Chapter 8 The igneous rocks

Introduction

The particulars as to the localities and mode of occurrence of the igneous masses and dykes of the Island have been given along with the topographical details of the sedimentary rocks into which they are intrusive (Chapters 4 and 5), so that it remains only to discuss their classification, general relationship and petrographical characters in the present chapter. The petrographical study of the rocks has been carried out by my former colleague, Professor W. W. Watts, as explained on p. 95; and, unless otherwise stated, the descriptions of microscopic slides and general petrographical notes given in the following pages are from his pen.

The dyke-rocks of the Island are especially numerous and varied, and their study is in many instances rendered peculiarly difficult by reason of the great mechanical deformation and mineral alteration which they have undergone. Several distinct periods of intrusion are represented; but owing to the limited range of the sedimentary rocks, the age of the different intrusions can be only approximately determined, though their relative order can sometimes be fixed within certain limits. The time-classification adopted for the igneous rocks is therefore as follows:

I. Pre-Carboniferous

including by far the greater part of the basic, intermediate and acid dykes and bosses intrusive into the Manx slates; and also the granites.

II. Carboniferous

chiefly confined to the basic intrusions in the vicinity of the Carboniferous volcanic outburst at Scarlet, but doubtfully represented by a few basic dykes in the Manx slates of other parts

III. Post-Carboniferous

comprising only the olivine-dolerite group of dykes, supposed to be of Tertiary age.

I. Pre-Carboniferous intrusions

The proof that the small basic and intermediate dykes by which the Manx slates are riddled are in most cases of Pre-Carboniferous age is directly afforded by the sections at Langness (described in Chapter 5.), where the basal conglomerate of the Carboniferous is seen to rest upon the denuded edges of these dykes, as shown in (Figure 50), p. 191. The granites and their associated elvans are proved by the field-evidence to be newer than most of these 'greenstones'. The evidence that they also are Pre-Carboniferous is less direct, resting mainly, so far as the Island alone is concerned, in the sheared condition of many of the elvans from the effect of earth-movements which were probably Pre-Carboniferous (see p. 72 *et seq.*).On like evidence, and because of their absence from the Carboniferous tracts in spite of their presence in adjacent slates, the mica-traps and some other dyke-rocks are believed to be also Pre-Carboniferous.

Before further discussing their grouping and petrographical characters it will be advisable to give a brief recapitulation of the general condition of the rocks in the field. The basic and most of the dykes classed as intermediate may for this purpose be combined into a group to which the old term 'greenstone' is roughly applicable—and indeed, in many cases when the rock is much altered, no closer definition of its affinities is attainable. These 'greenstones' however may include rocks of different ages; and they vary much in their present condi tion, though probably all are Pre-Carboniferous; on the published map they have been sub-divided according to state of preservation into two sets, lettered respectively B^D ('Greenstones') and B^G ('Altered Greenstones').

The majority of the 'greenstone' dykes are small in size, ranging from a few inches to 3 or 4 feet across; a few, however, are larger, attaining a width of 10 or 20 feet, but rarely more. They usually strike in the same direction as the slates, though sometimes locally diverging from this direction on the crests of folds and in traversing the harder portions of the Slate series.

From this parallelism of strike the dykes often resemble and have sometimes been mistaken for sills; but almost invariably a deep section at right angles to the strike will show that the bedding of the sedimentary rock is cut wherever it swerves from the dominant direction of dip' (p. 73), as in the crests and troughs of folds. This dominant dip,' as previously explained, is essentially a 'shear-cleavage' (p. 81). Like the dykes, it maintains its direction in places where the true bedding of the slates is locally aberrant. It is instructive to find that the parallelism of the dykes with the shear-cleavage is usually maintained where both cross the true bedding.

The sedimentary rocks must have been folded, packed, and in places reduced to the condition of crush-conglomerate' before the injection of these dykes (p. 68 and Figs.7,14); but it is none the less certain that the area has undergone further movement since their injection, as the dykes have been severely torn and crushed. In a few instances they even seem to have been sharply folded; as, for example, in the cliff between Tableland Point and Port-e-Myllin, near Ramsey, and again on the west coast in Niarbyl Bay; but in such cases it is difficult to decide whether the structure is true folding, or is due to the molten rock having followed an already folded bedding-plane.

Owing to the distortion they have undergone, it is rare to find the older dykes continuous for many yards, either horizontally or vertically. They have generally been dragged out into a series of curved and disconnected lenticles, as shown in the diagram (Figure 31) (p. 88), and the section (Figure 43) (p. 175). There are many indications that the later movements have been intensified along the dyke-filled fractures, and have there produced their greatest effect. Probably the dyke-rock was less amenable to stretching than the country rock, and was consequently dragged into segments.

The remarkable changes in intimate structure that have taken place in the smaller dykes in consequence of these movements deserve especial notice. The 'greenstones' are frequently sheared into a platy grey schist, scarcely distinguishable from the surrounding slate-rock, so that in small exposures it is often extremely difficult to recognise them as intrusive rocks; and, as will presently be shown, their original structure has been so thoroughly obliterated in such cases that even the microscope can lend but little aid in discriminating them.

Every stage in the crushing of these dykes may be studied, from a mere slight fracturing and distortion of the original crystalline constituents to the production of a calc-chlorite schist in which all trace of igneous structure is lost. In intermediate stages it frequently happens that the intrusive character of the rock is more readily recognised in hand-specimens than in microscopic slides, owing to the extremely decomposed condition of the minerals. For the same reason it is comparatively easy to separate in the field certain highly-sheared fine-grained greenstone-schists, usually of pale grey or greenish-blue tints — probably representing the oldest 'greenstone' intrusions of the Island — from other dykes which are less sheared, darker and greener in colour, coarser in texture, and probably of later age, though the difference between them is scarcely observable under the microscope.

Sometimes in the broader dykes the margin is crushed down to a schist, while the interior is comparatively uncrushed and exhibits the original igneous structure, even though its original minerals are much decomposed. The Horse Rock, under the Kinney Ghoggan cliffs [SC 19768 66297], described on pp. 175–6, affords a good example of this condition.

The micro-granite dykes or elvans associated with the Foxdale Granite and with the Dhoon Granite, as previously stated, are distinctly newer than the greenstones (pp. 128, 168, and (Figure 35), (Figure 36)), and, on the whole, are much less crushed. They have nevertheless undergone considerable deformation, especially along their margins or where exceptionally thin, and have been broken into segments like the greenstones (see p. 171, and (Figure 4)), and occasionally reduced to a platy schist.

A few general notes on the local distribution of the Pre-Carboniferous dykes may be useful here. The 'greenstones' are found in every part of the Manx Slate area, but are unequally distributed. It is in the coast-sections that they are most readily recognised; in the interior, as a rule, they weather more rapidly than the country rock, and consequently their presence is often concealed, or is indicated only by the occurrence of fragments of rotten ferruginous schist. They are most abundant in the tracts of striped slates and slaty flags, especially in such rocks in the south and south-east of the Island, and are rarest among the harder greywackes and grits; in one place, however, — around St. Ann's (Santon) Head [SC 33297 70264] —they are rather numerous among rocks of the last-mentioned type. The high ridges of Barrule Slate in the middle of the Island do not appear to contain many of these dykes, though they are abundant in the flaggy slates on both flanks. Few were found in the northwestern corner of the massif, west of Sulby Glen, but this may be in part due to the weathered character of most of the rock-exposures in that district.

On the coast the dykes tend to form clusters, in which they are thickly set, with intervening tracts containing only isolated dykes. Their development appears to reach its maximum in the vicinity of the coast on both sides of the Island, if it be not that the cliff-sections foster an erroneous impression in this respect. On the east coast they are particularly abundant on Langness and the coast northward to Port Grenaugh; and in Bulgham Bay and its vicinity; and on the west coast north of the Peel Sandstone; and again, south of Port Erin. Their strike in individual outcrops throughout the Island is most commonly W.20°–30′S.—E.20°–30′N.; but it is evident that, as discussed and illustrated at p. 88, (Figure 31), their true direction as a whole is more nearly S.W.—N.E.

The bosses or segments of greenstone shown in (Figure 41), p.162, affords a further instance of this arrangement. These appear to form part of a chain traceable north-eastward from near Dalby to an area north of the central valley. Small isolated bosses of the same kind occur here and there in other parts of the Island; they may possibly represent the main conduits of the molten matter, from which the dykes were fed.

The micro-granite dykes are much more "confined in their distribution, being found only in the central belt of the massif, as described in a previous chapter (p. 114) and shown in the sketch-map, (Figure 29) The majority are clearly connected with the two principal granitic intrusions. Their general direction is nearly the same as that of the greenstone dykes; their association with the belt of altered slates has been previously discussed (p. 114).

The remaining Pre-Carboniferous dykes include a few mica-traps, felsites, and rocks of ill-defined characters. The conditions under which these occur are usually like that of the dykes already described; further information regarding them will be found in subsequent pages.

The following notes on the greenstones, with their Petrographical classification, has been contributed by Professor W. W. Watts. Mr. B. Hobson included a description of a few of these rocks in his paper "On the igneous rocks of the south of the Isle of Man",<ref>Quart. Journ. Geol. Soc. xlvii. pp. 432–450; and Yn Lioar Manninagh, vol. 1, pp. 337–348.</ref> and was the first to apply the microscope to their study; they were classed by him as diabases and diorites.

Petrographic description of the greenstones and mica-traps. (Prof. W. W. Watts)

Diorites and lamprophyres

"The following slides are taken as typical of this group of dykes, and the subsequent general description is based on the characters observed in them:

(E1800) [SC 29428 67311] Dyke at gullet near Hotel at Langness: Diorite (camptonite).

(E1814) [SC 28813 66210] Dyke at small quarry in field near wall N.W. of The Goayr <ref>Names of places in italics are those not given on the one-inch map.</ref>, Langness: Diorite (camptonite).

(E1941) [SC 29171 66838] Dyke in field 20 yards S. of Claberry, Langness Augitic Diorite (camptonite).

(E2538) [SC 43958 81182] Boss, coast 200 yds. N.w. of Braggan Point, Garwick: Diorite (penetrated by granophyre vein).

(E2503) [SC 43955 81187] Same as (E2538) [SC 43958 81182], another part of boss: Augite-Diorite (penetrated by granophyre vein).

(E1964) [SC 21273 78630] Dyke or boss on shore at S. side of Niarbyl, about 70 yds. S.W. of cottages: Altered Diorite.

(E1811) [SC 27810 65294] Boss, west side of Gullet ny Guty, Langness Camptonite.

(E1816) [SC 28780 66118] Boss in field S. of Martha Gullet, Langness: Camptonite.

(E2090) [SC 24130 84664] Dyke on shore 35 yds. N. of Prison, St. Patrick's Isle, Peel: Camptonite.

(E2117) [SC 22992 79822] Dyke ? S. bank of Glen Meay, above pumping rod of old mine: Camptonite?

(E1971) [SC 23334 78496] Boss, in field 200 yds. N.20°E. of Doarlish Cashen, Dalby: Camptonite, sheared.

(E1815) [SC 28809 66148] Dyke, 120 yds. S. of wall at Martha Gullet, Langness: Augitic Camptonite.

(E2120) [SC 30735 69793] 8 ft. dyke, arch of Stack, 450 yds. N.E. of Port Soldrick; Augitic Camptonite.

(E1970) [SC 22013 79372] 6 ft. dyke on beach opposite Ballynalargy, Dalby: Augitic Camptonite with mica

(E2088) [SC 30628 69662] Dyke at low-water, 200 yds. E. of Port Soldrick: Augitic Camptonite ?

"It is necessary to group together the rocks belonging to these two types, as there are no sharp lines of division between them. Indeed this is the case with the majority of the Manx dyke-rocks. If a sufficient number of dykes be examined it is possible to obtain gradations between almost any two types.

"Langness may be regarded as a typical locality for the diorites, but they are also seen in many other parts of the Island, as, for instance, at Garwick and near Niarbyl. Although they do not precisely correspond with Rosenbusch's group of camptonites they have so many points in common with the genuine camptonites of the Island that they may all be considered together.

"The characteristics of all these rocks is the abundance of hornblende, which occurs in idiomorphic crystals, in which Mr. Teall noticed the following planes (110), (010), (100), and (001). Both brown and green varieties are common in the same rock, and the scheme of pleochroism is as follows, If light brownish or greenish yellow, β and γ darker brown, brownish green, or dark green. The brown variety has frequently a border of deep green mineral at its ends and sometimes at its other edges. This border passes readily, and the rest of the mineral a little less readily, into chlorite. Epidote is also frequently developed at the expense of the hornblende. In some rocks the hornblende is converted into a brown granular product, which is generally isotropic; and when the shape and cleavage are not well preserved, it is not easy to affirm the presence of hornblende in the rock.

"In the camptonites the hornblende crystals are usually smaller, and in some cases, as in slide (E2090) [SC 24130 84664], they occur as a mass of slender needles, which penetrate the felspars of the ground-mass in an ophitic fashion.

"Augite is not always present, but in many examples a few crystals occur, and in others the augite becomes a very important constituent. It belongs to the colourless variety known as malacolite, and it is sometimes little altered. It may usually, however, be seen in various stages of conversion into pale green uralite, and this mineral is sometimes to be found enclosed in the compact hornblende (E1941) [SC 29171 66838]. The normal rock at Braggan Point, Garwick, bears augite in abundance with but little brown hornblende, but where it is penetrated by an acid vein there is abundance of brown hornblende in it.

"A few much-decomposed rocks have been classed as augitic camptonites, as hornblende is not very plentiful in them, while they contain pseudomorphs in carbonates and chlorites which appear to have been augite. These occur porphyritically.

"Mica is not a common mineral in these rocks, but it occurs in a few examples which will be referred to later on.

"The felspars in all these rocks are much obscured by the development of secondary minerals, particularly epidote, calcite, and sericite. Both orthoclase and plagioclase (apparently oligoclase) are present, the latter in slight excess in the coarse rocks, but in no great quantity in the finer ones; while it is often altogether absent. In the coarse rocks the felspars are in rounded grains, but in the fine rocks they are in stumpy prisms like those generally met with in lamprophyres. In both cases they are set in a small residuum of interstitial quartz, and secondary quartz is generally associated with a considerable mass of chlorite.

"Iron ores are not very abundant, but both magnetite and limonite are present, the latter frequently passing into leucoxene.

"Epidote and zoisite are both common minerals, the former being yellowish-green, the latter almost colourless. They appear to have arisen chiefly from alteration of the felspars.

Texture — The idiomorphic hornblende is the characteristic feature of all the rocks. In the coarse rocks the texture is granular,. in the finer grained it is more like that of Rosenbusch's lamprophyres, in the crowded mass of small felspars whose interspaces are tilled with only a small quantity of interstitial quartz.

Veins — In the specimen (E2538) [SC 43958 81182] which is traversed by an acid contemporaneous vein, this latter consists of small, well-twinned plagioclase felspars and orthoclase, with much interstitial quartz and epidote; the orthoclase is associated with micropegmatite.

Decomposition — The decomposition of this class of rocks is accompanied by the production of much calcite and other carbonates. The form of the ferromagnesian constituents is generally well preserved, but that of the felspars in the ground-mass is utterly obscured and lost.

Shearing — The specimen (E1971) [SC 23334 78496] is very interesting, as it presents the effect of shearing in an undoubted camptonite. The plagioclase felspars are idiomorphic, and have not suffered much from the shearing. The "eyes" are formed of brown hornblende crystals, to which deep green hornblende has frequently been added at the ends. The sides and ends are sheared off, and "tails" of chlorite formed, in which, however, there are grains of brown hornblende, actinolite needles, and occasionally a little tremolite. Other eye-like patches of chlorite have probably had a similar origin, as they sometimes contain a little brown or else pale green (uralitic) hornblende.

Hornblende mica-traps

"Between the camptonites just described and the true mica-traps come the following rocks, which bridge over this gap:

(E2391) [SC 42094 77943] Dyke or boss, cliff on S. side of Port Groudle (see p. 152). Hornblende mica-trap.

(E2504) [SC 41784 78223] Dyke or boss, crags on golf-links S. of tram-station, Port Groudle (probably prolongation of (E2391) [SC 42094 77943]. Hornblende mica-trap.

(E1810) [SC 27827 65333] Dyke, north end of Gullet ny Guiy, Langness: much altered. Hornblende mica-trap.

"The chief constituents are brown and green hornblende, the latter generally predominating, and the former having a greenish tinge. Sometimes the idiomorphic crystals are brown at the centre and grade outwards into green borders, and outside this is often a fringe of actinolitic hornblende. The colour scheme is the same as that already given. Biotite varies in quantity, but is present in all this group, or rather pseudomorphs in chlorite and opacite occur, undoubtedly after this mineral. The ground-mass is made of idiomorphic crystals of plagioclase, and some of orthoclase, both of which in the Port Groudle specimen are surrounded and filled in with a beautiful growth of micropeginatite; a little quartz is also present in that example. In other examples no quartz is present.

Biotite mica-traps

(E1901) Dyke at E. side of Chasms near Port St. Mary.

(E1957) [SC 19917 66434] Dyke same as last; in cliff at N. side of Kioney Ghoggan. (See p. 176.)

(E2091) [SC 24022 84503] 5ft. dyke, foreshore W. end of St. Patrick's Isle, Peel.

(E2123) [SC 27228 86297] Interior of boss, at Cave, N. end of Wills Strand, near Peel.

(E2093) [SC 22896 82985] Dyke at old slate quarry; Contrary Head.

(E2119) [SC 23211 83372] 2ft. dyke, cliffs. side of Ladder, Contrary Head.

(E2399) [SC 42250 92311] Dyke, road below Neary Farm, Glen Auldyn.

(E2470) [SC 43143 86251] 8ft. Dyke, stream-bed under bridge below Engine House, Glen Agneash.

"A 'uniaxial' brown biotite is the characteristic phenocryst in these rocks. Usually it is pale internally, but with a deep and occasionally a black border. Internally they are frequently zoned. The ground-mass in some cases is like that of a microgranite and (E1901) consists of small crystals of orthoclase and plagioclase, mica flakes, and interstitial quartz. In other cases it is made of larger felspars ophitically enclosing small biotiteswithout any interstitial quartz. No useful purpose would be served by grouping these rocks as Minettes and Kersantites. When these rocks decompose only the forms of the minerals are recognisable. Chlorite and calcite are abundantly produced. The rocks are not as a rule much sheared.

