Chapter 4 Detailed description of the Manx Slate Series and the accompanying igneous rocks

Introduction

In the general sketch of the Manx Slates contained in the foregoing pages the greater part of the local information in regard to the series and the igneous rocks which traverse it, which was acquired during the prosecution of the survey, has been omitted. It is desirable, however, that this should be placed on record for the assistance of future investigators working in the same field. In the present chapter, therefore, will be given all such topographical details relating to these rocks as have not found place in the preceding chapter, along with the major portion of the information regarding the igneous rocks of the Island. As these details are for the most part based on working notes made on the six-inches-to-the-mile map, many place-names will be mentioned in them which do not appear in the published geological map on the one-inch scale. Such names are denoted by italics.

For convenience of local reference, the area to be described will be divided into three districts: Northern, comprising sheets 4 to 8 of the six-inch Ordnance Map; Central, comprising six-inch sheets, 9 to 14; and Southern, sheets 15 to 19. These districts will be further subdivided under the separate headings of,—first, the western coast-line of each district; next, its eastern coast-line and lastly, its interior, keeping generally the order and limits of the six-inch maps but transgressing this order in favour of the natural physical boundaries in the case of the chief valleys or other similarly well-defined features.

Northern Division

Western coast

On the north-western side of the Island, a tapering prolongation of the low-level drift platform of the north laps the old massif for several miles farther south than on the north-eastern coast, and has evidently once been continuous at least as far southward as Peel. In walking in calm sunny weather on the top of the cliffs between Peel [SC 24182 84554] and Ballacarnane [SC 29803 88903], although we find the solid rocks are now exposed down to low tide, we may frequently observe indications of the Pre-glacial limits of the Island, in the sudden ending off, beneath the transparent water, of the rich purple patches of the weed-covered rocks against the delicate green tint which denotes the smooth sandy bottom where the drifts make the foundations of the sea-floor. Near Gob ny Creggan Glassey [SC 29548 88767] this line of demarcation draws shoreward and passes gradually from low-water to high-water mark; and from this point northward Glacial and Post-glacial deposits form the whole of the cliff and foreshore (see sections, (Figure 92) and (Figure 93), p. 348), but are being rapidly stripped away by the continual encroachment of the sea (p. 13).

Off this part of the coast, as far south as Peel, the Admiralty Chart shows that the sea bottom shelves very gradually, the 10-fathom contour which farther southward lies usually within a few hundred yards of the cliffs, sweeping out here to seaward for a distance of over four miles 1mm the shore. There is, however, one striking break in the uniformity of the floor, where the "Craig Rock" [SC 26505 89273] of the chart rises suddenly, from a platform having a depth of about six fathoms, to within two fathoms of the surface, at the distance of 1½ miles from the coast near Gob y Deigan [SC 28350 87430]. Any evidence which might hereafter be obtainable as to the composition of this rock would be of great interest in view of the problems connected with the age in relations of the Peel Sandstones If the line of fault which brings in these beds is prolonged northward beneath the sea, with the direction it possesses on the foreshore at Wills Strand [SC 26917 86048], its course must lie in close proximity to the Craig.

Coast south of Kirk Michael

The chief features of the cliff-sections between Gob ny Creggan Glassey [SC 29548 88767] and Ballanayre [SC 27615 86778] have already been described (pp. 67–69), but there are a few further details respecting them which deserve

mention. In coming south, the first exposure of solid rock occurs at the foot of Glen Beg, a little ravine cutting back from the cliff across a narrow bench of drift; and it consists of dull black pyritous slate or mudstone, approximating to the Barrule type, containing vermicular markings probably of organic origin, and some curious small oval black phosphatic (?) pebbles or concretions. This material looks promising for graptolites, and though none have yet been found, it might repay further search. Striped slates with occasional grit bands, much contorted, and fractured both horizontally and vertically by planes of movement, and in places reduced to breccia, then occupy the cliff and shore for about a mile, with some alternations of the muddy pyritous slate.

At Glion Thoar [SC 29559 88556], another short gully cut back from the shore, close to the old 'Camp' marked on the one-inch map, a buried vertical wall of slate, about 30 feet high, is revealed, against which the drift is banked so that the solid feature is obliterated at the surface. This appears to represent a portion of a Pre-glacial buried valley, being probably the north wall of an old water-channel which, like the existing stream, has notched the coast-line in descending to the ancient shore at this point. Within the next 600 yards there are several interrupted strips of intrusive igneous material, from 1 to 3 feet wide, among the slates of the cliff and shore, representing small 'greenstone' dykes of the intermediate type (see p. 300), crushed almost out of recognition. A larger mass of similar intrusive rock, much crushed around the edges and broken by faults, forms the little headland on the northern side of Lady Port, and at least six more intrusions of smaller size are passed between this place and Gob y Deigan, 800 yards farther southward.

Gob y Deigan

The promontory of Gob y Deigan [SC 28350 87430], again, is composed of a sheared or faulted mass of somewhat basic igneous rock, and from this point southward, to the incoming of the Peel Sandstones, scarcely any section can be found which does not reveal these intrusive dykes in one form or another. Though these dykes, as already stated (p. 68), have clearly been injected after the brecciation, they have been implicated in the later movements to such an extent that it is rarely possible to trace them for more than a few yards continuously, or to distinguish which of successive parallel strips are separate dykes and which are repetitions by folding. The thinner strips are frequently crushed throughout into a palish chlontic schist in which no trace of igneous structure is preserved, while, when the dyke is thicker, its edges alone are sometimes frayed out, as shown in (Figure 33) on the following page.

The course of the similar dykes in most parts of the Island usually coincides with the strike of the dominant cleavage, *i.e.*, E.N.E. to W.S.W.; but in this district, while a few follow this direction, the majority run at about right angles to it, or N.N.W. to S.S.E. In sections farther south there are indications that the dykes which exhibit the N.N.W. strike may be of somewhat newer date than those striking with the cleavage; but no evidence of this kind seems forthcoming in the above-described examples.

On the shore of the bay south of Gob y Deigan (Lhiannag of the 6-inch map) some crumpled patches of pale green slate are revealed, among darker striped slates of the usual type. Similar small outcrops of pale slate of greenish tint will be subsequently noticed in other parts of the Island. It is possible that these may denote a definite horizon; but no evidence has yet been found to connect these widely separated and impersistent outcrops. They may, indeed, indicate only the final stage in the crushing and disintegration of igneous material; and the appearance of laminar bedding which they present may be merely secondary fluxion-stripe of the character illustrated in (Figure 27), p. 82.

North of Ballanayre Strand, in the grand sections of the crush-conglomerate already described (pp. 08–9), double cleavage-structure is in places admirably displayed, schistose planes dipping N.N.W. at 40° being crossed by a second fissility in the same direction but at a much lower angle, varying from nearly flat to 15°. 'Crushed quartz-veins of about the same age as the dykes, or a little later, are very abundant in these sections.

In the finer-grained bands of the supposed Niarbyl Flags of Ballanayre Strand [SC 27628 86779] (p. 38, and (Figure 13)), there is a rather strongly marked cleavage, dipping N. 10 W. at 20°, and an attempt has been made on a small scale to open a slate quarry in these beds at the northern corner of the bay. The faults which cut the flags in this vicinity seem to be later than all the crushing.

Certain pale dykes, of the intermediate type (p.100), which traverse the unbroken slates as well as the crush-conglomerate, between Ballanayre and Gob y Skeddan [SC 27306 86479], appear to be folded (see (Figure 14), p. 69), besides being frayed out at the margins and dislocated at short intervals. The severity of the later crushing in this locality is probably due to the proximity of the hard mass of diabase seen in the cliff in several places between Gob y Skeddan and Wills Strand [SC 26908 86048], the less resistant strata having been buckled up against it. This mass is itself torn by faults and much altered around the margin, while its interior, which is well displayed for about 100 yards in the headland north of Wills Strand, is uncrusbed and so petrographically distinct from its edges that it has been questioned whether there may not here be a combination of intrusions of different date, though, so far as can beudged from the field evidence, there is a gradual passage from the crushed to the uncrushed rock-types.

A thin strip of somewhat decomposed slate intervenes on the north shore of Wills Strand between the diabase above described and the fault which brings in the Peel Sandstone. Further details of this locality and of the sandstone cliffs to the southward will be found in Chapter 6. (p. 272).

Eastern coast of the northern area

Coast South of Ramsey

On the north-eastern coast, the solid rocks set in suddenly near Ramsey, 200 yards south of the ravine at Ballure, in an interesting section elsewhere described and figured (see p. 346, (Figure 91)). Here, even more strikingly than on the western coast, the outline of the Pre-glacial cliff may still be traced.

For over half a mile the recent rock-shelf extends only 40 or 50 yards outward from the cliff, and the remainder of the broad foreshore is underlain by red boulder-clay, revealed only when the sandy beach is swept aside by the waves. This boulder-clay evidently hides a Pre-glacial tidal platform, of somewhat lower level than that of to-day; it extends at low tide from Ramsey [SC 45333 94377] to Port Lewaigue [SC 46822 92990], and though there interrupted by the steep rocky shore of Tableland Point (Gob ny Rona [SC 47162 93207] of the revised Ordnance Map) is seen again at low tide on the foreshore of Port a Myllin [SC 47452 92743], 600 yards farther east.

Port Lewaigue

[SC 46822 92990]. With the exception of the narrow faulted strip of crush-conglomerate mentioned on a previous page (p. 66), the solid rocks, for the first 600 or 700 yards, consist of ferruginous dark blue or blackish slates of the Barrule type, exhibiting a faint much-disturbed colour-banding where washed smooth by the sea, but with the cleavage–structure dominant on subaerially weathered surfaces. This slate has been quarried on a small scale in the cliff 500 yards west of Port Lewaigue. Thin crushed strips of an intrusive 'greenstone' are visible here and there on the foreshore about 400 yards from the commencement of the rock-sections; and in approaching Port Lewaigue a larger belt of similar but more massive greenstone is encountered, apparently bounded on the north by a strike-fault, and on the south merging, through fissile schist, into pale smooth greenish slate resembling that noticed at Ballanayre (p. 319). Associated with this pale slate are some narrow strips, a foot or less in width, of a pale greenish sheared igneous rock, presenting a somewhat vesicular aspect, from the decomposition of a porphyritic constituent which has been dragged out into lenticles (see p. 319). The same combination of rocks is again seen on the eastern side of Port Lewaigue, where it is twice or thrice repeated by folding or faulting within the space of 150 yards; while at Tableland Point the massive greenstone is repeated, and forms the whole of the low rocky cliff.

The Carrick [SC 46754 93491], an isolated reef 400 yards N.W. of Tableland Point, submerged at high tide, but at low water having an extent of 50 yards by about 35 yards, is composed throughout of a massive tough palish grey rock weathering with a brownish surface, which possesses no distinctive character to denote its origin even when sliced and examined microscopically, but is probably an igneous intrusion decomposed and rendered structureless by shearing.

Port e Myllin or Vuyllin

[SC 47452 92743]. The cliffs on the eastern side of Tableland Point exhibit several fault-like fractures parallel to the cleavage, which seem to be the prolongation of those seen on the shores of Port Lewaigue. The rocks are greatly

shattered, confused, and traversed by quartz-veins in the vicinity of these planes; but strips of the pale slate, and of the associated vesicular-looking dyke, are again recognisable, along with a broader 'greenstone' dyke which appears to have been sharply folded. On entering the little bay of Port e Myllin from the west, we find dark striped slates, beautifully crumpled and on crossed by the dominant shear-cleavage, with small pyritous nodules lying in the shear-planes. These slates are traversed by a dyke of basic rock 3 feet wide, which is scarcely at all sheared, and seems to be of newer date than the majority of the intrusions (see p. 320). Eighty yards farther south, a sharp boundary, probably a fault or thrust-plane, brings in a pale felspathic mass of peculiar character, which may originally have been an elvan, but is now sheared beyond recognition. This extends in the low cliff for 150 yards, into the middle of the bay, and there suddenly terminates.

On the foreshore the felsitic mass is traversed, as shown in the following figure, by narrow later basic intrusions of two different ages, one of which has participated in the shearing and has been reduced to a schist, while the other is an unsheared dyke of the newer greenstone type, like that above described. This exposure will be further discussed in Chapter 8. (p. 319).

On the eastern side of Port e Myllin we reach the edge of a tract occupied by a firmer type of slaty rock, composed of alternating bands of dark blue argillaceous and pale grey somewhat arenaceous material, with thin layers of hard grit at frequent intervals. At first sight these rocks seem to be regularly bedded, with a steady dip of about 45° towards N. 15 W., but on nearer inspection the true structure is found to be a closely packed series of isoclinal folds, partly obscured by fluxion-planes parallel to the limbs, and partly by a later strain-slip cleavage having the same strike as the strata but dipping at a lower angle.

These banded slates are apparently the passage beds between the Barra, Slates mad the Agneash Grits, and they extend, with certain variations to be noted below, from Port e Myllin to Maughold Head [SC 49808 91571], a distance of 1½ miles, being well displayed in the cliffs and also in the craggy ground above, where they have been rather extensively quarried. In the first mile of this tract dykes are exceptionally rare, and those which do occur are small and featureless and do not call for special comment. There is an old lead trial at Gob Ago [SC 47778 92770], the eastern boundary of Port e Myllin, on which large sums of money were expended without result (see p. 640).

In approaching the rock-pinnacle of Stack Mooar [SC 48447 92670], half a mile east of Gob Ago, the slates become more sandy and flaggy, and much interpenetrated by quartz-veins. Just before reaching the Stack, a massive band of grit or quartzite, 6 feet thick, is encountered, and is probably seen again, on the same strike, in a field above the cliff, opposite Ballaterson West [SC 47989 92558], south of the slate quarries; but, as usual with beds of this character, its continuity between these places is doubtful.

