Chapter 28 The Later Dykes

Introductory

Twenty-one of the dykes of Anglesey traverse rocks of Carboniferous age, and nine of those which outcrop merely in the Mona Complex are so closely allied to them in character that they must be placed in the same group. Thirty in all are therefore known, but further research is almost certain to add to their number from among the hundreds now assigned provisionally to the older series.

Petrology <ref>Most of the slides were kindly looked over by Dr. H. H. Thomas.</ref>

They are dark, heavy rocks, brown-crusted and more basic-looking than the older dykes, coarser also on the whole, and with a much rougher and more hackly fracture; so that a specimen can be easily picked out from- a collection of the others. They often weather spheroidally, and, except in the spheroids, decompose readily, breaking-down to a mere basic sand. Their minerals are felspars, augite, olivine, hornblende (very rare), biotite, and iron-ores. Apatite is either very rare or absent. The dominant felspar is labradorite, but there is a range from a basic bytownite to andesine or even oligoclase. Most of the felspar is in laths with strong lamellar twinning, but some of the broader ones are zoned, and graduate from cores of labradorite to margins of oligoclase. In a few cases there are veinlets and margins of albite, but albitisation is rare and feeble in these rocks. Porphyritic crystals have been seen only in the narrow Traeth Bychan dyke, where their most basic parts have a refractive index but little below that of anorthite. Most of the augite is pale-brown, in large ophitic plates; but in some of the rocks there is a much deeper-tinted variety, somewhat pleochroic, with a faint tinge of violet in one position, which resembles the augite of the teschenites. In rare cases a little complementary brown hornblende borders the augite, but no true secondary hornblende has been seen. The olivine is occasionally hypidiomorphic and in large crystals, but usually in irregular granules. The brown mica borders the iron-ores in most cases. Some of the dykes have a brownish-green glass, full of rod-like and skeletal iron-ores, with other microliths.

Five sub-types can be recognised. First: a typical olivine-dolerite, rather coarse, and strongly ophitic, in which the olivine is wonderfully well-preserved (Plate 28), Fig. 6. That mineral, though early, is pierced by a few felspars, as are the iron-ores. Then follow the principal felspars,- and then the ophitic augites. Second: an olivine-dolerite almost as coarse, but with a little glassy matter, and. with all the olivine serpentinised. Third: a rather fine sub-ophitic basalt, which contains the deeper-tinted augite. Fourth: a fine type with abundance of glass full of iron-ore skeletons, known in one case to be porphyritic, which is allied to the tholeiites, and also to some of the North of England dykes described by Dr. Teall. All the foregoing appear to have contained olivine; but there is a fifth sub-type which is coarse and resembles the first in structure, but contains little or no olivine. The following partial analyses have been made:

	I	II	III	IV	V	VI
SiO_2	46.44	47.32	42.34	—	—	—
$Al_2O_3+F_2O_3$	—	—	27.88	—	—	—
CaO	—	—	8.74	—	—	—
MgO	—	—	7.57	—	—	—
Sp. Gr.	2.948	—	—	2.966	2.852	2.805

I. Holland Arms main dyke, railway cutting. Fresh olivine-dolerite (E9870) [SH 471 725]. Anal. J. O. Hughes.

II. Traeth Bychan dyke. Tholeiite (E10302) [SH 517 846] Anal. J. O. Hughes.

III. Henborth dyke, Holyhead, north end (E10123) [SH 208 818]. Anal. W. Roberts, B.Sc., under direction of J. O. Hughes.

IV. Plâs Newydd dyke.

V. Holland Arms lesser dyke.

VI. Porth-Wnol dyke, northern coast. Tholeiite (E10423) [SH 352 943]. Specific gravities by J. O. Hughes.

Veins and selvages

In the larger dykes there are some acid veins, an inch or two (but occasionally five inches) thick, almost entirely composed of albite, with a little quartz, iron-ores, and hornblende. They are true segregation-veins, as are also a few with very large augites. Thin longitudinal veins with compact selvages, composed of a vesicular eass full of microliths, in which are slender laths of oligoclase, are veins of second injection, and must have entered when, at any rate, the upper parts of the dyke were solid. The selvages of the large dykes are not often well exposed. At the cove between Porth Dafarch and Porth y Post is a selvage resembling the tholeiites, but full of minute augites, and with very little glass.