"There remain a few rocks with somewhat the habit of mica-traps but in which no biotite remains. Occasionally good-sized porphyritic crystals of a white mica may remain, and much muscovite in the form of minute flakes in the ground-mass, together with chlorite and felspar' and generally secondary quartz. Idiomorphic crystals of dolomite are frequent in the ground-mass of (E1947) [SC 21240 68085]. The rocks are all considerably sheared.

(E1946) [SC 21258 68132]. Dyke, on shore E. side of Chapel Bay, Port St. Mary, 50yds. s. of first rocks.

(E1947) [SC 21240 68085] Dyke: same locality as last, 85yds. S. of first rocks.

(E1949) [SC 32549 70304] Dyke: in recess at Purt Beg, St. Ann's Head.

.(E2539) [SC 48875 90024] Dyke, coast about 150 yards N. of Gob ny Garvain, Maughold.

(E2112) [SC 23990 70511] Dyke ? gutter s. of Ballagarmin, near Arbory, below spoil-heap.

Rocks bearing porphyritic augite

"A group of rocks occurs which is characterised by bearing large idiomorphic crystals of malacolite. One or two examples contain also a considerable proportion of hornblende and mica, and so have affinities with the augitic lamprophyres, but the rest are devoid of these minerals, so that it will be best to consider them all under the head of porphyritic diabases. The following descriptions of slides will illustrate the characters of this somewhat diverse group.

(E1942) [SC 29485 67098] 12ft. dyke: Cliff at Hango Broogh (near St. Michael's Island) Langness.

A medium-grained, dark green, massive, crystalline rock.

Micro.—The prominent feature is the large phenocrysts of augite, of which there are good cross-sections showing (110), (100), (010), and (001), and another basal plane: colourless to pale yellow-brown with only very slight pleochroism: converted along cracks into brown, highly refracting, fibrous, slightly anisotropic substance. Next in abundance is mica, in long flakes, all converted into chlorite, and the usual darker fibrous semi-opaque substance. Then come small idiomorphs of hornblende, brown and fresh. There is also much sphene, which seems to have been derived from ilmenite, of which there is still a considerable quantity left. The felspars, as a rule, are not perfect, and are slightly elongated, muddy, altered, and often much converted into sericite; they are generally well twinned. Ground-mass consists mainly of chlorite and quartz, both secondary. The affinity of the rock appears to lie with the lamprophyres and mica-traps, in its three porphyritic idiocrysts, and to some extent in its ground-mass. Another part of the same dyke is represented by slide (E1943) [SC 29470 67092], which showed the above features, with some modifications.

(E2833) [SC 33849 72686] 8ft. dyke: Crogga Glen, North of Lhergey Farm, Port Soderick.

Porphyritic diabase, with augite phenocrysts.

Micro.—This belongs to the type with large porphyritic augites, accompanied by hornblende and some mica. The augites are idiomorphic; malacolite, somewhat rounded and zoned with opacite belts; they are twinned and occasionally grouped; a little brown 'hornblende is sometimes contained in them. Brown hornblende is not very abundant or well-formed: in long crystals, the ends passing into dark green, and that into pale green hornblende and actinolite. A few chlorite replacements of brown mica occur, in which a little of the original mineral is still preserved. Iron ores are not at all abundant, and are almost entirely converted into leucoxene. The ground-mass is of not much elongated plagioclase felspars, set amongst abundant chorite, the felspars much altered into a white opaque substance, with only slight reaction on polarized light. There is a little secondary quartz.

(E1972) [SC 26853 83178] Boss in large quarry at Poortown, near Peel.<ref>This rock has been previously described by Mr. B. Hobson. Op. cit.</ref>

An almost black rock, showing numerous fairly conspicuous black crystals in a fine-grained dark green matrix.

Micro.—This rock is made up largely of phenocrysts of the same augite as in (E1942) [SC 29485 67098], but these are associated in groups, idiomorphic externally, allotriomorphic internally. A considerable amount of chlorite is associated with these patches, as though made from augite. The ground-mass is a tangle of lath-like plagioclase, with much chlorite and iron ores, mainly ilmenite, freely converted into sphene, and of this there is a fair quantity scattered through the chlorite and elsewhere in the rock. A little actinolite is associated with the chlorite.

This rock probably belongs to the same type as (E1942) [SC 29485 67098], but represents a slight concentration of the augites in rather less of the ground-mass. To name it is difficult, but it may be placed with the Augitic Lamprophyres.

(E1980) [SC 19777 66290] Horse Rock, at foot of cliff at Kioney Ghoggan (see pp. 175–6).

A dark green rock, slightly sheared, with conspicuous black crystals in a fine-framed green matrix.

Micro.—This rock clearly belongs to the same type as (E1942) [SC 29485 67098] and (E1972) [SC 26853 83178]. In it the augite is in clusters, and is converted into a pale green uralite, slightly fibrous and polarizing as though more compact than usual. The clusters are sheared off at their ends, and pass into chlorite, with which a little epidote is associated. The felspars of the ground mass are of fair size, well twinned, and tending to arrange themselves parallel to the general shearing. As usual, the ilmenite passes into sphene. Where the ground-mass is most sheared it passes into an aggregate of quartz and chlorite.

(E2089) [SC 14266 63946] Dyke at Chicken Rock, off The Calf (p 173.). A porphyritic diabase (augite and felspar).

Micro.—In addition to large uralitized augites, as in (E1980) [SC 19777 66290], the slide contains porphyritic plagioclases, which are well twinned and in which the chief alteration is into epidote and chlorite. The minutely granular ground-mass as usual contains felspar, chlorite, quartz, and calcite. The fairly abundant iron ores are almost converted into sphene.

' "The following slides also bear more or less resemblance to those above described, and may be classed with them.

(E1948) [SC 32681 70302] 9ft. dyke: east corner of Purt Beg, St. Ann's Head.

(E1944) [SC 20660 67107] Dyke at S.E. side of recess next north of Towlfoggy, near Port St. Mary.

(E2483) [SC 45980 86136] 8ft. dyke, with clusters of augites; cliff N. of Dreem-e-jeeskaig, Bulgham Bay.

Other porphyritic diabases

"A large number of the 'greenstone' dykes, though still retaining traces of their porphyritic structure are too much decomposed to show their original composition, and therefore cannot be assigned to any particular group. In these rocks the felspar is frequently the only original mineral which can still be recognised. The three following slides will suffice to illustrate these rocks.

(E1974) [SC 26990 86105] Boss or dyke: headland N. of cave, Wills Strand, N. of Peel; a medium-grained dark-green massive rock.

Micro. There are a few porphyritic felspars, generally simply twinned and sometimes in cross-twins, and with internal alteration to muscovite as though they were potash felspars (orthoclase). The plagioclase is in long laths, with subophitic arrangement, associated with chlorite, calcite, and some quartz, the bulk of the latter being interstitial and apparently secondary. Iron-ores plentiful, and apparently chiefly magnetite, as there is little or no leucoxene. A little apatite is present. The felspar is too much altered to show the extinction angles.

"This diabase may be taken as the type of the Manx greenstones; in many respects it is like the North Welsh and Corndon set, of post-Upper-Silurian date.

(E2114) [SC 21029 67891] 10 ft. dyke: cliff under the school-house, Port St. Mary. A crushed porphyritic diabase.

Micro. Porphyritic felspars plentiful, but completely converted into a sericitic tangle; a mere trace of twinning remains. Ground-mass of small twinned felspars, secondary quartz and calcite, with some chlorite. Some of the carbonate tangles may represent augite, but nothing can be made out of them.

(E2134) [SC 30242 85977] Middle of Boss: quarry 200 yards s. of of high road near Cronkbane, between Kirkmichael and St. John's (p. 137).

A porphyritic diabase, somewhat abnormal, and rather acid.

Micro. The undoubted felspar phenocrysts are converted into granular aggregates of quartz and felspar, which are floating in a great mass of chlorite the rock has been much sheared; sericite is present in quantity. Some of the phenocrysts are like orthoclase.

(E2390) [SC 40135 94279] <ref>Reprinted from Quart. Journ. Geol, Soc, vol. p. 596.</ref>Boss or dyke intrusive in crush-conglomerate: quarry at Kerroo Mooar, Sulby.

Micro. This rock, which has macroscopically the appearance of a diorite, consists of large irregular masses of plagioclase (oligoclase or andesine), with both albite and perichne-twinning; the edges are very irregular. The granular matrix is chiefly made up of felspar, but it contains a certain amount of quartz, which is associated with calcite, often in large grains. Chlorite is now the sole representative of any ferromagnesian mineral which may have been present; it occurs in masses in which the fibres are arranged in one direction so as to yield straight extinction. The rock is an altered diorite or dolerite, most probably the latter. It is this rock which has affected the contact alteration of the crush-conglomerate described at p. 105.

The following dykes, among others, may be placed under this heading:

(E1981) [SC 17631 67796] Dyke with large sheared crystals: Halfway Rocks, S. of Port Erin (p. 172). (Plagioclase felspar the most important por-phyritic constituent.)

(E1960). 8–10 feet sheared dyke: coast 120 yards S. of Clet Aldrick, S. of Port Erin. (Plagioclase felspars alone remain.)

(E2003) [SC 21739 71453] Dyke: in grits, on Carnanes, 300 yards S. of Ballarock, near Fleshwick. (Felspar phenocrysts, probably oligoclase.)

(E2092) [SC 23154 83284] 1 foot dyke: cliff at Chastal Vooar, Contrary Head.

(E2098) [SC 24781 80988] Boss in field w. of road, 1100 yards s. of Barnell, Kirk Patrick. (See p. 162 and (Figure 41)).

(E2821) [SC 43332 79038] 12 ft. dyke: cliff 300 yards s. of Yn, Scregganagh, Clay Head. (E2825) [SC 29260 75204] Dyke: road 100 yards N. of Thalloovell, St. Mark's.

Decomposed greenstones

"We next proceed a stage further in the degree of alteration, and find the greenstones, even where not greatly sheared, in a condition such that scarcely a trace of the original structure remains. In the field, in small exposures, the dykes of this kind were very difficult to distinguish from the hard bands of fine-grained greywacke which sometimes occur isolated among the striped slates intermediate between the Barrule Slates and the grits of the Manx Series.

A large number of slides were therefore cut and examined to aid in the mapping of these rocks; the five following examples will show their general characters:

(E1945) [SC 21036 67629] Dyke at landing stage in inner harbour. Port St. Mary. Light-grey fine-grained diabase.

Micro. A very fine-grained rock in which twinned needles of felspar are embedded in a fine ground-mass of felspar and chlorite; pyrites is present, and carbonates, probably of lime. Traces of flow-structure in direction of phenocrysts. Ferro-magnesian minerals not observable. A fine aggregate of white mica.

(E1960) 1 ft. dyke, apparently intruded into a larger greenstone dyke 8–10 ft. thick. Cliff 122 yards s. of Clet Aldrich, s. of Port Erin. Greenish-grey highly schistose rock.

Micro. Fine-grained ground-mass of felspar and chlorite, embedding small phenocrysts of felspar, not quite so much elongated as in case of (E1945) [SC 21036 67629] though the rock is clearly of the same type. There are some traces of flow-structure and also shearing. Some rather large slivers of chlorite occur, and idiomorphic dolomite crystals are very abundant.

(E1962) [SC 21688 76530] 20 ft. band: Cliff at Fheustal, Niarbyl Bay. Medium-grained grey rock; decomposed diabase.

Micro. Shows igneous structure; possibly was porphyritic; little or no shearing perceptible. A confused aggregate of quartz, calcite, chlorite, and more sericite than usual; limonite; a few small felspars.

(E2099) [SC 28389 87487] Boss or dyke: Coast at end of Gob y Deigan, N. of Peel. Decomposed diabase.

Micro. Larger felspars altered to masses of sericitic tangle; ferromagnesian mineral altered to chlorite films, and generally with parallel arrangement and occasional pleochroic halos. Calcite and quartz freely developed. Igneous structure observable. No marked foliation in slide.

(E2401) [SC 41070 94219] Hard bed Quarry at Laurel Mount, Lezayre. Grey rock, sheared, with calcareous spots in shapes of crystals, and other pseudomorphs chiefly in chlorite; decomposed ophitic diabase.

Micro. Apparent relics of ophitic structure are seen, the felspars altered into calcite, the ferromagnesian mineral into chlorite; phenocrysts in carbonates and chlorite which look like olivines; apparently felspar phenocrysts are also present, and a little ilmenite not much altered.

Among the numerous other slides of this character in the Survey Collection, the following are mentioned to illustrate the wide distribution of these dykes in the Island:

(E2121) [SC 30761 69798] 8 ft. dyke (coarse-grained part): in arch of Stack, 450 yards N.B. of Port Soldrick.

(E2113) [SC 29480 84325] Atnagh, Stream, N. side of road-crossing to Glen Helen.

(E2129) [SC 33384 83320] Dyke (loose blocks]: w. side of Lhargee Ruy, Greeba, 90 yards w. of road w. of u. of *Ruy.*

(E2107) [SC 23114 70814] 10 ft. dyke: E. side of Colby Glen, in plantation above weir.

Schistose greenstones

<ref>From this point onward to the end of the chapter, Prof. Watts is not responsible for the general notes introducing and connecting his descriptions of the slides. G. W. L.</ref>

When the dykes are not only decomposed, but crushed down also, and plated out by shearing, they ultimately take the form of calc-chlorite or talc-sericite schists which, as previously remarked, present few or no distinguishing features under the microscope. The mode of occurrence of dykes of this character in the field is illustrated in (Figure 43) & (Figure 47). The petrographical notes on the following slides are arranged to illustrate the progressive stages in the obliteration of the igneous structure.

(E1979) [SC 17913 66371] 15 ft. sheared dyke Cliff 100 yards N. of Creg ny Jaghee, Calf Sound: Grey schistose rock; originally a porphyritic diabase.

Micro. Phenocrysts, still undecomposed, of twinned felspar, with refraction index higher than balsam (l labradorite), often grouped, broken, sheared, and in "ayes". Small darkpatches, rich in rutile, probably from alteration of titaniferous iron-ore. Rather large slivers of chlorite. Ground-mass of chlorite, calcite, felspar, and quartz, with pyrites.

(E2428) [SC 43426 91989] Dyke (one of several): Glen Crinn (branch of Glen Auldyn), 500 yards N. of mountain-road.

A rock with dark grey matrix, sheared, with greenish chloritic folia, and porphyritic groups of crystals; probably originally an abnormal porphyritic diabase, now a chlorite schist.

Micro. Chlorites rather large; small porphyritic felspars (plagioclase and oligoclase) just visible, in groups; some of the chlorites suggest micas, and it is possible this may be an altered mica-trap, but the small amount of calcite present is decidedly against this, and also marks it off from the other altered rocks.

(E1977) [SC 27924 65332] 9 ft. dyke in cross-cut of copper-mine, Langness Point.

Rather pale green somewhat schistose rock; a talc-chlorite schist, almost certainly a sheared camptonite.

Micro. The large masses of ferruginous carbonate probably represent hornblende; and those of chlorite sometimes associated with calcite probably represent augite; and possibly a little mica may have been present. Calcite and chlorite with some quartz grains constitute the sheared ground-mass.

(E2192) [SC 46242 92988] Dyke ?: quarry at West Folieau, near Ramsey.

Sheared greenish rock with pseudo-vesicular structure; diabase, sheared to a calc-chlorite schist.

Micro. Phenocrysts in granular carbonates with new growth of calcite and quartz at edges under influence of shearing; these form "eyes" and are much sheared off at the ends, graduating into the ground-mass. The latter is a fine schistose aggregate of quartz, carbonates, sericite, and opacite which appears to represent an iron-ore.

(E2194) [SC 46997 93137] Dyke ?: beach 40 yards N. of jetty at Port Lewaigue, near Ramsey.

Rock similar to (E2192) [SC 46242 92988].

Micro. Like (E2192) [SC 46242 92988], but appears to have been moved subsequently to decomposition, as the carbonate granules are dispersed, and the chlorite slivers are puckered and have a strain-slip cleavage. This appears to represent very advanced shearing and decomposition.

(E2926) [SC 22485 68731] Sheared dyke: Black Rocks, Kentraugh, Bay ny Carrickey. A buff-grey streaked schist.

Micro. A schistose mass of sericite, chlorite, and in places crypto-crystalline quartz-mosaic, and spots of iron-ores; carbonate also in spots. Absolutely no trace of igneous structure remains.

To conclude the account of the sheared greenstones, we give the following description and analysis from the notes of the present director of the Survey, Mr. J. J. H. Teall, who undertook the investigation of a few specimens of these rocks collected soon after the commencement of the survey of the Island in 1892:

"(E1965) [SC 21719 75387] 20ft. dyke: Cliff at N. side of Da Leura, S. of Niarbyl Bay. A compact pale-grey slaty rock.

Micro. A microcrystalline aggregate of quartz or felspar (or both), sericitic mica, chlorite and carbonates.

"In the hope that the determination of the chemical composition might throw some light on this rock, I analysed it, with the following result:

	Per Cent.
Silica	65.4
Alumina	16.2
Ferric oxide	3.5
Lime	4.2
Magnesia	1.6
Potash	1.25
Soda	1.9
Loss on ignition	5.7
	99.75

"This does not help one to interpret the rock, and 1 must leave its original nature completely undetermined".

Among other examples bf the sheared greenstones of which slides are preserved in the Survey collection are the following:

(E2125) [SC 31584 70266] 2ft. dyke: cliff w. of Banner Rock, Santon.

(E2820) [SC 34717 72118] 3ft. dyke: cliff N. side of headland N. of Staiden, Santon.

(E2193) [SC 47178 93190] Dyke: cliff E. side of Tableland Point near Ramsey.

(E2482) [SC 46777 93495] N. side of boss forming Carrick low-water reef, Ramsey Bay; (a sericite-chlorite schist, more acid than usual).