Maughold Head

[SC 49822 91579]. The Stack is separated from the cliff by a prolongation of the Maughold hematite lode, which in this locality is a conspicuous mass of vein-stuff. (quartz, disturbed slate, fault-breccia, etc., with cavities containing hematite but not in profitable quantity) in places 40 feet wide, striking nearly N.W., and inclined 75° towards N.E. [SC 49185 91228] As a surface-exhibition of a mineral lode, this section is second only in attractiveness to that at Bradda Head in the south-west of the Island (p. 540).

The breadth and character of this lode might be taken to imply the presence of an important fault; yet it seems to be without effect upon the stratigraphy, except that to the eastward the slates again become, for a space, somewhat less sandy. The vividly striped slates which occupy the cliff 200 to 300 yards farther east have been so welded together by the shearing they have undergone, that they can be raised in large fibrous blocks, with faces determined mainly by the strain-slip cleavages; and in these rocks some quarrying has been done on the foreshore. In this vicinity, the first of a set of microgranitic dykes is seen in the cliff: in aspect, a light-coloured close-textured band, 3 to 5 feet thick, scarcely distinguishable from quartzite, agreeing in strike and dip with the dominant cleavage- and bedding-planes. A second example—or possibly the first repeated, since the cliff is intersected at intervals by fractures which may be overthrusts or strike-faults—is exposed 450 yards farther east; and others, of greater breadth, between 200 and 300 yards to the southward of Cor Stack. The most typical dyke of the group, however, is an example 12 feet in thickness, revealed in

Gob ny Skey 800 yards south of Cor Stack [SC 49527 92079] and close to the extremity of Maughold Head. The general petrographical description of these dykes will be found on p. 314; they are characterised by the presence of small porphyritic grains of bluish quartz in a ground-mass of minute microgranite; and from their connection with others farther south we know them to be offshoots from the Dhoon Granite.

Cor Stack [SC 49527 92079] is another rock-pinnacle resulting from the scour of the sea upon the crushed rock in line of fracture which in this case strikes N. 10 W. These outstanding rock-masses are common on every part of the eastern coast, sometimes still united to the cliff by a tunnelled neck, and sometimes completely separated from it. In many instances their development appears to date back to the period of the Raised Beach. On the western coast they are less numerous.

Between Maughold Head [SC 49822 91596] and Clay Head [SC 44202 80553], joints and fractures wide enough to contain vein-stuff and fault-breccia are frequently stained deeply by hematite, the discoloration sometimes extending irregularly a little way into the adjacent slates, and in several places trial adits have been driven along them in search of this iron ore, sometimes with some measure of success (pp. 540–1). This peculiarity appears to be confined to the northeastern portion of the Island. It has, with reason, been suggested,<ref>See chapter on Geology in Jenkinson's Practical Guide to the Isle of Man, Lond., 1874.</ref> from the conditions of occurrence of hematite among the Skiddaw Slates of the Lake District, that New Red rocks have once overlapped upon the Manx Slates in this area; and the subsequent discovery of Triassic and Permian strata beneath the northern plain of the Island has lent strength to the supposition (see Chapter 7).

The thin grit-bands, which reappear in greater number among the strongly striped slates between Cor Stack and >Gob ny Skey, <ref>It may here be noted that the shore may be reached by a rather difficult path near Stack Mooar, giving access, at low water, to the rugged coast for some distance eastward and westward; but between Cor Stack and Maughold Head the cliffs are practically inaccessible exct pt by boat in favourable weather.</ref> are extraordinarily crumpled upon themselves, the tremendous inpacking and foreshortening which the rocks have undergone being thereby beautifully demonstrated. Under such conditions, the estimate which has been made of their original thickness by calculation from the dip and breadth of outcrop is, of course, without value.</ref>

In Traie Curn [SC 49785 91565], the little beach between Gob ny Skey and Gob ny Strona the most easterly point of the headland, the crumpling of the rocks in limited patches into true brecciation, though not quite of the "crush conglomerate" type. The structure is no doubt due to the proximity of the Agneash Grits, which occupy the upper portion of the high cliff on the southern side of the recess, while the lower part is composed of grey striped flags with thin layers of grit or quartzite. Even although thus exposed in a great cliff-section, the complicated folding renders the exact character of this junction doubtful, but we may suspect that a block of the plicated grit has been broken from the main mass and overthrust upon the flags.

A vein of fault-breccia, stained with hematite, strikes into the cliff S. by W. across Traie Curn, but has not been identified on the opposite side of the headland. In Traie ny Foillan [SC 49780 91292], on the southern aide of Gob ny Strona, indications of copper were found in a small fracture partly filled with dolomite like many of the crevices in this neighbourhood, and a level has been driven along it north-westward into the cliff (see p. 548).

A few small crushed strips of the 'older 'greenstone' type of dyke occur in the sections between Traie Curn and Traie ny Foillan, which may possibly be repeated exposures of the same intrusion.

At Dhyrnane [SC 49379 90981], of the six-inch Ordnance map,<ref>According to information gathered from the miners, this name is affixed to the wrong inlet on the six-inch map: Dyrnane, as known to the miners, is 200 yards farther south, where the' Dyrnane level" enters the cliff.</ref> a small inlet 500 yards west of Gob ny Strona, we encounter the most northerly example of an olivine-dolerite intrusion on the coast. This type, constituting the newest dyke-rocks of the Island, is supposed to be of Tertiary age (see p. 327). The dyke is in places three feet wide, but shows a tendency, frequent in these dykes, to split into branches. Though a comparatively fresh and sound rock on the beach, it appears to have been decomposed in the cliff to a brown earth, which has been mined, along with the adjacent stained and rotten slate, as

umber by means of a level (see p. 556).

Wherever seen, with the rarest exceptions, these olivine-dolerite dykes strike from points between south and east to points between north and west, their average direction being north-westerly (see List, p. 329). Hence their course cuts that of the Pre-Carboniferous greenstones almost at right angles; and cases of the intersection of the older by the newer dykes are not unusual. An example of this relationship is afforded in the low cliff bordering Dhyrnane on the west, where the dolerite cuts a dyke, three feet in width, of the older type. One hundred yards farther south another olivine-dolerite intrusion, similar to the last, is exposed on the foreshore. Between this place and Port Mooar [SC 48813 90838] the rocks (Lonan Flags) assume the flaggy character which prevails thenceforward along the whole of the eastern coast of the Island. They consist of thinly laminated grey and blue slate and fine arenaceous mudatone in places containing nodules, with occasional thicker bands of more sandy character.

The cliff-sections in this neighbourhood touch the belt of alteration described in the last chapter, and we consequently find that thin slaty layers between harder bands are frequently speckled with minute secondary minerals, apparently the result of dynamo-metamorphism (see p. 109). In this vicinity, also, we cross the structural anticline, and the hitherto dominant north-north-westerly dip' of the combined bedding and cleavage give place, after some vacillation, to the south-south-easterly dips of the opposite side of the axis. In the transitional belt the dominant cleavages, though very irregular and complicated by faint cross-fissility, are frequently flat or nearly so; and the bedding planes also often assume a comparatively low dip, though, as described and figured in the previous chapter (p. 32, (Figure 2)), this appears, in some places, to be due to the presence of recumbent folds.

The foreshore between Dhyrnane and Port Mooar is cut by several approximately parallel north-west or north-north-west fractures, filled with breccia and vein-stuff, including calcite, dolomite, chalybite, hematite, quartz, etc. The largest of these constitutes the Dyrnane Lode, which has been extensively worked for hematite by a level from the shore and a shaft in the field above (see p. 540). Copper-staining was noticed along two of the smaller crevices.

Some of these fractures certainly denote faulting, as they displace a set of the older greenstone dykes, five or more in number, which traverse the broad foreshore to the eastward of Port Mooar in a direction nearly at right angles to the fractures. The interruption to the westerly inland course of the grits of Maughold Head, already commented on, may be caused by the cumulative effect of these faults, or by a master-fault concealed in Port Mooar, of which these may be the concomitants. However, no marked stratigraphical effect has been detected in the coast sections, where there is no greater change in the character of the rocks than might well be attributed to folding.

Port Mooar

[SC 48813 90838]. In entering Port Mooar from the east, we find a broad rocky foreshore of thickish grey flags with blue slaty partings (Lonan Flags), thrown into a succession of low folds, with gentle dips and boat-shaped crests, and this arrangement is continued on the opposite side of the bay. The intervening space, though dry at low water, is much obscured by boulder clay and sea weed, but enough can be seen to show that it is occupied by folded flags, probably broken by fractures similar to those already described, and traversed at about half-tide level by a small greenstone dyke rendered schistose by pressure.

In the interior of the bay a narrow lining of Raised Beach is preserved, which tapers out southwards, and a little beyond its termination the fore shore reveals an olivine-dolerite dyke, nine feet in width, which accom panies a fissure filled with brecciated rock stained with hematite. No further example of this type of intrusion is known until we reach Laxey Bay, over six miles to the southward.

The thick hard flags constituting this part of the coast are also tra versed, on the upper part of the shore, 200 yards south of the olivine dolerite, by 's. dyke of rather handsome porphyritic elven of the Dhoon type, 8 to 12 feet wide, which appears to be pinched out before reaching low water.

Farther southward the folds into which the flags are thrown become more acute, especially in the more thinly bedded rocks, until the planes of stratification stand nearly vertical; and from this we pass to sections in which the limbs of the folds gradually assume the isoclinal tendency towards S.S.E. which characterise the rocks of the eastern flank of the

Island.

Gob ny Garvain

[SC 48883 89840]. On the northern approach to Gob ny Garvain, a group of seven or more small sheared dykes (or perhaps a less number folded) of the older greenstone type, striking nearly east and west, is visible in the cliff. The head land itself is traversed by an intrusion of porphyritic microgranite, 8 feet thick, resembling the previously described example. In this locality some of the thinner flags are thickly marked with the 'Palaeochorda' worm-castings Two hundred yards south of Gob ny Garvain, three or more small dykes of greenstone which are exposed on the crest of a broad anticlinal fold of the flags, instead of having the usual E.N.E. course, strike approximately north westward. Similar instances of divergence of these intrusions from their usual direction while crossing the crests of folds have been observed in other parts of the Island. The dykes of this type rarely exceed 3 feet in thickness, but 550 yards south of Gob ny Garvain there occurs an example having the unusual breadth of 25 feet; it has somewhat baked and altered the flags immediately contiguous to it. In the gully adjacent to this dyke, at the spot marked "Iron Mine" on the 6-inch map (Sheet 8), a short level has been driven along one of the iron-stained fractures which occur at intervals all along this coast and strike usually to some point between N. and N.W. There is a local reversal of the general dip in this vicinity, the folded slaty flags tending on the whole towards north-west but soon returning to the opposite quarter.

Traie ny Uainaigue

[SC 48150 89123]. Two hundred yards farther south, where the coast shoulders round westward towards Traie ny Uainaigue, a bold dyke of somewhat sheared micro-granite of the Dhoon type, 24 feet in thickness, forms the face of the cliff, hading seaward with the dip of the country rock. Though dislocated in three or more places by faults, this elvan can be traced for 400 yards, to Traie ny Uainaigue, where in a most interesting section see (Figure 35) a greenstone intrusion is intersected by a quartz-porphyry apparently associated with the elvan which then strikes inland.

Between Traie ny Uainaigue and Traie ny Hallsall [SC 47652 88604] <ref>Halsall of 6-inch map; Hallsall of 1-inch. I could not find that the name was now in use.</ref> the constituent strata are chiefly thickish grey flags, occasionally gritty, containing scattered calcareous and siliceous nodules sometimes with cone-in-cone structure in the outer layer. Among the hard flags there occurs a narrow strip of soft striped blue and grey pencil-slate, bounded by thrusts or faults, which perhaps represents the remnant of a broken infold. In the ground to the southward of this strip the prevalent dips both of bedding and shear-cleavage swing round from S.E. to nearly due eastward.

At the northern corner of Traie ny Hallsall we again find a micro-granite dyke 15 to 20 feet thick, on the shore and in the cliff. This appears to strike inland like the last, but is interfered with westward by one of the north and south fracture-lines. Three-quarters of a mile farther southward, at the extremity of Gob ny Cally [SC 47269 87483], a similar dyke once more emerges at low water mark and strikes westward along the shore. With regard to these exposures, the presumption is strong that what seem to be several separate dykes are in reality the reappearances of one, or at the most of two, dykes (see pp. 129–30) brought about by some method of folding or faulting. It is difficult otherwise to explain the absence of these dykes on their line of strike in the interior, especially in the Cornah valley which should intercept the whole of the series traversing the shores between Maughold Head and Traie ny Hallsall, yet where, in spite of the many excellent rock exposures, not one of them is seen.

In the face of the cliff at Traie ay Hallsall the micro-granite is so greatly decomposed, probably from the proximity of the fault, that it can be dug with the spade.

Two hundred yards southward from this recess a dyke of greenstone, of noteworthy thickness and character, rises into the cliff. Its aspect suggests a double intrusion at different dates along the same fissure, one portion being much more sheared than the other, with a well marked parting between them, its total thickness being 12 or 15 feet. This peculiarity may, however, denote that the dyke has been locally duplicated by overthrusting, or that it has originally consisted of two parallel branches, one of which has been more severely crushed than the other. In close proximity to this dyke, a level known as the Ballaskeg Mine has been driven into the cliff along an east and west lode which contained a little copper pyrites (see p. 542). One hundred yards farther south, another greenstone dyke, 10 feet in width, is seen at the base of

the cliff; and some smaller strips, striking nearly north and south, occur between this place and Port Cornah.

Port Cornah

[SC 47318 87798]. On the southern side of Traie ny Hallsall the crumpled grey flags dip south ward at angles between 10° and 20°; but in Gob ny Ow [SC 47527 87906], the north shoulder of Port Cornah, the structure becomes very complicated, the limbs of thefolds plunging steeply eastward at about 70°, with a severe strain-slip cleavage in nearly the same direction but at a much lower angle, viz., about 20°, traversing and partly brecciating them. In the weathered crags above the cliff these intersecting planes give the rock a singular corded aspect. The nodules which occur in the hard flags at this point have had many new minerals developed in them, and the question arises whether their metamorphism is due to the proximity of the Dhoon Granite, or to the severe dynamic action, or to a combination of both causes (see p. 96.).

