dyke are inconspicuous in the field, especially inland, and it is likely that further research will show that they are more numerous than they seem at present.

Sills of intermediate composition

There are a few small sills which, with a texture like that of the diabases, are evidently much less basic. Unfortunately, nearly all of them are badly decomposed, but they can be seen to consist for the most part of a felspar, with a little of some ferro-magnesian mineral, and sometimes a small quantity of quartz. They appear to correspond to the leucophyres of Gumbel.

The acid dykes

Acid dykes are found in two parts of the Island, the north and the centre. In general appearance they are typical quartz-porphyries', internally grey, but weathering to a delicate cream-colour. On inspection with the hand-lens, the matrix may often be seen to be a good deal less compact than that of ordinary felsites. Some are beautifully spherulitic, the little spherulites, which are about one-eighth of an inch in diameter, being redder than the ground-mass.

The minerals present are quartz, felspars, biotite, epidote, sphene, chlorite, and white mica. The phenocrysts include both quartz and felspar, and almost all the rocks are porphyritic. The quartz is in the hypidiomorphic or rounded grains usual in felsites, invaded sometimes by the matrix; and in Mid-Isle it is occasionally so plentiful as to quite crowd the rock. In some of the dykes it has a cloudy border full of microliths, which is in optical continuity with the phenocryst, being an addition during the consolidation of the matrix. The porphyritic felspars, broad and stout, are albite, with some of micro-perthite. The biotite is deep-green, with strong pleochroism, and is apt to occur in groups, near which may be groups of a pale epidote. It has not been seen in many slides, but a little chlorite, probably after it, is generally to be found. The white mica, which is minute, may be regarded as secondary. Fluidal structure is rare, and the perlitic has not been observed.

The ground-mass of many of the Northern and of most of the Mid-Isle dykes is of the ordinary crypto-crystalline type, and is composed of quartz and albite, probably representing an originally glassy base, while the porphyritic felspafs are also albite. Such rocks may be termed simply Sodium-felsites.

Much more interesting are those in which the ground-mass is micro-crystalline, and in which the phenocrysts include micro-perthite as well as albite. The matrix of these rocks is highly complex, for in addition to the granular quartz and albite small irregular tracts of micro-pegmatite appear. Around an albite phenocryst a fringe of micro-pegmatite may develop, and growing outwards, with a tendency to radial arrangement of its narrow elements, grouped in quadrants of an hour-glass form, may retain a rectangular outline, becoming thus a phenocryst of micro-pegmatite.<ref>See J. S. Flett (*Proc. Edin. Geol. Soc.,* 1898, p. 482) on phenocrysts of micro-pegmatite.</ref> In others, the elements of the mosaic become elongated, also with a tendency to radial grouping; and from this all stages can be traced up to the perfect spherulites that are visible to the unaided eye. These spherulites may start from a small albite or micro-perthite nucleus, and for some distance appear to be composed of extremely slender elements of albite and orthoclase, forming a shell of micro-perthite, with. a little quartz; then the albite fibres thin out, those of quartz widen, and the outer shell is micro-pegmatite with elongated elements. The spherulites are therefore closely allied in character to the phenocrysts of micro-pegmatite. In different cases, different combinations of these structures are to be found, up to the complex and beautiful developments of the Hafod-onen dyke. (Plate 28), Fig. 2.

The rocks as a whole may be included under the general term of Sodium-felsite. The prevalence of micro-perthite both as phenocrysts and in the matrix might justify the grouping of some of them with the keratophyres; and, on the other hand, the abundance of micro-pegmatite would tend to bring them under the general heading of Sodium-granophyres. Their common outstanding feature is the dominance of albite, pointing to a high percentage of sodium.

Contact-metamorphism

This has not been observed in many places, for the rocks traversed are not good subjects, and the dykes are seldom of sufficient size. At Drum, and between it and Coeden, however, the principal felsites destroy the foliation of the schists, especially on the high boss on the north-west side of the road, where the latter are converted into a pink banded rock (E9525) [SH 376 895] full of spots, which are dusty spherulites of quartz. The foliation-micas have disappeared, and the rock is a confused mosaic of quartz, with a little alkali-felspar, parts of which are crowded with minute hairs of rutile.

The acid sills

These are greenish-grey internally, weathering almost white with perceptibly granular crust, and are sodium-felsites, closely related both in composition and in structure to the acid dykes. Spherulitic structure, however, has not been observed, and porphyritic crystals are less common. When phenocrysts of quartz are present, they are globular, with the cloudy zones of enlargement very well developed. A little chlorite that is present is probably after biotite. The Trwyn-du sills contain phenocrysts of albite in a matrix corn-posed of patches -of micro-perthite and micro-pegmatite which enwrap numerous microliths of original albite. The rock is full of white mica, which may be largely a product of the metasomatism that has affected that portion of the Island. The felsites of Parys Mountain and Rhos-mynach-fawr are so much altered (see Chapter 19) that the original characters can barely be made out. That of Parys Mountain contained porphyritic felspars in a fine felsitic base, and there is a parallel banding in several places.

Lamprophyres

At the river's mouth, Aberffraw, are three dykes of mica-trap. They weather to a ruddy crust, but are bluish grey internally. Specimens from their middle parts are medium-grained to rather fine; but little plates of a dark mica flash as they are turned about in a good light, and are quite abundant. There are good chilled selvages.

When the powder of the rocks is examined under the microscope, the micas are seen to be a brown biotite in sharp and well-formed hexagonal plates, with strong pleochroism. A thin section (E9488) [SH 353 680] shows the characteristic texture of a lamprophyre, with, unfortunately, the usual poor state of preservation. Originally it consisted of a felspar, hornblende, biotite, apatite, iron-ores, and apparently also an augite, but is now full of chlorite, calcite and secondary quartz. A few large porphyritic pseudo morphs have the form of augite. The felspar has a refractive index less than 1.544, is optically positive, with nearly straight extinctions, and is therefore an albite-oligoclase near to oligoclase. The hornblende, which was in slender prisms, is now wholly represented by brown pseudo-morphs, and was abundant, exceeding in quantity the biotite. Long needles of apatite are very plentiful. The felspar, which is not often lath-shaped, is for the most part later than the biotite and hornblende. The rock is therefore a kersantite, but its richness in hornblende brings it near to the vogesites. It may be called a Hornblende-kersantite.

The occurrence of these lamprophyres is of interest, as rocks of that group have not been recorded hitherto in 'the North Welsh province. It is unlikely that these three are the only ones in Anglesey, yet no others have been observed since the Aberffraw district was surveyed in 1905. They might easily escape notice, however, among the great numbers of small and rusty-weathering dykes, especially inland; so that further research upon the dyke-system is likely to extend the range of this group.

Petrological generalisations

The whole intrusive suite may be presented schematically as

	Dykes	**Sills**
		{Hornblende-picrites
	Hornblende-olivine-dolerites	{Minverites
Basic		{Camptonites
	Hornblende-dolerites	{Proterobases
	Dolerites	Diabases
	Lamprophyres	
Intermediate	Quartz-porphyrites	Leucophyres
Acid	Sodium-felsites	Sodium-felsites

Unity of the intrusions

The suite is both typical and comprehensive, suggesting that its variety is but an expression of an underlying petrological unity. Let us consider the relations and connexions of the several types. The acid sills and the acid dykes have such peculiar characters in common that there can be no doubt as to the intimacy of their relations. They differ in nothing but the manner in which they traverse the divisional planes of the rocks they penetrate. It will also be shown on p. 509 that the acid dykes of Mid-Isle should not be separated from those of the north. The acid intrusions, therefore, must be regarded as a unit.

Among the basic intrusions, many of the dykes and sills are also petrologically identical, some of the sills being essentially dolerites. The hornblende-picrite appears at first sight to be an exception, for no true picrite dykes are known. But the Rhoscolyn dyke is pene-picritic, linking the hornblende-picrites with the dykes of hornblende-dolerite, and through these with the ordinary dolerites. Diabases with brown hornblende, and proterobases genetically connected with thee picrites, are, in turn, members of that very family of basic sills with which we must connect the basic dykes, indicating that the whole group of basic intrusions must be regarded as a unit. Lamprophyres, of course, are somewhat on one side, but there are dolerites so rich in biotite and apatite that they may, perhaps, be regarded as a link.

Finally, the gulf between the acid and the basic series is bridged by the porphyrites and the leucophyres.

The entire suite is therefore to be regarded as a geological unit. When the intrusive succession comes to be considered, moreover (pp. 515–16), we shall see reason for suspecting that even the most widely different in character were not separated by any very great interval of time.

General characters, with comparisons

A natural group of any kind, however diverse its individual members, may be expected to present certain general characters when considered as a whole; so a brief general study of these intrusions may make it possible to draw some comparisons.

Their leading felspars are labradorite, albite, and oligoclase. Orthoclase is found only in very small quantities. Oligoclase is of importance only in the porphyrites and lamprophyres, whose dykes are few in number, and the oligoclase of the lamprophyres is a sub-albitic variety. Owing to the great numbers of the dolerites, labradorite must have been, originally, the dominant felspar, but its extensive albitisation soon cast the balance, for the suite as a whole, in favour of albite, The Mona Complex (pp. 144–5) we found to be a sodium-complex, and even the old felsite of Bwlch-gwyn is a sodium-rock. Once more in Anglesey, though in a lower degree, sodium emerges as a characteristic element.

The principal pyroxene is ordinary brown augite, but a colourless variety is abundant in the picrites. The rhombic pyroxenes are very rare. Olivine, important in a few of the rocks, has but a restricted distribution. Biotite in small quantity is very common, and is abundant in some cases; developing perfect idiomorphs in the lamprophyres. It is almost always brown, but a green variety is present in the acid dykes. A contrast with the Mona Complex is that all the hornblende which is known to be original is brown, though green and even colourless enlargements are not uncommon. With regard to the iron-ores, magnetite, is frequent, but so also is ilmenite, which appears to be equally, if not rather more prevalent. The titanium content of the intrusions. (*cf.* p. 146) thus reflects remarkably their sodium content. In the Mona Complex, where sodium is dominant, so also is titanium. In these intrusions, where the balance appears to be somewhat though not greatly in favour of albite, ilmenite seems to be somewhat in excess of magnetite.

Coming to the early secondary changes, early albitisation, though widespread among the basic rocks, was not carried anything like so far as in the Mona Complex. The albite-diabases of the Gwna Group, for example, were once labradorite-rocks, with probably much the same composition as the Paleozoic dolerites. But they are now so albitised that a labradorite core is very rarely found, whereas that felspar is commonly still in excess of albite in the dolerites of the present group. Some of the chloritisation we know to be also early, because it is precedent to the minerals produced (see Chapter 18) by the Post-Silurian earth-movements. Its chlorite is one of catamorphic dissolution, and has the usual characters of such. Not only the pyroxenes, but the biotites and even some of the hornblendes have been chloritised.

None of these intrusions can be called plutonic, unless it be the picrites, which are coarser than many true gabbros. Chilled selvages, extremely rare in the Mona Complex, where they are known only upon the amphibolised dolerites and (perhaps) the albite-diabases, are here general, being developed even upon the picrites; and the thermo-metamorphism is correspondingly moderate.

The range of composition is rather less than in the ancient suite, for though the acid extremes in both cases have probably about the same silica percentage, the present suite includes no rock so basic as a dunite-serpentine.

The Palaeozoic intrusions thus display some striking parallels, and also some contrasts, to their predecessors. The repetition (albeit with a waning) of a high sodium and a high titanium content is too remarkable to be a coincidence; and its bearings will be considered in Appendix 9.

Behaviour on the large scale

As the form of the intrusion becomes now the leading consideration, this subject will be arranged in a different manner from the petrology, dykes being considered along with dykes, and sills with sills.

Behaviour of the basic dykes

Distribution — They are found at intervals all over the Island, from Llanddwyn to Point Lynas and from Beaumaris to Mynachdy, a much wider extension than that of any other group of these intrusions. Geologically their distribution is remarkable, for out of the great number that have been mapped, only eight have been found outside the limits of the Mona Complex.

Trend — The average trend is about north-west by west and south-east by east; but there are constant variations on either side of this direction, and it will be observed that these deviations are seldom isolated, but that the majority of the dykes in a given district are apt to be affected by the same deviation. A few run almost north and south, such as the large dyke of Llechcynfarwy, and some on the Aberffraw coast. A few others, such as the large dyke of Gaerwen, and one at Llyn Llwydiarth, are almost east and west. Hardly any pass into the north-east—south-wes't quadrants, and then only by a few degrees and for a short distance. It will be seen that they pursue this north-westerly course all through the Island quite independently of the strike of the rocks which they traverse. They are therefore true dykes.

Curvature — All dykes that can be traced for any distance have some degree of curvature, but it is often too gentle to be shown upon the one-inch map. Bends that are more abrupt will be noticed in the large dykes of Holy Isle, in those at the Menai Suspension Bridge, in a group north of Trefdraeth, and in the Mynydd Mechell (Figure 226). Good exposures indicate that these deflections are apt to be due to a diversion along pre-existing planes of rupture or foliation. The shortest and sharpest bends of all are displayed by little ones only about four or five inches wide. In the Llanddona district, a sweeping round of the trend of a whole group of dykes, from north-north-west at Bryn-cogail to west-northwest in Mynydd Llwydiarth, takes place in about four miles of curve.

Width — They are of all magnitudes, from the narrowest little 'strings' of less than an inch, up to the great dyke of Holyhead which exceeds 150 feet in places. Moderate dimensions, however, are the commonest; a very frequent width being from 15 to 25 feet. The following table of selections will give an idea of the sizes that prevail:

Mynydd Llwydiarth	usually less than 20 feet.
Gallows Point to Garth Ferry	usually less than 25 feet.
Llanddwyn Island	usually less than 15–30 feet.
Mynydd Mechell	usually about 20–40 feet
Menai Bridge	usually about 40 feet
Bodorgan, south of House	usually about 50
Bryn-yr-odyn	usually about 50
Gaerwen dyke	usually about 75
Rhoscolyn dyke	usually about 100–120
Holyhead dyke	usually about 100–150

They maintain, as a rule, even widths for considerable distances. Those of Menai Bridge do not depart much from their average between Castellior and the Strait. The great dyke of Holyhead varies rather more, but it is on a great scale altogether, and its form, when seen as a whole upon the six-inch maps, looks tolerably constant. Lenticular forms and sudden swellings are rare.

Length — Most of the dykes are short. Very few can be traced for a mile, but a good many for half a mile. The longest are:

The Castellior dyke, Menai Bridge	1½ miles
The Rhoscolyn dyke, Holy Isle	2½ miles
The Holyhead	3 miles

The 'length' of dykes, however, is really length of outcrop at the present level of erosion, and the underground length may be very different.

Mutual associations and grouping — There are three: the solitary', the gregarious', and an intermediate habit, which is well seen in the central parts of the Island. In such a district, although it is certain that many dykes are concealed by drift, the number of boulders being out of proportion to the exposures; yet the coasts and rocky moors make it clear that the total number of dolerites is moderate. The two great dykes of Holy Isle are examples of the 'solitary' habit. The 'gregarious' habit, is illustrated in the following table, the numbers being taken from the .0004 and six-inch maps:

Gallows Point to Garth Ferry in 1 mile of coast, 20 dykes.

Mynydd Llwydiarth in ¼ sq. mile, 30 dykes

Mynydd Mechell in less than 4 sq. m., 243 dykes

Penrhyn Pt. Cemaes in 60 yds. across strike, 15 dykes

In these groups, the one-inch map is a mere abstract, and (Figure 226), (Figure 227), taken from the larger scales as well as the section (Figure 234), give some idea of parts of them, but even then inadequately. In the district east of Ainlwch, and the northern part of the western seaboard, on the contrary, these dykes are very rare. Along the seven miles of coast from Valley to Porth y Bribys only three are seen, in the three northern miles of this from Trefadog to Porth y Bribys only one, and that a, small one.