Contact-metamorphism

The Holland Arms dyke sets up spots in the grey mudstones of the Red Measures and in the cherts at the top of the Carboniferous Limestone. The Capel-mawr dyke has converted a clean limestone of the D3 sub-zone into a saccharoid marble at Tycalch. Henslow describes the effects of the Berw mine dyke upon the Coal Measures, which are of the usual kind. The Cadnant dyke develops chlorite-spots in the Gwna Green-schist and reconstitutes its albite.

Much more interesting results are produced by the Plâs Newydd dyke at the Menai Strait. All that has been seen of late is a banded grey lydianite produced from a dark shale in the D2 limestones. But Henslow's specimens (the following study of which is from the paper by Dr. Harker) show all stages from mere spotting to perfect crystals of garnet and of a mineral resembling analcime, often closely clustered along bedding-planes; shells of *Productus* also being occasionally studded over and penetrated by them. The garnet is yellowish-green to olive-brown in colour, with a resinous lustre, its hardness under 7, and specific gravity 3.353, indicating a variety approaching grossularia. The crystals are not all isotropic, they contain much foreign matter, and have often a concentric zonal structure. The principal faces are those of (110), sometimes bevelled by narrow facets of (211). The analcime-like crystals, where best developed, show the faces of (211); and they also have concentric zoning.. They were analysed for Henslow by Cumming. Dr. Harker reconciles his figures with the published analyses thits

	I	II	III	IV	V
Silica	49	49	54.4	43.6	49.00
Alumina	17	24	23.4	24.9	24.15
Lime	12	12	—	27.1	13.55
Iron	4	—	—	—	—
Soda	9	9	14.1	—	7.05
Water	5	5	81	4.3	6.20
Loss	4	—	—	—	
	100	99	100	99.9	99.95

I. Cumming's analysis.

II. The same, modified by assuming the iron to be present as Fe_2O_3, and replacing it by Al_2O_3.

III. Analcime, calculated from the formula $H_4Na_2Al_2Si_4O_{14}$.

IV. Prehnite, from $H2Ca_2Al_2Si_3O_{12}$.

V. The mean of III and IV

The composition of this mineral is therefore peculiar, but resembles that of an impure calcareous analcime. Dr. Harker; in a letter of May, 1913, writes that a thin slice shows no prehnite.

Most of Henslow's specimens are in the Sedgwick Museum at Cambridge; but a few of them are hi the collection of the Geological Survey. Two of these, from the edge of the Plâs Newydd dyke (E11440) [SH 521 696]–(E11441) [SH 521 696], are pale compact limestones full of finely-divided silica, and studded with minute spots, which are colourless garnets enclosed in shells of calcite. Some of the garnets are idiomorphic, and all of them are anisotropic, breaking up into sectors between crossed nicols. Delessite has also developed. Some isotropic material of low refractive index is present, which Dr. H. H. Thomas considers to be a glass, containing extremely minute needles of rutile, and apparently also of a monoclinic pyroxene.

Comparison with the Palaeozoic dykes

The members of the present suite are, as a whole, more basic; and no late intermediate or acid dykes are known. Olivine, very rarely present in the older dykes, in this group is very rarely absent; while the felspars now range to the borders of anorthite. Apatite, so abundant in the older series, has not been seen in these. The Palozoic dykes are very seldom spheroidal, these are almost always so. Their secondary characters are still more contrasted. Fresh olivine, which is unknown in the older dykes, is often abundant in these. None of the signs of deformation so frequent in the Palaeozoic are to be found in these dykes. There is often, it is true, a series of divisional planes, at low angles usually, 'that simulates a schistosity. But it produces no deformation in the minerals, does not disturb the albite veins, and passes through the spheroids, whereas a shearing would bend round them. It seems to be an early cooling structure. No post-consolidation hornblende has been found, chloritisation is moderate, and albitisation very slight; whereas the Palaeozoic intrusions are full of secondary hornblende, and are highly chloritised and albitised. Probably the resistance of the older dykes to decomposition is due to the greater stability of their secondary minerals. Indeed, the state of preservation is almost a diagnostic character in separating dykes of the two series.