Were it not that still closer to the granite, on the westward side of Port Cornah, the flags resume their prevalent south-easterly dip, we might have supposed the disturbance above described to have been in some way caused by the influence of that intrusion. But although earth movement has undoubtedly taken place later than the intrusion, it is evident, from all the exposures near the contact, that the flags were already packed into folds before the igneous mass burst up among them. In the little recess 200 yards S.W. of Port Cornah a north and south fracture filled with quartziferous lode-stuff crosses the beach, and has been tested in the cliff for copper by a shaft and levels (see p. 543).

A very tough dyke of dioritic 'greenstone', 12 feet wide, probably altered somewhat by the granite, of a character likely to be well-adapted for road metal, is seen on the low rocky foreshore on the western side of Port Cornah and similar though thinner intrusions may be traced at intervals along the base of the dangerous cliffs westward of Gob ny Cally, until we reach the bold pale crag, 700 yards south of the Cornah beach, in which, for the last time on this coast, the micro-granite dykes emerge from the sea and pass up into the cliff. The section at this place is particularly interesting, mamma as the micro granites, two in number, each from 10 to 18 feet in width except where pinched, are seen to intersect and alter the greenstones in such a manner as to suggest that shear-structure had been imparted to the greenstones prior to their contact-alteration by the acid dykes, though the latter have, in turn, themselves been rendered schistose at the margin by post-consolidation movement (see p. 309, and (Figure 36)).

Unfortunately the spot is difficult of access, as it cannot be approached from the shore, and to reach it one must descend the steep dip-slope 600 to 700 feet high, by which Barony Hill plunges to sea-level. Up this slope the two dykes may be traced, by occasional outcrops, to the brow of the hill, where they are well exposed in some small openings made in the attempt to quarry them, and thence their course crosses the little moorland to the margin of the Dhoon Granite [SC 45686 86956] only 200 or 300 yards distant.

It is noteworthy that in spite of the altitude and extent of the granitic outcrop on the hill so near the cliffs; the granite is not exposed in the coast-section, the two elvans alone being visible there, although the flags in the sections adjacent to it are somewhat baked and altered.

To the southward of the elvans we may observe three further examples of the altered greenstone dykes in the cliff before reaching Dhoon Bay [SC 46167 86432], the largest, 9 feet wide, being 400 yards distant from the more southerly elvan. Strips of similar basic dykes have been traced here and there along the brow of the hill above. Some prominent lenticles of vein-quartz are also conspicuous in the coast-section.

Dhoon Bay

[SC 46167 86432]. In approaching Dhoon Bay, the thick gritty flags which have prevailed for some distance give place to thin-bedded grey slaty flags. These descend from the hill to the shore in long smooth dip-slopes, with structures suggesting stretching and shearing but rarely crumpling. The little bay owes its origin to parallel lines of fracture running W. 10–20 N., which may indicate considerable faulting. The rocks are softened and stained red and yellow along definite zones in the vicinity of these dislocations, cud the same features recur in several places between this recess and Bulgham Bay. The mining trials of the locality are described on p. 525.

Bulgham Bay

[SC 45792 85758]. The headland to the southward of Dhoon Bay contains several dykes of the 'greenstone' type, which are also numerous Bulgham Bay and in the headland to the southward, over thirty, ranging in width from 1 to 12 feet, having been counted in three-quarters of a mile of this coast. There is here some proof that these are mostly separate intrusions and not repetitions, inasmuch as in one or two instances they possess individual characters which could be recognised if the dyke reappeared; thus, an example 8 feet wide, 350 yards south of Dhoon Bay (due east of Dreem-e-jeeskaig [SC 45553 86140] of the 6-inch map), is characterised by the occurrence of small augite crystals in clusters. The outcrops of several of these dykes are prolonged among the high crags which surround Bulgham Bay [SC 45682 85604] in a curious cirgue-like form, some distance back from the true cliff. Near the summit of these crags, at an altitude of 600 feet, there is a cutting for the high road, wherein some of the dykes are again visible and the broadest has been guarried for road metal. At the extremity of the headland bounding Bulgham Bay on the south, there occurs a greatly sheared pale intrusion, 5 feet thick, which is of felsitic aspect but seems guite different from the Dhoon granite elvans. Among the numerous greenstone intrusions 200 or 300 yards farther south are two or three which are broader and fresher-looking than usual; and these, instead of the ordinary schistose aspect, weather with a massive, rough, vesicular surface from the decay of the porphyritic constituents. This part of the coast furnishes a good example of the tendency of the intrusions to cluster together, leaving intervals in which they are comparatively rare. As a rule they are more abundant among the thin slaty rocks than among the more massive flags and grits, suggesting that they have risen up along the planes of least resistance and have found the latter rocks more difficult to penetrate. Thus, around Bulgham Bay, where the dykes are so numerous, the predominant rocks are of striped flaggy slate much shattered by faults and crush-planes, and in places partly brecciated, and more akin to the rocks of the 'unseparated' tracts than to the typical Lonan Flags, while both to the northward and southward there are areas of thick-bedded greenish grey sandy flags in which the dykes are comparatively rare.

A small abandoned quarry ?[SC 46012 86241], marking an attempt to find roofing-slate, occurs on the slopes north of Bulgham Bay. The rock in places looks promising, for fossils, but my search discovered only obscure "worm-markings".

The description of the coast farther southward is resumed on p. 151.

Interior of the Northern Division

Slieau Curn

[SC 34196 90692].Starting at the north-western corner of the massif (<u>(Sheet 4)</u> of 6-inch map), we find the solid rocks emerge from the drift-plain ¼ mile S. W. of the village of Ballaugh, whence, rising steadily, they form the long narrow ridge of Slieau Curn (1,148 feet) between Glen Dhoo and the sea. The predominant rock of this ridge is a greenish-grey striped rather flaggy slate with occasional grit-bands, but on the lower western margin of the hill there is a fairly well-defined belt of flaggy grit, as previously described (see p. 48).

The 'unseparated' rocks of this part of the Island exhibit a strongly-marked tendency to splinter in two directions more or less at right angles to each other, apparently as the result of strain-slip cleavage crossing the bedding or an earlier cleavage. This structure gives rise to a short faggoty fracture of the rock and renders it almost useless as a building stone. It is perhaps best developed in the southward prolongation of the ridge, around Slieau Dhoo (in (Sheet 7) of 6-inch map), where the walls bounding the moorland, built of material from shallow excavations in the immediate vicinity, are often composed of short billets of stone piled up lengthwise. 1 he dominant dip of the fissility, which sometimes agrees with and sometimes crosses the original bedding, is generally towards north-west, but there is a local reversal to the opposite quarter on the summit of Slieau Curn, apparently due to the influence of a gritty belt.

This ridge is peculiarly free from drift and the solid rocks are notched in places by dry stream-cut gullies, in positions where it is impassible that any water could flow under present conditions. These phenomena are discussed and illustrated in Chapter 9. (p. 363, (Figure 101))

Glen Dhoo

Glen Dhoo [SC 35049 91283], the short straight valley deeply trenching the hill-chain due south of Ballaugh, is more interesting to the physiographer and glacialist than to the student of the solid geology, as its bottom is chiefly filled with gravel and rubbly drift. There are however some rock-exposures deserving mention in the craggy slopes around its coombe-like head (in (Sheet 7)), where the manner in which highly contorted greenish-grey gritty flags are cut and sheared by fluxion structures and strain-slip throws considerable light on the production of the matrix of the crush-conglomerate farther east, as shown in (Figure 37). These rocks much resemble the more gritty portion of the Lonan Flags. (See also p. 48.)

There are good rock exposures towards the head of the picturesque Glen Shoggle [SC 35705 91726] (which branches away eastward from Glen Dhoo at Ravensdale House), chiefly in pale bluish-grey striped slate of the 'unseparated' type At the head of the middle fork of this glen the drifts are banked against a buried cliff of slate. In the northern fork there is an old trial adit on a north and south fracture.

Gob y Volley

[SC 37075 93914]. On the high moorland ridge between Glen Dhoo and Sulby Glen the rock, though everywhere near the surface, is usually covered with rubble, and the exposures are few and unimportant until we reach the bold northern slope descending to the drift plain. In the lower part of this slope about one mile eastward of Ballaugh, there are several quarries in compact striped blue slate approximating to the Barrule type, one of which seems to have been a trial for roofing slate. The later cleavage is nearly vertical, but apparently before this structure was developed the rock was welded by an earlier fluxion-movement parallel to the broadly-folded bedding planes. From the combined effect of the two structures, the slate has a fibrous texture, especially in the trough of the folds, and lifts in long firm beam-like blocks; and on this account the more northerly quarry was at one time much resorted to for lintels, gate-posts, etc. A single slab of slate, 24 feet long by 3 feet wide, which bridges the stream at Ballacrosha near Ballaugh, has probably been obtained from this quarry. At Spanish Head [SC 18195 65825] in the south of the Island the slate possesses the same peculiarity in a still higher degree (see p. 174). These rocks if prolonged on the line of strike should continue into the cape-like termination of the ridge at Gob y Volley, overlooking the mouth of Sulby Glen, but the predominant strata at this point are of a more sandy and flaggy type with gritty intercalations, the folding of which is well shown in a roadside quarry and in the crags rising above it. Traces of small greenstone intrusions were noticed in three places near the eastern crest of the ridge.

In the vicinity of the gritty beds in this neighbourhood there is a tendency of the dominant bedding-planes to swing over locally to the southeastward, although the prevalent dip is to the opposite direction. The grits have been found to possess a similar influence on adjacent slaty rocks in many other parts of the Inland where the dips are high. The local reversal in such cases probably betokens that the rocks immediately under the shelter of the grit-masses yielded less readily than elsewhere to the compressive force which established the isoclinal arrangement of the folded strata.

Sulby Glen

[SC 38084 93495]. On entering Sulby Glen we find for the first two miles scarcely any rock-exposures in the river itself, but fine sections in the high craggy walls of the valley on either side. In these the zone of crush-conglomerate is magnificently exposed, flanked on the west by highly contorted grits and on the east chiefly by Barrule Slates. To the account already given of these sections (pp. 60–5), it will now only be needful to add a few points of detail not previously described.

The greenstone dyke which cuts the crush-conglomerate in the section near the Cluggid [SC 38562 92395], shown in (Figure 7) (p. 61), probably crosses to the western side of the valley a little farther south, as an intrusive dyke of similar character is visible among the breccias three-quarters of a mile higher up the valley, 200 yards northward of the cascade descending from Killabraggah [SC 37694 91056], where it has been quarried for road-metal. Another exposure of intrusive greenstone occurs 1½ miles south of Killabraggah, in the crush- conglomerate at the craggy shoulder above the junction of the streams north-east of Druidale farmstead [SC 36787 88771]. These outcrops are the more likely to represent one and the same intrusion since dykes are comparatively rare in Sulby Glen and in the country to the westward, though to the eastward there is a belt in which they are very common.

The unnamed eastern tributary of the Sulby which drains the depression between Slieau Monagh and Snaefell, flowing past Block Eary [SC 39609 89793], traverses the last-mentioned belt of intrusions, its bed containing small exposures of some interesting varieties of igneous material. Within 30 yards of its junction with the Sulby [SC 38108 90250], and again in the bed of that river above the junction, we encounter a hard close-grained band six feet wide, which is probably a sheared dyke. In the same neighbourhood, on the northern side of the ravine, are some extensive old slate-trials exhibiting excellent sections of the Barrule Slates (see p. 561).

Between the two larger of these quarries, the Block Eary stream crosses a narrow strip of crush-conglomerate, apparently at the margin of the Barrule Slates; and above this, it flows mainly over firm striped flaggy slate with sandy intercalations until near its source on the northern shoulder of Snaefell, where it trenches for a short distance upon the principal zone of the Barrule Slates.

Nine hundred yards above its junction with the Sulby, or 100 yards above the Waterfall marked on the six-inch map, we find the stream-bed occupied by a belt of pale splintery rock, which is probably a felsitic dyke but is so greatly crushed and decomposed that its igneous structure is no longer apparent even to microscopic examination (see p. 323). Between 400 and 750 yards farther east four or more basic dykes cross the stream, the second of which, 200 yards due west of Block Eary farmstead [SC 39609 89793], is the beautiful example of 'actinolite trap' described petrographically in Chapter 8. p. 309, while two others seem to be of the later less altered diabase type.

Traces of these intrusive greenstones are also visible at several points in the bed of the little feeder descending the hill-side west of Block Eary. Two old trial-adits penetrate north-west and south-east into the hill from the valley near this place, on a fracture which is supposed to be the prolongation of the Snaefell Lode (p. 527). Higher up the stream, two minor examples of sheared and altered greenstones are encountered; and then, 500 yards E.S.E. from Block Eary, we reach a more important dyke, with an outcrop many yards in width, of pale crushed microgranite, probably one of the elvans from the Foxdale Granite like the great dyke at Crosby. The south-easterly border of this dyke has somewhat the aspect of a line of a fault or overthrust, but this may be due simply to the crushing of the slates against this massive bed. Immediately above it, the character of the country rock changes, as previously mentioned, from thin flags with grit bands, to dark blue lustrous Barrule Slate, somewhat altered, and inter-penetrated by many quartz-veins.

In the three short tributaries of the Sulby to the southward of and parallel to the Block Eary stream [SC 38256 90040], [SC 38059 89664], [SC 37823 89539] between Ballaskella and Tholt-e-Will, the exposures, so far eastward as they extend, resemble those just described, excepting that in the first two the belt of crush-conglomerate close to their junction with the Sulby is broader, probably because of the higher altitude at which they flow. The last of the three, at Tholt-e-Will just above its junction with the Sulby, has cut a pleasant little gulch into the Burnie Slate, into which it descends by cascades, probably along faults or thrust-planes. In the higher part of its course numerous greenstone dykes are visible.