Branching on the small scale, that is, giving off little tongues (which often, unlike their parent, behave as sills) (Figure 228), (Figure 229), (Figure 230), (Figure 31), is very frequent; branching on the large scale (Figure 226) less so. Overlapping outcrops, however, nearly but not quite in the same straight line, a common mode of alignment, are doubtless due to branching underground. No cases of intersection have been seen. Anastomosing groups, due to branching in reverse directions on the strike, are found in several places. The ordinary margins are not smooth, but a little irregular and enibayed, especially in traversing the coarser rocks.

Xenoliths are generally to be seen in dykes of any size, usually near the edge. They are seldom turned round, but as a rule rptain their strike. A few cases are on so large a scale as to bring about what may be described as a splitting and reuniting of the dyke. For instance, the large dolerite at Llyn Llwydiarth (Figure 185) contains a mass of old schist 400 feet in length, and at Drum (Figure 244) there is another about 225 feet long. The Rhoscolyn dyke behaves in the curious manner shown in (Figure 232).

Hade — That great numbers, probably the majority, are vertical (Figure 233) or nearly so, is evident along the sea-cliffs. Any departure from verticality is almost always in the direction of the dip of the rocks that are traversed, as is well seen in (Figure 234). The behaviour of the dykes where they pass through the heart of the great Engan spilites between Dinas and Ty'n-dryfol is curious. They are crossing the strike at right angles, and the dip of the ancient foliation is vertical. Yet they bend down to so low an angle that their outcrops curve to and fro with the undulations of the land-surface.

Another exceptional case is that of the western part of the Northern Region. They are here true dykes, with the normal strike and high average hade. But the strike of the Mona Complex locally coincides with theirs, presenting them with numerous planes of easy passage, of which accordingly they are apt to avail themselves, and to pass for short distances into sills. This gives rise to frequent abnormalities of outcrop, the narrow, even, dyke-band expanding here and there into sudden widenings that are not really thickenings, but the denuded surfaces of sill-like portions.

Sometimes the true nature of these expansions is revealed by the texture of the rock being fine even in the middle of them; sometimes the schist can be seen to emerge from beneath, sometimes to rest, in little outliers, upon them. (Figure 235), (Figure 236), (Figure 237). The same relations are displayed by a dyke at Careg-onen (Figure 258).

Vertical range — True upward terminations (except of thin tongues) have not been observed. As dykes cross the summit of Mynydd Llwydiarth at more than 500 feet above the sea, it is evident that they must have ranged far above the present surface of the land. Their true upward limit can only be determined stratigraphically, and will be discussed on pp. 509–10.

Behaviour of the lamprophyres and porphyrites

Only three lamprophyres are known, and they cannot be traced beyond the coast. They are all close together, as if tending to be gregarious, and their trend is north by east or north. They attain a width of only five feet, and contain a few inclusions.

Not many porphyrites have yet been recognised; but such as are known have the trend of the acid dykes, and are of about the same dimensions. Relatively to their small total numbers they are distinctly gregarious, and they haunt the acid plexi.

Behaviour of the acid dykes

Distribution — Acid dykes, being found only in the north and centre of the Island, are far less widely distributed than the basic dykes. Their geological distribution is even more restricted, for only one is known to pass outside the tracts of the Mona Complex. This is the dyke at Pen-gorphwysfa, Llaneilian, which after running along the boundary of the Complex for 133 yards, has (Figure 245) been traced through the Ordovician rocks for 600 yards eastwards.

Trend. The majority of them have the same trend as the basic dykes. In the A mlwch area, however, and in Mid-Isle, they run about east-north-east and west-south-west, that is to say, parallel in a general way to the strike of the foliation. When, moreover, we consider that where they have a north-westerly course, the strike of the foliation is also north-westerly, it becomes evident that their trend is not, as is that of the basic dykes, determined by a steady parallel system of fissures, but has been influenced in some degree by the strike of the rocks into which they are injected. There are, however, a few dykes among those of Mid-Isle that strike northwest and cut the foliation of the schists at right angles. Those of the Mynydd Mechell show curvature even on the one-inch, and still more on the six-inch, maps, sometimes as abrupt as that of the basic dykes. On the whole, however, their courses are more gently curved.

Width — Thin veins and strings are not so common as among the dolerites. Yet no acid dykes attain the width of the great basic dykes of Holy Isle, and the maximum they do reach is only maintained for a short distance. Many of those of Mid-Isle are only a few feet wide. The table may be compared with that of the basic dykes.

Llyntaes	usually less than 10 feet
Gwalchmai	usually less than 10 feet
Coedana	the majority less than 10 feet
Mynydd Mechell	usually about 20–30
Mynydd Mechell	six are about 50
Coedana	one is about 50
Pen-gorphwysfa	60
Careg-lefn	75
Gwalchmai	a group of five about 100
Pencarnisiog	130

Variations in width, and sudden expansions, are rather more frequent than in the basic series.

Length — The majority are shorter even than the dolerites; but the Pencarnisiog dyke and three of those in the Mechell attain a length of about a mile and a quarter. The large dykes at Gwalchmai are less than a quarter of a mile in length.

Grouping — The gregariou's habit is conspicuous in the Mynydd Mechell (Figure 243)–(Figure 244)), the rest having the habit referred to as intermediate'. Even where gregarious, they are less in number than the dolerites. Thus—

Mynydd Mechell… in less than 4 sq. m. 49 dykes.

But all these occur in the eastern half of the area, so the proportions are more nearly:

Basic: Acid:: 243 : 98

i.e. about 12 : 5

Branching and xenoliths — The parallel overlapping 'en échelon' is very marked in the Mechell. The form of the margins is typically intrusive in both districts (Figure 238), (Figure 239), (Figure 240). No intersections have been seen. They branch, but more simply than the basic dykes, nor are there as many little tongues and veins proceeding from them. Nearly all the branching noticed is towards the north-west in the Mechell (Figure 244). The large group at Gwalchmai branch both to north-east and south-west, but cannot be said to anastomose (Figure 241). Xenoliths are very rare, and splitting like that of the basic dykes has been observed only once.

Hade — As they are seen only three times in coast section direct observations on their hade are confined to rather low crags. Those of the Mechell behave much as do the basic dykes among which they run, and often act like sills for a short distance. Those of Mid-Isle appear to be generally at high angles; but there are exceptions, of which (Figure 242), reproduced from the six-inch map, is the most remarkable case. It appears to be a felsite sill at quite low angles, with an outlier of granite into which thin dykes go vertically up.

Vertical range — Fortheir real upward limit, set pp. 509–10. The highest visible range is that of the Pengorphwysfa dyke which rises above the 400-foot contour, thickening and thinning quite independently of its rise from the 287-foot level and attainiug its maximum width of 60 feet at its highest point.

Composite or multiple dykes

Both in Mid-Isle and in the North, but most conspicuously between Maes-mawr and Llyn Hafodol, the basic dykes are intimately associated with the acid ones. Indeed, though basic are commonly found apart from acid, acid dykes<ref>The basic and acid sills, though occasionally in contact, do not behave in the same manner.</ref> are seldom found unassociated with basic. They run side by side, sometimes, for half a mile. at a time, the basic every now and then crossing over and running along the other side of the acid one (Figure 243)–(Figure 244), and often splitting it. There are also large multiple dykes, in which the relations of the two magmas, though always in sharp mutual contrast, may be complex (Figure 260). In all the foregoing types, felsite and dolerite can be shown by separate colours on the six-inch maps. But there are dykes, usually short, though not always narrow, containing felsite and dolerite in varying or even approximately equal proportions, and so involved with each other, that it was necessary, on the six-inch scale, to apply a single colour (usually vermilion) and letter them 'F D' or 'D F'. It is remarkable that such intrusions, which are in reality miniature 'igneous complexes', were able to maintain both their integrity as dykes and the usual steady trend. The line of fissure must have been so thoroughly determined that the second magma had; no choice but to follow it. Finally: one of the porphyrites of Coedana behaves in the same manner; splitting, crossing, branching in, and detaching fragments of a felsite.

Behaviour of the basic sills

Distribution — Most of the Basic Sills are distributed over a broad and rudely crescent-shaped area, concave northwards, whose ends are on the north-eastern and north-western coasts and whose convex curve sweeps as far south as Llaner-chymedd. Elsewhere, they are known round about the Tywyn Trewan, in the Llangwyllog area, and along the hills between Holland Arms and New-borough. They are never gregarious like the dykes. On and east of Mynydd Eilian, however, 34 are laid down upon the six-inch maps. There are 20 sills of hornblende-picrite, 14 being near Llaner-on Mynydd Eilian, and one in the Llangwyllog area.

Form and Dimensions — They vary much in size and shape, but most of them are rather short and thick. That of Porth-y-nant, a mile and a half long, is exceptional; and the large picrite of Mynydd Eilian has a complicated outcrop (Figure 245).

Sill-Relations — That they really are sills appears from the manner in which they follow, in a general way, the strike of the rocks among which they lie. But their sill-relations are also to be seen in many good sections. In a quarry about 70 yards east of Llandy-frydog Church (Figure 246) several small sills of rather fine dolerite are well exposed. The section was quite clear when seen some years ago, and the sill-relations are typical, the rock invaded being a shale. None of the dolerites are more than a few feet thick, and they have had to be shown as one even on the six-inch map. The igneous rock at Llanerchymedd Station is an outlier from a sill of massive diabase, resting upon grits and gritty shales, and twice faulted (Figure 247). On the north coast of Dulas Bay, south-east of Llys Dulas, three sills of diabase are well exposed. The middle one, which is at the spot where the Bifidus-zone graptolites were found, is shown in (Figure 248). The bedding of the shales and mudstones is in part conformed, to, in part transgressed at quite sharp angles. The large sill north of Ogo-fawr on the coast of Mynydd Eilian is cut through by a fine sea-cliff. It is about 120 feet thick, and dips at a high angle. On its upper side it partly truncates, partly sends tongues into, the slaty shales (Figure 249). The dolerites of The Skerries are also sills, for they have been injected along pre-existing divisional planes, which, however, are not bedding, or even foliation, but old jointing of the massive schistose grits, as described on p. 320. The sill below the Lighthouse is about 20 feet thick in all, but is rather complex, and includes large masses of the grits (Figure 250). Inclusions on the small scale have not been seen so often in the sills as in the dykes.

Behaviour of the acid sills

Distribution — They are confined almost exclusively to the north-east of the Island, only one being found elsewhere, and that in the north-western corner. All occur within Palaeozoic rocks.

Size and Form — By far the largest is the great sill of Parys Mountain, which has even now an outcrop two miles long, and whose maximum thickness cannot be much less than 300 or 400 feet. The Trwyn-du felsites are a group of 11 little sills (the largest of which (Figure 251) is only 92 yards long) which occur on the steep eastern slopes and rugged coast of Mynydd Eilian, in a space of ground about 300 yards square. Some of them are well exposed upon the cliffs, and are seen to have rudely lenticular forms, rather simple in outline, without branches or inclusions. But their great extent destroyed, though divisional planes of the shale.

The age of the intrusions

Is it possible to arrive at any definite ideas as to the age of this great series of igneous intrusions? Well, three different sources of evidence are available, and it will be found that from these a *terminus a quo* and also a *terminus ad quod* (to adopt the convenient language of historical criticism) can be obtained; and that the intrusions can be assigned with confidence to a particular epoch of geological time. The chronological problem, it may be remarked, is now greatly simplified by our ability to treat the whole suite as a geological unit.

Relations to the Mona Complex

All the foliations of the Mona Complex, the planes of its autoclastic mélange, and all its foldings, are cut by the dykes, both basic and acid. The thermal aureole and the deformation-planes of the serpentine-suite are cut by the pene-picritic Rhoscolyn dyke. The Coedana granite with its hornfels aureole and xenoliths, the foliations both of granite and hornfels, the adjacent Penmynydd foliation, and even the final mylonites of the, granite, are cut in the most conspicuous manner by the basic dykes.

The case of the acid dykes of Mid-Isle calls for some discussion; for their association with the Coedana granite naturally suggests that they are an older series, genetically connected with that intrusion, and belonging to the Mona Complex; especially as, on the one-inch map, they all seem (at first sight) to strike north-east and south-west. We have seen, however, that even in the Northern original margins have been to a here and there they truncate the Region, the trend of the acid dykes is more influenced by preexisting planes than is that of the basic series; besides which, the trend of many of these is really east and west, while a few actually strike north-west and south-east. Only the aforesaid association, indeed, can be urged in favour of separating them from the rest of the dykes; while one negative and nine positive considerations are evidence to the contrary. The negative consideration is that no pebbles of them have been found in the Arenig conglomerates, though pebbles of the Coedana granite abound therein. Next, their microscopical characters are precisely like those of the crypto-crystalline felsites of the north. Of still greater significance is the fact that they are even more thorough sodium-rocks than the northern dykes, no felspar but albite having been found in them; whereas the Coedana granite is rich in orthoclase. Any argument, indeed, intended to show that they are merely the last acid emanations of the granite magma would prove too much, for it would prove the same of biotite- and hornblende-porphyrites whose felspar is oligoclase. Again, they are associated with and split by basic dykes in the same manner as are the felsites of the north, and yet it is patent that the basic dykes are subsequent, not merely to the granite but to the whole metamorphism of the region. Turning to their own relations to the structures of the Complex, we find, first, that the old foliation of the granite is cut by them. So also are the thermal textures, and (in spite of their dominant strike) the foliation of the hornfels, one of them even striking north-westerly across it. Others traverse all the structures of the Bodafon quartzite, which is (pp. 80, 96) in the same thermal aureole. One of them has been found in the mica-schist of the Penmynydd Zone, whose foliation (p. 127) is later than the consolidation of the granite. Finally, their margins truncate the late zones of catamorphic shearing in the granite, which must therefore not only have consolidated but have undergone its last deformation before they were injected. And these mylonites are (p. 201) the very last structures of the Mona Complex. These dykes may therefore be assigned with confidence to the same period as the other acid dykes and sills. As this is the only case where any doubt was possible, we obtain a first *terminus a quo;* for the whole of the intrusive series referred to in this chapter must be regarded as later than the final completion of the Mona Complex.

Horizons traversed by the intrusions

The basic dykes, as has been seen, traverse, in addition to the Mona Complex, the Careg-onen rocks and. the Baron Hill outlier. Three of them rise into the grit at the base of the zone of *Didymograptus extensus* at Garth Ferry, and one into the basal Arenig near Berw. One of the acid dykes rises into barren shales at Llaneilian that may be referred to the Glenkiln. Basic sills are found on various horizons of the Ordovician from the zone of *Did. extensus* upwards, one of the picrites lying in the zone of *Neon. gracilis* at Trescawen. On Parys Mountain and Mynydd Eilian, basic sills, including picrites, traverse the barren green shales that are provisionally referred to the upper Hartfell series. The little acid sills of the north-east coast lie among the same green shales. We thus obtain a second *terminus a quo,* and can safely regard the intrusions as being as late as a part, at any rate, of Upper Rartfell time.

The great acid sill of Parys Mountain certainly lies, in some parts, between the Parys green shales and the zone of *Monograptus niodestus,* while on the southern escarpment it is in contact with shales that appear to be at or close to the base of the Tarannon. One or two basic sills traverse this acid sill. But there is much cleavage and deformation; we know of several powerful thrusts, from which minor ones may diverge; while the rocks (see Chapter 19) have been extensively mineralised and their structures obscured, so that the horizons which the sills appear to attain may not be the real ones. Nevertheless, for the present, their mere adjacency raises, if not a presumption, at any rate a suspicion that the intrusions may be as late as Tarannon time, or even Post-Silurian altogether.