(E2126) [SC 30958 88455] Dyke: quarry in coppice on E. bank of stream, 300yds. above Spoot Vane, near Kirk Michael.

(E2127) [SC 25206 81447] Sheared dyke or boss: old quarry in plantation at S. side of Ballacosnahan, near Kirk Patrick.

(E1966) [SC 22660 78556] Hard band: crag in Ballelby Glen, 600yds. E. of high road, near Dalby.

(E1958) [SC 16189 64965] Sheared dyke or boss: coast 150yds S. of Kione Halby, Calf Island.

Metamorphosed greenstones and actinolite traps

We have next to deal with the alteration of the older dyke-rocks, by later intrusions and by the obscure causes which produced the curious metamorphism of the sedimentary rocks described in a former chapter (p. 108–14).

The effect of later intrusion is be it seen in the vicinity of the Dhoon Granite. As previously described (p. 142), this granite has burst throughslates already traversed by greenstones, and has sent out elvans which intersect these older dykes, as shown in (Figure 35), (Figure 6) and pp. 128–30. Several of these greenstones are exposed in the cliffs between Port Cornah [SC 47396 87895] and Dhoon Bay [SC 46140 86436], immediately to the eastward of the granite; and the first two slides described below are from the dykes of this locality. The third slide is from an example at contact with an elvan on the same coast 1½ miles farther north, and the fourth from a dyke in the vicinity of the Foxdale Granite.

(E2476) [SC 46748 86940] Altered greenstone dyke, ½ in. from contact with 15ft. elvan (see p. 130, (Figure 36)): cliff S. side of Barony Hill.

Micro. There appear to be traces of twinned felspars, one or two suspiciously fresh, but the rest converted into several minerals: sphene, epidote, and zoisite are very abundant, and all embedded in a ground-mass of brown mica; a little uralitic hornblende is present. Apparently a thermo-metamorphosed greenstone very highly altered.

(E2524) [SC 46968 87272] 3ft. altered greenstone dyke, on N. side of intersection with elvans; same locality, etc., as last.

Micro. Pale fibrous porphyritic uralite in abundance; ground-mass—quartz, felspar (1), chlorite, and brownish hornblende, with abundant sphene. Probably one of the augitic diabases, now thermo-metamorphosed.

(E2480) [SC 48197 89167] 8 to 10ft. sheared greenstone dyke, at junction with elvan: cliff at Traie ny Uainaigue, Maughold. (See p. 128. (Figure 35))

Micro. Original igneous structure preserved: a quartzose diabase, with small felspar phenocrysts: iron ores preserved, but calcite alteration, and much chlorite often in rather large patches. A small amount of brown mica has been developed. A vein of porphyritic rock with much larger felspars is seen in the fine-grained rock—almost andesitic in habit.

(E2828) [SC 27081 78969] Sheared dyke: stream 120 yards S.W. of Glendhoo Farm, Doarlish Head, near Foxdale.

Micro. A. salt-sericite schist, finely foliated: iron ores preserved: much calcite; chlorite in broad streaks, edged with small flakes of brown mica, which occurs in larger crystals in the body of the rock, often crossing the foliation-planes, but evidently developed *in situ;* ground-mass of quartz and felspar (?) A thermo-metamorphosed sheared diabase.

We have now to discuss the changes in the mineral structure of the greenstone dykes where they traverse the belt in which the slates have undergone their most severe alteration.

As the following descriptions will show, the dykes in this belt are often completely metamorphosed; and a characteristic feature of this kind of alteration is the abundant development of actinolite and epidote in the dykes, which appears to be correlative with the development of garnet and a chloritoid mineral in the accompanying slates of the belt.

Starting from the north-east, the actinolite traps first become conspicuous in the vicinity of Snaefell (p. 139), and may be thence followed across the watershed into the head of the Baldwin Valley. They are seen again on the northern slope of the central valley N. of Crosby (p. 158), and on the southern slope opposite Greeba (p. 168), whence they are continued into the highly schistose area around the old Cornelly mine (p. 168). They are probably prolonged into the head of the Silverburn Valley and a little farther south-westward, but are inadequately exposed and have been less closely investigated there.

The petrographical descriptions and list of slides given below as example of these actinolitic-traps are placed in the order of occurrence as above outlined.

(E2389) [SC 39392 89759] 3ft. Actinolitic dyke: stream-bed 120 yards below foot-bridge near Block Eary, N. of Snaefell.

Micro. An exceptional actinolite trap, with large masses of secondary quartz growing among the chlorite: a little epidote and actinolite apparently formed subsequently to the shearing and often crossing its direction: pyrites present. There are a few phenocrysts which remind one of the large augites of the augitic diabases. An altered diabase, now an actinolite-schist.

(E2407) [SC 39800 89540] 6ft. palish dyke: same locality as last, 380 yards above footbridge.

A quartz-chlorite schist with epidote and actinolite; an altered diabase more acid than usual.

(E2402) [SC 38052 88952] Sheared dyke: Tholt-e-Will stream, 130 yards above boundary of Hotel grounds, w. of Snaefell.

Micro. Evidently a diabase which has been much sheared (probably twice) and undergone a slight amount of actinolitic change. Traces of what appear to have been idiocrysts of felspar are present, but the conspicuous elements are slivers of chlorite, rather large and with strain-slip cleavage, and granules of calcite inside and outside the chlorite. The main ground-mass is granulitic quartz with chlorite, but apparently no felspar. The iron-ores are partly converted into leucoxene. A little sheafy actinolite is developed at the expense of the chlorite.

(E2388) [SC 39067 86631] Sheared dyke: stream-bed 600 yards E. 10° S. of Snaefell lower hotel.

An actinolite-chlorite-schist.

Micro. A chloritic and quartzose schist, with perhaps secondary felspar. In the masses of chlorite are idiocrysts of epidote, zoisite and sphenes (probably from ilmenite), and these masses pass into bundles of actinolite with compact shafts and branching ends, generally conforming with the foliation, but often across it. Actinolite needles run into the secondary quartz. No carbonates are present.

(E2420) [SC 38620 85487] Altered rock,? slate or dyke: crags 500 yards S.S.W. of Carnane Bane, Beinn-y-Phott.

Micro. A garnet-hornfels: a yellowish-grey rock with an appearance of false bedding or shearing, some bands being rich in large dark micas and other minerals. This has all the appearance of an injected junction of the actinolite-trap type and a sediment. One side consists mainly of granular quartz, 0.001 inch, 0.005 inch, 0.015 inch, with brown mica and an occasional bit of sphene, but with occasional layers (I injections) of a more basic rock richer in brown mica, sphene, and epidote. Beyond a quartz-vein the rock is merely a thermometamorphic greenstone of actinolite-trap type, full of brown mica, chlorite, hornblende, epidote, sphene and garnet. There are, however, seams of granular quartz in it, like seams of the sediment between injection veins. Actinolite-trap and sediment, contact ?

(E2392) [SC 35953 85078] Dyke: at junction of east branch of stream N. of Ingebreck.

A greenish-grey rock chiefly made up of radiating actinolite.

Micro. Of the usual character, but with great abundance of actinolite. , often springing from crystals of compact hornblende; in the actinolite there is a warm brown mica freely developed, with sphene and epidote; there is little ground-mass, and an absence of carbonates and felspar. An actinolite-achist with brown mica.

(E2826) [SC 37685 84530] 3 ft. much-altered dyke: East Baldwin River, 150 yards w. of Creg-y-Cowin farm.

An actinolite trap with abundant brown mica and epidote.

Micro. This is a coarsely crystalline rock with schistose structure. Where ground-mass is present it is of the usual finely granular quartzose type. Chlorite is largely present, and passes into actinolite in places, but not into massive hornblende. Well-crystallized epidotes are developed in great quantity in the chlorite, and also much sphene and a little calcite. The other common constituent is a brown mica in large compact crystals, also not conforming to the shearing.

"The impression from the three above-described rocks is that the brown mica and epidote have been produced independently of the shearing, and after it; and their production is just like that known as the result of thermo-metamorphism" [W.W.W.] There is, however, no known outcrop of igneous-rock, except in small dykes, within three or four miles of the localities [G.W.L.]

(E2823) [SC 33718 81115] 10 ft. altered dyke: Cronk Breac, N. of Braid, near Crosby.

Micro. Radiating masses of actinolite abundant: a little pale brown mica, developed at expense of chlorite; much sphene and some epidote; small scattered crystals of plagioclase, considerably decomposed, associated with chlorite and quartz.

(E2827) [SC 32096 78642] Altered dyke: Ellerslie Glen, S. of Crosby, 200 yards S. of dam.

Micro.—Actinolite-trap, with igneous structure no longer observable; epidote in great quantity and often idiomorphic; a very little radiating actinolite in ground-mass apparently mostly of granular quartz and some secondary felspar. Groups and single large crystals of a twinned chlorite occur. Zoisite appears also to be present.

(E2824) [SC 30823 79542] Dyke; corner of field N. of Cooillingill, W. of Crosby.

Micro.— Actinolite-trap of advanced character, with great sheaves of bluish green fibrous hornblende and more fibrous actinolite; sphene, epidote, and iron ores in small grains and not so abundant as usual.

Granitic rocks

Turning now to the consideration of the more acid intrusions of pre-Carboniferous time, we have first to deal with the two principal granite-masses of the island—that of the Dhoon in the north-east, and that of Foxdale in the middle of the slate massif. As elsewhere noted, both intrusions crop out in the neighbourhood of the central stratigraphical axis of the Manx Slates see (Figure 29), p. 84), and their elvans run parallel to this axis, and are confined to a comparatively narrow belt on both sides of it. Through more finely-grained, these elvans preserve the distinctive petrographical characteristics of the two granites for a few miles each way from the main intrusions, but with closeness of texture increasing with the distance until finally they become difficult to discriminate.

The two granites differ considerably in mineralogical composition, and also in mode of occurrence and in structure. The Dhoon Granite, as previously described (p. 144), appears to form a rude column with steep walls, while the Foxdale mass shelves gradually beneath the slates and is probably more or less laccolitic in outline. Both granites are to some extent deformed in places at the margin by shearing movement, but this deformation (see (Figure 38), p. 143) is much more conspicuous in the Dhoon than in the Foxdale intrusion. There is no distinct evidence as to the relative age of the two intrusions, but it seems likely that the Dhoon Granite is the older.

The Dhoon Granite and its elvans

The local details respecting the outcrop of the granite have been given in Chapter 4., pp. 142–4. Its petrographical characters will now be described.

(E2897) [SC 45853 86688] Granite; large quarry at Dhoon.

Macro. Grey granite with patches of brassy mica white felspar, and blue (opalescent) quartz; black minerals fill up the angles between the white ones.

Micro. The conspicuous character of this rock is the presence of porphyritic crystals of plagioclase (oligoclase) 0.25 inch (6 mm.) long. Smaller phenocrysts both of plagioclase and orthoclase occur, generally well-formed and with good angles and edges; they are, however, very impure and are really a mass of other minerals—muscovite, quartz, epidote, and chlorite, in a ground-mass of felspar substance; this character should permit of the identification of the elvans from this mass, as the Foxdale granite itself has singularly pure felspars. Irregular patches of biotite are common, generally with pleochroic halos, and "embroidered" with quartz and iron ores. Epidote and iron ores are often closely associated with the biotite. Sphene in fair-sized grains is not uncommon, and leucoxene occurs looking very like sphene. A few phenocrysts of quartz also occur, strained and granulated and occasionally containing felspar crystals. The ground-mass is of granular quartz associated with minute biotite flakes, and there are irregular patches of muscovite which do not appear to be original. The chlorite present appears to be due to the decomposition of biotite. There is generally a little new growth round the felspars. There is a little, but not much, white mica in the ground mass.

The rock belongs to the porphyritic micro-granite series, rather than to the true granites.

(E2381) [SC 45558 87203] Granite; same locality as last.

Micro. General features like (E2887) [SC 39589 88159], but with a larger proportion of small felspars in the ground mass; and biotite is in larger groups, associated with epidote. The association of sphene with iron ores suggests derivation from ilmenite. Zoisite 0.12 to 0.05 inch long. In the quartz-bodies several adjacent granules separated by veins of mosaic behave as a whole optically, and there are injections of mosaic also inside the grains.

(E2488) [SC 44811 87754] At junction of granite with flags: moorland, N. of Ordnance station, w.s.w. of Ballelin, Dhoon.

Crushed micro-granite.

Micro. This appears to be a crushed form of the Dhoon Granite. The felspars are brecciated, and have lost their sharp outlines; the quartz is more freely granulitized; the ground-mass is lineated, and contains brown and white mica and chlorite in greater abundance, while all the larger biotites are converted into chlorite with pleochroic halos. One part of the rock appears to be so crushed out that the micaceous felspars appear to have been incorporated with the ground-mass.

(E2487) [SC 45991 87351] and (E2898) [SC 45843 86688] Granite-vein in altered flags: northern edge of granite on Barony Hill.

Micro. These slides show thin veins of microgranite injected into schist, and probably crushed out with it. The veins have lost most of their characters. The ground-mass is rolled out and associated with much muscovite, sometimes in fair-sized grains, and some rutile is present. In (E2898) [SC 45843 86688] felspar phenocrysts are occasionally recognisable, but generally smashed; and quartz phenocrysts also occur.

The slate at the margins is much altered and is converted into a muscovite-biotite schist with abundance of (probably) small felspars and quartz. A few small garnets are present, mostly occurring along particular bands.

The elvans which spring out from the eastern margin of the Dhoon granite are described at pp. 127–30. The following slides of these rocks are arranged in the order of increasing distances from the granite. The dykes frequently show a platy semi-schistose structure due to shearing, which is admirably brought out in some of the slides. In the field, these elvans may be distinguished from the other microgranites by the presence of small roundish grains of opalescent blue quartz.

(E2900) [SC 46590 87313] Southern elvan: Barony Hill, Dhoon.

A fine-grained micro-granite or microcrystalline quartz-porphyry.

Micro. Orthoclase, plagioclase and quartz phenocrysts, the latter strained and granulitized, but still sometimes with trace of the bi-pyramidal form: biotite aggregates, also with the usual forms and pleochroic halos, and a number of small scattered garnets. The ground-mass is a minute micro-granite, with felspar, quartz and very abundant muscovite, with a lineation which is at first not conspicuous, but which corresponds with that of some of the biotites. The felspars are a little cleaner than usual, but the bulk of them are full of muscovite.

(E2901) [SC 46408 87165] Same elvan as last: shore below Barony Hill.

Micro. Like (E2900) [SC 46590 87313] but with less felspar and much less biotite, but abundant quartz: felspars fairly clean. There is one perfect crystal of microcline. The ground-mass is much more sheared, and contains abundant muscovite, Carlsbad felspar, and quartz: a few small garnets.

(E2386) [SC 46740 87077] From the elvan in a quarry at the crest of the cliff-slope; shows similar features to the last, but with large gamete and sphene, and with microcline in fair-sized grains, and with the addition of phenocrysts of micro-pegmatite. No biotite is present.

(E2902) [SC 46553 87707] Same elvan, and same locality as (E2901) [SC 46408 87165], at junction with 'green-stone' dyke (see p. 130, (Figure 36)).

A quartz-sericite schist or quartz-porphyry rolled out.

Micro. A perfect quartz-sericite augen-schist, with quartz granulated and torn out: felspars few, and the cleaner ones not much crushed, but the "dirty" ones passing out into "flaser", with shape and characters gone. The ground-mass is " damascened" with muscovite amongst quartz and water-clear felspar.

(E2481) [SC 48264 89225] 4 to 6 ft. quartz-porphyry dyke: cliff at Traie ny Uainaigue, Maughold. See (Figure 35), p. 128.

Micro. A crushed quartz-porphyry, evidently an elven of the Dhoon set. The ground-mass is cryptocrystalline, with biotite in small flakes in parallel arrangement. Phenocrysts of quartz and felspar, as usual, crushed, strained and full of mica; the biotite phenocrysts are all gone to chlorite; iron-ores, sphene, a little apatite, and a few garnets present.

(E2384) [SC 49550 92072] 6 ft. dyke: cliff 200 yards S. of Cor Stack, Maughold Head.

A sheared grey rock, horny and felsitic, without any obvious porphyritic constituent; a fine-grained microgranitite of the Dhoon set.

Micro. The ground-mass is a minute biotite-bearing micro-granitite, with phenocrysts mainly of felspar loaded with muscovite and quartz; epidote fairly abundant, in large grains chlorite after biotite; sphene; iron oxides. Parallel series of folia which traverse the rock are about 1 inch apart, and consist of granular quartz, epidote, zoisite, chlorite and leucoxene, with or without iron-oxides, but this is more altered to leucoxene in these bands than elsewhere.

(E2382) [SC 49843 91652] and (E2385) [SC 49845 91643], from the interior and margin of a dyke, 12 ft. to 15 ft. thick, at Gob ny Skey, Maughold Head.

This dyke is somewhat similar to (E2384) [SC 49550 92072]; the interior is more acid than the margin.

From the same set of elvans on the opposite or south-western side of the granite outcrop, the following example from a deep level of the Laxey mine deserves notice on account of its unweathered condition.

(E2499) [SC 43176 86367] 20 ft. dyke: 255 fathom level of Laxey mine, 490 yds. N. of Dumbell's shaft (see p. 521).

Micro. The structure of the ground-mass lies between minute microgranulitic and cryptocrystalline, with quartz, felspar and muscovite; it is crushed and foliated. The chief phenocrysts are quartz with ground-mass inclusions and edges on which the ground-mass intrudes. Nests of muscovite in the ground-mass probably represent the relics of vanished felspars.

Other slides of the elvans at greater distances S.W. from the granite include the following:

(E2478) [SC 41872 86504] 6 ft. sheared dyke: at 700 ft. contour on tram-line to Snaefell.

Micro. Much crushed, with abundant development of muscovite; biotite all converted to chlorite; sphene, epidote, and a few zircons present.

(E2477) [SC 40909 85445] 6 ft. "greenish quartz-porphyry" dyke: north feeder of Glen Roy, under Close Mooar.

This has not got the usual micaceous felspars, and differs somewhat from the Dhoon set.