The upper reaches of the Sulby basin will be subsequently described (see p. 139).

Slieau Monagh or Meanagh

Turning now to the high ground to the eastward, sparingly covered with drift, between Sulby Glen and Glen Auldyn, we find among the scattered rock-exposures some sections in the crush-conglomerate which have already been described (see pp. 65–66). Near the summit of Slieau Monagh (Meanagh) [SC 39636 90967], a large quartz-vein which crops out in Creg Bedn [SC 39466 91335] at an elevation of about 1,200 feet, has been glaciated in such a manner as to afford proof that an ice-sheet has moved in a S.S.E. direction over the plateau (see p. 363). Near the head of the stream on the eastern side of Slieau Monagh [SC 40459 90874], a thin band of graphitic schist with beautifully polished planes of shearing, occurring among pyritous dark blue slate, was revealed by the workmen in quarrying stone from the bank for the erection of a fence. Traces of the same mineral have been found near Beary Pairk, six miles farther south (see p. 550). The above-mentioned stream is diverted sharply eastward at Ballaneary [SC 39867 92116] to flow through The Cluggid [SC 38562 92395] (p. 60) to the Sulby but it probably once continued in its initial N.N.W. direction, and down one of the valleys which unite with Narradale at Cronk Sumark [SC 39537 93964]. It has been intercepted and diverted by the eastward cutting back of the ravine above the Cluggid [SC 38562 92395]. Other high-level feeders of the Sulby afford proof of similar physiographical changes, due to the deep trenching of the lower part of the main glen during the period of

elevation (see pp. e-7), which stimulated the activity of all the short transverse streams falling directly into the trough, and led to their rapid backward transgression. The chief branches of the Sulby seem all to have occupied their present relative positions in Pre-glacial times, but it is not uncommon to find that in re-excavating channels blocked with drift, the streams have here and there missed the old galleys for a short space, and have cut straight-sided notches in the solid rock adjacent to them, sometimes afterwards abandoning these for the more easily excavated old hollows, and thereby leaving dry notches high above the present stream (see p. 449;. A good example of this occurs on the Sulby, opposite to Druidale [SC 36984 88497].

The lower part of Narradale affords a further illustration of Post-glacial change, 400 yards east of Cronk Sumark [SC 39516 93966], where the stream from a comparatively open valley with high banks of drift into a little gully in slate at right angles to its former course. The bottom of this silly shows the outcrop of a small dyke of the later olivine-dolerite type, which is probably connected with that already mentioned (p. 59) at Kerroo Mooar [SC 39891 94152], 700 yards to the north-eastward, and is similarly intrusive through crush-conglomerate. This is the most westerly point to which these supposed Tertiary intrusions have been traced in the district to the northward of the central valley. The present example is probably a member of the group seen on the eastern coast near Port Mooar (p. 127).

Kerroo Mooar

At Kerroo Mooar a rather extensive but unsuccessful mining trial has been made in search of lead, on a north and south lode which was found to intercept one of the olivine-dolerite dykes (see p. 546) [SC 40199 94356], [SC 40199 94234]. Numerous other instances have been noticed in the Island in which these dykes are associated with veins containing small quantities of the metalliferous ores; and the possibility of some connection between them deserves and will receive further consideration (see p. 488). The interesting boss of older greenstone of dioritic type adjacent to the old mine is described on a later page (p. 305).

Continuing along the steep northern edge of the massif (entering (Sheet 5) of the six-inch map), we find, at Laurel Mount [SC 41088 94273] half a mile east of Kerroo Mooar, a deep narrow quarry opened into the hillside for road metal. This appears to be the quarry mentioned by Harkness and Nicholson,<ref>Quart. Journ. Geol. Soc., vol. xxii., p. 489.</ref> who describe it as follows: "The bulk of the rock here is grey hard quartz-rock, with occasional rounded pebbles of quartz embedded therein. The quartz rock here has a great affinity to the grey rocks of Cornah, which have no distinct stratification. Here, however, black shales occur in the quartz rock, which dip at a high angle to the north-west". The implication in this description that the "quartz-rock" is of sedimentary origin seems, however, to be erroneous; for although so greatly decomposed and crushed that even the microscope fails to throw much light upon its original condition (see p. 306), it bears a general resemblance to rocks in other exposures which are known to be highly-sheared intrusions; and it may, with some confidence, be regarded as a dyke which, like the rock forming The Carrick in Ramsey Bay [SC 46754 93491] (p. 123), has lost its igneous structure. Its extensive development in the face of the quarry appears to be due not so much to its breadth as to its repetition, either by folding or overthrusting. This out crop may serve as a good example of the problematical kind of rock constantly recurring among the slaty rocks in the Island, which one notes down in mapping as "hard band (dyke ?)", and finds it difficult ever to get further with the description.

At the mouth of Glentramman [SC 41618 93934], 600 yards farther east, are two old quarries, probably slate-trials, in striped blue and grey slate with a faggoty structure like that of Sliean Curn. This material seems to lie at the margin of the zone of crush-conglomerate, without definite evidence for the order of their superposition. Indications of north and south faulting are visible in the bed of the Glen, but the depth and narrowness of the gully have prevented the thorough investigation of the sections.

Glen Auldyn

If we cross the ridge from the head of Glentramman to the feeder draining into Glen Auldyn from Parkneakin, we find small outcrops of a palish sheared igneous rock, probably of the 'intermediate' type (p. 300), in the stream-bed 500 yards east of the Parkneakin ruined farmstead [SC 41820 92820], and again in several places lower down, near an old mining trial [SC 42227 92919], among crush-conglomerate, and also on the adjacent plateau, 250 yards N.N.W. of Skyhill farm. Farther south, on the steep slopes descending into Glen Auldyn, small exposures of dykes of other types occur, including

mica-trap in the zigzag road 900 yards S. of Skyhill, and diorite in a small old quarry by the roadside in the bottom of the Auldyn valley, 100 yards S. of the sharp easterly bend in the river. Higher up the Glen, two dykes are visible in the bed of a little feeder joining the eastern side of the river just below the most southerly slate trials; the lower, probably a mica-trap, not more than 3 feet wide; and the upper, close to the moorland fence, a sheared palish rock, 10 to 15 feet broad, of the doubtful 'intermediate' group. It is impossible to show these scattered strips of dykes on the one-inch map, and wearisome to describe them. The exposures are usually so limited, and the characters of the rock so obscure, that even where the igneous origin is determinable at all, it is made apparent only by close investigation.

The slate-trial just mentioned is one of an extensive series in the Glen, on which much money must have been spent. The rock in this vicinity is strongly striped blue slate with occasional grit bands, dipping N.N.W. at high angles, and cleaved in the same direction at lower but variable angles. Towards the head of the Glen, a much folded belt of thick-bedded quartz-veined grits is seen among these rocks for a short space. The thin slaty partings of these grits are speckled with small alteration-crystals (see p. 109).

Lower down the Auldyn valley the gritty characters disappear and the prevalent rock is dark blue ferruginous slate, with the homogeneous aspect characteristic of the Barrule Slate, which is continued northward until the crush-conglomerate sets in under Sky Hill.

The little streams, unnamed on the map, which drain the north slope of North Barrule and unite to discharge into Glen Auldyn at Balleigheragh [SC 43679 92867], flow chiefly over firm strongly striped slate with grit bands, of the 'unseparated' type, resembling that of Maughold Head, in which autoclastic structure is visible in places. The westerly fork, known locally as Glen Crinn [SC 43426 91989], reveals several 'greenstone' dykes in the stream-bed, especially in its upper reaches, where one or two of the intrusions are of rather unusual character and seem to be more nearly allied to the acid than to the basic group. In Braid Foss [SC 44063 92379], the easterly branch, there is much obscure faulting and crushing, especially in the vicinity of an old lead mine (see p. 545). The upper part of the main arm of this stream follows the north-west course of a branching olivine-dolerite dyke, 8 feet wide in places, which is well exposed in the walls and bed of the little cation for about 200 yards, and then strikes across into the parallel gully 100 yards farther west, where it is seen in the mining excavation. It can also be traced in the opposite direction up to the slope below the mountain-road.

On the eastern side of Glen Auldyn, banded slates like those of Maughold Head prevail in the steep slope south of Crossags Farm [SC 44105 93718], giving place to a wedge of thickish grits opposite Claghbane [SC 44554 93672]; east of which, as already described, crush-conglomerate is the chief component of the sections.

Ballure Glen

In the upper part of Ballure Glen [SC 45506 92615], above the Ramsey Waterworks Reservoir, several 'greenstone' dykes may, with difficulty, be detected; while on the steep hillside nearly due east of the Reservoir and on the opposite side of the Glen, a small quarry has been opened in a boss of rather fresh-looking diorite, and the same rock is visible in the adjacent mountain road. There seems to be considerable difference of petrological character between this rock and that on the shore at Port Lewaigue, already described (p. 123); otherwise the field evidence suggests that they may be parts of the same intrusion. West of Ballure Glen, and adjacent to the little gully running parallel to the new mountain-road at Park Mooar, a broadish band of pale felspathic material, probably the prolongation of the Port e Myllin mass (p. 124), is seen at intervals for 600 or 700 yards, striking E.N.E.; and a detached strip of like character is poorly exposed, 250 yards farther south, in the cross-road to Dreem-e-Lhergy [SC 45688 91953] (between a and n of Roan on (Sheet 5) of the six-inch map). In the field on the western side of the road at Roan an upfold of coarsish grit, 4 feet thick, crops out for a short distance and is well shown in a small guarry. Immediately to the southward lies the great belt of Barrule Slate, the edge of which has been quarried in a slate-trial near Dreem-e-Lhergy and again half a mile farther to the north-east, on the slope facing the sea at West Folieu. In another guarry at the latter place, 150 yards S.E. of the slate guarry, we find a highly sheared basic dyke, accompanied by pale bluish and greenish lustrous sericitic schist; these appear to be the inland continuation of the rocks seen on the shore at Port Lewaigue [SC 46665 93063], 500 yards distant (see ante, p.123). The adjacent rounded hill-top of Slieau Lewaigue [SC 46098 92370] exposes a fine example of crushing and shearing in hard grey gritty flags with thin slaty partings, the teazing out and intermixture of the bands where they lie athwart the direction of movement being very remarkable. A 'doubtful' dyke occurs in the same exposure.

We return now to the north-western flank of the Island to take up the investigation of a strip of country to the southward of that examined above, comprising those portions of the six-inch sheets 6, 7 and 8 not already described, commencing with the inland tract between Kirk Michael and the northern edge of the Peel Sandstone.

Interior south of Kirk Michael

[SC 31623 90674]. The belt of cleaved flags and grits running S.S.W. from Kirk Michael is exposed in a small quarry where the high-road crosses Glen Mooar, as well as in the adjacent railway-cutting; and in low crags higher up the slope around the farmsteads of Ballacarnane Mooar [SC 30247 88755] and Beg [SC 30185 88480], and Skerestel Mooar [SC 29566 87885]; and again in a roadside quarry at Glion Cam [SC 29091 87637];and in many smaller outcrops. Worm-markings can usually be detected m these flags, which afford also some interesting structures from the intersection of the bedding and cleavages. Disturbances of the strike of both bedding and cleavage, by which both dips are brought round to north-eastward, occur in many places along the eastern edge of the belt.

Behind the farm-buildings of Skerestel Beg [SC 29971 87846], three quarters of a mile inland, a broadish dyke of mica-trap is visible, but the exposure is poor and weathered. Four hundred yards farther east, amid an area of pale blue sericitic slate of ill-defined characters, a low crag of massive bluish, quartzite, weathering very pale, crops up in the corner of a field close to the high-road, on the parish boundary between Michael and German. One might expect that a strong band of this kind would be continuous for some distance, and would be of service in the task of unravelling the structure of the Island. ; but it disappears immediately in both directions, being barely traceable in the field on the opposite side of the road. From analogous examples in the cliffs, the outcrop probably marks the isolated segment of a broken dome-like fold which has burst into the slates. A somewhat similar rock occurs in the bank of the Glen Mooar stream, three quarters of a mile north-eastward, 400 yards N. of Chester [SC 30936 88443], but the quartzite is there associated with other smaller grit bands among banded slates. A 'greenstone' dyke, 9 feet or more wide, is exposed close by, on both sides of the stream.

In Glion Cam, 300 yards S.E. of the high-road [SC 29233 87403], a slaty breccia with the fragmental structure almost obliterated by later cleavage occurs at the highest point in the stream-bed where the solid rock is exposed and a small 'greenstone' dyke is revealed in the same locality. There is probably much of this slaty breccia farther westward, but the shivery ferruginous rubble into which it weathers usually hides the rock-surface. The exposure of the autoclastic structure in a small quarry near Corvalley [SC 29430 86870], half a mile S.E. of Glion Cam, has previously been mentioned (pp. 66–7). Pale blue sericitic slate, which shatters into lustrous platy debris and is associated with occasional gritty layers, predominates in the ridge (extending into 6-inch (Sheet 9)) between the depression leading into the valley of the Neb and the low country underlain by the Peel Sandstone. At Knocksharry [SC 27667 85829] there is an outcrop of coarse grit, apparently the thinning out of a wedge which expands southward (pp. 48–9); and a mass of sheared basic igneous rock is seen at Creggan Mooar in its vicinity.

Crank y Voddee and Barrowgarroo

[SC 30169 85901]. At Crank y Voddee, 1½ miles farther eastward (at the S.E. corner of <u>(Sheet 6)</u>), a boss of sheared and decomposed porphyritic diabase, having affinities with that of the Poortown Quarry (p. 304), has been quarried at the roadside adjoining the Parsonage; and a similar boss, though of different petrological aspect, occurs at Cronkbane [SC 30390 86128], 300 yards to the north ward, near an old mining-trial (p. 547). It is difficult to say whether these are originally isolated intrusions, or are dislocated fragments of a once continuous dyke the smaller shreds seen here and there in the vicinity of the larger masses lend favour to the latter supposition. A less basic rock, apparently of igneous origin and perhaps akin to that at Lhergydho (p.156), is exposed in a small quarry <u>(Sheet 7)</u> on the hillside 700 yards N.E. of Cronk y Voddee Chapel ("St. John's Chapel" of 1-inch map) and 200 yards S. of the milestone ("Castletown 13 m".) [SC 30820 86173] on the high-road. In this quarry igneous and sedimentary rocks seem to have been folded and crushed together. Other small outcrops of ill-defined intrusions were noticed 300 yards farther east, and again a mile to the northward, at the head of Glion Cannell [SC 31749 87308], east of the high-road. This hillside has been the site of numerous small workings in search of lead, and an attempt has also been made to develop a slate-quarry in the dark blue Barrule Slates which occupy the ridge between the Ramsey high-road and the valley of the Neb.