On the other hand, not one of the suite penetrates the Old Red Sandstone, though 14 of them occur within half a mile of the outcrop of its base. Nor do they ever penetrate the Carboniferous rocks. The dykes that cut that series (see Chapter 28) are not only of a different type, but in a totally different condition. Strong negative evidence, therefore, indicates a first *terminus ad quod.*

Pebbles in conglomerates

As might be expected from the foregoing evidence, no fragment of any of these rocks has been found in an Ordovician conglomerate. The remarkable boulder-bed of Lligwy Bay, at the base of the Carboniferous Limestone (see Chapters 22, 23) has, however, yielded some pebbles that can be recognised (E9517) [SH 498 871], (E9518) [SH 498 871], (E9519) [SH 498 871]. One of these is a well-rolled boulder of dolerite, about three inches in diameter. It has been extensively calcified, but its lath-felspars, its iron-ores, its amygdules, and its textural characters are thoroughly typical of the average dolerite dykes of this series. Another is a pebble of quartz-felsite, with the characteristic micro-crystalline matrix of the acid sills and dykes. The porphyritic felspars are easily visible under the hand-lens, but have been calcified. The phenocrysts of quartz have not only the usual form, but also the peculiar cloudy zones of enlargement that have been described on p. 494. A third boulder, too much decayed for slicing, appeared to be composed of hornblende-picrite.

We thus obtain, decisively, a first *terminus ad quod,* and can affirm that these intrusions are at any rate Pre-Carboniferous.

The effects of earth-movements

Members of all the great classes of this suite can be found, at one place or another, to have been affected by crushing, shearing, or deforming stresses, and some degree of anamorphism has been induced in many cases. The intensity of the effects varies greatly. Sometimes it is, locally, very powerful, sometimes none has been discerned at all, but in the majority of cases careful scrutiny will reveal a little. The petrological modifications induced will be described, as such, in Chapter 18. They will be discussed here only in so far as they afford evidence as to the geological age of the intrusions. Those cases will be considered first where the deformed intrusion occurs in beds of known horizon, the evidence which they furnish being then applied to those which outcrop only in the Mona Complex.

Intrusions in rocks later than the Mona Complex

The little dyke in the Careg-onen slates is considerably crushed, though hardly in proportion to the intensity of the cleavage, which is probably of older date. The western one in the Baron Hill outlier is traversed by a zone of mylonisation, and is also sheared in places. Those in the Garth Ferry grit are cut off by the boundary fault, are severely crushed in parts, and rudely schistose along certain zones. The large acid dyke of Mynydd Eilian has been affected by shearing stresses from the north, which, at a place 500 yards east of Pen-gorphwysfa, have rendered it quite schistose for a little space, and broken it down into lenticular augen for a greater distance.

The basic sills can generally be found to display, either in the field or under the microscope, some degree of deformation. This is feeblest in the middle of the Island, where the enclosing Ordovician rocks are not much cleaved, and increases rapidly towards the northwest and north-east. The sill at Llanerchymedd Station is cut by two faults (Figure 247), but otherwise not much affected. That of Porth y Bribys and Hendy is so sheared as to have acquired a marked parallel structure, especially along its northern side. About Mynydd Eilian parts of many of the sills are schistose.The large one on the cliff at Ogo-fawr is not only deformed along the margins, but along slide-planes which pass obliquely into its interior (Figure 252), one of which has a horizontal displacement of only two feet. The adjacent sill, where it crosses the brook west of Ogo-fawr, has become quite fissile, and the new planes are actually folded, quite sharply, with a southward overdrive, which is the most advanced stage of dynamic modification induced upon any member of the series. Lastly, the great hornblende-picrite 'sill of Mynydd Eilian has, especially on the north side of the summit, been rendered schistose through a thickness of nine feet, and its selvage converted into a chlorite-schist (E10465) [SH 473 919], (E10466) [SH 471 916].

Some of the acid sills on the north-east coast have been torn into lenticular augen, and curved wedges of shale driven in between these along the margins. Between the augen the felsite is, often schistose, the dip of the planes being at low angles to the north. In conclusion, the great sill of Parys Mountain is more or less sheared almost throughout, and in places highly schistose.

Wherever, therefore, either of these four classes of intrusion has reached the Palaeozoic sediments, it can be shown to have been intruded before, or at any rate before the close of the great Post-Silurian earth-movements.

Dykes of the Northern Region

We must now consider the intrusions whose outcrops are within the Mona Complex, and it will be best to deal first with those of the north, because they can be seen in relation to a plane of known age. Now, of the numerous dykes, both basic and acid, of this region, many can be traced to within a very short distance of, two of them even right up to, the Carmel Head thrust-plane<ref>Evidence as to the existence and the nature of this thrust will be found in Chapter 18.</ref>; but not a single one has been found to pass beyond it. That circumstance in itself points to their being older than the thrusting movements, but there is more conclusive evidence. The two small dykes mentioned, a felsite and a dolerite, can be followed right out on to the escarpment, only a few yards above the outcrop of the thrust-plane, about half-way between Creigiau-mawr and Gwaen-ydog (Figure 269). Both are, though not appreciably broken up as wholes, thoroughly shattered internally, and traversed by innumerable planes of shearing and seams of pale green mylonite (E10395) [SH 370 888], (E10396) [SH 367 885]. Their condition, as seen under the microscope, resembles that of the rocks that are brought forward on the major thrust-planes of the North-West Highlands of Scotland. Further away from the outcrop of the thrust-plane, similar shearing can be detected, though not conspicuously, in the dykes of the Mynydd Mechell. But the dynamical effects have not been molar only, they have been molecular as well. Their nature will be described in Chapter 18; so it will be sufficient here to state that the augite of some of the dykes above the thrust-plane has been converted (E10394) [SH 363 894] into green hornblende<ref>It will be shown in Chapter 18 that all these dykes must be cut off downwards by the thrust-plane at no great depth below the surface.</ref>.

The evidence is, thus, decisive that these multitudinous dykes of the north, although they fail to reach any beds of Palozoic age, are also older than the great Post-Silurian overthrusts.

Dykes in the other parts of the Mona Complex

Although these are not found in relation to either sediments or planes of movement that are definitely known to be of Paleozoic age, yet the petrological unity of the intrusions as a whole would in itself suffice to enable us to refer them to the same period of time. But that is not all. In Holy Isle, in the West, in the Middle and Aethwy Regions, the dykes that must, on petrological grounds, be referred to this system are found, over and over again, to have been affected by deforming movements of the same general character, and of about the same general degree of intensity as have been the intrusions whose age has just been demonstrated. A few selected cases will make this clear.

In the Aethwy Region: a dyke by the Tower, Llanddwyn Island, is traversed by a rude parallel structure transverse to its course, but too feeble to deform the potphyritic felspars. The large dyke at Pant-howel, Llandegfan, is cut off at the top and prevented from outcropping for a while. Films of shearing which traverse the dolerite shift the margin as they run out (Figure 253), (Figure 254). Zones of movement that are precisely like those in the Garth Ferry dykes can be seen in many of the dykes along the shore of the Strait south-west of Gallows Point. One of them cuts off the tongue at the cliff's foot shown in (Plate 30) and (Figure 233). Where it runs along the eastern side of the dyke above the tongue it produces brecciation, but on passing down into solid dolerite it becomes a system of small curving shear-lines. The large dyke of Gaerwen, at a quarry 283 feet west by south of the Church (Figure 306), though very fresh and massive-looking as a whole, is traversed even in its core by thin lines of shear and mylonisation. On the north side of the large inclusion of quartzose schist, however, it becomes full of shear-planes that are so close together that at first sight it looks like a member of the Mona Complex; but the little lenticular augen between have the texture of the dolerite, with its mesh-work of lath-felspars.

In the Middle Region, the dykes are affected by movements of precisely the same kind, and on the whole, to about the same degree. A few typical examples will suffice. A dyke on the foreshore opposite Careg Lydan is cut by several small faults (Figure 255). That these are not mere irregularities of course is shown by the fact that, along the lines M F, F M, there is a chilled margin, which is not found along F F. Dykes (Figure 256) near Gwalchmai are traversed by a rude schistosity like that of the Llanddwyn example, almost at right angles to their course. Those on the north cliffs of Porth Tre-castell are cut and shifted (Figure 257) by many thin shear-zones like those of Pant-howel just described. Not far off, at the Barclodiad-y-gawres, a dyke seen in a chasm of the sea-cliff exhibits the most extreme deformation yet found among the dykes of Anglesey. It is more or less deformed throughout, but on its western edge two sets of shear-planes, bending round, come together for a while, and in this double shear the dolerite is completely converted into a fissile chlorite-schist (E9515) [SH 328 708].

In Holy Isle, the large dykes are found to be no exception. That of Rhoscolyn is crossed by many lines of shearing. These are best seen on the crags that overlook the north side of the alluvium near Cromlech farm. Seams of inylonite (some pseudomorphed in quartz) dipping at very gentle angles to the north, traverse even the coarsest portions of the dolerite, which is rendered somewhat schistose for about half an inch.

The great Holyhead dyke has also been affected at Porth Namarch. Along its north-east margin, and especially along some large inclusions a little way within it, the dolerite has been, in part brecciated, in part mylonised, and even rendered schistose for some distance, the divisional planes being, in this case, longitudinal, and at high angles.

Finally, many dykes in all these districts show needles of fine, pale-green; secondary hornblende.

This is found in the large dykes of Holy Isle, so that, whatever the nature of their other amphiboles, there can be no doubt of the secondary, dynamical, origin of this.

The quartz-felsites of the large group south of Gwalchmai are also crushed, and traversed by mylonitic seams; and those of the Coedana country are in the same condition. So also are the quartz-porphyrites. The lamprophyres of Aberffraw have been crushed and sheared in the same way and to the same degree as is common in the dolerites of that district.

It thus appears that the movements which have acted on the dykes of these regions are essentially similar to those by which all the rest have been affected, and, in the absence of evidence to the contrary, must be regarded as belonging to the same period of disturbance.

A second *terminus ad quod* is therefore obtained. The whole of this intrusive series was injected before the close of the great Post-Silurian earth-movements.

Thermometamorphism and deformation

The period of intrusion may, in some cases at any rate, be still further narrowed down. The spilosite along the southern margin of the great picrite sill of Mynydd Eilian is traversed by some planes of cleavage. It is crowded with the little white micas of thermal alteration. Yet, in spite of the cleavage, these micas lie with their basal planes in all directions, and even where in immediate contact with the cleavage-planes, are not (E10460) [SH 474 919] dragged out or deformed in any way, nor is their optical stability disturbed. The planes of cleavage must therefore have been in existence before the intrusion of the picrite. Yet it has been already shown that the picrite itself has undergone severe deformation along certain zones. Its intrusion must therefore have taken place during a late interval, in the Post-Silurian movements. In Chapter 18 it will be shown that the thrusting-phase of those movements was subsequent to the compressing phase that induced the cleavage. Some, at any rate, of the intrusions are consequently referable to the interval between those two dynamic phases.

This one, moreover, about 90 yards from its southern end, actually bakes the Gwna Green-schist that is driven forward on the Cor was thrust-plane, along whose outcrop it runs for nearly a quarter of a mile. It must therefore have made its appearance during a pause of the thrusting, on whose resumption it suffered shearing and deformation.

The intrusive succession

In the multiple dykes, the basic member may split, branch in or detach fragments of the acid one, and presents at all clear junctions a chilled selvage to it. Chilled selvages are also presented to acid sills by basic sills, and to an acid dyke by the proterobasic margin of the Eilian picrite. There can be no doubt, therefore, that the basic series is the later of the two. The porphyrites also split and branch in the felsites, behaving in the same manner as do the dolerites. Now the forms and distribution of the basic sills indicate that they spread along the bedding before the sediments were folded, and from the deformation of both sills and dykes they are evidently older than the cleavage, certainly older than the thrusting. The Eilian picrite we have seen to be later than the cleavage, later even than some of the thrusting. The precise relations of the porphyrites, leucophyres, and lamprophyres to the dolerites are not known, but they have been affected by deformation to the same degree, and there is no sign that they are later, and as the porphyrites are sub-acid they must not be divorced from the felsites alongside of which they run. With them may be provisionally placed the ill-preserved leucophyres.

We thus obtain the following succession:(1) sodium-felsite, (2) porphyrite and leucophyre, (3) lamprophyre, (4) dolerite and diabase, (5) hornblende-picrite.<ref>This is the reverse of the order now recognised as usual among igneous rocks, which is duly observed by the plutonic intrusions of the Mona Complex. Reversal of that order has, however, been recognised among the dyke-phases in more than one region. (See Harker, Tertiary Igneous Rocks of Skye', p. 426.) The plutonic phase of the Paleozoic Intrusions of Anglesey is invisible.</ref>

Where traversing the Mona Complex, the intrusions behave almost invariably as dykes; but in the Paleozoic rocks almost invariably as sills; from which we may infer that the dykes represent the channels through which the sills were fed. The rapidly folded rocks of the Mona Complex, not presenting planes adapted for easy lateral eipansion, were fissured; the magma spreading out laccolitically along the bedding when it rose into the Ordovician sediments. No sign whatever of escape into the open as a lava-flow has been detected.

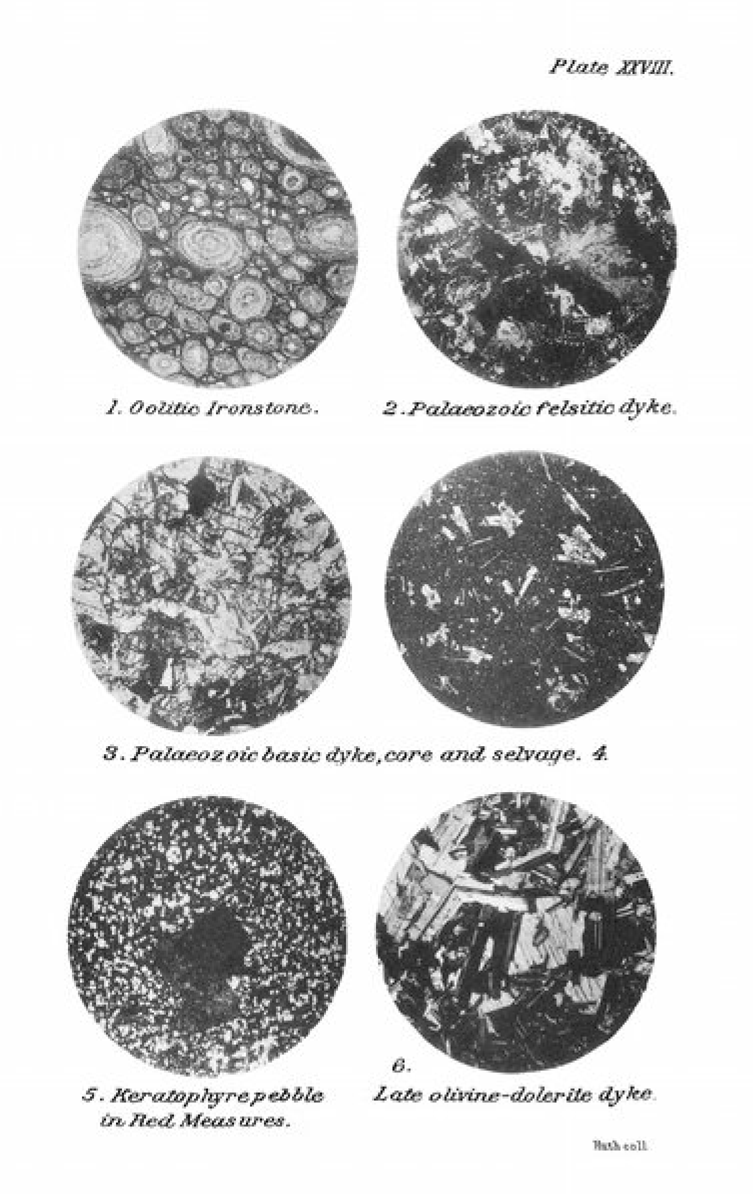
Concluding remarks on the chronology

The felsites may have preceded the whole of the Post-Silurian earth-movements.<ref>There is a temptation to attempt to connect them with the great acid lavas of Snowdon. But, apart from the fact that the precise horizon of those lavas appears to be still somewhat uncertain, all such correlations are excluded so long as any doubt remains as to the relations of the intrusions of Anglesey to the Silurian rocks of Parys Mountain.</ref> But the appearance of some of the intrusions at intervals of these movements is suggestive of a genetical connexion with them. The splitting of dykes by dykes, also, suggests that the interval between the injection of the acid and basic magmas was not very great. The parts of the acid dykes now accessible to us were cold when the basic injections arrived, and although the flank of a dyke would be an easy path, it is difficult to believe that the heart of a rib of solid felsite could offer any facilities. If, however, the lower parts of the first intrusion were still hot, much hotter than the surrounding rocks, they might offer such facilities, and the path, once taken, might be continued in the cold upper portions.<ref>Some such conditions must be assumed in order to account for the phenomenon of veins of second injection (p. 488).</ref>

To conclude: it is certain that these intrusions must have taken place between Upper Hartfell time and a late interval of the Post-Silurian movements. And it is probable that they began but a short time before those movements.