The Foxdale Granite and its elvans

Like the Dhoon granite, the Foxdale Granite forms, as it were, the node of a string of dykes extending with the strike of the country rock in both directions from the neighbourhood of the intrusion (see (Figure 29), p. 84). Its general field-relations and characteristics have already been described; as also those of its elvans, which are usually distinguished by the presence of small hexagonal crystals of white mica; and the petrology only remains to be discussed.

For the main mass of the granite, the following slide of an unweathered specimen from one of the Foxdale shafts may be taken as representative.

(E2791) [SC 27945 77936] Granite; bottom of Bawden's Shaft, Foxdale Mines.

A moderately coarse-textured grey muscovite-granite.

Micro. The oldest minerals appear to be cores of felspar, usually striped and very much corroded so that mere skeletons remain. These are filled in and filled out by new felspar growth, also usually striped, giving rise to fairly angular and well-defined crystals. A few singly twinned orthoclase crystals are present, without such good boundaries. Muscovite appears to be the next mineral; it also has irregular boundaries and does not contain many inclusions. Quartz is the next, and of this there is a considerable quantity, quite clear, and free from inclusions of other minerals. It and both feispars in small crystals are enclosed in large patches of microcline. A little quartz-mosaic is present. There are no signs of movement, and none of the minerals are crushed, bent, or broken, nor is there any undulose extinction.

Another slide (E2890) [SC 29853 77332] from the granite at the surface showed no microcline and very little orthoclase, the predominant felspar being well-formed plagioclase, probably oligoclase. In a slide described by Mr. Harker, brown mica was also present, in part in parallel intergrowth with the white, both micas exhibiting pleochroic halos surrounding minute zircon crystals; and occasional grains of garnet were also observed.<ref>"Naturalist" for 1894, p. 68.</ref>

The concealed granite reached by the shaft of Cornelly Mine (see p. 517), though exhibiting a general resemblance to the Foxdale Granite, is by no means identical with it, as the following description will show. The difference between them, however, is no greater than might occur between different parts of one and the same intrusion.

(E2893) [SC 29651 79593] Granite: from spoil-heap of Cornelly Mine, 1½ miles N.E. of Foxdale.

Micro. In this rock the structure is hypidiomorphic, granular, with the crystalline outlines of the felspar less marked than usual. Plagioclase is abundant, and it often shows micro-perthite intergrowths which are sometimes twinned, and also micro-pegmatite. The bulk of the 'orthoclase' is moire or microcline. Both biotite and muscovite are present, the former more or less replaced by chlorite, and the quartz is in large grains. The order of consolidation is not at all apparent. The rock is a *two-mica* granite, which differs from that of Foxdale in the presence of biotite and in the abundance of microcline, microperthite, and micropegmatite.

Of the Foxdale group of elvans the best-known and most accessible is the broad dyke exposed in the quarries close to the railway station at Crosby (p. 168), and this may be taken as the type for the set. Its petrographical characters have been previously described by Mr. B. Hobson,<ref>In the paper to which references are given on p. 300, Mr. Hobson applied the term "quartz-keratophyre" to the rock.</ref> and the rock has been analysed by Messrs. Dickson and Holland, with results quoted in Appendix 2., p. 575. Large garnets may occasionally be observed in the small strings of vein-quartz at the margin of this dyke..

(E1983) [SC 32507 79206] Crosby dyke (20 to 30 ft. wide), 4 ft. within its western margin: upper quarry, Crosby.

Macro. Light grey fine-grained rock containing hexagonal plates of a nearly white biaxial mica. One end of the specimen shows marked signs of shearing and the plates of mica, have been distorted.

Micro. Occasional porphyritic crystals of orthoclase, plagioclase, and muscovite generally in fibrous aggregates, and quartz in aggregates; the extinctions of these are undulose and some are bent; most are crushed and some separated.

The ground-mass is granulitic on a small scale, quartz and orthoclase being present in about equal proportions, while striped felspar. is absent. The muscovite is in small flakes between the grains of the other constituents. There is no linear arrangement, but the smallest grains show undulose extinction. There is no tailing off of the phenocrysts. A few nearly colourless garnets are present, like those sometimes seen in the Foxdale Granite. A muscovite-granite, crushed.

The crushing noted in the above slide is very generally observable among the dykes of this set; and as in the Dhoon elvans, shows much local variation in severity. The next two slides show the more advanced stages in the process.

(E2796) [SC 28289 75397] Elvan: small quarry on Windy Common (N. of m), S. of Foxdale Granite.

Micro. Phenocrysts of plagioclase, orthoclase, muscovite and quartz; the last strained, broken and granulated; the two first tailed into mosaic, often arranged obliquely to the foliation in their crystallographic axes, but in form phacoidal with the foliation. The ground-mass is a foliated granulite, and doubtless represents a fairly marked stage in the crushing, as it consists of a felted aggregate of interlocking grains of quartz and unstriped felspar with muscovite interlacing amongst it; little or no chlorite. A porphyritic foliated granite, probably once a micro-granite.

(E2083) [SC 349 991] Sheared elvan: S. end of Beal-feayn-ny-Geay, W. side of Cronk-ny-Arrey Lhaa.

Micro. A sericite-schist with surviving knots of quartz, whose edges are crushed down to quartz-mosaic and muscovite, the latter penetrating the solid quartz of the knots. The rest of the slide is a minute quartz (? + felspar) mosaic filled in with sericite and chlorite, and with some folia made entirely of sericite. A few small garnets are present.

Among other slides examined of which the rocks probably belong to the Foxdale set of elvans were the following:

(E2795) [SC 29390 79700] 1 to 2ft. vein: West branch of Glion Darragh, W. of farm; near Cornelly mine (somewhat crushed).

(E2904) [SC 27694 79051] White trap: Foxdale river, below Ballamoore, N. of Foxdale. (A quartz-mosaic schist with augen: contains a peculiar chlorite, or chloritoid: a crushed elvan having affinities with Dhoon set.)

(E2797) [SC 26987 76908] 8ft. elvan, sheared; S. entrance to South Barrule Slate Quarries. (Well-foliated, and with no igneous structure left.)

(E2000) [SC 19934 71673] Elvan: base of cliff at Raclay, E. side of Fleshwick. (Porphyr-itic constituents fresher than in Crosby dyke, and no sign of crushing.)

Acid dykes of doubtful relationship

Besides the recognisable Dhoon and the Foxdale elvans, other more or less acid dyke-rocks were discovered during the survey in various places, but principally, and indeed almost exclusively, on the N.w. side of the central axis, which could not be definitely assigned to either set and may in certain cases represent an independent and perhaps older type of intrusion. As these rocks were close-grained originally and have since been much disturbed and altered, and as, for the most part, they are seen only in limited exposures, the main evidence for their igneous character has been obtained from their examination under the microscope.

Lhergydho Trap

One of the largest and best-marked of these intrusions occurs at the foot of the hills at Lhergydho, 2 miles E.N.E. of Peel, and is quarried for road-metal (see p. 156). The following is a slide of this rock:

(E2133) [SC 27466 85158] Dyke-rock: N. quarry at Lhergydho.

Micro. The porphyritic ingredients are mainly orthoclase in small crystals, often associated with plagioclase in groups of dozens of crystals and some fibrous sericite. No porphyritic quartz appears to view in association with these or alone. The matrix is very distinctive, though fine-drained. There are prisms (the length of which is twice or thrice their breadth) of orthoclase and plagioclase set in interstitial quartz; abundant and minute sericite flakes occur in and amongst them, and also in small associated masses of chlorite: carbonates are plentiful, but with nothing to show their origin. The rock is linked with the other elvans, but the ground-mass is somewhat distinct in having the visible and perfect prisms instead of grains.

Similar features are seen in another slide (E2916) from the same rock.

A porphyritic micro-granite or keratophyre, or acid andesite having affinities with the Ivernites.

The above rock lies outside the belt in which the Dhoon and Foxdale elvans occur, and so far as the field evidence alone is concerned, it cannot be connected with any other group of intrusions, though one or two unsatisfactory exposures in the country to the westward, mentioned in Chapter 4., may possibly represent the same rock in a more decomposed condition.

Still farther westward and north-westward, around the head-waters of the Glass and Sulby rivers and extending thence north-westward to the east coast south of Ramsey, exposures of much-crushed pale rock are seen at intervals, which when submitted to microscopic examination show some affinity to the Lhergydho exposure. Their field-positions however rather suggest a relationship with the Foxdale elvans, and their difference from the normal type might perhaps be accounted for by the increased distance from the granite. The following is an example of these rocks:

(E2396) [SC 44715 92568] Pale dyke (?); gutter at Park Mooar at bench-mark 680′ 3″, near Ramsey.

A cream-coloured crushed rock with felspar-crystal eyes surrounded by pale chlorite; occasional broader ferromagnesian bands.

Micro. This seems to belong to the Lhergydho set in its porphyritic crystals, but in its matrix it is more obscure; still, the general character is in favour of this idea; it possesses somewhat more quartz, but not definitely in phenocrysts.

Other slides of similar character are

(E2395) [SC 37147 86778] Pale dyke (?); Glen Crammag stream, 650 yds. N. of road from Snaefell to Kirk Michael (see p. 139).

(E2479) [SC 44254 90642] Large pale dyke or boss; S. flank of North Barrule above Park Llewellyn (contains an exceptional amount of zoisite and epidote).

(E2506) [SC 42806 81636] 6 ft. pale trap with dark needles; tram-line at S. side of Glen Gawne, Garwick.

The last-mentioned is noteworthy as being the only known occurrence of the type so far to the eastward of the structural axis of the Island. The dark needles of the rock are composed of chlorite.

Altered elvans

The remarkable alteration of the greenstone dykes where they traverse the belt of altered slates has already been described, and we have now to deal with a similar, though less marked, alteration of the elvan dykes under the same circumstances. While the dykes which are thus altered are always in a crushed condition, the preceding descriptions will have shown that there are crushed elvans in other parts of the Island which are not markedly altered.

That the elvans should have been anywhere altered implies that at least some part of the alteration has been of later date than the intrusion of the granites, since these elvans appear to have represented the latest phase of intrusion (see p. 166). But as the slates had probably undergone a schistose alteration before the granitic invasion (p. 106), we are led to the conclusion that the metamorphic action was spread over aperiod of long duration, and probably came into play intermittently during this period.

The most striking example of an altered elvan is that occurring on Greeba Mountain, a little to the eastward of the summit, as described in Chapter 4., p. 158. The following is a slide from this locality. Red garnets were abundant in some parts of the rock, but apparently were absent from this slide.

(E2798) [SC 31578 80751] Sheared elvan; near summit of Greeba Mountain, N.E. of the cairn.

Micro. A characteristic Foxdale elvan, but without phenocrysts quartz-felspar mosaic, lineating but not foliating the rock, and abundance of muscovite. The striking feature is chloritoid crystals, which enclose the quartz-felspar matrix inside them, so that the inside of the crystals is a mere aggregate; the outside being much more pure. The muscovite is sometimes gathered into fan-shaped groups. Altered elvan.

The more common kind of alteration of these elvans is shown in the next slide, which is from an intrusion exposed in the stream draining the N. slope of Snaefell, not far from the actinolite traps (E2389) [SC 39392 89759] and (E2407) [SC 39800 89540] described at p. 309.

(E2398) Boss or dyke: stream S.E. of Block Eary, 140 yards E. of mountain-fence.

A white granular rock with bands of black mica; sheared microgranite.

Micro. A fine granulitic quartz-felspar matrix of Foxdale-elvan type; well-foliated, with only rounded porphyritic quartz. The foliation is mostly due to muscovite or sericite in sheets, in which occur flakes and crystals of biotite, the former in the foliation, the latter frequently. extending across it. Associated with the biotite are occasional patches of leucoxene.

Among other examples of similar character in the Survey Collection are the two following slides, in which, however, zoisite and garnet are seen, as well as biotite.

(E2800) [SC 35493 81638] 20 to 30 ft. boss or dyke: bed of River Glass, 450 yards N. of Baldwin Chapel.

(E2801) [SC 35500 81647] 2 ft. dyke: same locality, 500 yards N. of Baldwin Chapel.

Other of the altered acid dykes approximate more nearly to the Lhergydho type, of which the following may serve as an example.

(E2393) [SC 35457 84814] 8 ft. dyke: Injebreck stream, due W. of hotel.

Pale microgranite or felsite with ferromagnesian mineral and brownish spots on the cut surface.

Micro. Characteristic Lhergydho type, with few porphyritic crystals. Matrix characteristic except porphyritic felspars which are sometimes grouped. The only other porphyritic ingredients are biotites, sometimes changed into pale brown chlorite, polarizing in weak colours. These have the appearance of development subsequently to consolidation and they may be metamorphic.

Port-e-Myllin dykes

The curious group of intersecting dykes at Port-e-Myllin [SC 47467 92735], described and illustrated at p. 124, (Figure 34), deserve notice before we conclude this account of the elvans. The oldest rock (lettered F. in the figure), which is cut by the two greenstones, is probably a much-crushed intrusion approximating to the Lhergydho type, as the field-evidence suggests its connection with the rock at Port Mooar, 1 mile farther west, which is believed to belong to that set (see previous description, slide (E2396) [SC 44715 92568]). While the intersection of greenstone dykes by later intrusions of microgranite, as already shown (pp. 128–30), is a comparatively common phenomenon in the Island, this is the only known instance of the intersection of one of the acid group by green-stone. Moreover, the smaller of the intersecting greenstones is much sheared, and therefore probably one of those early basic intrusions which are elsewhere seen to be cut by the Dhoon and Foxdale elvans. The rock into which it is intrusive must, of course, be still older; so that the antiquity of the more acid rock would seem to be considerably greater than that of the above-mentioned granites. If its correlation with the Lhergydho set be accepted, this set would thus appear to constitute the most ancient intrusive rocks known in the Island. The earlier greenstone (lettered BG) is itself reduced to a talc-chlorite schist, while the later greenstone (lettered Bo) which cuts it, is comparatively unaffected by movement and can be recognized as a porphyritic diabase. The slides of the three rocks are as follows:

(E2920) [SC 47315 92903] The pale rock; F. of (Figure 34): Port-e-Myllin. A grey medium-grained rock, much sheared.

Micro. It bears some resemblance to (E2918) [SC 46974 93069] (an intrusion on the N. side of Port Lewaigue, ½ mile to north-westward, which contained augenmade up of plagioclase, quartz, and micro-pegmatite, associated with abundant apatite, chlorite, and calcite), but is further sheared. The flaser contain quartz in rather larger masses than (E2918) [SC 46974 93069], but the felspar and micro-pegmatite are less easily recognizable, although undoubtedly present in some cases and strongly suspected in others. Limonite, sericite, chlorite, and abundance of carbonates are the other minerals in the ground-mass, and to some extent in *the flaser.* Sheared dacite (or elvan?)

(E2921) [SC 47322 93058] Sheared greenstone cutting (E2920) [SC 47315 92903]; BG. of (Figure 34) Port-e Myllin.

Much sheared greenish-buff rock, with knots of carbonates.

Micro. Very like (E2919) [SC 46757 93055] — (a schistose dyke cutting (E2918) [SC 46974 93069] on the N. side of Port Lewaigue, see p. 123, which showed flaser of carbonates, granular quartz and felspar, with chlorite around them, and a few flakes of muscovite (?) lying between and shut in the flaser)—and the muscovites (?) are similarly situated, but are better developed, while the perfect terminations and rather low interference colours sometimes raise a doubt as to whether they are all muscovite: it tends to occur best at the junction of the carbonate-flaser with the chlorite ground-mass, but occasionally in the body of both. Calc-chlorite schist.

(E2922) [SC 47304 93069] Greenstone cutting (E2920) [SC 47315 92903] and (E2921) [SC 47322 93058]; BD. of (Figure 34): Port-e-Myllin.

A buff fine-grained rock, showing small needle-like phenocrysts.

Micro.—There can be little doubt that the phenocrysts have been felspar, but they are now converted into groups of fair-sized grains of muscovite. The ground-mass is a fine-grained tangle of small felspars with elongated iron-ores, with muscovite in places. Altered porphyritic basalt.

Quartz veins

The quartz veins associated with the Dhoon and Foxdale granites deserve notice here, as the most conspicuous vein at Foxdale has been considered by Mr. Harker to possess the characteristics of greisen<ref>Quart. Journ, Geol. Soc.; li., p. 143.</ref>, and therefore to represent the residual material from the cooling of the granitic magma. As already described, these veins are a marked feature throughout the Manx Slates, occurring everywhere, either in narrow strings frequently crumpled and torn, or in broader lenticular "eyes". At the margin of the granite-bosses they are especially well-developed, the majority gashing the granite, as well as the country-rock, in an approximately N.–S. direction. They frequently contain small quantities of other minerals as inclusions, such as (roughly in the order of abundance) yellow mica, chlorite, tourmaline (see p. 143), felspar, ilmenite, etc. Their mode of occurrence is in many respects comparable to that of the elvans; but, so far as we could find, they do not anywhere present indications of a gradual passage into either granite or el van, though such might have been expected if they were truly greisen. On the contrary, their boundaries in these rocks are always sharp and distinct. On the whole, that they have been formed in crevices by infiltration and segregation under the influence of thermal waters appears more probable than that they have been injected along continuous fissures like the dykes. They are evidently of widely different ages, and may have been produced under diverse conditions.

The Oatland (Santon) Complex

The small boss of granitite with its peculiarly associated rim of dark basic rock which crops out at Oatland in the parish of San-ton, as described in Chapter 4., p. 185, is deserving of especial attention from the petrographical standpoint, but unfortunately is not well-exposed. The more acid rock occupying the central part of the intrusion<ref>This rock was first described by Mr. B. Hobson: *op. cit.*</ref> is clearly of later consolidation than the basic rock which it penetrates in a series of veins, though the actual junction of the masses could not be seen at the time of our examination. Angular and subangular fragments of the dark rock are included in the granitite in increasing numbers towards its margin, until, as some of the boulders around the outcrop show, the inclusions bulk more largely than the acid matrix; and finally the granitite is reduced to a few narrow veins traversing the dark rock. In certain places, however, the appearances suggest that there may locally be a passage or blending of the two rocks, possibly the result of refusion of the older, as augite crystals occur isolated in the grey granitite. No conclusion has been reached as to the length of the interval between the intrusions; nor as to whether the complex has been the result of the differentiation of a single magma of which the basic margin was first cooled, or of two separate intrusions of different composition along the same conduit.