Glen Wyllin and feeders

[SC 31456 90293]. The physiographical features of this neighbourhood deserve attention. The broad shallow depression through which runs the high-road from Kirk Michael to St. John's has probably owed its origin to a single stream flowing northward, but now gives birth to small streams which run, respectively, northward through Glen Wyllin, westward through Glen Mooar, and southward into the deep valley of the Neb. The Pre-glacial elevation quickened the activity of the shorter westerly and southerly drainage, so that these streams tapped the head of the old basin and divided its waters. Since Glacial times the northerly stream seems to have been gaining ground, having swept the drifts out of Glen Wyllin more rapidly than its rivals have been able to deepen their solid channels, thus increasing the fall northward from the col at Barrowgarroo [SC 31952 88057].

The curious dry valley of glacial age which trenches the ridge on the eastern side of Glen Wyllin is described in Chapter 9., p. 365 and (Figure 102)

In Glen Wyllin the rock-exposures are scanty and unimportant until we approach its head in the deep coombe-like glens on the western slopes of the mountains. Glion Kiark [SC 32560 87906], the more southerly of its branches, between Sartfell [SC 33347 87143] and Slieau Freoaghane [SC 34047 88400], is excavated in ferruginous hard dark blue slate with occasional crumpled bands of dark muddy pyritous grit, shown on the map (with some misgiving) as Barrule Slate, and the same firmly welded slate occupies the western slopes of the adjacent mountains. Large slate-trials have been made in this rock in Glion Kiark and again on the south-eastern shoulder of Sartfell near the place marked 'Level (Lead Mine)' [SC 33767 87713] on the six-inch map (Sheet 7). The upper part of the glen enters striped slates and sandy flags, of the 'unseparated' type, much crumpled and frilled with transverse shear-cleavage; and rocks of similar type extend thence, over the summits of Sartfell [SC 33347 87143] and Slieau Freoaghane [SC 34047 88400] to the upper basins of the Neb and Sulby; and indeed, with minor variations, westward up to the main eastern belt of Barrule Slate in Snaefell and Beinn y Phott. In some pale grey tints prevail, in others blue, but oftener the strata show these colours in thin strongly contrasting alternate layers. Where there is a well-defined cleavage across the bedding, the slate has the 'faggoty' or sometimes pencil-like fracture already described. 'Fluxion-structure', pseudo-ripple-marking, pulled lenticles, and partial brecciation are of frequent occurrence throughout this tract.

Dykes appear to be rare until we descend into the Sulby basin, but this may be partly because the exposures are not as a rule favourable for the display of the smaller intrusions. In the deep coombe [SC 34152 88972] between Slieau Curn [SC 34196 90692] and Slieau Freoaghane [SC 34062 88409] there is an abandoned lead-mine, for an account of which see p. 547.

Upper Sulby Basin

[SC 36333 88296]. The wet grassy slopes of the upper part of the Sulby basin above Druidale are usually underlain by drift, the solid rocks being rarely seen except in the stream-courses. The striped flaggy strata are often on the verge of disruption, even where they do not pass over into the actual crush-conglomerate of the sections already described (p. 65). Generally throughout the Island, in descending from the hills into the valleys we find an increasing proportion of gritty material, and this part of the Sulby basin is a case in point. On the western side of the river, a belt of flaggy grit (shown on the one-inch map) is revealed in the beds of the little feeders west of the Druidale farmstead; and again half a mile farther north in the deep gully under Sharragh, Bedn [SC 36503 89776], where the grits seem to be cut off by a W.N.W.—E.S.E. fault which has attracted some mining exploration. On the eastern side of the river also, thickish grit bands (not shown on the map) are seen in the beds of the two uppermost feeders, 500 to 600 yards from the main stream, nearly on the line of strike of the great zone of crush-conglomerate. In the more northerly of these feeders the grit is associated with bosses or veins of quartz of unusual dimensions, one mass occupying the bed of the stream for several yards.

A general knowledge of the geology of this part of the Island may be gamed by scrambling up-stream along the bottom of Glen Crammag [SC 37115 87593], down which a tributary of the Sulby flows northward for 1½ miles from the western shoulder of Beinn y Phott [SC 37402 86103]. For the first 300 yards after leaving the main river we find the bed of the stream to be composed chiefly of crush-conglomerate, with a fault or crush-plane at its southern margin along which a short trial-edit has been driven. We next cross a wide stretch of banded slates, partly brecciated in places and much cut

by fault-like fractures and by quartz-veins. A dyke of 'greenstone', 6 feet wide, is found, 750 yards distant from the mouth of the Glen. Then, 150 yards higher up, some pale greenish and bluish beds are seen, recalling those on the shore at Port Lewaigue (p. 123); and close by, a pale felsitic trap, 9 feet wide, probably belonging to the microgranite group. In the next 600 yards several small dykes of 'greenstone' are visible, traversing strongly-striped and somewhat altered slates with thin gritty bands; and then another example of the pale trap is met with, and two others 300 yards farther up, which we recognise as microgranites like that of Block Ferry, probably emanating from the Foxdale granite (see p. 317); while between the pale traps are other small 'greenstone' intrusions. Whether these dykes be repetitions by folding or faulting it is not possible to determine, but the whole group seems to be prolonged into the next glen eastward, which carries the drainage from the western slope of Snaefell and opens into the Sulby only 300 yards below the mouth of Glen Crammag. In this easterly glen the dykes begin to be seen 400 yards above its mouth, and recur at short intervals throughout the next half mile, up to the sharp elbow east of Lhergyrhenny [SC 38212 88136] where there appears to be some faulting, above which for over a mile dykes are exceedingly rare. The slates in the lower part of this glen possess the same characters as in Glen Crammag, but the section is carried back farther eastward. Above the elbow just mentioned, we find beautifully striped slaty and gritty flags much veined with guartz, affording excellent studies in partial brecciation and double cleavage (see (Figure 24), p. 79). Then, near an old lead-mine' a narrow belt of the dark blue sericitic Barrule slate is crossed, like that forming the greater part of Snaefell and Beinn y Phott. This slate has been intensely sheared and cross-cleaved. It probably lies in a synclinal trough, which expands upwards into the above-mentioned hills; and this suggestion is borne out by the reappearance higher up the stream of striped slates with gritty alternations, like those seen lower down. From 800 to 1,100 yards above the old mine, several small decomposed basic dykes are poorly exposed in the stream-bed, and the question arises whether these may, like the sedimentary strata, be repetitions of those revealed on the opposite side of the infold. But they are apparently unaccompanied by the acid dykes, and present some differences of petrographical character which seem to distinguish them from the previous set. In common with the slates, the dykes in this quarter have undergone considerable alteration, amounting in the ease of the intrusive material almost to re-crystallisation. This metamorphism may be still better studied half a mile farther south, across the col, in the little glen draining into the Baldwin River, where an altered 'greenstone' intrusion occurs in a larger and less weathered exposure in a low crag on the lower slope of the mountain, 100 yards west of the stream.

Snaefell

[SC 39757 88101]. There are also some striking illustrations of alteration in the slates themselves on the western and northern sides of Snaefell, in the cuttings for the recently-laid tramway to the summit, where, as described on p. 110, the sections showed, in places, the sporadic development of garnets in the slate adjacent to hard bands. A broad decomposed dyke, in which actinolite has once been abundant, was exposed in a cutting on the line about 1,400 yards W.S.W. of the summit, and another of smaller size in another cutting 150 yards N.E. of that spot. In several places nearer the mountain top, up to the highest level attained by the tram-line (about 2,000 feet), the excavations revealed good examples of glacially striated rock-surfaces (see p. 361). On the N.E. shoulder of the mountain (at the western border of (Sheet 8)) a small quarry has been recently opened in a dyke-like mass of actinolitic 'greenstone', 18 feet wide, which may be the same rock as that of the tramway section, in a less weathered condition.

North Barrule

[SC 44269 90963]. Following the grassy mountain ridge of Barrule Slate north-eastward from Snaefell (p. 50), we find a few traces of intrusions, both of the acid and basic types, in the form of scattered blocks marking the proximity of outcrops, on both sides of Clagh Onyre [SC 41451 88969]; and a small dyke of microgranite, like that of Clagh Ouyre, is scantily revealed at the side of the new mountain-road due north from the cairn on the summit of Clagh Ouyre, and again in the bed of a gully in the same vicinity, 200 yards below the road. Along the emit of the ridge the dark blue slate has an almost continuous outcrop in low scars, much seamed with quartz-veins (containing some chlorite and mica), while south-eastward the slopes break away into lines of steeper crags overlooking the Cornah Valley. In the lower range of these crags, on the southern side of North Barrule north-east of Park Lewellyn [SC 43869 90007] farmstead, a large mass of igneous material, many yards in width, is exposed in a succession of lens-like bosses. The rock is of the 'doubtful' type, pale greyish, close-grained and splintery, seemingly intermediate between the greenstones and the microgranites. It is, however, too much crushed and altered to yield much information even under the microscope (see p. 317).

Higher up the hill we find traces of some small dykes of greenstone 1 to 3 feet wide, which are of somewhat unusual aspect, being lather coarsely porphyritic. The glacial striations occurring on the crest of the ridge are referred to on p. 361.

The bold crags in which North Barrule terminates abruptly eastward afford a good opportunity for studying the internal structure of the ridge. A series of roughly parallel planes dipping N.N.W.—*i.e.,* in the same direction as the cleavage — splits up the Barrule Slates into tabular or wedge-shaped blocks resting one upon another, not unlike ordinary bedding, and giving the appearance, at a distance, of true stratification. When more closely examined we find that the rock near these planes invariably shows evidence of crushing and sliding, and that the actual bedding is only occasionally parallel to them. They appear, in fact, to be small overthrusts by which the previously folded slate has been split into thick slabs and piled or packed together. In the process of weathering these divisional planes give rise to ledge-like features simulating stratification dipping into the hill.

Cornah district

Descending to the foot of the slope, we find, in a field adjoining the old mountain-road 500 yards north-west of Cardle Veg [SC 45542 90136], in the thinly drift-covered ground a group of large blocks of massive quartz-veined grit, evidently denoting an outcrop of this character. This has been mapped as the northern edge of the Agneash Grits, but there is a strong possibility that it may represent the reappearance of the isolated band of quartzite seen on the east coast at Stack Mooar (p. 124). The ground to the eastward is cultivated, with no rock exposures for over a mile excepting in the gutter of a little stream running to Cornah from Margher-e-kew, where there are scanty outcrops of flaggy striped slate. Between Ballasaig [SC 47002 91270] and Magher-e-breck [SC 47151 90560], however, we find much rocky ground, made up in part of flaggy grits, and in part f strongly striped slate or slaty flags in which the dark argillaceous bands are speckled with alteration-products.

At Magher-e-breck [SC 47151 90560] a north and south lode has been mined for hematite with fair result (p. 541). A small quarry 250 yards N.N.E. of the farmstead at this place has been opened on a massive band of coarse grit and hematite-stained vein-quartz, apparently thrust in among shaken and altered slates.

It is worth noting that on the glacially-rounded rock-face to the northward of this quarry, two highly burnished fragments of vein-quartz, one-eighth to three-eighths of an inch in diameter, were tightly impressed and fixed in a singular manner upon the firm surface of the slate. The anomalous condition and position of these fragments did not seem referable to glacial agency, and yet were otherwise difficult to account for; unless the action of the lightning upon the crag seems a possible explanation.

Cornah Valley

[SC 44833 89679]. To the southward of the supposed Agneash Grits, the ground up to the coast on the east and the deep valley of Cornah on the south is wholly occupied by the inland extension of the Lonan Flags. These hard dap, weathering more or less slaty in crags but showing little or no trace of fissility in the stream-courses, are well exposed in the picturesque little glen south of Ballaglass [SC 46149 90244] and on the hill-top beyond, at Ballachrink [SC 46156 89695]. In the glen an attempt has been made to develop a lead-mine (p. 342), and in the bed of the stream, 50 yards to the westward of the ruined mine-buildings, a curiously fresh-looking dyke, 2 feet wide, of lavender-grey close-grained splintery rock is exposed.

Following up the Cornah stream above the crossing of the main-road at Corrany [SC 45314 89659], we enter an area of the highly-contorted flaggy Agneash Grits which are admirably displayed in all their intricate folding in the bold crags a little to the southward of the stream.

We are here in the proximity of the structural axis of the Island, since a little way farther to the south and south-east the prevalent clips are south eastward, while in working westward upstream we find the limbs of the folds become more and more definitely inclined towards north-west, the cleavage-dips also swinging over, but not quite concurrently with the bedding. The mineral alteration of the slaty partings interbedded with the grits is very distinct in these sections, and continues westward throughout the glen. That its development is independent of the Dhoon granite seems indicated by

its abatement in the rocks farther south and nearer to the granite.

Several of the north or N.N.W. to south or S.S.E. fractures which occur at intervals in the Cornah Glen have been systematically explored for metal-ores, but only one of the mines was in work at the time of the Survey (see pp. 524–5). One of these veins, which is exposed in the little side-ravine striking north to Park Lewellyn [SC 43868 90011], has brought about extensive decomposition of the country-rock in its vicinity, the striped slates being softened and stained into rich lilac, green, and purple-red shaly clay, and the grit bands and quartz-veins reduced to a sharp quartz-sand.