Recapitulation

The intrusions treated of in this chapter have a composition-range from picrites to sodium-felsites, and include some lamprophyres. They behave partly as dykes, partly as sills; the dykes being extremely numerous, and having a general north-westerly trend. The picrites and dolerites may, when large, be very coarse, but all develop chilled selvages, and induce moderate degrees of contact-metamorphism. Many of the basic rocks became somewhat albitised, not long, apparently, after their consolidation. The intrusions traverse all the rocks of the Island that are anterior to the Silurian, and apparently, also, the Silurian rocks themselves. In spite of their great variety, both of composition anti relations, they, are in reality a unit, products of one and the same episode of igneous activity, which took place before the close of the great Post-Silurian earth-movements, the picrites appearing during a late interval in those movements. Many of the rocks are affected by some degree of dynamo-metamorphism, which, however, is never intense. It would thus appear that the whole intrusive suite was itself a product of the same disturbances that brought about the great displacements of the rocks, and in the end the deformation and metamorphism of the dykes and sills themselves.



(Plate 28) Microphotographs of rocks later than the Mona Complex. 1. Oolitic Ironstone. 2. Palaeozoic Felsite Dyke. 3, 4. Palaeozoic Basic Dyke. 5. Keratophyre Pebble in Red Measures. 6. Late Olivine-Dolerite Dyke. See Appendix 3.

FIG. 225.

SECOND INJECTION (3—4 inch thick) IN DOLERITE DYKE.

(Figure 225) Second injection (3–4 inch thick) in dolerite dyke. Menai strait, east of Pen-y-parc.

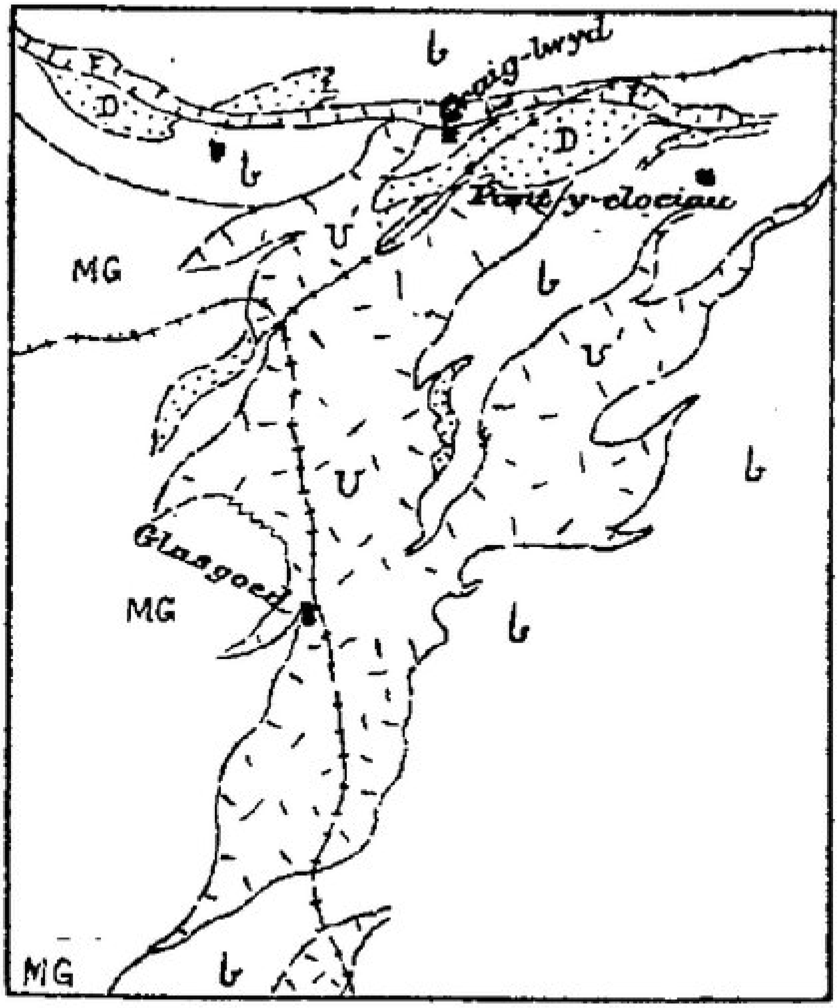


FIG. 245.
INTRUSIONS ON MYNYDD EILIAN.

(Figure 245) Intrusions on Mynydd Eilian. From the six-inch map. MG = Gwna Mélange. b = Ordovician. F = Felsite. U = Hornblende-picrite. D = Proterobase. Cross-hatched lines = roads.

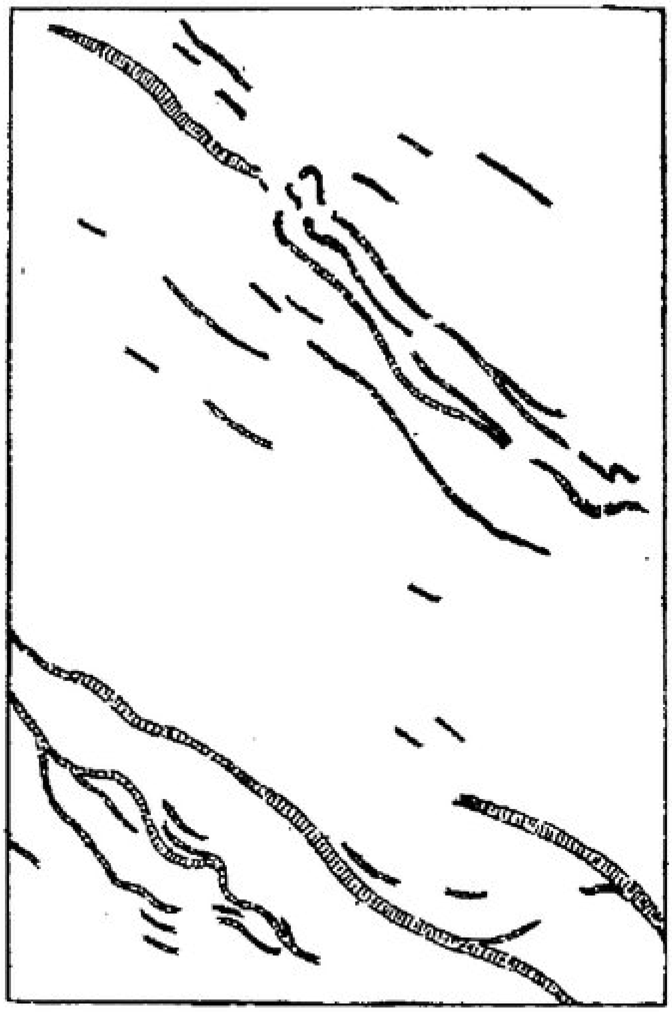


FIG. 226.

DOLERITE DYKES CROSSING MYNYDD MECHELL.

(Figure 226) Dolerite dykes crossing Mynydd Mechell. From the six-inch map.

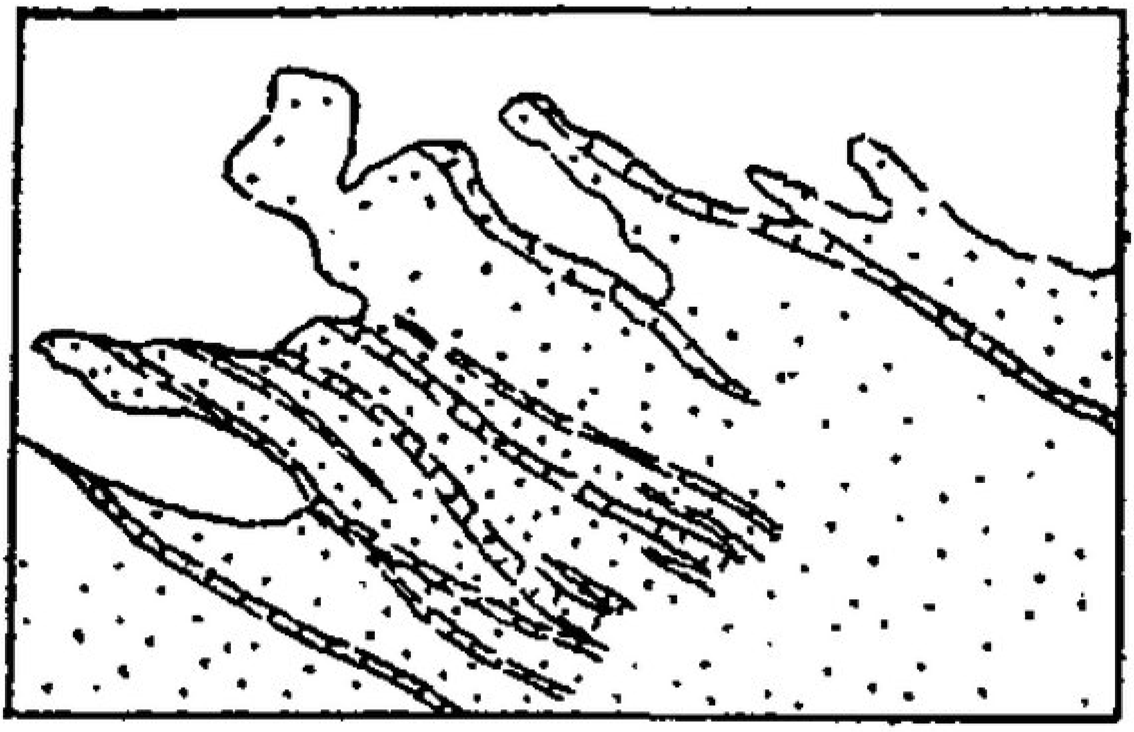


FIG. 227.

BASIC DYKES AT PENRHYN, CEMAES.

(Figure 227) Basic dykes at Penrhyn, Cemaes. From the .0004 (1:2500) maps.

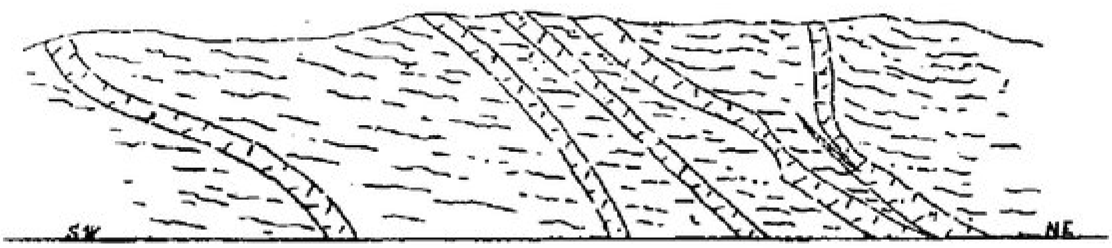


FIG. 234.—GROUP OF SMALL (six to 12-inch) DYKES.

(Figure 234) group of small (six to 12-inch) dykes. Menai Strait, east-south-east of Pen-y-parc.

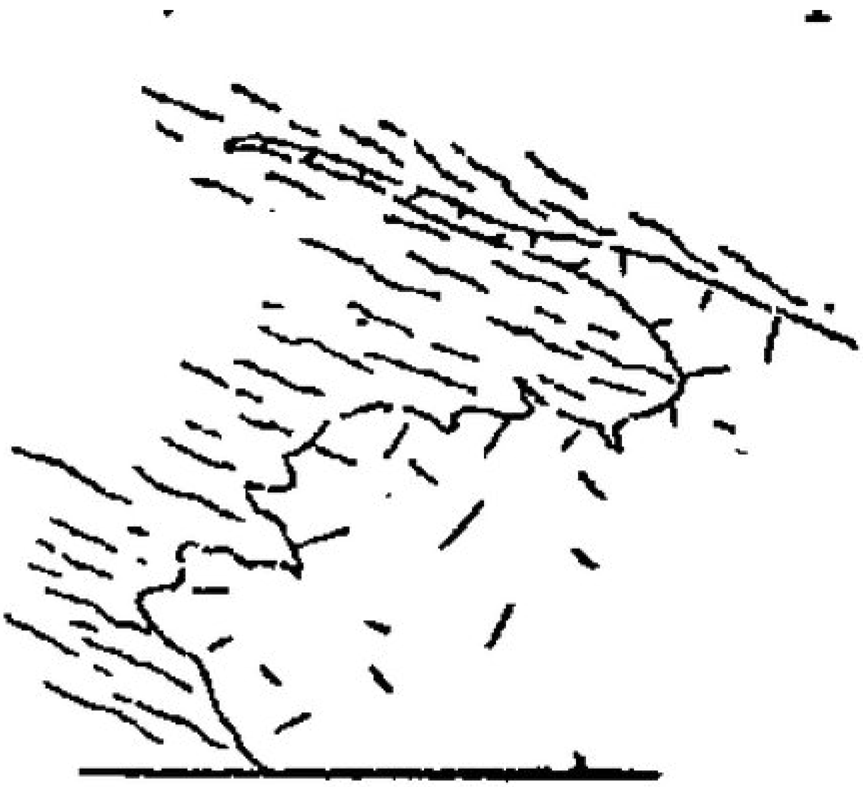


FIG. 228.

MARGIN (6 inches) OF SMALL DOLERITE DYKE, MENAI STRAIT.

(Figure 228) Margin (6 inches) of small dolerite dyke, Menai Strait.

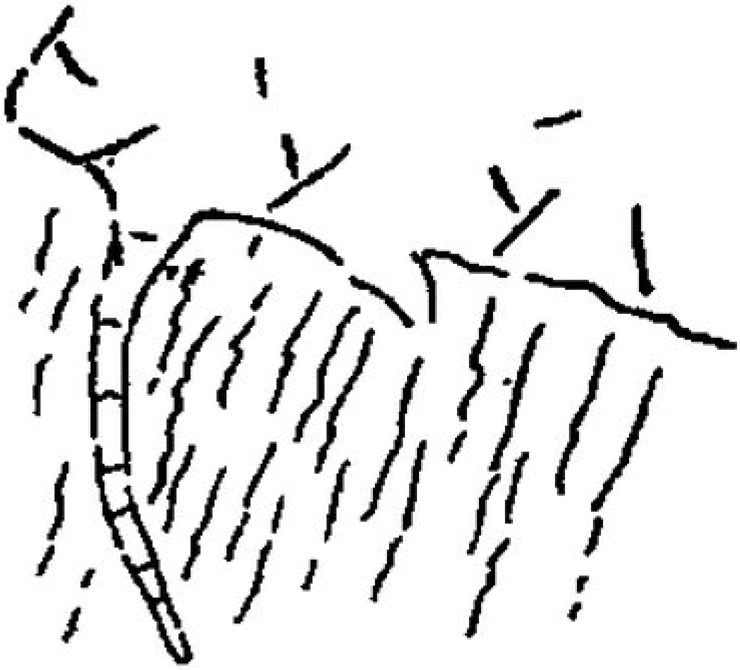


FIG. 229.
ONE-FOOT VEIN FROM DYKE IN CEMAES BAY.