Behaviour on the large scale

Though so few in number, they are found over the whole extent of the Island. In trend they differ but little from the older dykes, which led to their being so long confused with them, their normal trend being NW–SE. But though divergences from this to WNW–ESE. are known, those towards NNW–SSE. are rarer than among the older suite. All those that can be traced for any' distance exhibit a good deal of curvature in places. When allowance is made for their small numbers, their average width seems to be greater than that of the older series, large ones being the rule. The Holland Arms dyke is 120 feet in width, and that of Capel-mawr 175. The latter is larger than any of the Palaeozoic series, and has been traced for two miles. The Henborth dyke, about 90 feet wide, gives rise to the grandest features of any dyke in the Island (Plate 42). As is usual with large dykes, they are not gregarious. Branching and inclusions are rarer than in the older series, but the Porth-yr-afon dyke splits up at its western end. Their bade is not often seen well, but seems usually near the vertical, inclined, if at all, to the north-east. That of Holland Arms where it meets the old dyke of Gaerwen is at an angle of 45°. The Henborth dyke in the chasm hades eastward at about 20° from the vertical.

Relations to the Paleozoic dykes

A Junction of a Later with an Older Dyke is to be seen at present in one section only, which is of great interest. It is at the entrance to a quarry on the south side of the high road, 275 yards west (by a little south) of Gaerwen Church, and opposite to the 014 Jerusalem Inn (six-inch map). The section is just below the footpath that goes up the fields, under a gorse bush; is already somewhat soiled by rainwash, and likely to deteriorate. Here the great Holland Arms dyke meets an unusually large one of the older series. The later dyke is strongly spheroidal, and very decomposed; the older one is not spheroidal, and is fresh except near the margin. The selvage of the older dyke is not reached at, the junction section; the later one is chilled against, and has evidently encroached somewhat upon it. The older dyke (pp. 513, 519) is traversed by a strong schistosity for some yards from its northern margin; the later is completely undeformed, Finally, the margin of the later dyke has a northward inclination of 15°, and it creeps over the edges of the schistose planes of the older, which dip in the same direction at about 55° to 60° (Figure 306). There can therefore be no doubt whatever of the great difference in age of the two series of dykes.

Relations to sedimentary groups

The horizons traversed by these intrusions are the Mona Complex the Ordovician rocks, the Carboniferous Limestone, the Millstone Grit, the Coal Measures, and the Red Measures. Out of the 21 dykes that pierce the Carboniferous, four pass up into the Millstone Grit, two into the Coal Measures, and two into the Red Measures. Also, a large olivine-dolerite dyke of the same type as these cuts and bakes the conglomerate at the base of the Red Measures (see p. 674) on the shore at Llanfair-is-gaer Church on the opposite side of the Menai Strait.

Geological age

From the evidence given in this chapter and in Chapters 16 and 17, it is abundantly evident that Anglesey contains two groups of basic dykes which, though of similar trend, are of widely different ages.<ref>There is a coincidence of the same kind, it may be remembered, in the southern parts of the North-West Highlands of Scotland.</ref> This much might still have been established even if none of the later group had reached the Carboniferous deposits; for one group is older, the other later than the great Post-Silurian earth-movements, and the rocks of the two groups differ both in chemical and mineral composition. We have seen, however, that the majority of the dykes of the later group do traverse Carboniferous rocks of various horizons, and that some of them cut, alter, and are later than the Red Measures which rest unconformably upon everything below. They must therefore be either of Permo-Carboniferous or Tertiary age. But the main Holland Arms dyke does much more than cut the Red Measures. In the space of 300 yards it passes from those beds across the Upper Limestone cherts ascribed to the Posidonomya zone, and thence across the adjacent Ordovician belt, into the Pen-mynydd Schists of the Mona Complex. The three boundaries are faults; one of them being the main line of the Berw fault, with a displacement at that point of not less than 1,500 feet, another its Esgeifiog branch, which cannot be less than 600 feet in throw. The cherts and Red Measures had been thrown into their present positions by the faults before the dyke arrived; and it traverses all these great lines of movement without the least sign of being affected by any one of them. If affected at all, it can be but slightly, to such degree as might result from minor late movements along an old fracture. It is therefore most unlikely that these dykes belong to the Permo-Carboniferous volcanic episode. No regular system of NW–SE. fissures is known in connexion with that episode, and such dykes, did they exist, could hardly pass across powerful faults of so late a date as these.