The same peculiarities are visible at the head of a parallel and immediately opposite gully on the other side of the main stream; and again in the upper reaches of the valley, on the slope below Clagh Ouyre [SC 42035 88780], where the decomposed slate seems to follow the general strike of the strata, as it also does in Dhoon Bay and Bulgham (p.130).

The massive bands of quartzite which cross the stream opposite Cornah farm [SC 43691 89596] and probably the continuation of those of Margher-e-kew [SC 45918 90835] and Magher-e-breck [SC 47134 90565]. The manner in which these bands ascend the adjacent southern hill-slope has been described in the foregoing chapter (p. 40).

In two places in the stream-bed, between 150 and 300 yards to the east of the 'North Laxey' Mine [SC 42630 88930], crushed strips of 'greenstone' are exposed, and a small dyke of the same kind is cut in an upper level of the mine. Higher up the valley, on the north bank of the river, 350 yards west of the mine, there is a larger boss of 'greenstone' among sheared and altered striped flaggy slates of the 'unseparated' type; and 300 yards still farther south-westward we find a weathered basic intrusion which may be traced thence at intervals for 200 to 300 yards, to the head of the glen. Climbing then to the grassy moorland-ridge separating the Cornah valley from Laxey Glen, we discover further indications of greenstone dykes in small rock-exposures along the old mountain-road going N.W. toward Snaefell [SC 39791 88141], half a mile east of the summit of Slieau Lhean [SC 43088 87595] (1,515 feet), where we are once more within the belt of the Agneash Grits.

Agneash

[SC 42995 86103]. Turning eastward along this ridge (which lies wholly within 6-inch (Sheet 8)), we find at intervals obscure outcrops of dark banded slate with numerous flaggy layers of grit, while below us to the southward lies the typical exposure of highly-contorted quartz-veined grits in Creg Agneash. Where we cross the structural anticline in this vicinity the beds are folded almost vertically, but in Creg Agneash the grits on the whole show a north-westerly inclination, while the more slaty strata at lower levels along the same axis, in Glion Ruy (the upper portion of Glen Agneash<ref>It is a peculiarity of Manx topographical nomenclature that the name is applied to the glen and not to the stream, and that different portions of the same glen receive different names. The Agneash stream is a case in point: its total length is 1½ miles; it starts in Glion Ruy; flows through Glen Agneash; into Glen Mooar; and then joins the main stream in Laxey Glen. (See six-inch map, (Sheet 8).) As another example, in (Sheet 12) we have Glen Rushen continuing into Glen Mooar and Glen Meay. To the stay-at-home Manx crofter of old days the method might have its advantages, but it is confusing for anyone not wishing to spend his life in one glen, especially as almost every stream in the Island has its Glen Mooar (Big Glen) somewhere or other.

From the manner in which the grits keep to the high ground around the head of Glion Ruy, leaving the intermediate hollow to the striped slates and flags of the 'Lonan Flags' type, it would appear that the valley descends below the horizon of the folded grit-platform. But the pioneer level driven northward from Dumbell Shaft of the Great Laxey Mine (two-thirds of a mile to the southward), at a depth of over 2,000 feet beneath the summit of Creg Agneash, encountered flaggy grits like those forming the Creg, apparently indicating that some portion of the grits are continuous downward to that depth. Several fault-like fractures are visible in the stream-bed of Glion Ruy, and as usual we are unable to decide whether faulting or folding should be held responsible for the position of the strata.

On the summit of Slieau Ouyr [SC 43518 87960] the quartz-veined grit-bands become less prominent, merging gradually into pale sandy Lonan flags like those of Port Cornah. We are here within 600 yards of the edge of the Dhoon Granite on

Slieau Ruy [SC 44105 87266], but the rocks do not show any notable increase in the degree of alteration.

Dhoon Granite

Though the ground is heather-covered, with only meagre exposures, the margin of the granite on the crest of Slieau Ruy [SC 44114 87246] can be fixed within a few yards. It is 630 yards S.E. of the cairn marking the highest point of Slieau Ouyr, and the granite is continuous thence south-eastward along the parish boundary between Maughold and Lonan for 400 yards, when we pass from it again to sheared flags decidedly more altered than those of the opposite border. The granite itself has undergone movement after consolidation, being rendered schistose in places in a direction parallel to the fissility of the flags, especially along its north-western margin; and it seems probable that the strata which were originally in immediate contact with it may have been afterwards displaced by overthrusting or normal faulting, and that the slight amount of alteration now visible at some parts of its boundary may be thus explained (see p. 106). Westward the granite disappears within 700 yards below the crest-line of the hill, the slopes descending into Glen Agneash being wholly of sedimentary rock; and the deep levels of the Laxey mine, 1,600 feet below the Glen, are altogether in the with an elvan, seen also at the surface, as the only indication of the proximity of the igneous mass. Eastward the granite extends with an irregular outline, for 1∎ miles, to Barony Hill [SC 46286 87604].

Following its northern margin in this direction we find no good exposures until we cross the straight mountain-fence running N.W. from Rhenny [SC 44914 86570] towards Cornah, about 800 yards west of the high road, where in a craggy hillock separated from Slieau Ruy by a boggy hollow, we see the actual junction of the granite with the flags. The highly altered country-rock is here streaked with little apophyses of the intrusive material and crushed into a schist, while the margin of the granite is rendered platy by crushing and appears to have been actually folded, as shown in the following figure (p. 143). On leaving this hill, the boundary is lost beneath the thin drift-covering of the shallow depression along which runs the high-road, but we recover it on the rise of Barony Hill, 300 yards east of the road, where low outcrops scattered among the heather enable us to fix the line within narrow limits, the junction-phenomena being, however, less clearly seen than where above described. The north-eastern corner of the intrusion just reaches the long fence enclosing the summit of Barony Hill, and seems there to send out the more northerly of the two elvans) which, as already stated (p.p. 129–30), may be traced eastward down the precipitous slope to the sea.

Turning southward from the fence, we have good indications of a ragged junction of the granite and flags for 150 yards farther, when the second elvan breaks away from the mass, following a parallel course to the first into the cliffs. Near this point the boundary begins to show a westerly trend, but enters cultivated land and is not seen again until we reach an old quarry overgrown with gorse, 500 yards to the south-westward, on the verge of Dhoon Glen, below the ruined farmstead of Kionehenin [SC 45794 86919]. In this quarry [SC 45851 87085], the sheared granite margin is full of highly altered included fragments of the flags. We descend from this point 200 or 300 feet almost precipitously into the deep glen cut nearly to sea-level, in which we find altered slaty flags only, and the various mining levels driven beneath the Glen (p. 528) were also wholly within the slate-series, proving, as in Laxey Glen, the absence of any notable expansion of the granite downwards to some depth beneath the surface. The steep valley-walls of the branching feeder whirl flows south-eastward into Dhoon Glen below Kionehenin reveal crags of slate cut by a thin elvan from the granite (noticed by Henslow<ref>Trans. Geol. Soc., vol. v., p. 491.</ref>); but above the point where the stream forks, both the easterly and westerly branches have trenched the massive granite. The intrusive rock is here traversed by veins containing much fibrous tourmaline, which was formerly excavated in these glens for use as a polishing powder (p. 556). The rock adjacent to the veins is in places so thoroughly decomposed that it is easily dug with a spade.

In endeavouring to trace the southern boundary round westward across the aforementioned drift-covered depression, we can fix the margin within narrow limits in the shallow cuttings in weathered rock on the new tramline; and then find no further evidence until 300 yards west of the high road, where the little gulley of the north fork of Dhoon Glen, which below this point is wholly in slate, shows a poor exposure of granite apparently brought against the slate by a north and south fault. Thence we pass across two cultivated fields and the boggy hollow on the edge of the moorland, to the slope of Slieau Ruy, without further indication for the exact position of the junction.

The whole area of granite thus enclosed is about half a square mile in extent. A large quarry for paving setts by the side of the high-road half a mile north of Dhoon Glen Hotel [SC 45553 87208] affords the most favourable opportunity for

studying the central portion of the intrusion. In this quarry the joint-faces are frequently coated with molybdenite. The petrographical features of the mass and its relation to the other igneous rocks of the Island are discussed in Chapter 8. p. 312.

To the northward of the granite the little stream which runs down the eastern slope of Slieau Ruy [SC 44758 87716] reveals a continuous section of baked gritty flags, having a predominant dip south-eastward, or towards the intrusion and this is the general direction of the bedding and cleavage planes all round the mass. In fact, the granite does not appear to have affected the arrangement of the rocks into which it was intruded, but merely to have punched out room for itself through the previously packed and folded flags, and to have been affected after consolidation by a renewal of the shearing forces acting in the same direction as before, but with less intensity. It is highly suggestive that the only elvans which can be traced for any distance from the granite are those which stream out from opposite ends of the mass roughly parallel to the cleavage. Those from its eastern margin have already been described; and those from its extreme western margin take a similar course in the opposite direction, crossing Glen Agneash, Laxey Glen and Glen Roy, as indicated in (Figure 29), p. 84. Directly to the southward of the outcrop, with the exception of short protuberances close to the edge of the intrusion no dykes have been discovered; and to the northward, only one small elven is found in the bed of the aforesaid stream from Slieau Ruy, 400 yards west of the upper high-road, and another on the northern slope of Barony Hill, 800 yards N.E. of Ballig [SC 46265 88608], neither of which seems to extend more than a short distance from the granite present analogous features (see p.311).

Rhenab Glen

If we follow the little stream round the northern slope of Barony Hill into the picturesque glen at Rhenab [SC 46590 88560], three-quarters of a mile north of the granite, we find pale flaggy altered slate, with its dominant dips at first towards S.S.E., but afterwards changing, 600 yards east of the high-road, to the unusual direction of E. or E.N E., with flattish cleavage and curious schistose structures almost or quite obliterating the bedding. This abnormal dip, corresponding to that on the north side of Port Cornah [SC 47396 87895] (p. 129), does not appear to be connected with the intrusion of the granite, but to have been caused by the proximity of the anticlinal axis of cleavage. In the lower part of its course the stream runs in a deep gully between vertical walls of highly confused baked splintery flags, still showing the abnormal easterly dip and traversed by schistose hard bands which are probably crushed greenstone dykes. There is something so peculiar in the structure and composition of these rocks that they deserved fuller investigation than they received, but the sections in the walls of the ravine are unfortunately difficult of access. Shreds of altered basic intrusions are visible on the slopes above the ravine on both sides,—to the northward in the steep road leading across to Cornah, and to the southward in the fields of the old Barony enclosure E. 15 N. of the shepherd's house.

Laxey Glen and Glen Agneash

In the lower part of Laxey Glen [SC 43567 84148] (in <u>(Sheet 11)</u>) a narrow alluvial flat occupies the bottom of the valley, but the Lonan Flags with dominant S.E. dips are revealed in many sections in the steep slopes on both sides, occasionally traversed by small 'greenstone' dykes. The extensive mining work on the Great Laxey Lode which has been one of the most productive metalliferous lodes in the British Islands, is described in Chapter 13., p. 519.

The lode is a definite fracture-line striking about N. by W. and hading towards E., but it does not appear to be accompanied by faulting of much moment; its course leaves the main glen and enters that of the Agneash tributary (Glen Mooar, 6-inch (Sheet 8)) above the junction of the streams, where for a few hundred yards it nearly coincides with the river-bed. The Bulgham Bay group of gieenstone dykes (p. 131) seems to cross the same ravine, basic intrusions being obscurely exposed at short intervals wherever the country-rock is laid bare. Among these dykes there is, however, one—a mica-trap, seen in the stream-bed north of the Big Wheel—which has not been recognised in the coast-section. Farther upstream in Olen Agneash, above the mines, 200 yards north of the upper reservoir, the dyke of Dhoon microgranite, 20 feet wide, of which mention has already been made, is well exposed it is also indistinctly seen in the moorland road to E.N.E., 400 yards nearer the granite; and its debris is abundant in the spoil-heap of a small shaft on the opposite hill-side, 300 yards W.S.W. of the stream. A second dyke of similiar composition, but only about 1½ feet in width, is visible in Glen Agneash 450 yards north of the above-mentioned example. Pale hard sandy flags prevail in this part of the glen, intermediate in character between the Lonan Flags and the Agneash Grits; the bedding of these rocks is

almost vertical, or turned over slightly toward S.S.E.

Returning to the main Laxey Glen above its junction with Glen Agneash [SC 42847 85402], we find similar sandy flags revealed at intervals in the valley bottom, highly crumpled and folded, but with a tendency toward W.N.W. Among these flags, bands of quartz-veined grit make their appearance, and increase in numbers in going westward, until the rocks attain the typical characters of the Agneash Grits. The thin slaty partings among these grits are sometimes full of partially-developed alteration-minerals of much petrographical interest (see p. 109).

A fine 20-feet dyke of microgranite like that of Agneash is exposed in the Laxey stream rather over three-quarters of a mile above the aforesaid junction [SC 42562 86258], or 950 yards S.E. of the farm of Laggan Agneash. Its position is somewhat to the eastward of the line of strike of the Agneash dyke, but there is little doubt that they are identical. The manner in which these intrusions have been chopped up into segments that have been displaced either by faulting or folding, is evident in the crags of the high valley slopes on either side. On the north we find a sheared and broken elvan of the Dhoon type among the grits bordering the rivulet which tumbles into the Glen 150 yards east of Laggan Agneash [SC 41895 86791]; but in the stream-bed and on the opposite or southern side of the valley, we search in vain for its direct prolongation, until we go 500 or 600 yards farther east on the south side of the valley, where, in the tramway cutting and the crags above and below it, we encounter an excellent exposure of a similar elvan, about 15 feet wide, accompanied by others of smaller dimensions. There is much reason to believe that, in spite of their apparent discontinuity, the above described outcrop in the river and those of the north and south slopes of the villey have once been continuous and all represent parts of the same elvan. Two hundred yards farther south there is another exposure of microgranite, on the hillside below the tramline; and yet another, 500 yards distant from the large dyke in the tramway cutting, in the gully of a rivulet flowing eastward into the main glen. These also are discontinuous along their strike (see p. 314).