(Figure 229) One-foot vein from dyke in Cemaes Bay.

FIG. 230.

3-INCH DYKE NEAR GARTH LODGE GATE.

(Figure 230) 3-inch dyke near Garth Lodge Gate. 125 feet north-east of '67'.

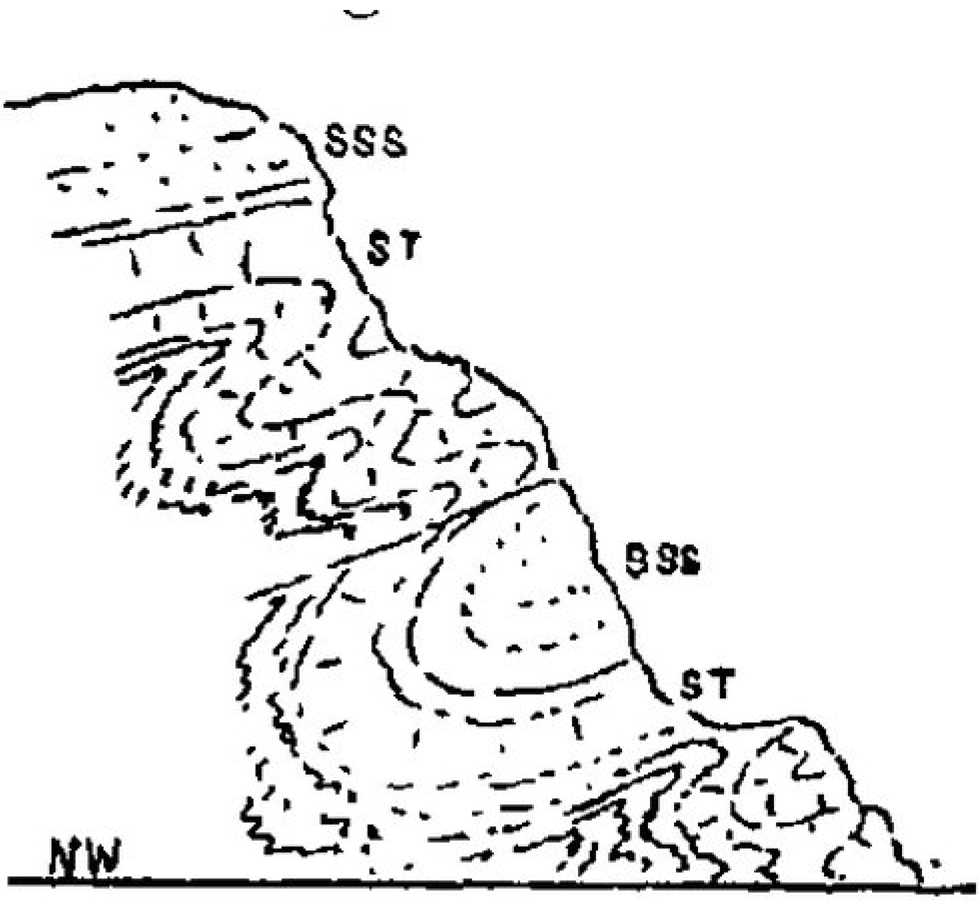


FIG. 31.

(Figure 31) Spilitic Tuff (ST), Passage Beds, and South Stack Series (SSS), At Lifeboat Cove, Rhoscolyn. Height, about 30 feet.

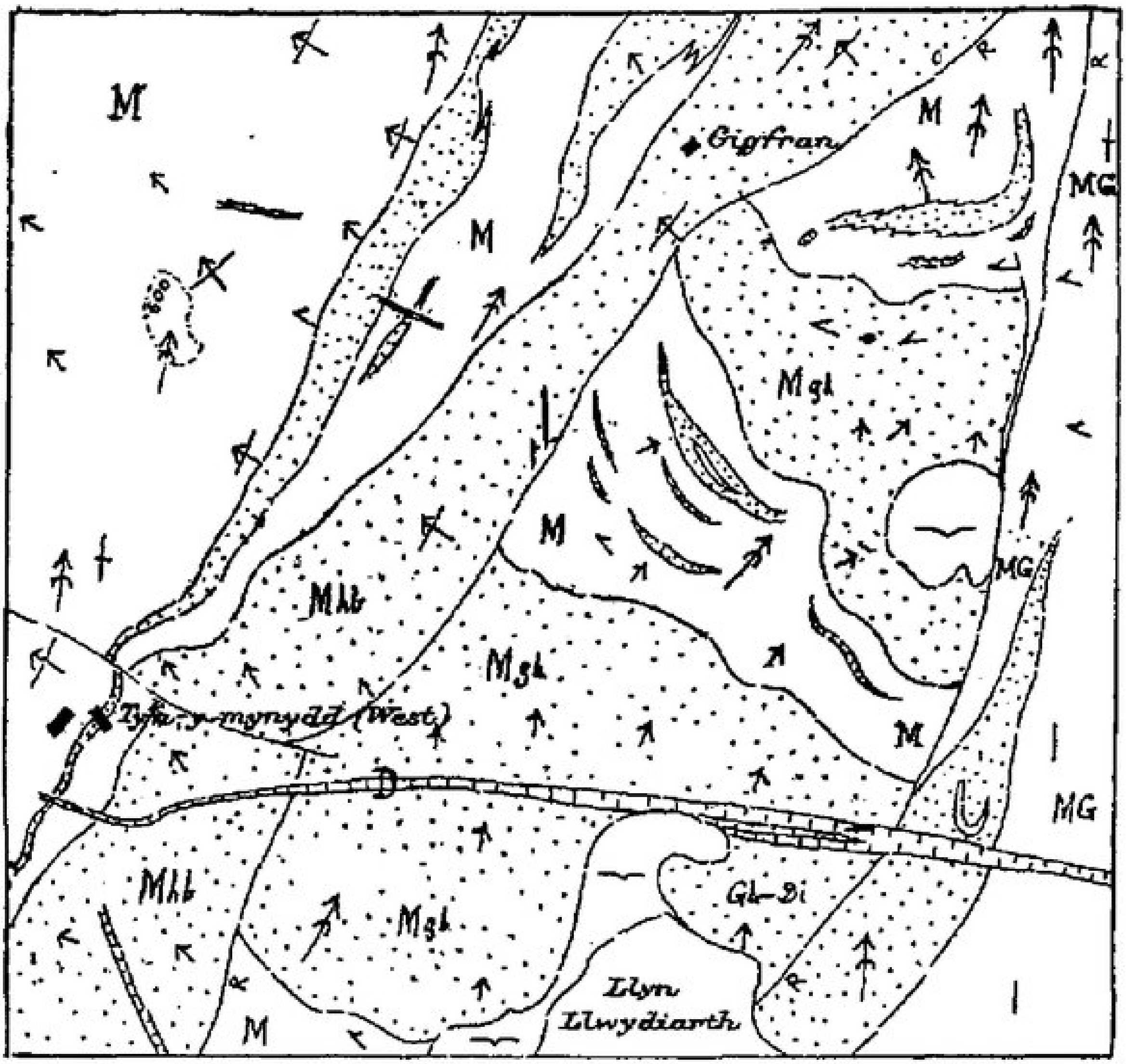


FIG. 185.—THE SOUTHERN PARTS OF MYNYDD LLWYDIARTH.

(Figure 185) The southern parts of Mynydd Llwydiarth. From the six-inch maps. Eastern summit at the 500-foot-contour. MG = Gwna Green-schist. M = Penmynydd Mica-schist. Mhb = Hornblende-schist. MGl = Glaucophane-schist. Gl-Di = Glaucophane-Diorite. D = Palaeozoic dolerite dykes. [Alluvium symbol]= alluvium. RR = the diverging pair of Ruptures. The symbols indicate dip, isoclines and pitch, all of foliation.

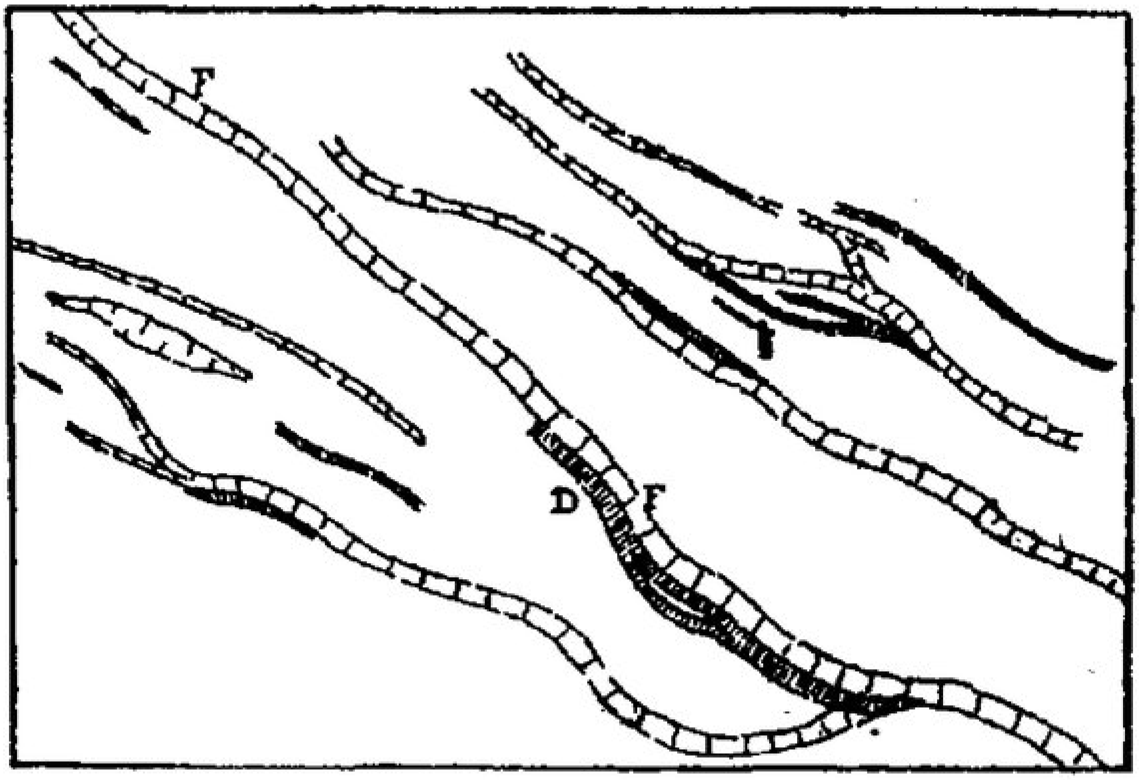


FIG. 244.—FELSITE, DOLERITE, AND COMPOUND DYKES AT DRUM.

(Figure 244) Felsite, dolerite, and compound dykes at Drum. From the six-inch map.

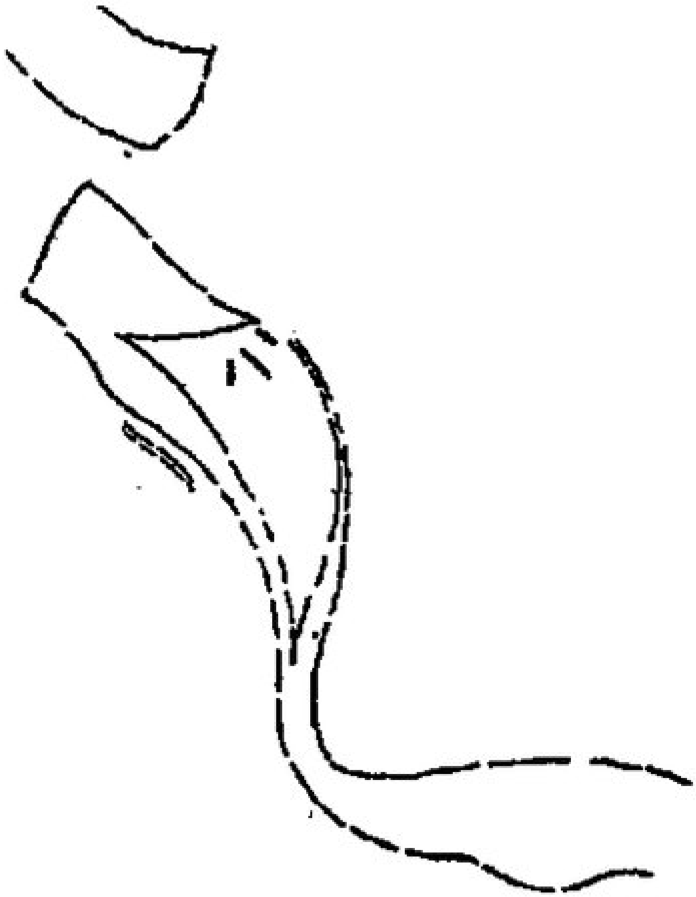


FIG. 232.
SPLITTING OF THE
RHOSCOLYN DYKE.

(Figure 232) Splitting of the Bhoscolyn dyke. Scale: .0002 or 1: 5000.

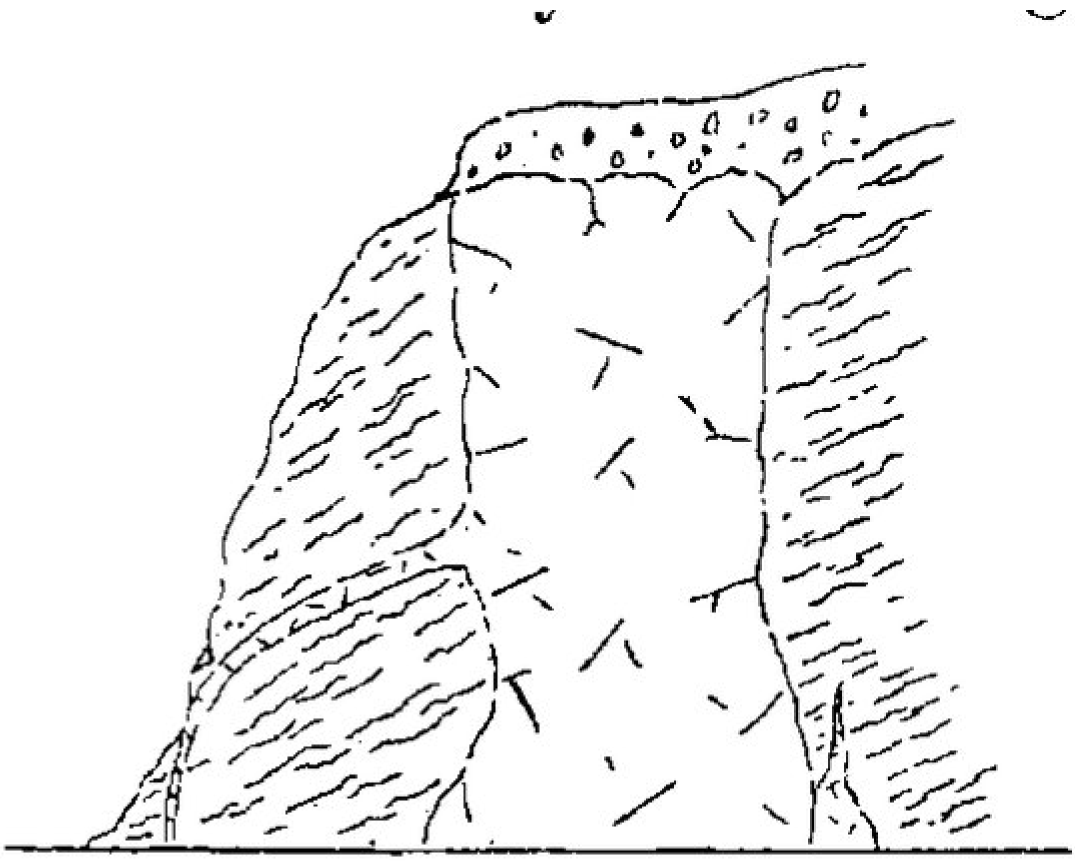


FIG. 233.
13-FOOT DYKE OF PLATE XXX.