Now the next period of volcanic activity in Britain is that of Tertiary time. In that period, fissure-dykes with the same trend as these were, as is well-known, extremely numerous. Petrologically also, these Anglesey dykes are closely allied to types well-known in the Tertiary system. Dr. Teall writes of one of them' as a wonderfully fresh olivine-dolerite. In its composition and state of preservation it differs so markedly from the "greenstones", and approaches so closely many of the Carboniferous and Tertiary dolerites that one is inclined to regard it as a rock of much later date.<ref>'British Petrography', p. 215, footnote.</ref>

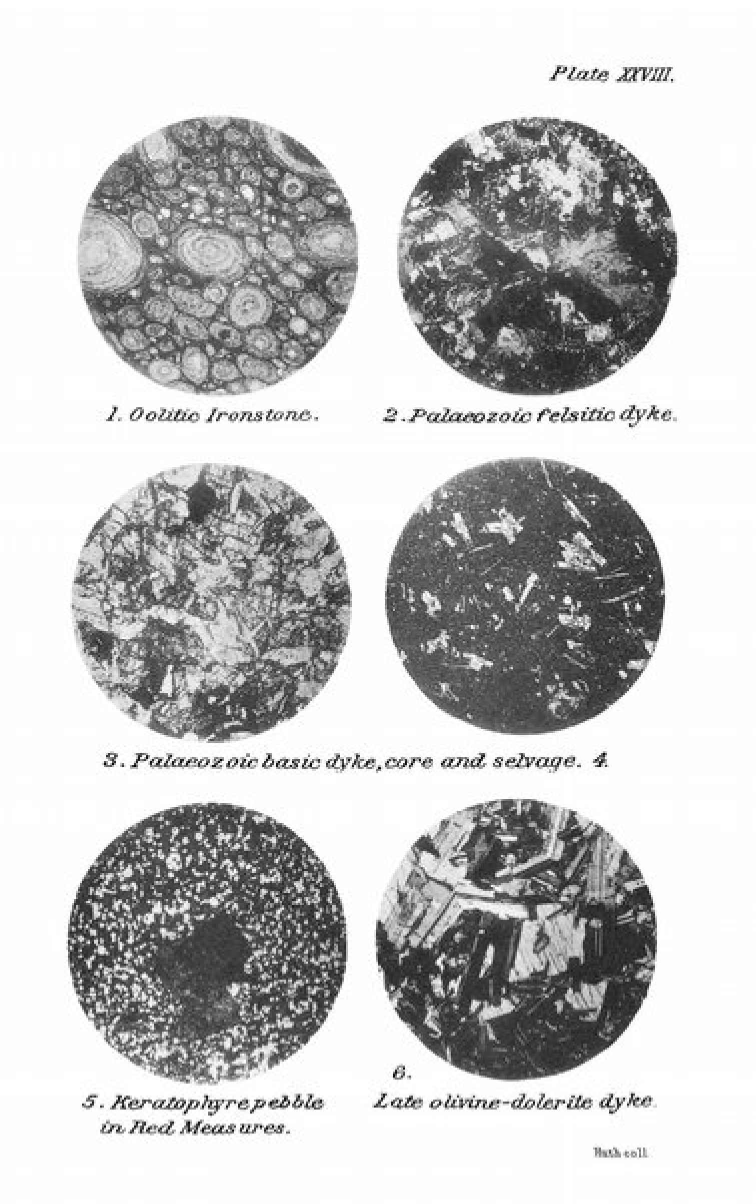
The Holland Arms dyke, again, can be matched by one from Goat Island, Raasay; and olivine-dolerites of the same type are described by Dr. Harker.<ref>The Tertiary Igneous Rocks of Skye' (Mem. Geol. Surv.), pp. 320–324</ref>.