The mass as a whole is very little sheared, except along a plane near its centre, wherea small quarry recently opened revealed a certain amount of crushing such as might accompany a fault.

As the following petrographical notes will show, the basic rock has close affinities with some of the previously described 'greenstone' dykes of the Island, while the granitite is not far removed from some of the diorites. The boss may, indeed, be regarded as the largest of the knobs or nodes on the clustered dykes which run along the south-eastern side of the massif parallel to the central axis.

(E2907) [SC 32193 72424] More acid portion of granitite: quarry near Oatland, Santon. A grey rock showing felspar, quartz and chlorite on the broken surface.

Micro. The felspar is much altered and crowded with muscovite, so that it is hardly possible to recognize the twinning; the plagioclase is the more perfect, the pinacoidal faces being well marked; the orthoclase is recognizable generally in much less regular grains, with only traces of crystal faces. The chlorite has the habit of altered biotite and is full of pleochroic halos; a little hornblende and epidote are associated with it. The quartz is generally clear and in large interstitial grains; here and there it is in small grains, but the general habit is quite different from the Dhoon granite and more like the Foxdale granite in this respect. There are a few epidote veins. A granitite.

In another slide (E2908) [SC 32185 72425] where the rock is slightly more basic, similar features are observed, but epidote is more abundant. There are no signs of crushing in either slide.

(E2910) [SC 32377 72537] Specimen from near western margin of Oatland granitite. Granitic ground-mass with very abundant crystalline masses of hornblende up to ¼ inch across.

Micro. This rock has a ground-mass quite like that of the rest of the Oatland granitite, made up of much clouded felspar embedded in quartz. Embedded in this is green hornblende which appears to be original, and a considerable quantity of another mineral which has high refractive index, low double refraction, slight pleochroism, and a muddy brown colour, and in certain sections splits up with a fine ragged cleavage like a mica; the extinction appears to be straight. Embedded in this rock are large rounded grains of uralitized augite of a pale green colour and very slight pleochroism. They are always bordered with a more or less complete ring of green hornblende. These augites probably compare with those in one set of greenstones.

Hornblende granitite containing augites.

Another slide (E2911) [SC 32347 72436] from a similar rock on the north-eastern side of the granitite showed the same features, intensified.

(E2909) [SC 32171 72478] Knobs of basic rock in normal Oatland granitite.

These are large black knobs containing large hornblendes in a felspathic matrix, loaded with hornblende at the margin.

Micro. The "normal" rock furthest from the junction shows, first of all, chlorite after biotite, mingled with green idio-morphic hornblende, and the usual felspar and quartz of the granitite. Then a brownish-green hornblende begins to come in; then, one or two large patches of mingled green and brown hornblende associated round a fibrous mass of actinolite (7) (the centre is probably uralitized augite). The felspars are very much clouded, and increasingly so towards the margin, where only small traces of biotite are left.

Across the boundary into the basic knot everything becomes allotriomorphic, and large masses of felspar grains occur, with hornblende masses submerged in them. The hornblende, as before, is green and brown mingled, and the association is suggestive of the hornblende outside, as if it had been derived from here. Quartz occurs only very occasionally.

The chlorite in this slide is beginning to take on the characters of the unidentified mineral in (E2910) [SC 32377 72537].

(E2912) [SC 32348 72434] Basic part of Oatland intrusion.

A dark-green hornblendic rock showing large faces of hornblende.

Micro. The chief mineral here is augite more or less changed into uralite, but often unchanged. Interpenetrating it in ophitic fashion is much brown hornblende in tiny particles round the edges and sometimes enclosing one or several augite grains, but in optical continuity with them is much brown hornblende. A third mineral in cloudy highly refracting irregular grains is abundantly present; it may possibly be one of the epidotes, but has not been definitely identified. Some ilmenite or magnetite is present.

Ballabunt Dyke

About 2¼ miles N.N.E. of the Oatland intrusion there is a small boss or dyke of igneous rock of abnormal composition which has some features in common with part of the Oatland mass, and is therefore described here. The details respecting the exposure have been given in Chapter 4., p. 170. The following is the petrographical account of the rock:

(E2831) [SC 34112 75956] Porphyritic mass: quarry on W. side of road striking S. from Ballapacidag, near Ballabunt.

Macro. Large dark-green porphyritic crystals, sometimes ■ inch in length, in a nearly white fine-grained matrix.

Micro. This rock has decided affinities with the medium basic rock of Oatland. There are large masses of uralitized augite, pale green and slightly pleochroic, often with actinolitic tangles in their interior, while the outer border is frequently changed into dark green hornblende in exact optical continuity. Small interior patches of fibrous colourless amphibole (?tremolite) occur occasionally inside these masses. A little compact green (original) hornblende is present, and a considerable quantity of biotite now entirely altered into chlorite, and a few grains or skeletons of ilmenite, more or less changed to leucoxene. The felspars are idiomorphic, just like those of Oatland, and changed to mica masses; even the genus is indeterminable: they project into quartz with exactly the Oatland habit. Augitic granitite.

Another slide from the same quarry (E1982) [SC 32207 72437] is practically identical with the above, but apatite is present, and occasionally microcline takes the place of interstitial quartz.

Rocks of doubtful origin

In the preceding pages reference has been made to the occurrence among the Manx Slates of bands of rock regarding the original character of which neither the field-evidence nor the microscope gave definite results. From the prevalence of dyke-rocks in which the igneous structure is barely recognisable, it is probable that most of these doubtful rocks are also of igneous origin. Numerous slides of these rocks were prepared and examined, but as they rarely present any salient features, being usually in the condition of fine-grained schists, it is needless to enter into details respecting them. The only example which will be given, is the following, which presents somewhat unusual characters.

(E2394) [SC 39061 90044] Pale hard bed; 1 dyke-rock. Second side-glen w. of Block Eary, Ballaskella.

Macro. Compact pale rock rich in quartz: some pyrites and a white cleavable mineral in small grains. In its present state the rock is undoubtedly elastic and made almost solely of quartz, with bands parallel to the quartz-veins probably made of a carbonate, which does not, however, appear to be calcite, and, as it is generally associated with iron ore, may possibly be leucoxene. I cannot make out any felspar at all in the rock, nor can I name the cleaved mineral. The structure, however, must, I think, have been produced *in situ,* as the grains fit one another exactly or else are separated by a minute mosaic whose grains similarly fit together. The grains in the quartz-veins similarly accommodate one another. Average size of main grains 0.005 in., of mosaic grains 0.001 in.

A minute quartz-breccia.

Supposed tuff

The curious isolated patch of andesitic breccia outcropping among the Manx Slates near Dalby, as described in Chapter 4., p. 163, presents the following characteristics:

(E2118) [SC 22591 79006] Andesitic breccia or tuff (?): field-road, 100 yards E. of high road at Ballaquane, near Dalby.

Micro. An andesite with needles of plagioclase in what has been glass but is now turbid and isotropic: holes and veins filled with quartz, chlorite, and siderite: no trace of "bombs", and the rock has every appearance of having been brecciated *in situ.*

(E2985) [SC 22502 79137] and (E2986) [SC 22508 79135]. Same rock as last: small quarry in field, 50 yards S.W. of last.

Micro. The ground-mass is very obscure, but contains felspar crystals: the fragments are mainly of an andesitic or felsitic nature—probably both, angular and set in a much finer-grained matrix without any sign of stratification. Each slide contains lapilli — probably once glass — full of spherical amygdaloids. Andesitic tuff.

A rock shown by the microscope to have some affinity to the above, but supposed, when the specimens were collected, to be a dyke, was observed in two places in the S.W. corner of the Island, but unfortunately in both cases in limited and obscure exposures. The slides from these places are:

(E2105) [SC 19097 67385] Sheared dyke (?): N. side of road at most easterly house of Cregneish.

Micro. A breccia made of a trachytic kind of rock solely. The fragments are generally rounded, and consist of a rock made up of felspar prisms (laths) embedded in interstitial quartz (with (I) felspar). Occasionally a mica pseudomorph is found in them. What ground-mass there is seems to be chlorite and quartz grains. It must, I think, be a rock of trachytic character broken up *in situ.*

(E2109) [SC 19624 66792] Grit or dyke (?) Hillside 40 yards N. of road, 500 yards E.N.E. of Chasms House.

Micro. Related to (E2105) [SC 19097 67385], and either an igneous rock brecciated *in situ* or a volcanic tuff: fragments rather more rounded than in (E2105) [SC 19097 67385], as if waterworn.

II. Carboniferous Volcanic Series

As the petrography of the Carboniferous Volcanic Rocks has been treated of in detail by Mr. B. Hobson in the paper already cited, and as the present investigation has confirmed his results, it will be sufficient here to give one or two illustrative examples of the more conspicuous of these rocks, with a few additional notes on points not dealt with by Mr. Hobson. The complicated structure and general relations of the series have been discussed in an earlier chapter (p. 226).

The following is a general description of the porphyritic basaltic rocks forming the Stack of Scarlet and the broken dyke-like ridges (probably originally lava-flows: see p. 248 and (Figure 68), (Figure 70)) between the Stack and Cromwell's Walk, based on the slides (E1802) [SC 25445 66291], (E1803) [SC 25452 66287], (E1804) [SC 25490 66259], (E1805) [SC 25273 66252], (E1806) [SC 24893 66521] and (E1807) [SC 28227 65747] of the Survey Collection. he rocks are of a dark greenish-grey colour, with porphyritic plagioclase crystals up to ¼ inch in length, and are often amygdaloidal, especially at the margin.

Under the microscope the structure is usually porphyritic with large idiomorphic plagioclase crystals in a ground-mass of small needle-like felspars embedded ophitically in chlorite, calcite and abundant iron-ores. In one of the slides (E1804) [SC 25490 66259], however, the large felspars are absent. In another (E1803) [SC 25452 66287] chlorite replacements after olivine or hypersthene are recognisable. The amygdules are filled with carbonates, chlorite, quartz, and a zeolite, the last generally radiating.

Mr. Hobson applied the term "augite-porphyrite" to these rocks, but as they all belong to the basic rather than to the intermediate group, and as augite, though no doubt originally present, can no longer be recognised in them, it seems preferable to style them "porphyritic diabases", using "diabase" in the ordinary sense of an altered dolerite. In the general stratigraphical descriptions given in Chapter 5, the common term "basalt" has been applied to them in a broad general way.

Mr. Hobson has described a dyke-rock ("the melaphyre dyke ') occurring at the northern margin of the Volcanic Series at Scarlet, which differs from the rocks above described only in the presence of recognisable crystals of augite and pseudomorphs after olivine. There is no doubt that this dyke is connected with the Volcanic Series, and is therefore of Carboniferous age. Another dyke which appears to be of this age, also described by Mr. Hobson, occurs on Langness (see p. 195), rising through the slates into the overlying Carboniferous Conglomerate. Its characters are as follows:

(E1807) [SC 28227 65747] Dyke cutting slates and conglomerate: N, end of The Arches, Langness.

Micro. Amygdaloidal diabase, much decomposed; minerals entirely gone, but shapes of felspars quite unmistakable. Amygdules consist of fine chlorite with idiomorphic dolomite crystals embedded, and the outside of the cavities appear to have been of interstitial matter which was abundant in the rock.

Another dyke which may belong to the Carboniferous group occurs on the outer margin of the shore south of Castletown harbour, as described on p. 203. The following is a slide of this rock:

(E1954) [SC 26561 66835] Dyke or boss in Carboniferous Limestone: Creg Kermode, Castletown Bay. Compact grey rock with a brown crust.

Micro. Much decomposed to calcite and chlorite; resembles the Carboniferous set. Felspar needles in ground-mass amongst chlorite and interstitial matter which increases near the amygdules, and eventually forms a ring round them sometimes thicker than the diameter of the amygdules themselves. The latter are almost entirely calcite with a little chlorite. The interstitial matter has been quite a tachylyte filled with rods of iron ore.

In a slide (E1953) [SC 26008 66908] from another part of the mass, where the rock was of darker colour and more definitely crystalline, it more nearly resembled a fairly coarse ophitic olivine-dolerite of the supposed Tertiary group, much decomposed.

The reef Lheeah-rio, which is uncovered at low water in Castletown Bay about ¼ mile S.E. of Creg Kermode, seems for the reasons given on p. 247 to be more closely associated with the Carboniferous Volcanic Series than with the later set of olivine-dolerite dykes. The petrographical evidence tends to link it with these later dykes; but as the two slides from Creg Kermode show that different parts of the same mass may suggest association in one case with the Carboniferous Series and in another with the later set, this evidence can scarcely be regarded as decisive. The following is the description referred to:

(E1955) [SC 26655 66278] Basaltic rock: from near the centre of Lheeah-rio, Castletown Bay. A dark-green medium-grained massive rock.

Micro. Ophitic olivine-dolerite without phenocrysts and with hornblende replacements of olivine; the augite is pale-brown — not so deep as in the Strandhall dyke (E1808) [SC 27237 70387] (see p. 328). A zeolite which appears to be ana cime occurs between the felspar laths. The balance of evidence is in favour of associating this slide with the olivine-dolerite set rather than with the Scarlet set.

In a few places outside the limits of the Carboniferous tracts, basic intrusive rocks occur, which so far as their microscopic structure is concerned might be classed with the Carboniferous set; but in most cases the field-evidence affords no ground for separating them from the pre-Carboniferous greenstones along with which they are found. The diverse character of the greenstones has already been discussed, and it must be acknowledged that some are of later date than others; but until better evidence is forthcoming to discriminate their age, it is perhaps safest to regard all the dykes of the Manx Slate area as pre-Carboniferous, except the (Tertiary ?) olivine-dolerites. Among the dykes which have been thought to show petrological affinity to the Carboniferous set were two on the west coast near Peel, and another in the interior two miles west of Peel (see p. 156); and these are all close to the margin of the Peel Sandstone, but do not intrude upon that formation, and are therefore scarcely likely to be oflater date. Further details will be found in Chapter 4. as to the localities where greenstone dykes of the newer aspect occur.

Volcanic ash and ashy limestone

The structure and composition of the volcanic ash is sufficiently described in the passages quoted on pp. 228–33, from Sir A. Geikie's account of the series, the petrographical examination under the microscope having revealed no additional features.<ref>See also Mr. B. Hobson's descriptions: *op. cit.,* pp. 442–3.</ref> In most of the slides no signs of crushing were visible. A specimen from one of the strips of chert enclosed in the ash at *Close ny Chollagh Point* (p. 236) was cut and examined (E2929) [SC 24542 67039]: it is seen to be rudely bedded and twisted, and exhibited no trace of elastic grains, and no organisms. An ashy limestone from the same locality (E2991) [SC 24558 67113] (see p. 237) proved to be made up of fragments of crinoids, corals, shells and other organisms, with indubitable lapilli of a basaltic rock, full of bubbles, and no elastic fragments of any other kind. A slide of calcareous ash (E2993) [SC 24359 67581] just below a small thrust-plane on the foreshore, N.W. of the Poolvash quarry (p. 235), showed the vesicles to be drawn out and twisted, and a certain amount of veining parallel to the twisting direction, rather suggesting that the rock had been crushed. Other slides of the disturbed rocks exhibited little or no indication of structural modification.

III. The Post-Carboniferous (Tertiary ?) olivine-dolerite dykes

Cumming was the first to distinguish between these dykes (the newest 'solid' rocks of the Island) and the older intrusives. Beyond the fact that they are Post-Carboniferous there is no direct evidence for their age in the Island, but as they agree very closely in composition, mode of occurrence and general northwesterly direction of strike, with the basaltic, dykes of Tertiary (Miocene) age in Ireland, Scotland, and the North of England, it is believed that they belong to the same period of eruptive activity. They are especially numerous in the Carboniferous rocks of the south of the Island, where they have been frequently studied; but our mapping has shown that they occur at irregular intervals throughout the slate-massif also. They tend to run in groups, which probably traverse the Island from side to side, though the individual dykes can rarely be traced for more than a short distance. They are well-exposed in the coast-sections, but more rarely in the interior owing to their rapid destruction by weathering. They appear to decrease in numbers with the altitude of the surface, and not a single example has been found at over 700 feet above O.D. (See list, p, 329.) If not simply due to weathering and consequent lack of exposures, their absence at greater altitudes may imply that the injection-pressure was insufficient to force them up through the higher ground of the Island.

The dykes vary in width from an inch or two to about 24 feet (excluding, as doubtfully of this age, the much larger masses of Creg Kerinode and Lheeah-rio previously discussed). The broader dykes traversing the Carboniferous Limestone have decolourized and slightly altered that rock for an inch or two along the contact, but their metamorphic effect is usually almost imperceptible. Except that they are sometimes slightly broken and shifted bysmall faults, these dykes have suffered no deformation; and their intrusion was evidently subsequent to the latest of the severe earth-movements affecting the Island.

The occasionally close association between these intrusions and the metalliferous lodes is a point of economic as well as scientific importance; but will be more conveniently discussed in a later chapter (p. 488). In view of this practical interest, a full list of the dykes is given at the end of the present chapter, to which the reader is referred for detailed information regarding them.

The petrographical characters of the olivine-dolerite dykes of the south of the Island have been carefully described by Mr. B. Hobson, and we have nothing. to add to his detailed account of their structure. It will be sufficient to give for comparison a short abstract of the features of a typical slide from this area; and afterwards an account of two or three slides from other parts of the Island where these dykes had not previously been recognised.

(E1808) [SC 27237 70387] 18 ft. dyke: beach at Strandliall, Bay ny Carrickey. Greenish-black massive rock.

Micro. Sub-ophitic; plagioclase laths; pale-brown augite quite fresh; large green hornblende patches which are almost cer tainly after olivine; glass-patches of considerable size.

(E2001) [SC 22647 72764] Dyke, crossing E branch of Colby stream, 150 yards above junction at Ballacannell, Arbory.