(Figure 233) 13-foot dyke of (Plate 30).

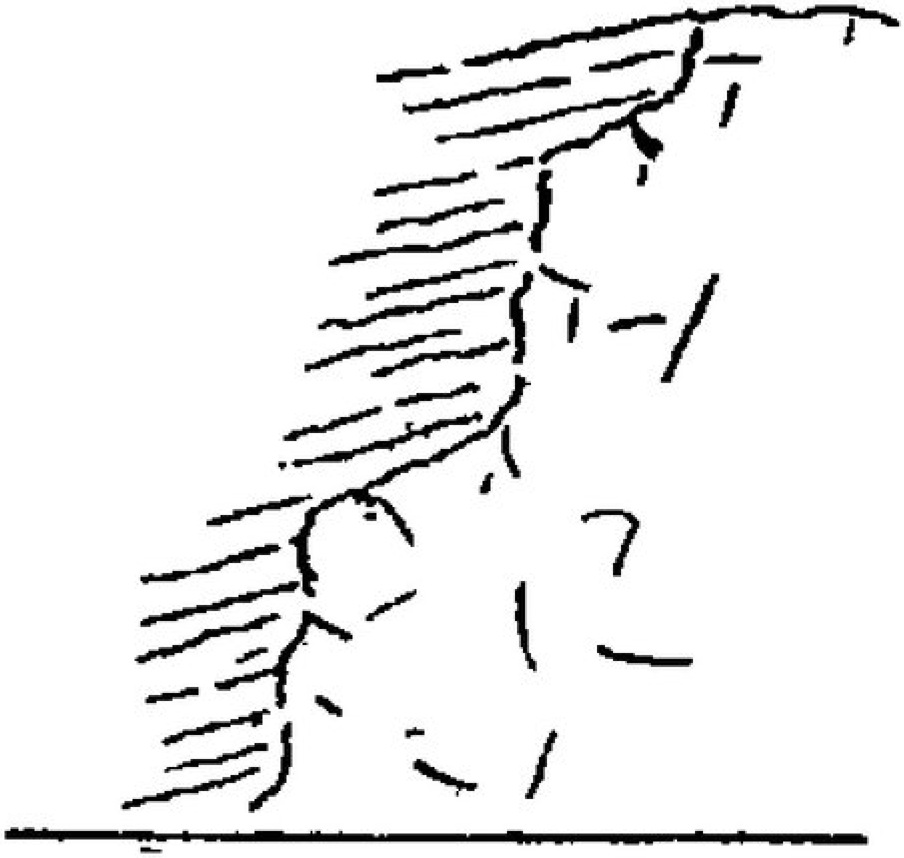


FIG. 235.

LARGE DYKE.

(Figure 235) Large dyke. Quarter of a mile east-south-east of Llyn Bwch.

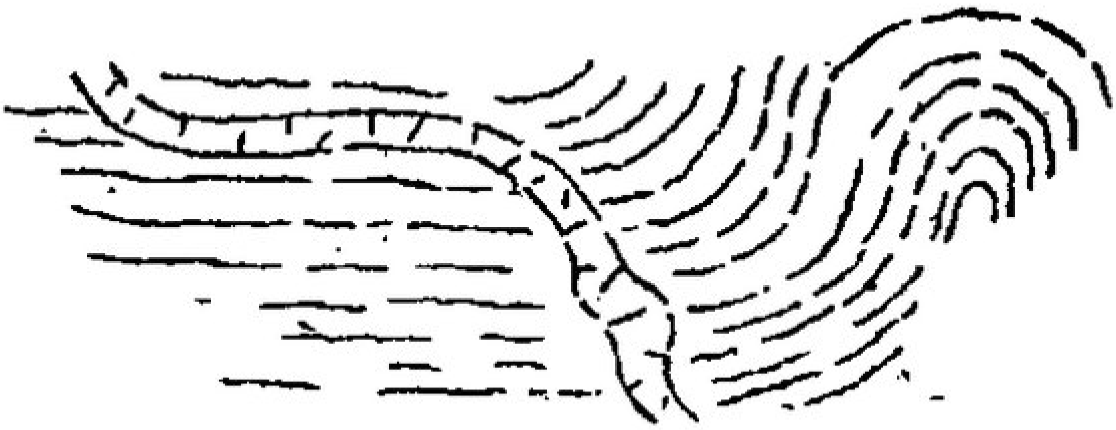


FIG. 236.

SIX-INCH DYKE.

(Figure 236) Six-inch dyke. 286 yards south-south-east of Llanddygfael-hir.

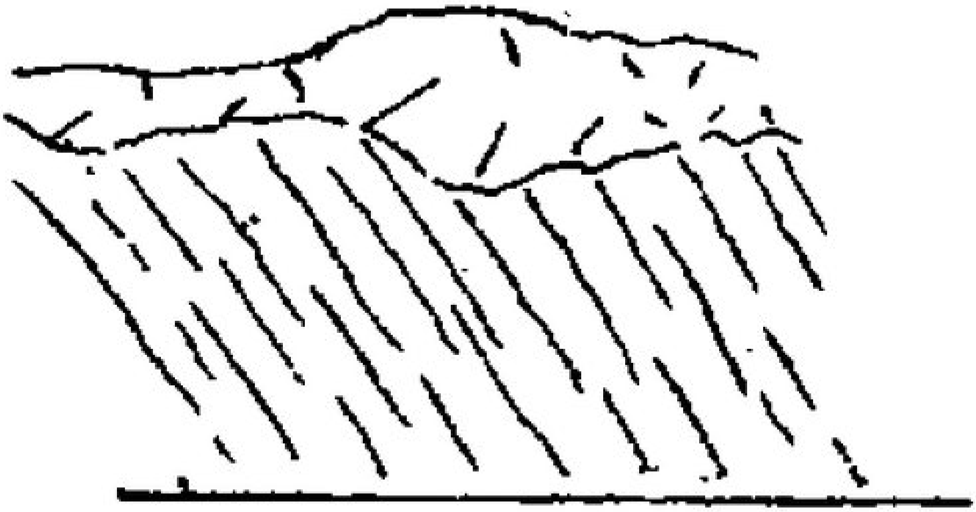


FIG. 237.

TWO-FOOT DYKE.

(Figure 237) Two-foot dyke. Three-eighths of mile north of west of Bwlch.

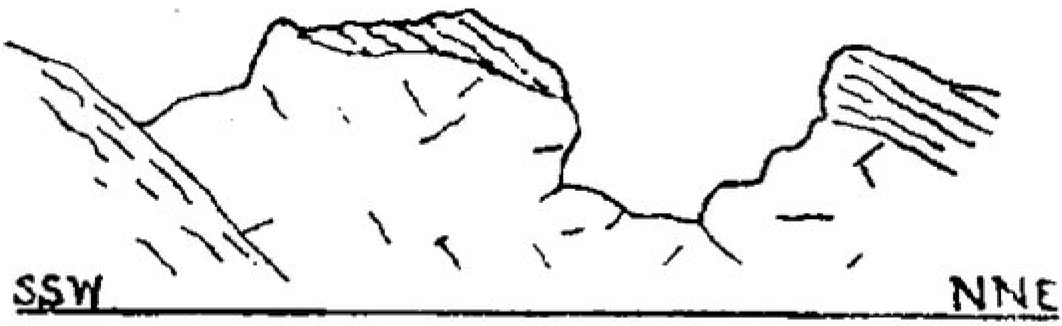


FIG. 258.—DOLERITE ON COAST WEST OF CAREG-ONEN.

(Figure 258) Dolerite on coast west of Careg-onen.

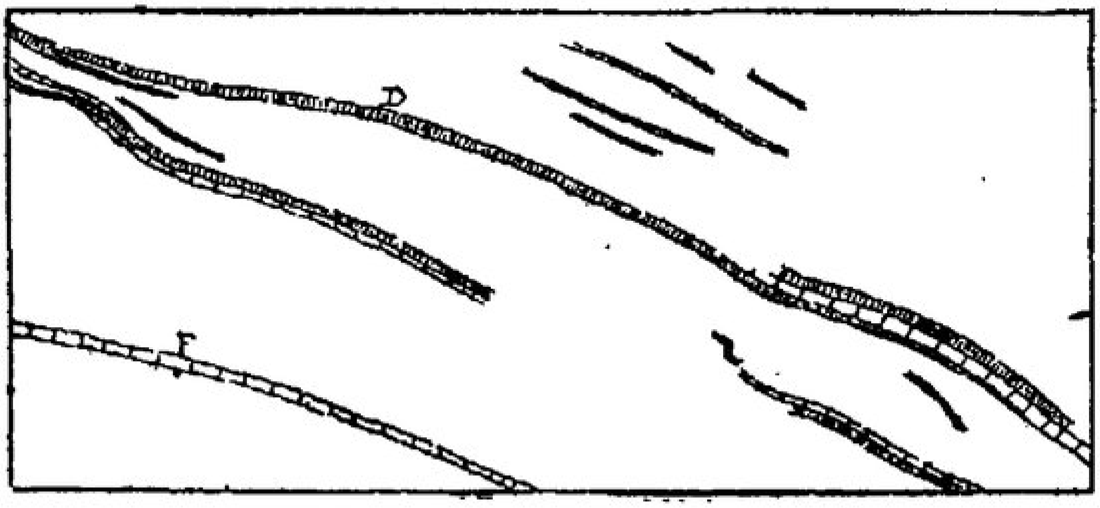


FIG. 243.—FELSITE, DOLERITE, AND COMPOUND DYKES.

(Figure 243) Felsite, dolerite, and compound dykes. North of Coeden. From the six-inch map.

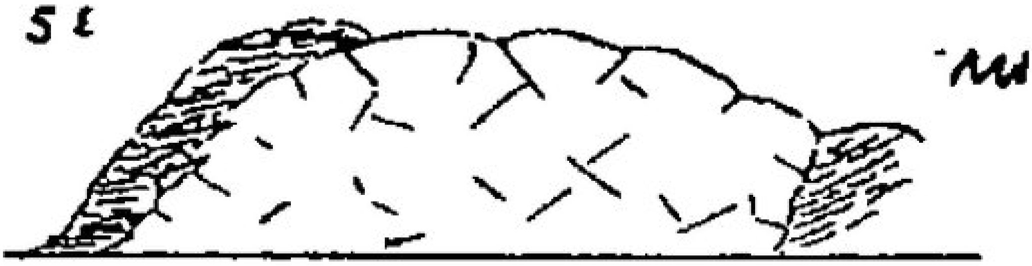


FIG. 238.

FELSITE DYKE, YNYS-FAWR.

(Figure 238) Felsite dyke, Ynys-fawr. Nine yards wide.

FIG. 239.

FLANK OF FELSITE DYKE.

(Figure 239) Flank of felsite Dyke. Group south-west of Gwalchmai.

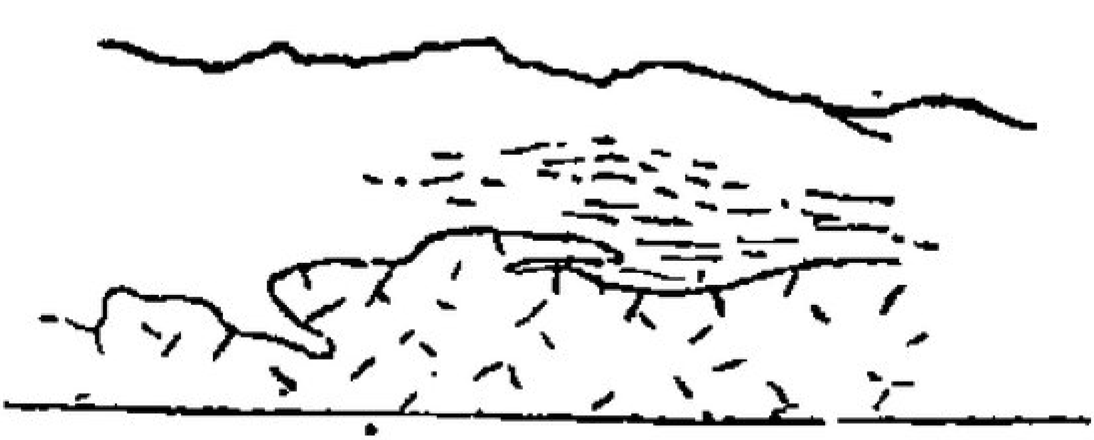


FIG. 240.

FELSITE DYKE.

(Figure 240) Felsite dyke. 270 yards west-north-west of Gwalchmai Inn.

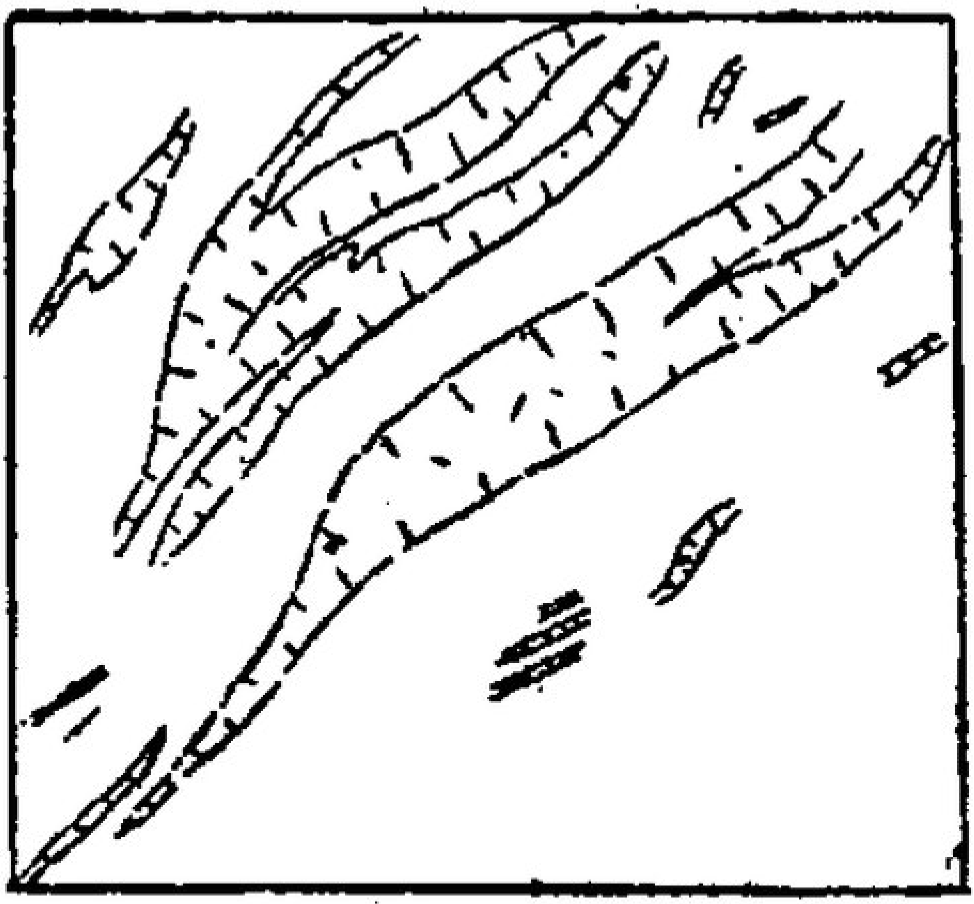


FIG. 241.
FELSITE DYKES.