In the higher reaches of Laxey Glen we pass out of the Agneash Grits into banded slates of the 'unseparated' type. These lie within the belt of alteration, and present the usual indications of incipient metamorphism. In the vicinity of Laggan Agneash [SC 41750 86804] several small dykes of altered greenstone and one or two of the intermediate type are revealed in the stream-bed, and others again 200 to 400 yards farther westward. Where the stream forks, just below the Snaefell Leadmine [SC 40776 87522] (p. 526), the strata are greatly shattered, and it is probable that a fault of some magnitude crosses the valley at this point, striking N.N.W. along the course of the north fork. This crushed slate is seen in the banks of the stream and also proved in the underground workings of the mine; the slates are similarly shattered on a prolongation of the same line in the tramway cuttings on the southern side of Laxey Glen. This disturbance may be responsible for the truncation of the northern edge of the Agneash Grits on the lower slope of the hill above the Snaefell mine; though, as usual, an alternative explanation can be offered, in the supposition that the valley-bottom at this point may descend below the level of the sheet of grits.

A small dyke of actinolitic greenstone occurs in the bed of the north fork about 20 yards above the shaft of the mine, and another larger dyke-like hand crosses the stream 300 yards farther north. In the south fork, above which the tramline runs, strongly banded sandy flags with thin gritty layers are found, exhibiting excellent instances of partial brecciation. The tramline itself between this point and Laxey presents a fine succession of sections in which the complex folding and buckling of the Agneash Grits may be advantageously studied. Several basic dykes and elvans, like those in the river bed, are also laid bare, but are generally much weathered.

Head of Laxey Glen

There is a small quarry by the side of the mountain-path, 500 yards E.S.E. of the hotel at the crossing of the tramway and the high-road [SC 39638 86780] on the southern shoulder of Snaefell, in which the alteration of the banded slates is almost as well displayed as in the cuttings on the western slope of Snaefell (p. 110). The rock is streaked and frilled by intersecting planes of strain-slip; and small garnets and other minerals are abundantly developed in certain layers of argillaceous material adjacent to little beds of harder grit. Continuing along the aforesaid path, the high ridge of Mullagh Ouyr (in (Sheet 7)), chiefly composed of the quartz-veined Agneash Grits, lies to the south of us, while to the north we find a tract of altered 'unseparated' slaty rocks which are perhaps brought in by the effect of the Snaefell Mine fault, and occupy the moorland for about half a mile farther eastward, until replaced, in Cronk y Vaare [SC 40772 86443] (in (Sheet

8) and the upland to the south-eastward, by the Grits. The heads of the little streams draining southward from these uplands will be described when we reach the drainage system of which they form part (see p. 160).

Central Division (Six-inch Sheets 9 to 14).

Western Coast

The description of the western coast-line of this division northward of Peel [SC 24362 84217] is given in the chapter on the Peel Sandstones (Chapter 6., p. 272). In Peel Bay the fault which forms the western boundary of these Sandstones is concealed by drift, which descends in this vicinity considerably below sea-level (see pp. 441–3). On the western horn of the Bay, however, the Slate Series reappears, and is continuous thence southward to the extremity of the Island. For the first six miles (including the remainder of (Sheet 9) and the northern third of (Sheet 12)) the coast-sections consist exclusively (save for a capping of drift) of the Niarbyl Flags.

St. Patrick's Isle

[SC 24112 84615]. The most easily, accessible locality on the coast for the study of these rocks is St. Patrick's Isle, close to Peel. The shore here is low and shelving; and though very rugged, as indeed it always is when composed of the slate-rocks, it can be traversed without difficulty by the pat way under the outer walls of the Castle-yard. The palish grey and blue slaty flags here seen present a succession of folds, in some places rather open and in others pinched up so that the limbs are highly inclined; and in the troughs of the folds the pseudo-ripple-marking is sometimes well developed. There is a faint cleavage, of low angle, crossing the bedding; and the flags are fractured in places by fault-like lines of crushing. As indicated on the following enlarged plan of the Isle, two dykes, with possibly the crushed remnant of a third which is not howl', traverse the strata in a N.N.W. direction. The more easterly is one of the less crushed 'greenstones'; the more westerly, a fine example of mica-trap with conspicuous crystals of mica in a micaceous ground-mass. The latter dyke gives rise to a long channel near high-water-mark at the south-western angle of the Isle, and affords by far the best Manx exposure of this type of intrusion, elsewhere either scantily visible or outcropping in almost inaccessible positions. The same dyke is prolonged into the mainland cliff on the opposite side of the water-gully.

Contrary Head

[SC 22756 82882]. Most of the shore between St. Patrick's Isle and Contrary Head is only approachable by boat, though a risky descent of the cliffs may be made in one or two of the little bays. In every section the Niarbyl Flags exhibit magnificent contortions, the limbs of the folds usually standing at high angles and the troughs exhibiting much pseudo-ripple-marking and other interesting pressure-structurim (see (Figure 21), (Figure 22), (Figure 23), pp. 77–9). Occasionally the folds show domed or boat-shaped terminations, but unlike the plications of the eastern coast, these do not show a steady pitch towards one quarter. The cleavage varies considerably both in intensity and in angle of dip, being influenced in the latter particular in part by the wide differencea In the texture of individual beds, and in part probably by post-cleavage disturbances. In the more slaty bands between Peel and Contrary Head it is occasionally sufficiently strong to have encouraged small slate-trials; and in certain limited beds the quality of the product seems to have been better than is usual in the Island, but the quantity obtainable was too small for profitable working.

Fractures and lines of crushing abound, striking both along and across the direction of stratification. Small thrust-planes of low bade are also common, especially between Dalby Point [SC 21226 78728] and the Niarbyl [SC 20785 77515].

Dykes are not numerous, and are all of small size. Instead of following the bedding planes like the majority of the dykes of the opposite coast, they have usually a N.N.W. strike, or nearly at right angles to the bedding. They have all been injected after the folding, and are as a rule fresher and less crushed than is commonly the case with the Pre-Carboniferous intrusions of the Island; but that they are Pre-Carboniferous is indicated by the fact that while they traverse the slates all round the margin of Peel Sandstone, not one has been found to enter that formation. Several of these intrusions belong to the mica-trap group, this type being better represented here than in any other part of the Island. As the dykes in this area are widely spaced, it has been possible to show most of them on the one-inch map; and their position will, therefore, scarcely need further indication. On the north side of Contrary Head, near the base of the

cliff, two little seams, 4 inches thick, of a curious pale-yellowish-green steatitic material may be seen, apparently interbedded with the flags. These are possibly of igneous origin but are too much altered to reveal their genesis even to microscopic examination. Similar but still thinner seams were observed on the coast farther south in the vicinity of Dalby, and again on the eastern coast between Douglas Harbour [SC 38561 75186] and Douglas Head [SC 39060 74748]. They deserve mention because of a somewhat remote possibility that they may represent altered volcanic material.

Besides the outcrops in the cliff, one of the mica-trap dykes is exposed in two places in the crags, 300 to 400 yards inland from the coast south of Contrary Head, and 800 yards, S.S.W. of Knockaloe Moar farmstead [SC 23029 81924]. On the same craggy ridge half a mile farther east, in a quarry in the Niarbyl Flags 50 yards west of the high road to Dalby ? [SC 23029 81924], another basic dyke 6 feet wide is rather well seen. These are the only inland instances within the boundaries of the Niarbyl Flag where dykes have been observed, except in a doubtful case in Glen Meay close to the eastern edge of the division.

Coast south of Contrary Head

The cliffs to the southward of Contrary Head resemble those already described. At Glen Meay [SC 22478 79960] the coast is broken by a little precipitous east-to-west ravine carved out of the Flags, which coincides in part with a line of faulting, the fault breccia being reveled in places in its southern wall.<ref>This breccia seems to have been regarded by Harkness and Nicholson as a true conglomerate (see p. 163). See Quart. Journ, Geol. Soc., vol. xxii., p. 486.</ref> To the southward of this place the cliffs are lower and the foreshore broader, rendering the sections more easily accessible. A typical section on this part of the coast has been illustrated in a previous figure (see (Figure 3) p. 37).

A dyke of 'greenstone', 6 feet wide, traverses the foreshore opposite Ballaquane 850 yards south of Glen Meay. In the next recess southward, where the cart-road from Ballaquane [SC 22478 79960] reaches the shore, three small intrusions of olivine-dolerite are visible, the largest 3 feet wide, striking N.W. or N.N.W. This is the most northerly instance of the supposed Tertiary intrusions that we have observed on the western coast. Another dyke of like character and dimensions occurs on the north side of Dalby Point, half a mile S.W. of the last; and a third at Baiy ny Ooig [SC 21320 78568], 130 yards beyond, on the southern side of the Point; and no further example is then known for more than two miles, after which the coast intercepts another small cluster of these dykes (pp. 150–1).

The finer-grained flaggy beds in these sections usually all contain a trace of lime, but that substance is most abundant in certain bands between Dalby Point and Glen Meay, referred to on p. 36. At Elby Point [SC 21065 77718] close to The Niarbyl, the bedding planes exhibit the beautiful reticulate structures illustrated in (Figure 21)–(Figure 22), pp. 77–8.

The Niarbyl

The Niarbyl [SC 20926 77552] is a rough low reef of folded flags, one-third of a mile in length, at high water cut up into islands and partly submerged; and in this reef the Niarbyl Flags suddenly terminate, as already described (p. 35). The existence of the reef is due to the superior endurance of these flags over the softer strata to the southward, which consist of striped slates and thin sandy bands of the 'unseparated' type, greatly crushed and disturbed. At low water, when the edge of the reef is exposed, the softer beds seem to pass under the flags at an angle of about 25 degrees, an irregular streak of crushed rock and vein-stuff occupying the junction. In the adjacent little cliff, however, the line of division is steeper and more like a normal fault. The present relationship of the rocks at the junction is clearly due to some form of displacement; and if we are right in considering the flags to be the older division, we must, as already stated (p. 38), grant the existence of an overthrust at this point.

A small 'greenstone' dyke, 1 to 2 feet wide, strikes north-westward across the reef, 150 yards S.W. of the fisherman's house on the little beach. Among the softer beds in the floor of the bay, some curious disconnected bosses apparently of igneous origin are visible at low water, probably the remnants of a shattered intrusion of altered diorite (p. 300). From this place southward, small dykes of 'sheared 'greenstone' of the older type, often reduced to the condition of tale-chlorite-schist, are numerous; and them usually strike with the cleavage, or E.N.E. to W.S.W. The remarkable difference in the number, character and direction of the dykes in these slaty rocks as compared with those in the Niarbyl Flags seems at first sight to suggest that the Flags belong to a later system than the Slates, and that some of the dykes

which traverse the Slates may have been intruded before the Flags were deposited. But such a reading would mean a reversal of the order of succession advocated in the preceding chapter, and would imply a time-interval if not an actual unconformity between the divisions for which there is no other evidence. The suggestion is mentioned merely to show that it has been duly considered, and rejected in favour of the more probable explanation that the phenomena in question are due in the first place to the less penetrable character of the Flags, and secondly to their superior resistance as a mass to the later shearing-stresses, so that to a considerable extent, they protected and preserved the comparatively few intrusions that found entrance into them (see p. 299).

Coast south of The Niarbyl

An outstanding stack in Traie Vrish [SC 21366 77348], 360 yards south of the Niarbyl Cottage, is penetrated by one of the greenstone dykes. This appears to have been folded and broken by small overthrusts, affording a illustration of the deformation which the intrusions have suffered among the softer rocks in this quarter.

In the same locality, an edit has recently been driven into the cliff to explore a lode which many years ago yielded a small quantity of sulphide of antimony (p. 546). The dark striped slates on the foreshore contain many small nodules, as well as worm-like impressions. On the southern side of Traie Vane, where the Lag River pours in a little cascade to the shore, a belt of beautifully banded pale and dark green slates is revealed (see p. 123). The same slates are doubtfully recognisable in a few places on the steep hill-slopes east of Dalby, their appearance in weathered inland exposures being, however, not nearly so striking as on the smooth rock surfaces of the sea-shore. Lustrous sericitic slates occupy the shore and the cliffs farther southward, while, as shown on the one-inch map, a darker belt, probably representing an infold of the Barrule Slates, is exposed in the high broken precipices of Fheustal, three-guarters of a mile south of The Niarbyl. The same cliff is traversed by a band of tough ferruginous rock, in places 30 feet wide which is probably a decomposed basic dyke; and several other similar 'hard bands' of indefinite character occur between this place and Gob yn Ushtey. In approaching the latter locality we find the rocks assuming a more arenaceous aspect, with gritty layers which are frequently broken into pebble-like fragments, forming thin streaks of 'crush conglomerate', as may be well seen on the southern side of Gob Breac [SC 21498 75876] (six-inch map, (Sheet 12)). Under Gob yn Ushtey [SC 21468 75685] we encounter bands of rather coarse grit, in the vicinity of which the slaty material has become schist-like, through shearing. Among the numerous dykes in this neighbourhood is one which has a width of 20 feet. It adjoins the coarse grit, near the cascade formed by the stream from Glion Mooar [SC 21541 75650]. Vein-guartz abounds in these sections; and some of the fractures which gash the cliff may indicate faults of consequence, but the stratigraphy is too confused to enable us to estimate their value. In the face of the cliff 100 yards north of Gob yn Ushtey [SC 21530 75770], where there is a local coincidence of bedding and cleavage, an attempt has been made to win roofing slate.