A dark olivine-basalt with large cleavage faces of augite, twinned felspar and probably olivine: dark brown weathering.

Micro. Precisely similar to (E1808) [SC 27237 70387]. An ophitic olivine-dolerite with violet brown slightly pleochroic augite embedding long clear plagioclase laths. The augite shows no decomposition. There are considerable masses of green alteration products, varying from almost colourless to yellow, brown-yellow, light, dark and turbid green. The yellower varieties occur in masses suggesting the shape of olivine crystals, and sometimes infill the felspars. The very lightoccurs inspheroidal aggregates, also probably after olivine. The darker and turbid greens are strongly pleochroic with straight (so far as it can be determined in them) extinction. These have the other reactions of hornblende, and are somewhat fibrous in arrangement under a high power. Possibly this may be pilite. No trace of any interstitial matter, only here and there smaller felspars amongst the serpentine. The pseudomorphs often occur in augite plates, another point in favour of their being after olivine. The augites are often reduced to thin plates between felspars. A good deal of magnetite is present in large crystals.

(E2408) [SC 40484 93355] Dyke: Narradale stream, 300 yards E. of Grangee, Sulby. This rock is a porphyritic olivine-basalt. It contains long twinned laths of plagioclase felspar, and grains of olivine which are absolutely fresh, set in a plexus of felspar needles, which again are embedded in small grains of brown augite. The rock might well be a Tertiary dyke.

It is probably a prolongation or branch of this dyke which traverses the crush-conglomerate and also intersects one of the old 'greenstone' intrusions in the quarry at Kerroo Mooar, 700 yards to the north-eastward. (See p. 134.)

The last two dykes to be described differ from the normal type of olivine-dolerites, and some doubt is felt as to their inclusion with this group. Indeed the last of the two (E2498) [SC 439 798], as described on p. 152, has such a distinctive aspect in the field that it has not been included in the subjoined list of olivine-dolorites.

(E1956) [SC 37931 74012] and (E2818) [SC 37929 74012] Basaltic dyke: 200 yards S.W. of Slack Indigo, Douglas Head. A black compact basalt.

Micro. A tholeiite with intersertal structure. A few clear sanidine like crystals of plagioclase. A mesh-work of plagioclase laths, well preserved and bright and clear. The ground is much impregnated with carbonates and no glass can be found, though there is good reason to believe it once existed and is now devitrified. Decided grains of augite, a good deal altered to chlorite and calcite occur between the felspars; they are colourless, with the usual reactions. Plenty of minute crystals and rods of magnetite. No decided olivines, but serpentine pseudomorphs after enstatite or olivine, probably the former. No certain analcime; occasional calcite amygdaloids, round which is generally a zone of elongated plagioclases. Basalt (tholeiite), probably Tertiary.

(E2498) [SC 439 798] 3 to 4 ft. porphyritic dyke: cliff at the Clytt, Clay Head (p. 152).

Micro. Large porphyritic felspars, and probably olivines in much decomposed condition embedded in ophitic dolerite matrix, in which the minerals are much altered to chlorite, calcite, etc. This is likely to be a Tertiary dolerite.

List of outcrops of the Post-Carboniferous (Tertiary?) olivine dolerite dykes in the Isle of Man

Note — Of these dykes, those of the south-western coast probably represent the prolongation of those of the south-eastern coast; and of the last-mentioned, certain dykes seen on the outer or eastern shore of Langness no doubt reappear on both sides of Castletown Bay, and again on the eastern side of Bay ny Carrickey, but as their individual identification is difficult or impossible, all the outcrops are recorded separately. Unless otherwise noted the dykes are intrusive into the Manx Slate Series. Place-names in italics are those not given on the one-inch Ordnance Map. The distances given below have been measured on the six-inch field-map.

Number of Six-inch Sheet	Locality	Average Width of Dyke	Direction of Strike	Remarks
	North-Eastern District			
(Sheet 5)	Cliff and shore S. of Maughold Head, W. side of Dhyrnare	3 ft.	N. 35° W.	"Umber Mine" dyke, see p. 126.
(Sheet 8)	Cliff and shore S. of Maughold Head, 100 yds. S. of Dhyrnane	4 ft.	W. 15° N.	vein-stuff on S. side.
(Sheet 8)	Cliff and shore S. of Maughold Head, S. of Port Mooar, 300yds. S. of cottage	9 ft.	W. 40° N.	hematitic vein-stuff on N.E. side.
((Sheet 5))	Inland; head of glen adjoing Glen Auldyn at Balleigheragh	8 ft. and branches	W. 35° N.	
(Sheet 5)	Inland; S. fork of above glen, 50yds. S. of last	?	?	scanty exposure near old lead workings. Probably prolongation of dykes of Maughold Head.
(Sheet 4)	Inland; Karroo Mooar, in stone quarry	1 ft. to 2 ft.		Also in adjacent old mine, see p.134 Probably prolongation of dykes of Maughold Head
(Sheet 4)	Inland; bed of stream In gully 300yds. E.S.E. of Crook Sumark	?	?	inadequate exposure; rock unusually fresh see p. 328. Probably prolongation of dykes of Maughold Head. p.328.
	Eastern and Central District			
(Sheet 11)	Cliff 1 mile S. of Laxey, opposite Ballabeg	3 ft.	W. 15° S.	well exposed; *see* p.151
(Sheet 11)	Cliff ¾ mile S. of Clay Head, east of Ballakilley	4 ft.	N. 35° W.	
(Sheet 13)	Cliff ¾ mile S. of Douglas Head, 200yds. S.W. of Slack Indigo	5 ft.	N. 40° W.	classification doubtful; see p. 328.
(Sheet 13)	Cliff 2 miles S.E. of Douglas Head at extremity of Little Ness	two, each about 3 in.	N.W.	perhaps fliers from larger dyke not exposed.

(Sheet 13)	Cliff 2 miles S.E. of Douglas Head, recess west side of Little Ness	two, each about 6 in.	N. 20° W.	perhaps prolongation of last.
(Sheet 13)	Shore in middle of Port Soderick	4in.	W. 30° N.	
(Sheet 17)	Cliff 400yds. S. of Port Soderick.	l ft.	irregular, W. 15° N.	classification doubtful
(Sheet 17)	Cliff 150yds. W. of Purt Veg, Santon	2½ ft. and flier 1½ ft.	N. 30° W.	
(Sheet 17)	Cliff and cave 100yd.. E. of Port Greenough	1 ft.	irregular, W. 20° N.	with vein stuff.
(Sheet 17)	Shore 150 to 300yds. W. of Port Greenough	1 ft. to 2 ft.	W. to W.10° S.	
(Sheet 17)	Shore 150 to 300yds. and cliff, 400yds. W. of Port Greenough; 100 yards W. of Traie ny Gill	2 ft.	N. 35° W.	
(Sheet 17)	Shore and cliff, about 40yds. W. of last	3 ft.	N. 35°W.	
(Sheet 17)	Shore 500yds. east of Port Soldrick, Santon	1 ft. and flier.	W. 18° N.	
(Sheet 17)	Shore and cliff, 320yds E. of Port Soldrick, Santon	2 ft.	N. 40° W.	accompany fault stuff
(Sheet 12)	Inland; at East Foxdale Mines, Eairy	?	?	see p. 514
(Sheet 12)	Inland; S.W.of South Barrule in feeder of Silverburn, 850yds. above Castletown reservoir	1½ ft.	N. 40°W.	much decomposed; at altitude of about 700 ft.
(Sheet 12)	Inland; S.W. of South Barrule; in the west arm of Silverburn, 30yds. below highroad at Garey Mooar	?	N. 25° W.	much decomposed; worked in adit; at altitude of about 700 ft.
(Sheet 16)	Inland; stream 250yds. W. of Ballacannell, near head of Colby Elver	abt. 10 ft.	W. 40° N.	unusually fresh; altitude about 450 ft.
(Sheet 16)	Inland; Colby River, 20yds. below Colby Corn Mill	8 ft. and flier l ft.	W. 10° N.	at trial adit see p. 532. ? all one dyke
(Sheet 16)	Inland; Bellabbey Glen, at parish boundary 500yds. W. of Colby	?	W. 10° S.	at trial adit see p. 532. ? all one dyke
(Sheet 16)	Inland; Ballacorkish Lead Mines	?	?	at trial adit see p. 532. ? all one dyke
	South-western coast			
(Sheet 12)	Shore and cliff, 900yds. N. of Dalhy Point	3 ft.	N. 30° W.	also two smaller dykes 30yds. and 60yds. north of this.

(Sheet 12)	Shore and cliff, North side of Dalhy Point	2½ ft.	W. 20° N.	
(Sheet 12)	Shore and cliff, South side of Dalhy Point, Bay ny Ooig	2½ ft.	W. 10° N.	
(Sheet 12)	Shore and cliff, under Cronk ny Arrey Lhaa, 350yds. N. of Stroin Vuigh	3 ft.	W. 15° N.	
(Sheet 12)	Shore and cliff, under Cronk ny Arrey Lhaa, 70yds. S. of Stroin Vuigh	6 ft.	W. 30° N.	cuts a microgranite dyke.
(Sheet 16)	Shore and cliff, under Gob ny Beenn, 300yds. S. of The Stacks	1 ft.	W. 35° N.	cuts a microgranite dyke; 70yds. further South probably another dyke, poorly exposed.
(Sheet 16)	Shore and cliff, ¾ mile N. of Fleshwick, S. side of Grub ny Traie Ruy	4 ft.	N. 35° W.	
(Sheet 16)	Shore and cliff, N. side of Fleshwick, 250yds. S. of Raclay	1 ft.	N. 40° W.	probably another dyke 35yds north.
(Sheet 15)	Shore and cliff, 800yds. W. of Fleshwick; W. side of Lhoob my Charran	3 ft. branching	N. 30° W.	old mining trial adjacent.
(Sheet 15)	Shore and cliff, North Bradda Mine, acccompanying lode	1 ft. to 2 ft.	N.	see p. 630.
(Sheet 15)	Shore, Notth Bradda Mine, striking off from lode	3 ft.	W. 25° N.	see p. 530; probably seen also 300yds. inland.
	South-eastern coast<ref>A list of the dykes of this district has been compiled and privately printed by Mr. B. Hobson.</ref>			
(Sheet 16)	Shore 150yd's. N. of Loch Skillicore; in Carb. Limestone	1 ft., 3 ft., 1 ft., 3 ft., etc.	N. 40° W.	interlacing group of several dykes.
(Sheet 16)	Shore, Derby Haven, E. of Breakwater, 150 yds. N.E. of lighthouse, in Carb. Conglomerate and Limestone	2 ft.	N.W.	
(Sheet 16)	Shore, Derby Haven, E. of Breakwater, 120 yds. N.E. of lighthouse, in Carb. Conglomerate and Limestone	7 ft.	N.W.	

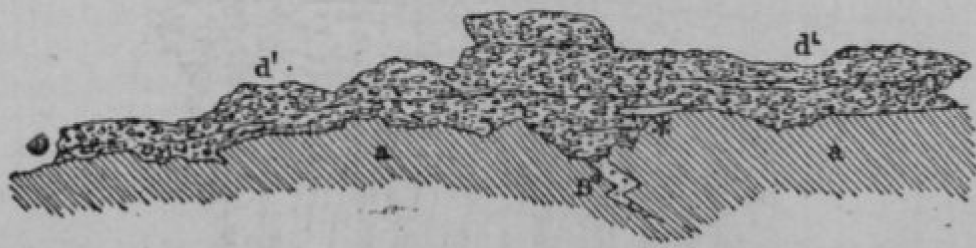
(Sheet 16)	Shore, Derby Haven, 150 yds. S. of lighthouse, in Carb. Conglomerate and Limestone	6 to 9 ft.	W. 35° N.	accompanying fault.
(Sheet 16)	Shore, Derby Haven, at N. end of Causeway to St. Michael's Island	1½ ft.	W. 10° N.	probably continuation of last three.
(Sheet 16)	Shore, Derby Haven, 55 yds. N. of Causeway to St. Michael's Island	2 ft.	N.W.	probably continuation of last three.
(Sheet 16)	Shore, Derby Haven, at S. side of gully separating St. Michael's Island from Langness	1 ft.	N. W.	probably continuation of last three.
(Sheet 16)	Shore, Langness, Martha Gullet	1½ ft.	W. 20° N.	
(Sheet 16)	Shore, Langness, 50 yds. S. of Martha Gullet.	3 to 7ft.	W. 30° N.	interlacing group.
(Sheet 16)	Shore, Langness, 75 yds N. of The Goayr	irregular branches	W. 25° N.	interlacing group.
(Sheet 16)	Shore, Langness, Spire Gullet	1 ft.	N.W.	
(Sheet 19)	Shore, Langness, at Dreswick Point	2 ft.	N. 30° W.	
(Sheet 19)	Shore, Langness, at Langness Point	1½ ft.	N. 20° E.	accompanying copper lode; see p. 538.
(Sheet 19)	Shore E. side of Castletown Bay, 200yds. N.E. of Port Bravag	4 ft.	N. 30° W.	probably same as Dreswiek dyke.
(Sheet 19)	Shore, E. side of Castletown Bay, opposite copper mine	branches, ½ ft. to 3 ft.	N. 15° W.	branching; accornpanying copper lode; see p. 539.
(Sheet 19)	Shore, E. side of Castletown Bay, 150yds. N. of copper mine	branches, 1 ft. to 4 ft.	N.W. W. 20° N.	numerous interlacing branches.
(Sheet 19)	Shore, E. side of Castletown Bay, 225yds. E.S.E. of Langness Farm; in Carb. Conglom. and Limestone	3½ ft.		
(Sheet 19)	Shore, E. side of Castletown Bay, W. of Langness Farm; in Carb. Limestone	8 ft.	N. W	

(Sheet 19)	Shore, E. side of Castletown Bay, N.W. of Langness Farm, 400yds. N. of last; in Carb. Lime. stone	4ft	N.W.	
(Sheet 19)	Shore, E. side of Castletown Bay, 100yds. N.W. of Poyll Breinn; in Carb. Limestone	2 ft. and 1 ft.	N.W.	two dykes. contiguous and parallel.
(Sheet 19)	Shore, outer harbour, Castletown; in Carb. Limestone	branches, 3 ft., 2 ft. and 1 ft.	N.W.	associated with galena; see p. 357.
(Sheet 19)	Shore, 100yds. W. of harbour, Castletown; in Carb. Limestone	2½ ft.	W. 25° N.	
(Sheet 19)	Shore, S. of Castletown, opposite Knockrushen; in Carb. Limestone	18 ft. to 24 ft., with fliers	W. 10°–15° N.	
(Sheet 19)	Shore, S. of Castletown, 150yds. S. of Knockrushen; in Carb. Limestone	6in.	N. 15° W.	
(Sheet 19)	Shore, S. of Castlet,wn, 80yds. S. of last; in Carb. Limestone	bin.	N. 30° W.	
(Sheet 19)	Shore, S. of Castletown; old landing place opposite Scarlet House; in Carb. Limestone	2 ft.	W. 5° N.	much decomposed.
(Sheet 19)	Shore, S. of Castletown; "Creg Kermode", at low water spring tides, opposite Scarlet House; in Carb. Limestone	? boss 80–90 ft. wide, and dykes 8–10ft wide	? W. 10° N.	perhaps connected with Carb. Volcanic series; see p. 325. Rock much obscured by seaweed.
(Sheet 19)	Lheeah rio; low water reef in Castletown Bay Shore, 200yds. N. of Scarlet Point; in Carb. Limestone	see p. 325 4 ft.	N. 40°W.	perhaps connected with Carb. Volcanic series; see p. 325. Rock much obscured by seaweed.
(Sheet 19)	Shore, in recess N. side of Scarlet Point; in Carb. Limestone	6 ft. and two fliers	W. 30° N.	at margin of Volcanic series.
(Sheet 16)	Shore, from 250 yds. W. of Cromwell's Walk to within 200yds. of Close ny Chollogh Point; In Volcanic Ash	l ft. to 2 ft.	N.W.	traceable at intervals for distance of 750 yards.

(Sheet 16)	Shore, near northern termination of last, 30yds. and 50yds. further N.	two small dykes or branches		
(Sheet 16)	Shore, S. side of Poyll Vaaish, under Fort; in Carb. Limestone and Ash	8 ft. and fliers	N. 40° W.	
(Sheet 16)	Shore, S. side of Poyll Vaaish at "marble quarry" and thence across to low water S. of (Thaw Gortagh in Carb. Limestone and Ash	12 to 18 ft.	W. 40°N.	splitting intobranches near low water
(Sheet 16)	Shore, S. and W. of Poyll Vaaish farm; in Carb. Limestone: three contiguous dykes	5 ft., 3 ft., and 2½ ft.	N.W.	traceable at intervals from middle of Poyll Vaaish to Poyll Richie.
(Sheet 16)	Shore, S. of Balladoole, W. of Poyll Richie; in Carb. Limestone	3 ft.	N.5°W.	parallel to and partly along fault.
(Sheet 16)	Shore, S. of Balladoole, W. of Poyll Riohie; three small dykes may be prolongation of Poyll-Vaaish group.			
(Sheet 16)	Shore, S. of Balladoole; at Poyll Breinn and across bay to Strand hall; in Carb. Limestone	18 ft.	N.W.	see p.204, another dyke obscurely seen 30yds.farther south, at Poyll Breinn, probably connected with this.
(Sheet 16)	Shore, S. of Balladoole, at Poyll Breinn, 50yds. N. of last; in Carb. Limestone	branching group thickest 3 ft.	N.W.	probably connected with last.
(Sheet 16)	Shore, east end of Black Rocks opposite Kentraugh, 150yds. W. of fault cutting out limestone	7 ft.	N 25°W.	cuts older dykes in slate.
(Sheet 16)	Shore, east end of Black Rocks, 90yds. W. of last	1 ft.	N.25°W.	cuts older dykes in slate.
(Sheet 16)	Shore, west end of Black Rocks, opp. Kentraugh House	2 ft.	N.30°E. and N. 20°W.	? diverted by a fissure.

FIG. 50.—*Section across foreshore at Langness Point, south of Lighthouse, showing eroded surface of slates beneath Carboniferous Basement Conglomerate.*

Height about 10 feet.