(Figure 241) Felsite dykes. South-west of Gwalchmai. From the six-inch map.

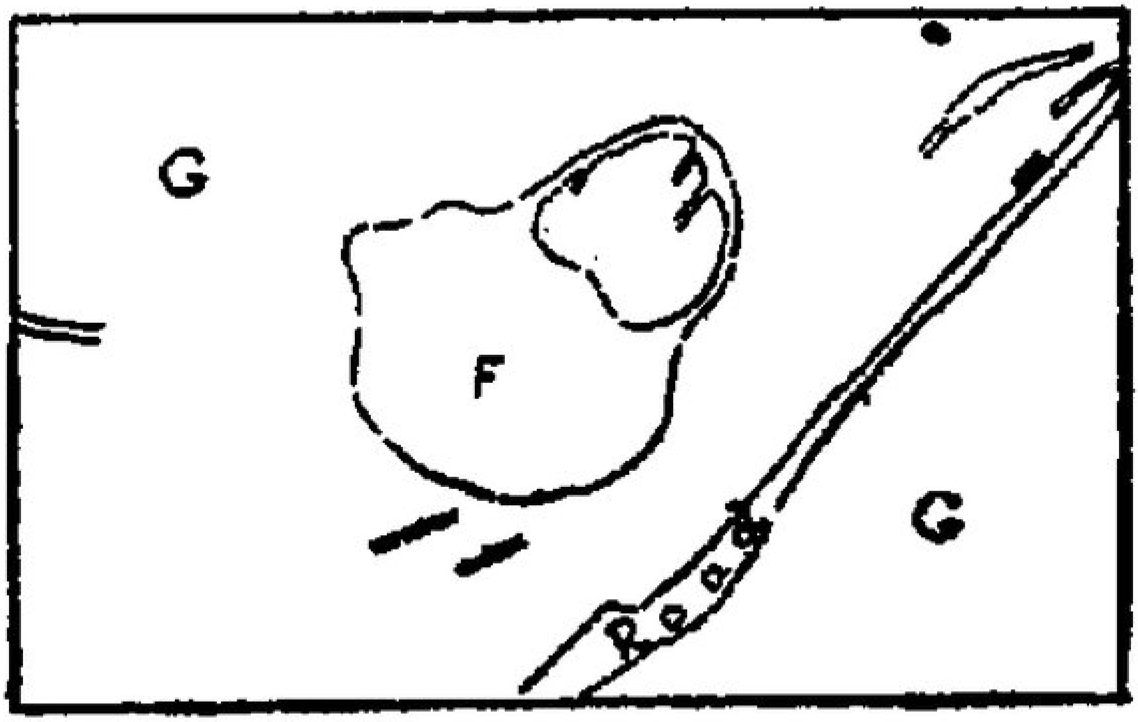


FIG. 242.

FELSITE SHEET WITH GRANITE OUTLIER AT BRYN TWROG.

(Figure 242) Felsite sheet with Granite outlier at Bryn Twrog. From the six-inch map.

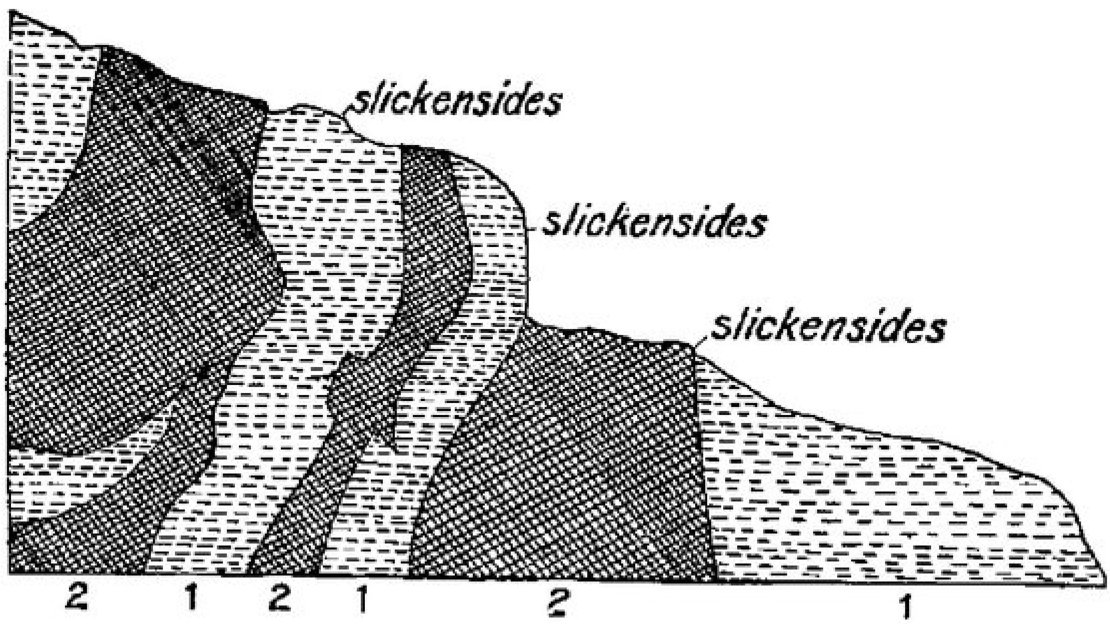


FIG. 260—SECTION IN THE COMPOSITE DYKE WEST OF LLANFECHELL. (Matley.)

Width shown = about 16 feet.
1 = Felsite. 2 = Dolerite.

(Figure 260) Section in the composite dyke West of Llanpechell. (Matley.) Width shown = about 16 feet. 1 = Felsite. 2 = Dolerite.

FIG. 246.

SMALL BASIC SILLS AT LLANDYFRYDOG.

(Figure 246) Small basic sills at Llandyfrydog.

FIG. 247.—FAULTED BASIC SILL AT LLANERCHYMEDD STATION.

(Figure 247) Faulted basic sill at Llanerchymedd Station. Not measured, but height about 20 feet.

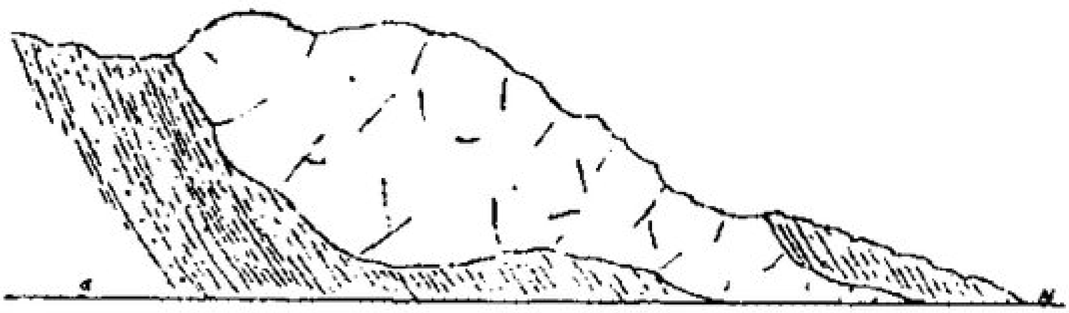


FIG. 248.

SILL OF DIABASE IN LLANVIRN SHALES.

(Figure 248) Sill of diabase in Llanvirn Shales. 166 yards north-east of bathing house, Dulas Bay. Height, 15 feet.

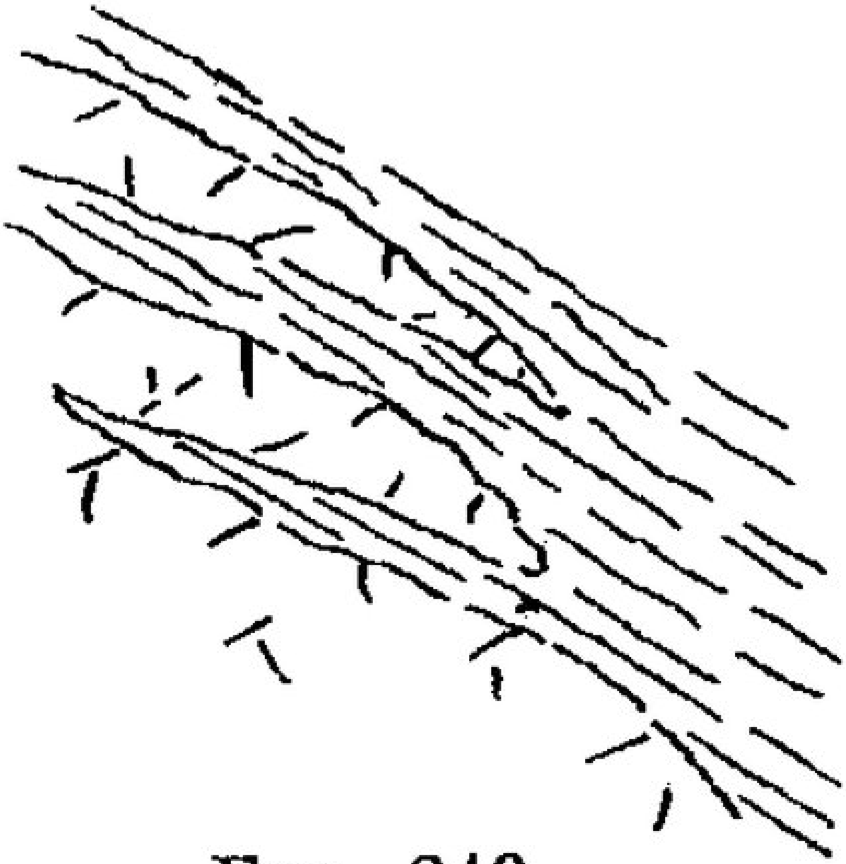


FIG. 249.

TONGUES FROM BASIC SILL. OGO-FAWR.

(Figure 249) Tongues from basic sill. Ogo-fawr.

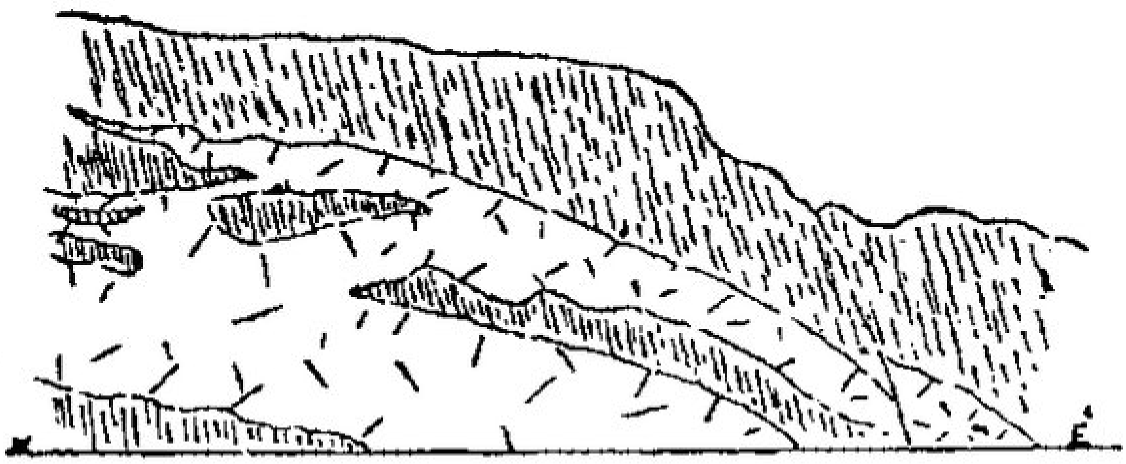


FIG. 250.

BASIC SILL ON LIGHTHOUSE CRAG, THE SKERRIES.

(Figure 250) Basic sill on lighthouse crag, The Skerries. Height about 20 feet.

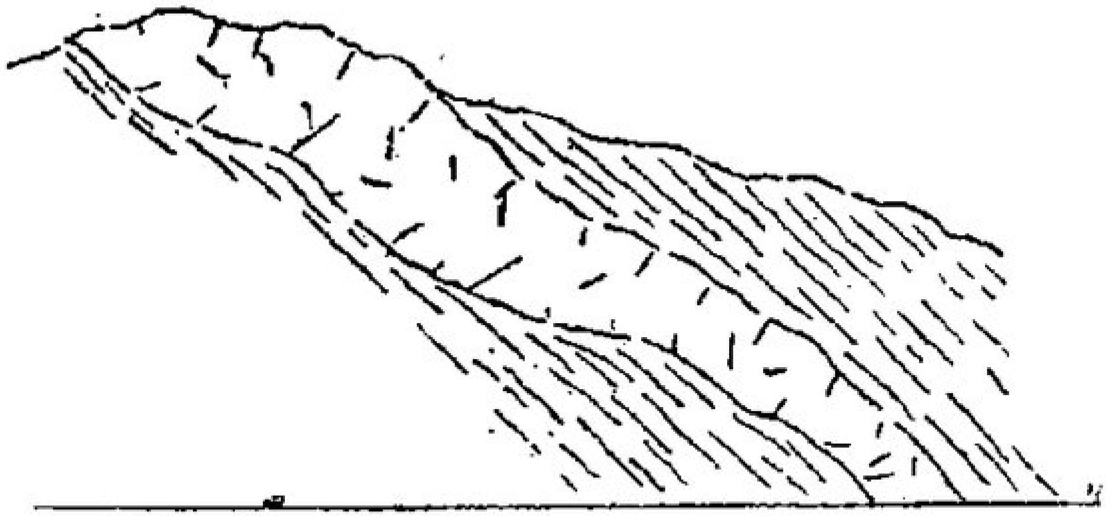


FIG. 251.

FELSITE SILL.

70 yards south of Ogo-fawr.

Height about 60 feet.

(Figure 251) Felsite sill. 70 yards south of Ogo-fawr. Height about 60 feet.

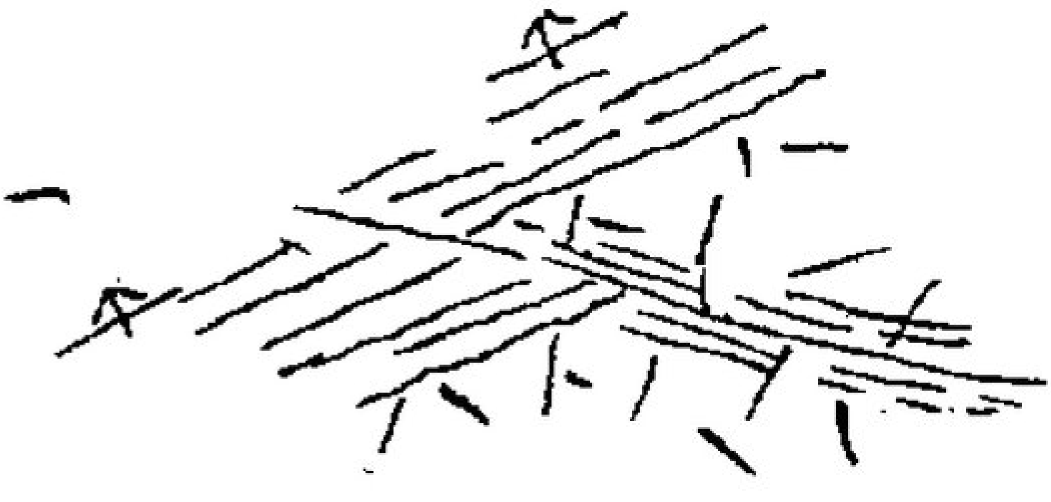


FIG. 252.

SHIFT OF MARGIN OF BASIC SILL, OGO-FAWR.