Late faults. There is some reason to suspect that certain small faults may also be of Tertiary date. We have seen that the internal fault-system of the Carboniferous areas (pp. 678–9) is never known to cut the external system. But an Ordovician boundary to the east of Pentraeth, which is a member of the great Berw plexus, is, on the west and south of Mynydd Llwydiarth, cut by six or seven small cross-faults whose trend is for the most part north-west and south-east. It is true that the member so shifted is not one of those that can be seen to cut Carboniferous rocks, and might be held to be one of the older Berw ruptures (p. 681). But the Braint faillt, undoubtedly one of the Post-Carboniferous external system, is cut, and shifted nearly 400 yards, by the Ms Mona cross-fault, whose trend is about west-north-west. The existence of late cross-ruptures with a north-westerly trend is thus put beyond doubt. Now the Pont-y-crug and Plâs Newydd dykes, though they run rudely parallel to the Pitts Mona cross-fault at distances varying from 150 to 280 yards, nowhere select it as a line of course, which their magma might have been expected to do. It is likely, therefore, to be later than these dykes, and thus of Tertiary date. If this be so, these late faults must be the last contribution to the solid architecture of the Island.</ref>

South of Cleveland, one undoubtedly Tertiary dyke is known in Britain, that of Swynnerton in Staffordshire; since the discovery of which several that are almost certainly of the same date have been met with in Midland coal-mines.<ref>See the 'Memoirs of the Geological Survey on the North Staffordshire Coalfield and the Concealed Coalfield of Yorkshire and

Nottinghamshire'.</ref> In the Isle of Man there is a series of Post-Carboniferous dykes of olivine-dolerite that have a north-westerly strike, and are considered by Mr. Lamplugh<ref>'Geology of Isle of Man' (*Mem. Geol. Surv.*), p. 327.</ref> to be of Tertiary age, a view that receives confirmation from the evidence adduced in this chapter.

The late dykes of Anglesey thus become of considerable interest. With these of the Midlands and the Isle of Man, together with the phonolite of the Wolf Rock, they go to show that the region, now so broad, separating the two volcanic areas of Europe, was not only far less broad' in Tertiary time, but was not even one of complete quiescence.



(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.

(Plate 42) Late olivine-dolerite Dyke. Henborth, Holy Isle.

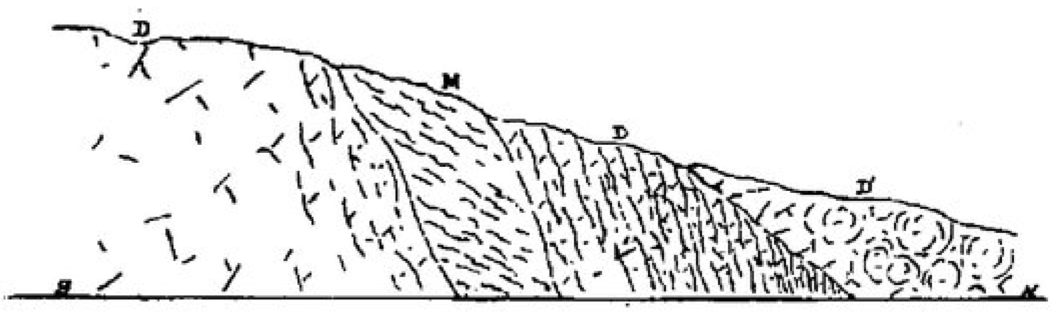


FIG. 306.—JUNCTION OF A PALÆOZOIC AND A LATER DYKE NEAR GAERWEN.

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.