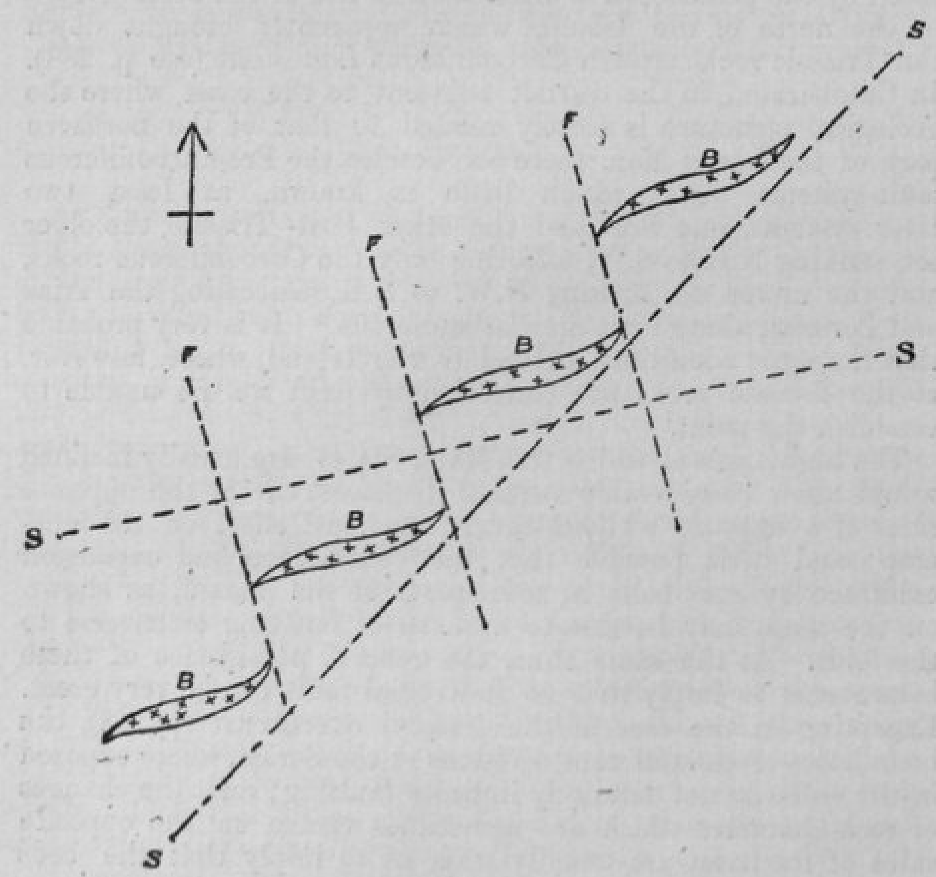
d^1 Carboniferous Basement Conglomerate, filling hollows in the slates: a large block of grit at * measures 4 ft. by 2 ft.

a Manx Slates.

B^G Pre-Carboniferous greenstone dyke, 8 inches wide, along which a gully 3 feet wide and 2 feet deep has been eroded on the Carboniferous shore. This is prolonged into a similar gully on the present shore.

*(Figure 50) Section across foreshore at Langness Point, south of Lighthouse, showing eroded surface of slates beneath Carboniferous Basement Conglomerate. Height about 10 feet. d^1 Carboniferous Basement Conglomerate, filling hollows in the slates: a large block of grit at * measures 4 ft. by 2 ft. a Manx Slates. B^G Pre-Carboniferous greenstone dyke, 8 inches wide, along which a gully 3 feet wide and 2 feet deep has been eroded on the Carboniferous shore. This is prolonged into a similar gully on the present shore.*

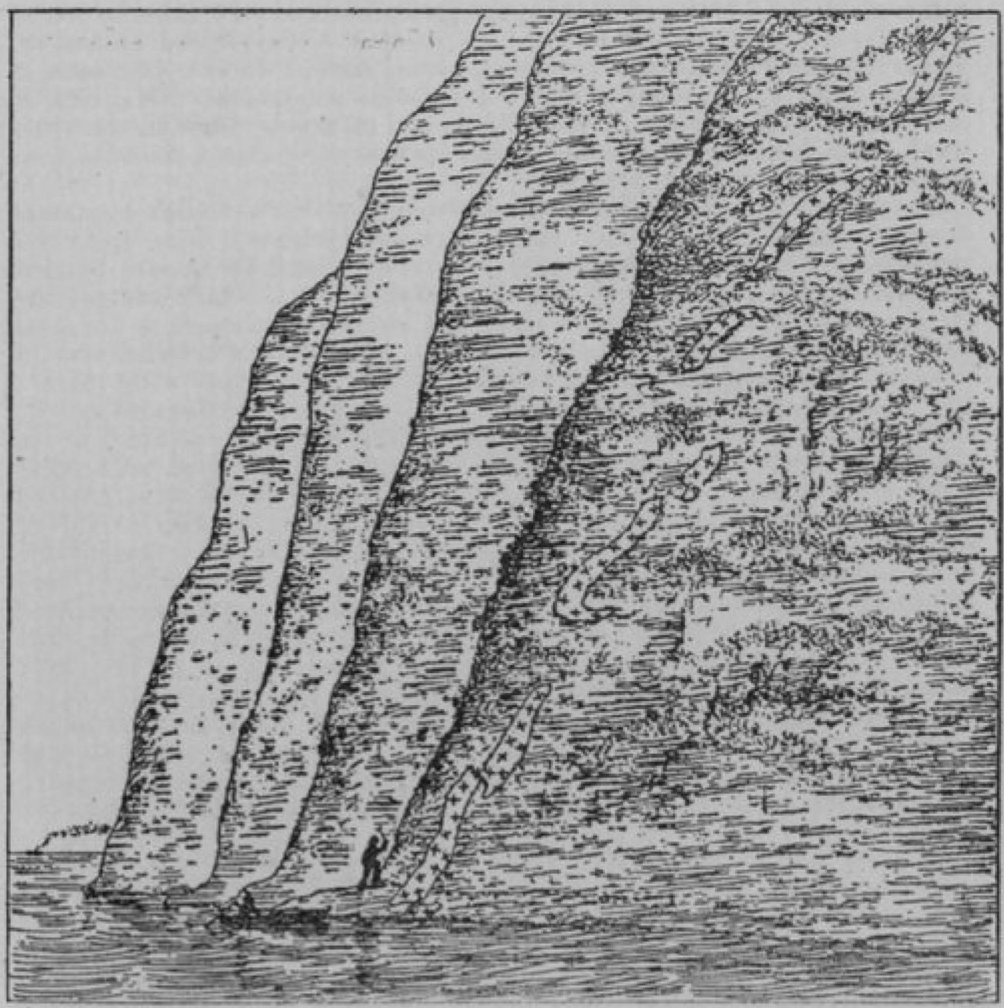
FIG. 31.—*Diagram (plan) to illustrate common structure in hard bands, whether dykes or layers of grit, in Manx Slates; showing divergence between strike of segments and strike of band as a whole.*



B, B.	Segments of hard band, pinched at terminations.
F, F.	Dislocation-lines (? normal or overthrust faults).
S - - S.	Direction of strike of individual segments.
S — - — *S*.	Direction of average strike of hard band.

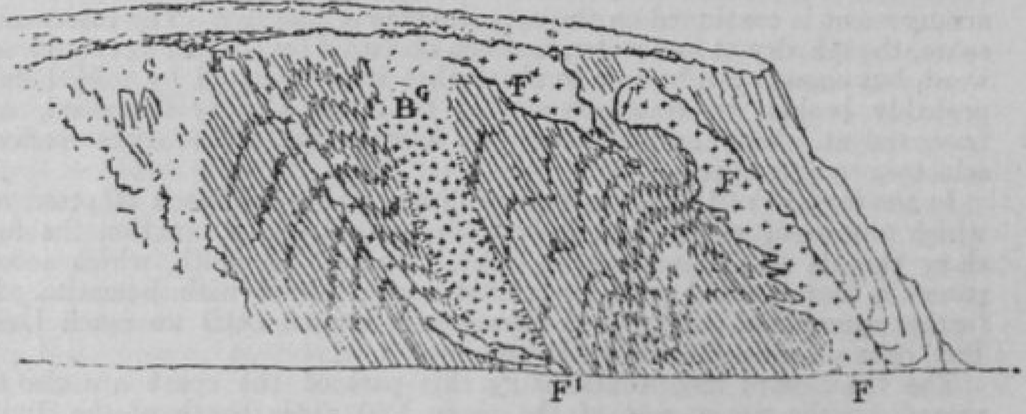
(Figure 31) Diagram (plan) to illustrate common structure in hard bands, whether dykes or layers of grit, in Mans Slates; showing divergence between strike of segments and strike of band as a whole. B, B. Segments of hard band, pinched at terminations. F, F. Dislocation-lines (I normal or overthrust faults). S- -S.Direction of strike of individual segments. S — -— S. Direction of average strike of hard band.

FIG. 43. *Diagrammatic sketch of disturbed greenstone dyke traversing Manx Slates in lower part of precipice at Slea ny Bery, Spanish Head.*



(Figure 43) Diagrammatic sketch of disturbed greenstone dyke traversing Manx Slates in lower part of precipice at,Slea ny Bery, Spanish Head.

FIG. 35. *Cliff-section in Lonan Flags on north-eastern side of Traie ny Uainaigue, Maughold. Height* 60 *feet.*



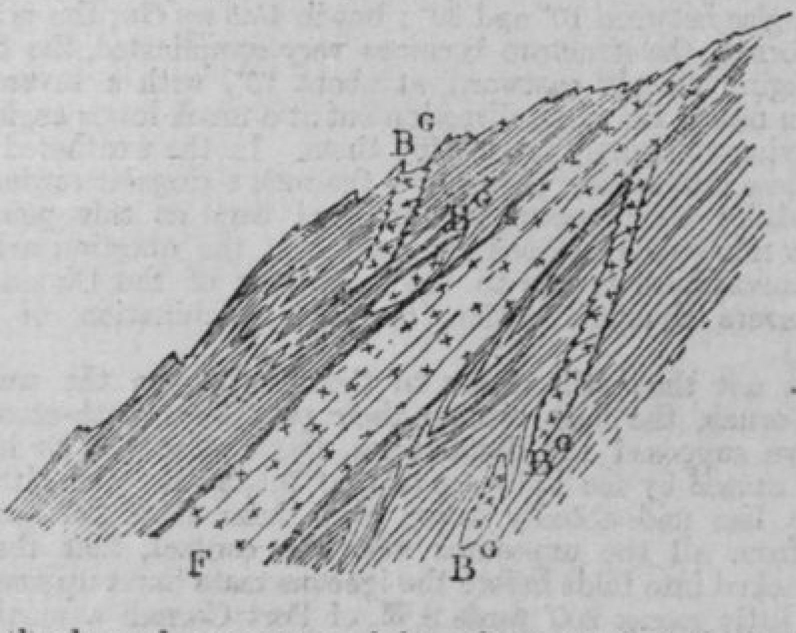
B^G Much-sheared 'greenstone' dyke, 8 to 12 feet thick.

F. Micro-granite dyke (Dhoon Granite type).

F'. Porphyritic dyke, probably connected with the micro-granite, intersecting B^G at the foot of the cliff.

(Figure 35) Cliff-section in Lonan Flags on north-eastern side of Traie ny Uainaigue, Maughold. Height 60 feet. B^G Much-sheared 'greenstone' dyke, 8 to 12 feet thick. F. Micro-granite dyke (Dhoon Granite type). F'. Porphyritic dyke, probably connected with the micro-granite, intersecting B at the foot of the cliff.

FIG. 36. *Section at foot of cliff under Barony Hill, showing contorted Lonan Flags traversed by dykes of two different ages, viz.:—greenstone (older) and micro-granite (newer).*



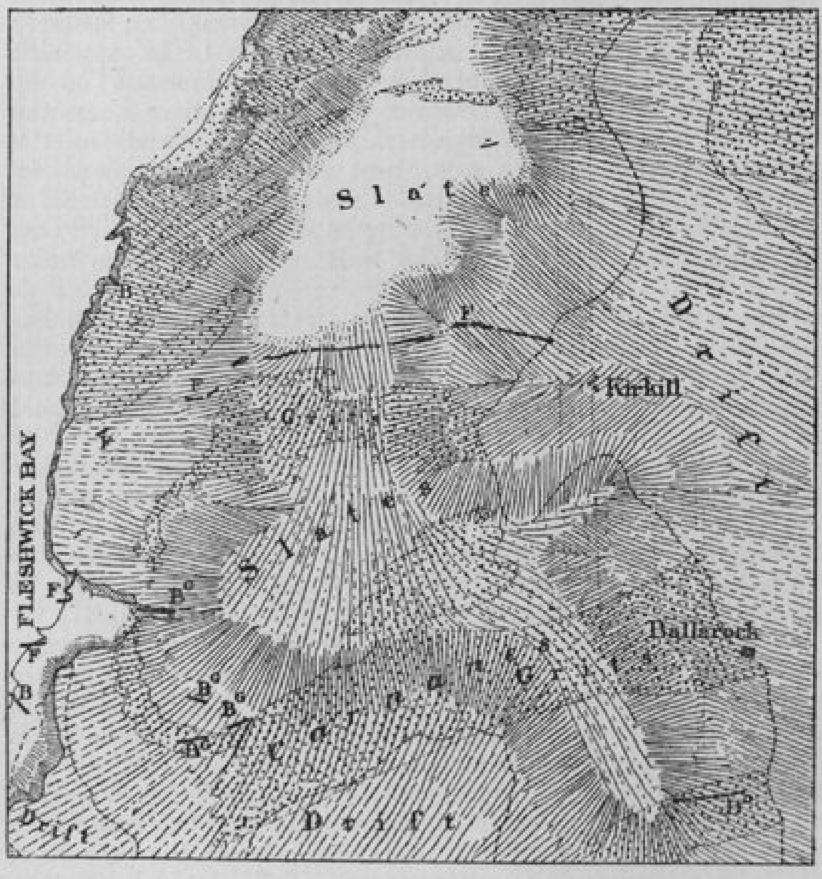
B^G. Greatly-sheared greenstone dyke, about 2½ feet thick, broken and faulted by F.

F. Micro-granite dyke (Dhoon type), 6 to 10 feet thick, rendered schistose at the margin by shearing.

(Figure 36) Section at foot of cliff under Barony Hill, showing contorted Lonan Flags traversed by dykes of two different ages, viz.: greenstone (older) and micro-granite (newer). B^G. Greatly-sheared greenstone dyke, about 2½ feet thick, broken and faulted by F. F. Micro-granite dyke (Dhoon type), 6 to 10 feet thick, rendered schistose at the margin by shearing.

FIG. 4.—*Map of coast and vicinity north of Fleshwick Bay.*

Scale 4 inches = 1 mile.

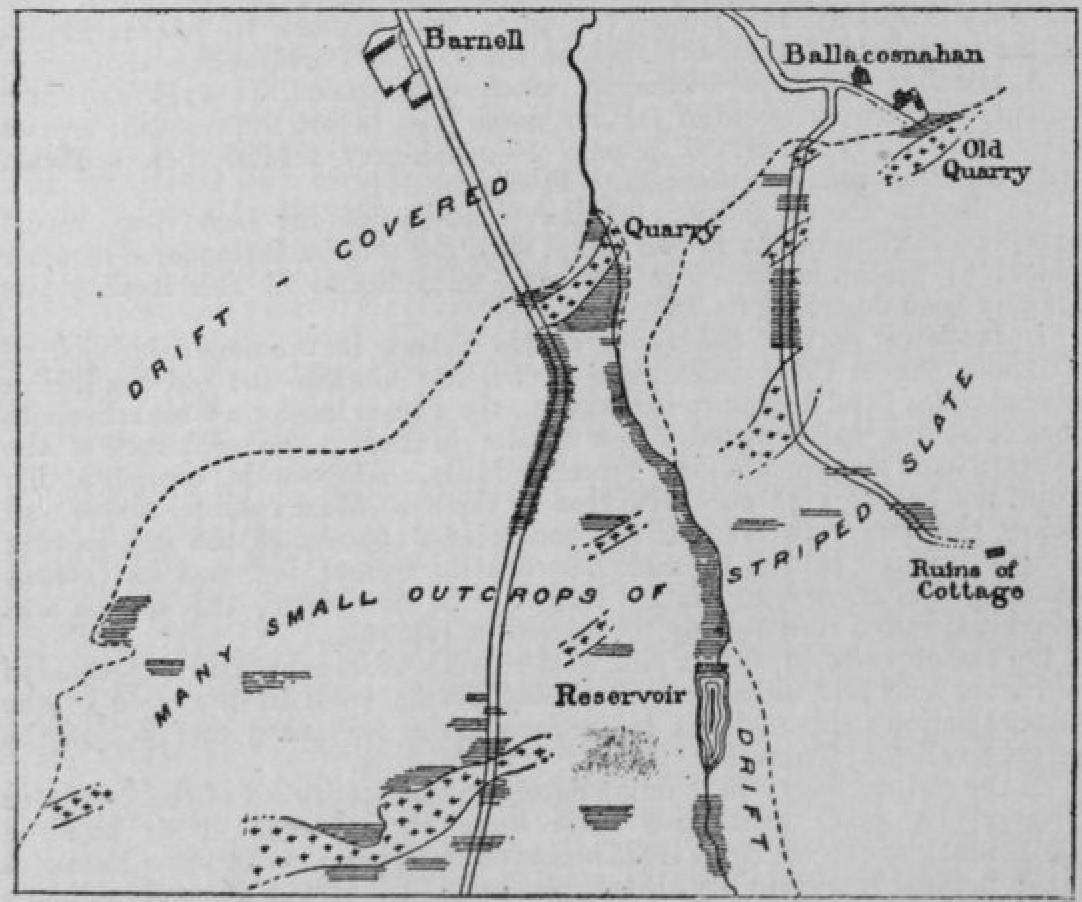


B Olivine-dolerite dykes (Tertiary ?).
B^D Greenstone dyke with large crushed felspars.
B^G Altered greenstone dykes.
F Micro-granite dyke (Foxdale Granite type), broken into segments.
The grits are represented by stippling.
The shading indicates the shape of the ground.