(Figure 252) Shift of margin of basic sill, Ogo-fawr.

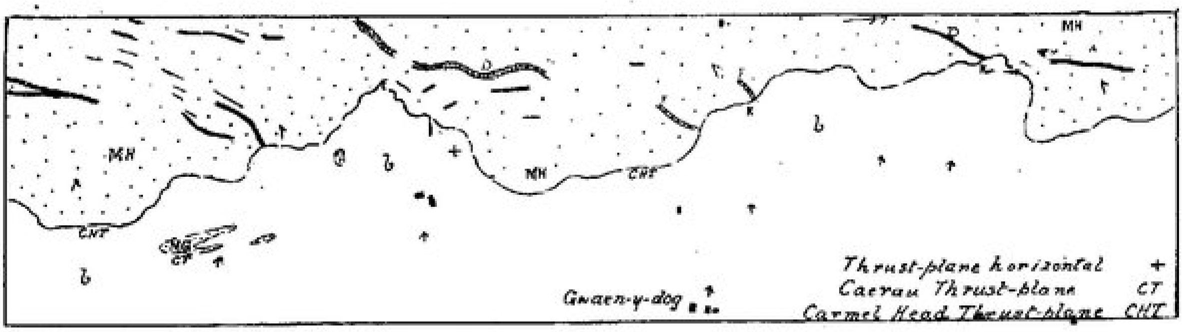


FIG. 269.—OUTCROP OF THE CARMEL HEAD THRUST-PLANE AT GWAEN-YDOG.
From the six-inch maps.

MH = Coeden Beds. MG = Gwna Beds. b = Arenig Beds.
F = Felsite Dykes. D = Dolerite Dykes. K = Crushed Dykes.

(Figure 269) Outcrop of the Carmel Head Thrust-plane at Gwaen-ydog. From the six-inch maps. MH = Coeden beds. MG = Gwna Beds. b = Arenig Beds. F = Felsite Dykes. D = Dolerite Dykes. K = Crushed Dykes.

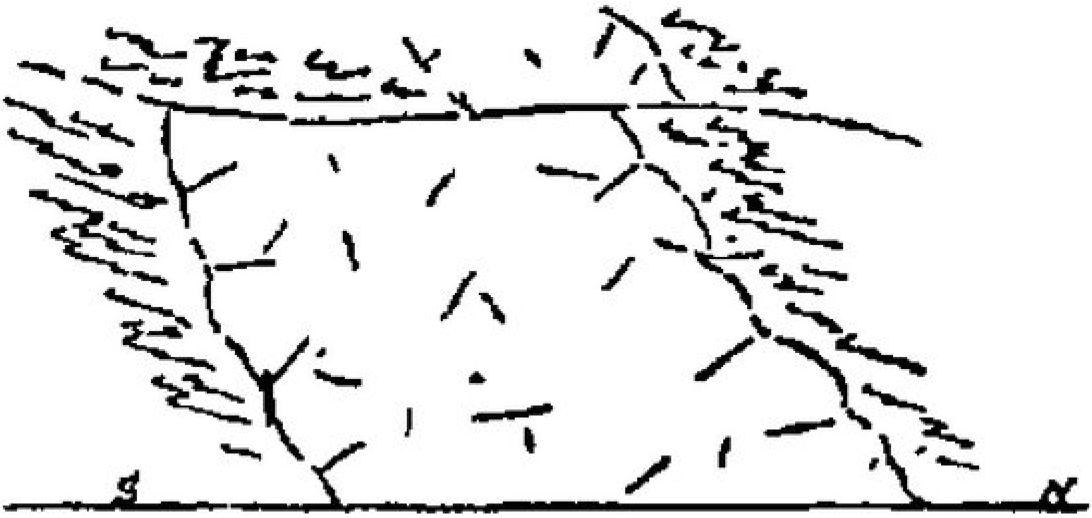


FIG. 253.

THRUST IN DYKE AT PANT-HOWEL.

(Figure 253) Thrust in dyke at Pant-howel. Height about 20 feet.

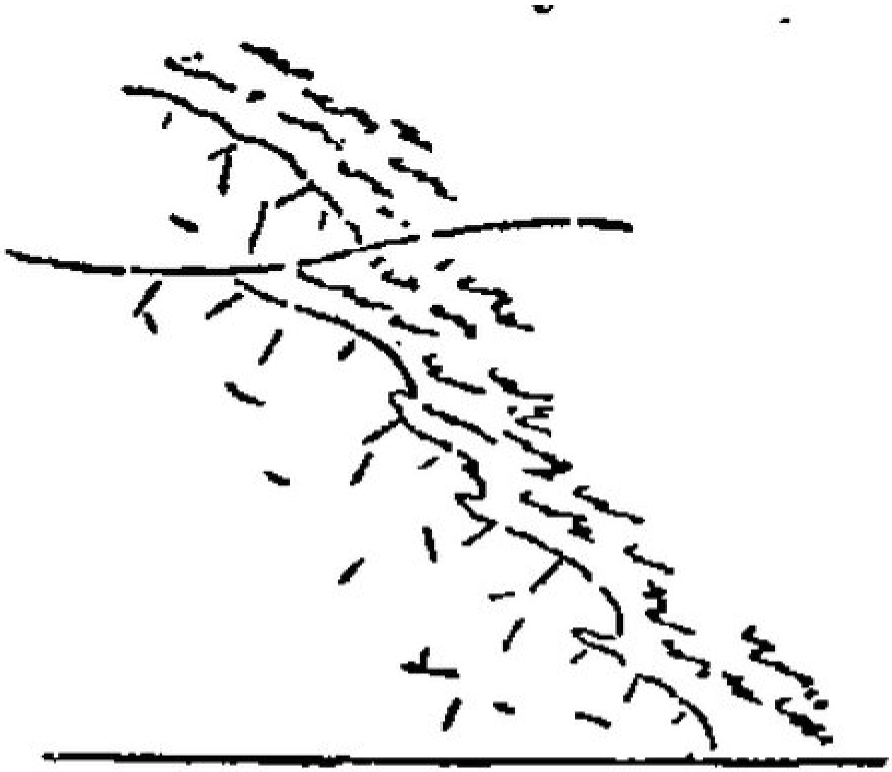
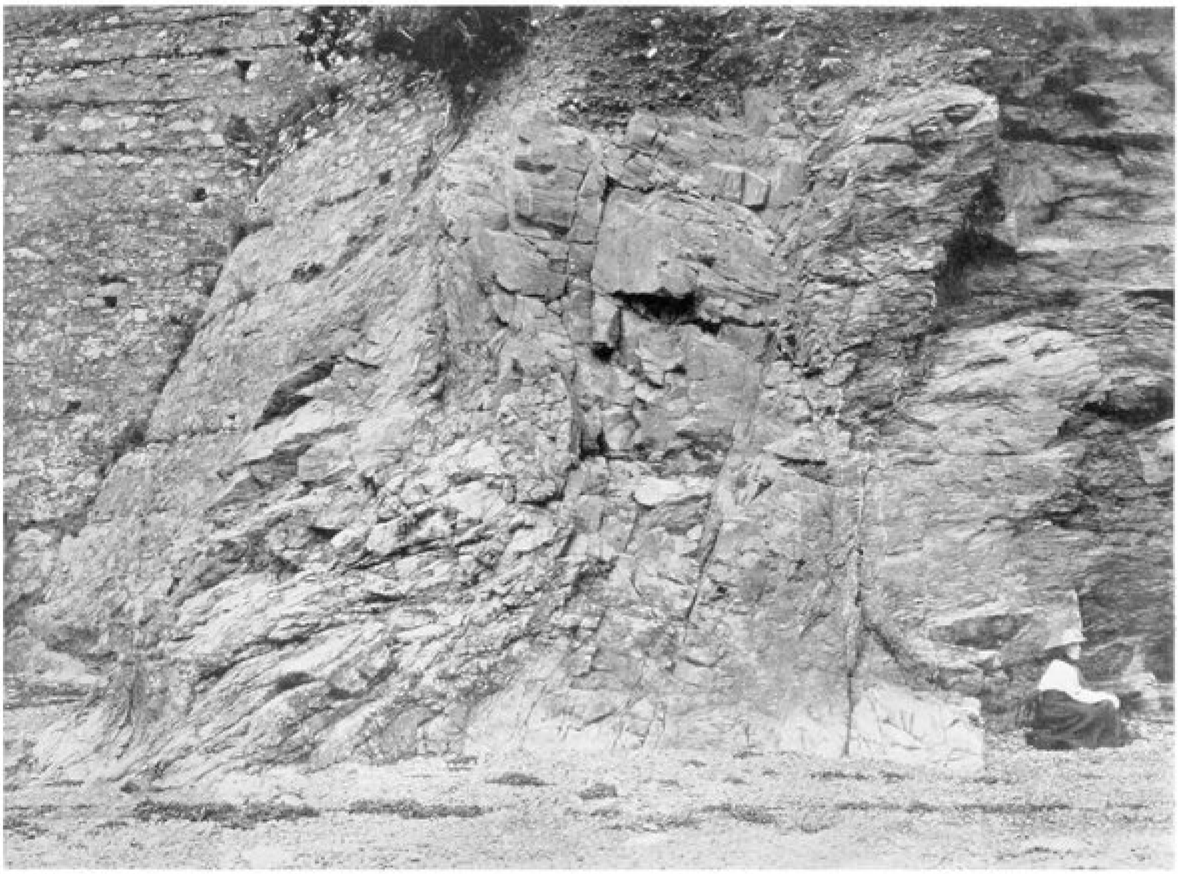


FIG. 254.

A FEW INCHES OF THE NORTHERN MARGIN SHOWN IN FIG. 253.

(Figure 254) A few inches of the northern margin shown in (Figure 253).



(Plate 30) Paleozoic dolerite dyke on the Menai shore.

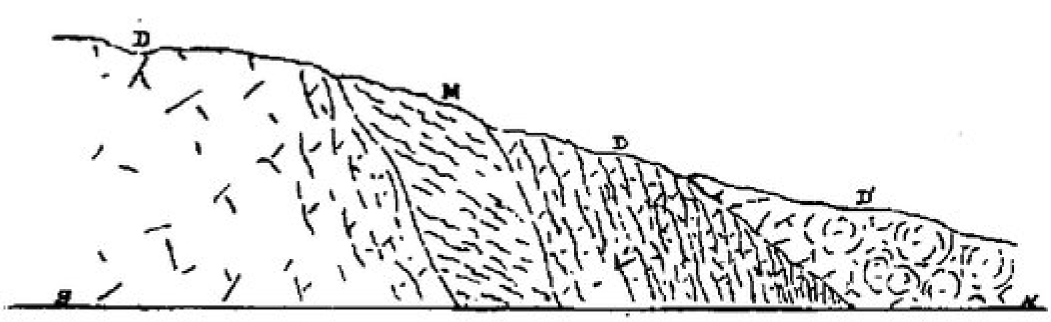


FIG. 306.—JUNCTION OF A PALÆOZOIC AND A LATER DYKE NEAR GAERWEN.

Scale: One inch = about 15 feet.

M = Penmynydd Mica-schist. D = Palæozoic Dyke.
D′ = Later Dyke.

(Figure 306) Junction of a Palaeozoic and a later dyke near Gaerwen. Scale: one inch = about 15 feet. M = Penmynydd mica-schist. D = Palaeozoic dyke. D■= later dyke.

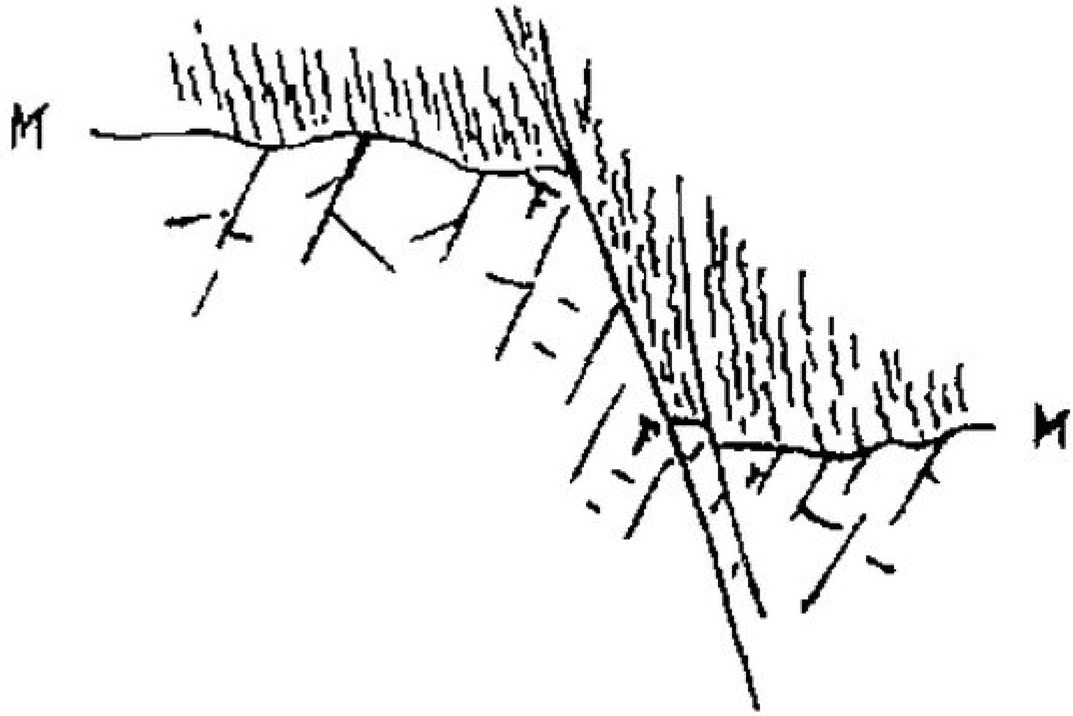


FIG. 255.

PLAN (2½ feet long) OF SHIFTS IN DOLERITE DYKE AT CAREG LYDAN.

(Figure 255) Plan (2½ feet long) of shifts in dolerite dyke at Careg Lydan.

FIG. 256.

SCHISTOSE DYKE AT GWALCHMAI.

Seven-sixteenths of mile north-east of Caer-glaw.

(Figure 256) Schistose dyke at Gwalchmal Seven-sixteenths of mile north-east of Caer-glaw.

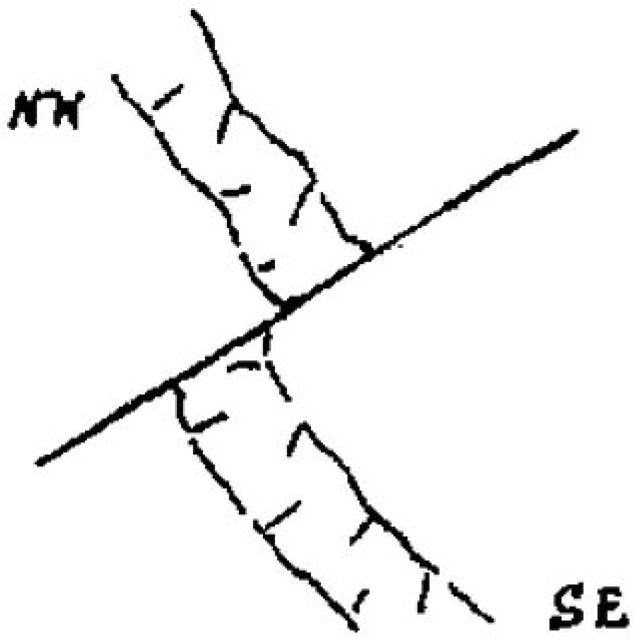


FIG. 257.

SHIFTED ONE-FOOT DYKE. NORTH CLIFF OF PORTH TRE-CASTELL.

(Figure 257) Shifted one-foot Dyke. North cliff of Porth Tre-castell.