(Figure 4) Map of coast and vicinity north of Fleshwick Bay. Scale 4 inches = 1 mile. B Olivine-dolerite dykes (Tertiary ?). B^D Greenstone dyke with large crushed felspars. B^G Altered greenstone dykes. F Micro-granite dyke (Foxdale Granite type), broken into segments. The grits are represented by stippling. The shading indicates the shape of the ground.

FIG. 41. *Plan of irregular outcrops of greenstone south of Barnell, Kirk Patrick.*

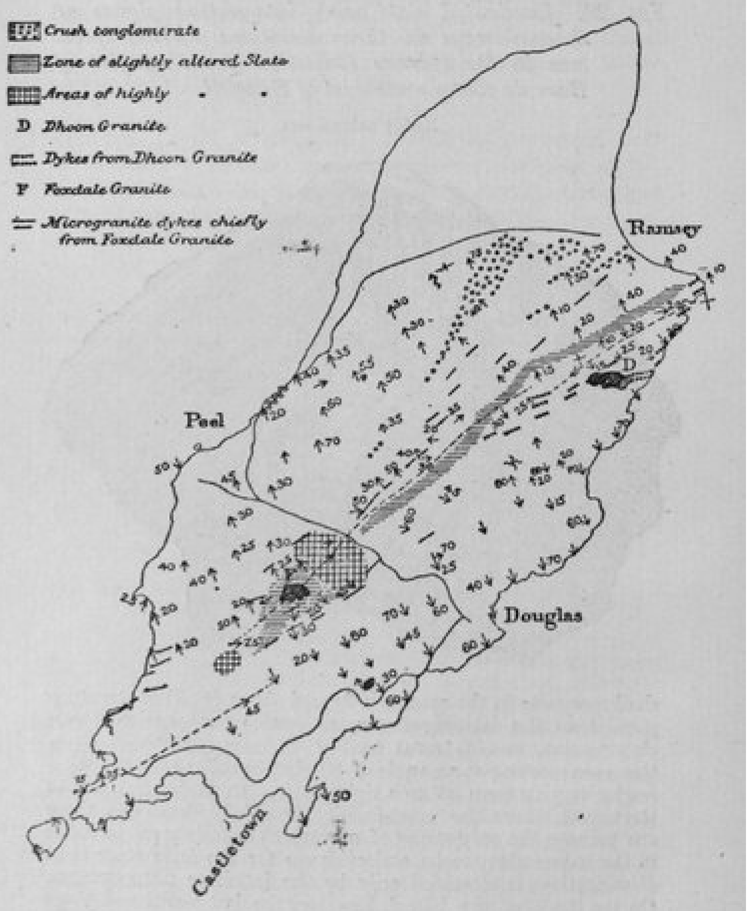
Scale, 6 inches = one mile.



The greenstone outcrops are indicated by crosses, and the slate outcrops by horizontal lines.

(Figure 41) Plan of irregular outcrops of greenstone south of Barnell, Kirk Patrick. Scale, 6 inches = one mile. The greenstone outcrops are indicated by crosses, and the slate outcrops by horizontal lines.

FIG. 29. *Sketch-map of the Isle of Man, showing (a) principal cleavage; (b) position of metamorphosed slates; (c) position of granitic intrusions and of dykes connected therewith; and (d) distribution of crush-conglomerate.*

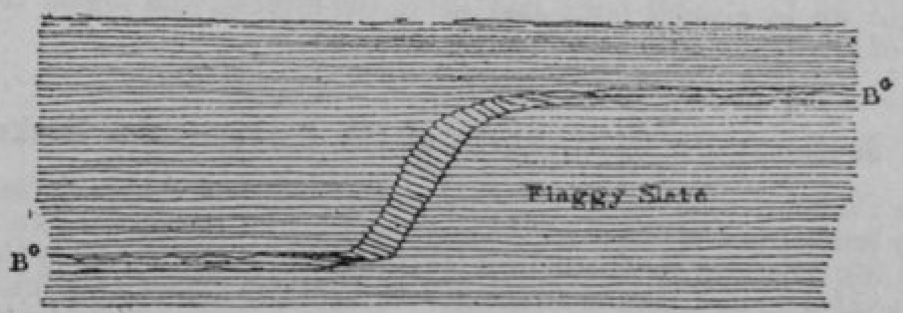


The arrows show the direction of dip of the dominant cleavage, and the figures the amount in degrees. The broken line indicates the position of the somewhat interrupted anticline of cleavage. The continuous lines mark the railways.

(Figure 29) Sketch-map of the Isle of Man, showing (a) principal cleavage; (b) position of metamorphosed slates; (c) position of granitic intrusions and of dykes connected therewith; and (d) distribution of crush-conglomerate. The arrows show the direction of dip of the dominant cleavage, and the figures the amount in degrees. The broken line indicates the position of the somewhat interrupted anticline of cleavage. The continuous lines mark the railways.

FIG. 47. *Ground-plan on shore south of Gullet Creagh Moainee, Langness, showing effect of shearing upon thickness of small greenstone dyke.*

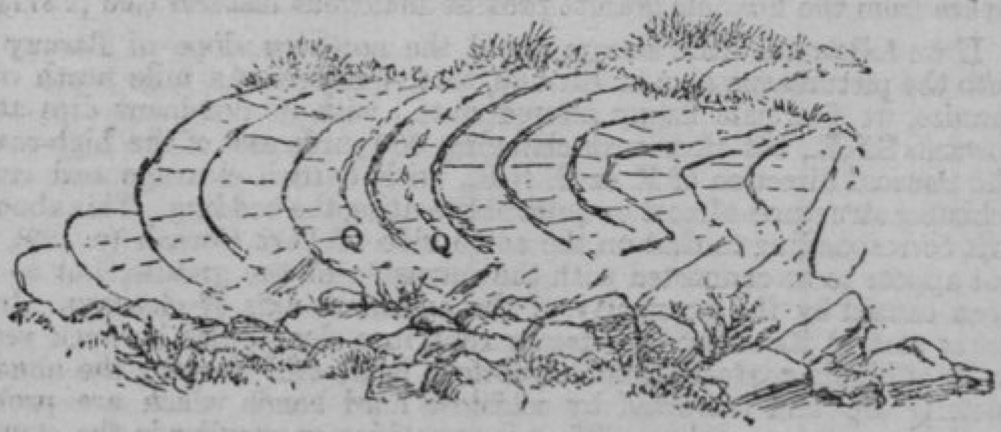
Area 35 feet by 15 feet.



Where the dyke (B^G) lies between the bedding planes of the flaggy slate, its thickness is from 2 to 4 inches; where it cuts across the bedding, it expands to 12 inches and shows oblique cleavage.

(Figure 47) Ground-plan on shore south of Gullet Creagh Moainee, Langness, showing ef fect of shearing upon thickness of small greenstone dyke. Area 35 feet by 15 feet. Where the dyke (B^G) lies between the bedding planes of the Baggy slate, its thickness is from 2 to 4 inches; where it cuts across the bedding, it expands to 12 inches and shows oblique cleavage.

FIG. 38. *Granite crag under Ordnance station on shoulder of Slieau Ruy W.S.W of Ballelin, exhibiting curved structure (not like concentric weathering) probably due to movement. Height about 8 feet.*

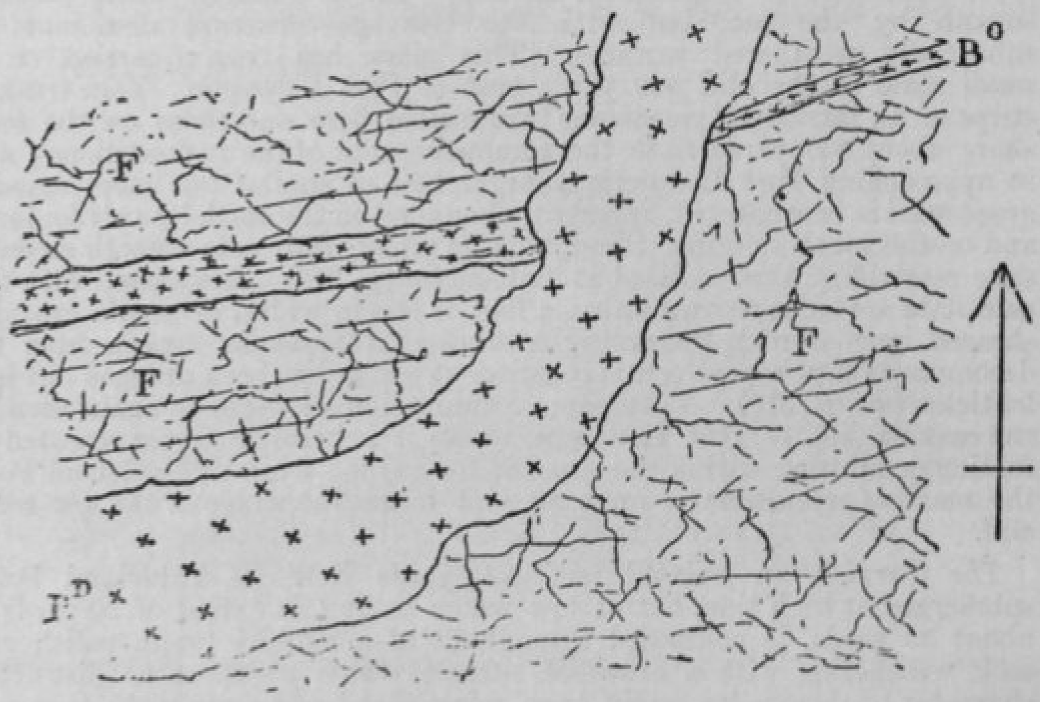


Q. Small quartz-veins participating in the curved arrangement.

(Figure 38) Granite crag under Ordnance station on shoulder of Slieau Ruy W.S W of Ballelin, exhibiting curved structure (not like concentric weathering) probably due to movement. Height about 8 feet. Q. Small quartz-veins participating in the curved arrangement.

FIG. 34. *Ground-plan of portion of foreshore in Port e Myllin, near Ramsey, showing igneous complex.*

14 feet × 10 feet.

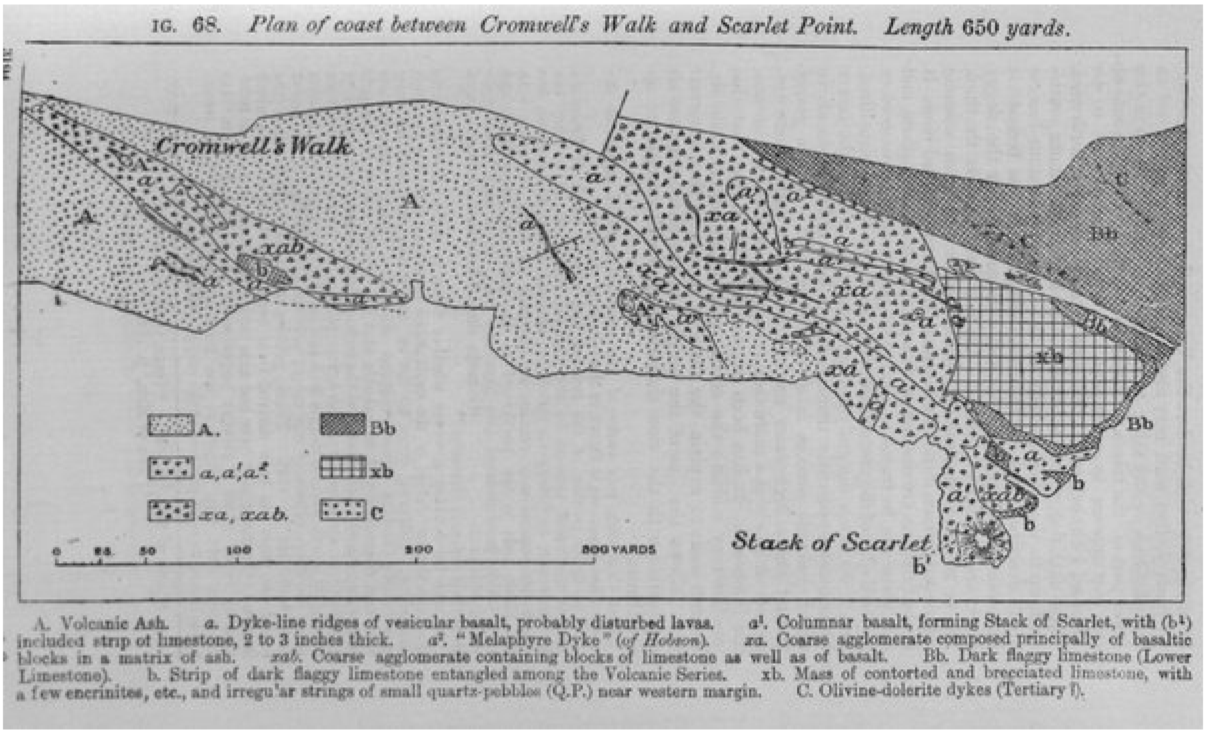


B^D. 'Newer Greenstone' dyke, yellowish-brown in colour, uncrushed, 4 feet thick; traversing F and intersecting B .

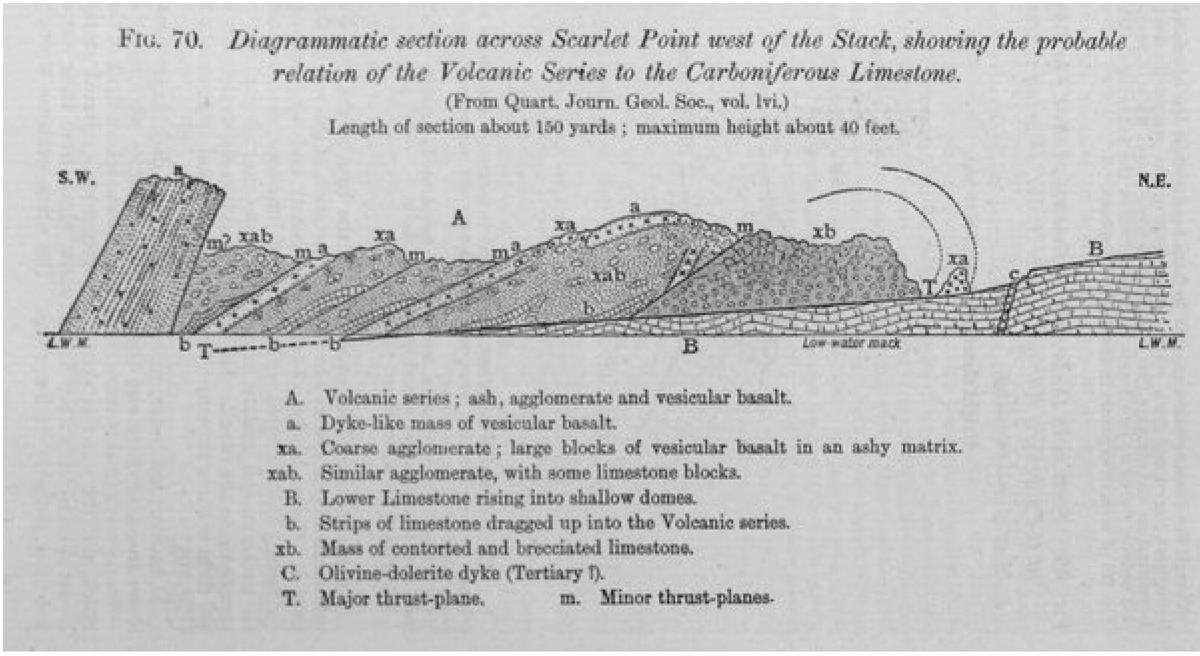
B^G. 'Older Greenstone' dyke, spotted yellowish-green, 3 to 6 inches thick, traversing F; greatly sheared and pinched, especially to the east ward of B^D.

F. Crushed felsitic mass, pale greenish-gray colour, intensely sheared and full of criss-cross quartz-strings.

(Figure 34) Ground-plan of portion of foreshore in Port e Myllin, near Ramsey, showing igneous complex. 14 feet x 10 feet. B^D. 'Newer 'greenstone' dyke, yellowish-brown in colour, uncrushed, 4 feet thick; traversing F and intersecting B. B^G. Older 'greenstone' dyke, spotted yellowish-green, 3 to 6 inches thick, traversing F; greatly sheared and pinched, especially to the east ward of B^D. F. Crushed felsitic mass, pale greenish-gray colour, intensely sheared and full of criss-cross quartz-strings.



(Figure 68) Plan of coast between Cromwell's Walk and Scarlet Point. Length 650 yards. A. Volcanic Ash. a. Dyke-line ridges of vesicular basalt, probably disturbed lavas. a^1. Columnar basalt, forming Stack of Scarlet, with (b^1) included strip of limestone, 2 to 3 inches thick. a^2. "Melaphyre Dyke" (of Hobson). xa. Coarse agglomerate composed principally of basaltic be blocks in a matrix of ash. rah. Coarse agglomerate containing blocks of limestone as well as of basalt. Bb. Dark flaggy limestone (Lower Limestone). b. Strip of dark flaggy limestone entangled among the Volcanic Series. xb. Mass of contorted and brecciated limestone, with few encrinites, etc., and irregular strings of small quartz-pebbles (Q.P.) near western margin. C. Olivine-dolerite dykes (Tertiary 7).



(Figure 70) Diagrammatic section across Scarlet Point west of the Stack, showing the probable relation of the Volcanic Series to the Carboniferous Limestone. (From Quart. Journ. Geol. Soc., vol. lvi.) Length of section about 150 yards; maximum height about 40 feet. A. Volcanic series; ash, agglomerate and vesicular basalt. a. Dyke-like mass of vesicular basalt. xa. Coarse agglomerate; large blocks of vesicular basalt in ashy matrix. xab. Similar agglomerate, with some limestone blocks. B. Lower Limestone rising into shallow domes. b. Strips of limestone dragged up into the Volcanic series. xb. Mass of contorted and brecciated limestone. C. Olivine-dolerite dyke (Tertiary ?). T. Major thrust-plane. m. Minor thrust-planes.