South of Gob yn Ushtey [SC 21543 75624] the upper portion of the high precipices are, for 300 or 400 yards, largely composed of flaggy grits, as shown on the map; but these do not always descend to the shore, which is still chiefly occupied by dark striped slates with occasional grit-bands. It would require a long and exceedingly difficult and even dangerous investigation to unravel the complexities of these coast-sections. For long stretches of the western coast south of the The Niarbyl it is only possible to approach the base of the great precipices by boat on the rare days of absolute calm; and in the few places where a precarious descent from above is practicable, the roughness of the block-strewn shore and the recurrence, at short intervals, of deep water channels which the sea has scooped out along the crushed fracture-lines, makes any progress arduous and risky. Under such conditions the work would be difficult even if the geology were simple; while, as the matter stands, this coast truncates the central axis of the Island and exhibits every form of complicated structure possessed by the much troubled massif.

Of the numerous dykes in the next half-mile south Gob yn Ushtey [SC 21669 74955], some belong to the dark less altered greenstone group, but moreto the highly sheared calc-chlorite-schists of the most hopeless type. Among the latter is the dyke, 20 feet wide, at Da Leura [SC 21742 75322] (of the six-inch map; the name should probably be written Dal Eura or Eairy), of which a description and analysis by Mr. Teall is given at p. 308. Another broad dyke-like mass, probably igneous though at first thought to be a pale mudstone, occupies the cliff at Ooig ny Sevir [SC 21624 74740], 200 yards north of Lag ny Keeilley where Chapel is engraved on the one-inch map.

At Con Shellagh [SC 21690 74989], 500 yards north of Lag ny Keeilley, a beautiful little fern-draped cave, into which the sea does not now penetrate, appears to belong to the Raised-beach period, and affords evidence of the slow rate of recession of this coast. The cave is well adapted for a hiding-place, and might repay archaeological investigation.

Lag ny Keeilley

[SC 21628 74456]. In the circle of crags surrounding Lag ny Keeilley, and also on the moorland slope above, 50 to 80 yards N.W. of the boundary between the parishes of Patrick and Arbory, we encounter the most northerly examples on the west coast of the microgranite elvans of the Foxdale type. These are fine-grained pale felsitic dyke-rocks, usually highly sheared, which might readily be mistaken for fine grits. They are, however, characterised by the presence of small hexagonal crystals of white-mica, sparsely distributed through the crypto-crystalline ground-mass. Further petrographical details respecting them are given at p.316. Like the Dhoon elvans of the opposite coast, these dykes are broken m the moorland exposures into disconnected shreds, which apparently do not descend directly to the coast, but are distributed *en échelon* on the crest of the southern spur of Cronk ny Arrey Lhaa [SC 22007 74165], separate segments being found in the crags Burrow Sodjey [SC 22001 74250], Burrow Meanagh [SC 21687 73952], and Burrow Mooar [SC 21648 73528], whence they at last descend to the coast, over half a mile south of their first appearance on the brow above.

From Lag ny Keeilley southward to Stroin Vuigh [SC 21260 74069] the cliff is composed of the welded dark blue Barrule Slates, which descend in a crumpled mass, full of quartz veins, in ranges of precipices, from the summit of Cronk ny Arrey Lhaa [SC 22449 74671] (1,449 feet) to the sea. Three hundred yards north of Stroin Vuigh [SC 21399 74310] one of the Tertiary (?) olivine-dolerite dykes, 3 feet wide, striking W. 15 N., emerges in the cliff. Immediately to the southward of Stroin there is a curious plexus of dykes of all ages; along with several small examples of the sheared talc-chlorite-schist type, we find here a less sheared greenstone, accompanied and apparently cut by a small Foxdale elven, and the two intersected by an olivine-dolerito 6 feet wide. A little farther southward, under Ny Pheastul [SC 21279 73694], a twisted and disjointed elvan about 10 feet wide wriggles along the cliff-face for 50 or 60 yards. Tough fibrous slate has been quarried close by.

The Slock

At Y Slogh [SC 21325 73476] (known now as The Slock), adjoining "The Stacks" [SC 21121 73456] of the one-inch map, the principal batch of elvans, after hugging the brow of the precipice as already described, comes down to the shore in a complicated group of segments, again accompanied by small sheared greenston0. The elvans seem to be displaced again by an east and west fracture, along which, in the cliff, a mining level has been driven in search of lead ore (see page 536). The country-rock in this vicinity is a pale somewhat sandy flaggy slate, not unlike the more argillaceous portion of the Lonan Flags.

In the cliff 300 yards farther south there is another exposure of a large elvan, 30 or 40 feet wide. This elvan is distinctly traversed by a small flier of olivine-dolerite about one foot wide, probably an offshoot from a broader dyke of the same material which may be hidden by talus in an adjacent ghaw.

Having now reached the southern edge of the Central Division (Sheet 12) on this coast, we will turn to the examination of the eastern coast in the division. The description of the remaining portion of the western coast of the Island is resumed at p. 171.

Eastern Coast of the Central Division

(Six-Inch Sheets 11, 14, and 13.)

Laxey Head

[SC 44562 83635]. Commencing at the northern edge of <u>(Sheet 11)</u> of the six-inch map, on the eastern coast about a mile to the northward of Laxey Head, we find —that for some distance the shore-line nearly coincides with the strike of the rocks, and as the beds are inclined steeply south-east, or seaward, the cliff presents the typical dip-slope characters. The rocks consist of Lonan Flags, of the usual type and with the usual structure, which extend from this place southward

to Clay Head with only minor changes. Toward Laxey Head some of the bands are peculiar in containing cubical crystals of pyrites, while nodules and 'worm-tracks' are common in many places. Several small dykes of greenstone occur; and one of these, best seen in the neighbourhood of Skeirrip [SC 45356 84156], is veined with quartz after the manner of the Agneash Grits. Two of these dykes are visible in the low cliff on the north side of Laxey Harbour [SC 44458 83649]. The notch in the crest of the cliff due east of Skinscoe farmstead [SC 45302 84332] marks an old channel of the little Strooan ny Gragee which now pours over the cliff through a new gully 200 yards farther south.

On the southern side of Laxey the rocks on the shore at high water contain the hollows left by decomposed nodules, which have given rise to so much discussion under the supposition that they might be "footprints" (see pp. 20, 90). From the aspect of the shore opposite the village, it is probable that boulder-clay underlies the beach-material in a pre-glacial prolongation of Laxey Glen, but no exposure was detected during the Survey.

Dykes of greenstone occur in increasing numbers southward, being especially plentiful about three-quarters of a mile south of Laxey [SC 43589 82764]. Their direction is more to the northward than usual, being approximately N.E. A fine dyke of olivine-dolerite, 6 feet wide, is visible on the shore 800 yards north of Garwick. Its north wall, well exposed in the cliff, shows a close-set system of parallel joints; its course is somewhat abnormal, being a little S. of W., but the dyke seems to have been slightly displaced by a neighbouring small fault. Usually when one of these dykes is found, others are not far distant; but this instance, so far as is known, is solitary, its nearest companion being one and three-quarter miles to the southward.

Garwick Bay

[SC 43521 81475]. In Garwick Bay and on Clay Head fault-like fractures roughly parallel to the strike of the flags are very numerous, and some of them have been tested for metalliferous ores by short edits. The general inclination of the contorted bedding continues to be south-eastward until we pass Braggan Point (six-inch (Sheet 11)), when it swings round by south and west (indicating the westerly pitch of the folds) and attains a steep north-westerly direction, which thence predominates on Clay Head and the coast southward, as far as Onchan Harbour. The axis of the synclinal trough runs roughly parallel to the coast and is never more than a few hundred yards inland (see (Figure 29), p. 84). The S.S.E. cleavage is not affected by the reversal of bedding, and therefore in this part of the Island, unlike the usual conditions, is more or less directly transverse to the bedding planes. It is noteworthy that here, as on Laxey Head, the minor plications of the limbs of the folds are often so arranged that their axial planes are parallel to the cleavage, as described and figured in the previous chapter ((Figure 30), p. 85). The narrow belt of thick-bedded quartz-veined grits, described on p. 46, which appears to be a local modification of the Lonan Flags, is intercepted by the cliff-line on the south side of Garwick Bay, 200 to 300 yards S.E. of the mouth of Glen Gawne [SC 43541 81313].

Clay Head

[SC 44352 80441]. Among the dykes of this part of the coast, the following are the more noteworthy. In Garwick Bay a porphyritic greenstone, 10 feet wide, strikes N.N.E. across the beach on the south side of the Glen. Between Gob ny Stowell [SC 43698 81299] and Braggan Point [SC 44092 81069], 600 yards farther to S.E., a curious boss of diorite, sheared around the edges, is exposed on the foreshore (see p. 300). It contains pinkish patches of more acid composition, recalling in this respect the mica-trap of Groudle (p. 302). A small dyke goes out from it which cannot be distinguished from the usual type of 'greenstone'. At The Clytt [SC 43950 79832] on the S. side of Clay Head, a dyke of unusual character, about 4 feet wide, strikes S.W. across the little promontory, and thence across the shore for 200 yards (see p. 328). It contains large porphyritic felspars and is uncrushed, though slightly displaced 150 yards S. of The Clytt by a small N.–S. fault. Its joints, like those of the adjacent country-rock, are in places stained with hematite. It hades with the S.E. cleavage and not with the N.W. bedding. It is evidently newer than the ordinary 'greenstones', but may be older than the olivine-dolerites; there seems to be no other dyke m the Island with which it can be directly compared. An olivine-dolerite, 4 feet thick, striking N.W., is seen in the cliff 450 yards S. of The Clytt [SC 43614 79551], and must intercept the above-described intrusion at about 200 yards mland. Several broken dykes of rough slightly sheared quartz-veined greenstone occur in the cliffs farther south; the smaller strike N.E. with the flags; but two of the larger, each about 12 feet wide, 1 mile S. of Clay Head, have apparently a transverse direction.

In this quarter the westerly pitch of the troughs and crests of the folded flags is well seen at the base of the cliff.

Port Groudle

[SC 42042 78191] Entering upon (Sheet 14) (six-inch), we find a plexus of greenstones in Baih Doo [SC 42618 78480], half a mile east of Port Groudle, and some smaller examples 300 yards farther west, the latter having an interrupted course S.W., to the north side of Groudle. It is perhaps the same group which reappears on the opposite shore of the Port, 60 to 100 yards S. of the shingle beach.

Besides the usual crush-lines and cross-fractures, the sandy flags of this locality are traversed by joint-like planes, inclined at about 300 towards S. 25 E., thinly coated with striated vein-quartz. These are independent of both cleavage and bedding.

On the shore of the westerly shoulder of Port Groudle, 250 yards south of the storm-beach, a mass of hornblendic mica-trap, about 50 feet wide, is exposed (see p. 302 for petrographical description). It is a dark micaceous rock, somewhat vesicular at the margin, permeated with veins and patches of pinkish material more acid than the mass. It strikes N.W. along the N.E. slopes of Banks Howe [SC 41770 78073], being visible in two small outcrops in the park below the electric tramway and again on the upper side of the line. A better exposure occurs higher up the hill, 250 yards (as measured on the 6-inch map) south of the Goudle Tram-Station [SC 41443 78298], where its strike appears to be nearly E.–W. At this place it could be conveniently quarried, and would probably, from its toughness, furnish useful road metal. It seems to occur, like most of the older Manx dykes, not continuously but as a series of lenticular bosses. No trace of it has been found in Groudle Glen.

A smaller dyke of quite different character, apparently one of the loss altered greenstones, is also exposed for a short space on Banks Howe, 60 or 70 yards west of the most westerly outcrop of the mica-diorite.

Northern side of Douglas Bay

West of the mica-diorite the coast for some distance runs parallel to the strike of the rocks. The flags dip into the cliff, and their edges protrude with a jagged ladder-like outline very different from the dip-slopes north of Laxey. Shreds of narrow 'greenstone' intrusions occur here and there, striking with the flags, but hading with the cleavage and across the bedding.

In Onchan Harbour [SC 40492 77646], where the coast recedes into the trough of the syncline, the beds are folded almost vertically. The N.N.W. fractures which have given rise to this recess seem somewhat to shift the axis of the trough, and may therefore mark faults of some moment. The basic dykes are again abundant in this neighbourhood, the largest, 12 feet thick, crossing the strike of the flags on the western side of the arbour. Several smaller intrusions, striking with the country-rock, cross the little headland into Port Jack, being well shown in the tramway cutting under Douglas Bay Hotel. The westerly trend of the coast having now carried us to the westward side of the syncline, we find on rounding the headland into Douglas Bay that the general dip of the flags is again south-easterly.

In Port Jack [SC 39958 77298], a little to the westward of the trough, a belt of quartz-veined grits like that of the north side of Clay Head is encountered, and it appears probable that, as shown on the map, a more or less continuous inland strip may connect the two localities (see p. 161), though if so, it lies nearer the axis of the syncline at Port Jack than at Clay Head.

The low-water rocks on the broad foreshore of Douglas Bay [SC 38945 76677] (6-inch (Sheet 13)) are for the most part greatly obscured by seaweed. They consist of Lonan Flags, rather slaty in places but with occasional gritty bands, much folded, with a general dip at high angles south-eastward up to the centre of the Bay and then north-westward, the synclinal trough crossing the shore again in the southern part of the Bay, between Conister Rock [SC 38856 75546] and the mainland. The pitch of the folds, where it can be observed, is southwestward. It is probable that a thin covering of drift may rest on the solid rocks in some parts of the inner curve of the Bay, where the beach is covered with sand and shingle, as the slope in the southern part of the town is drift-covered to its base. There is a curious gap in the low-water scars opposite Broadway [SC 38574 76221], which may mark a preglacial channel (see p. 446).

At the northern extremity of the Bay a 'greenstone' dyke, 10 feet or more in width, traverses the foreshore to the eastward of Derby Castle [SC 39752 77312]; and what is probably another segment of the same strikes into the cliff behind the Electric Power Station. A smaller dyke of similar character is seen in the stone-quarries behind the houses at the bottom of Burntmill Hill; another, or the same, is visible near the mouth of the little ravine of Glen Crutchery [SC 38821 78167]; while other thin segments occur in the rock-face behind Mona Cliff House (of 6-inch map); in the grounds of Falcon; and in a few places on the shores of the Bay in this vicinity. A porphyritic basic dyke, 2 or 3 feet wide, which strikes north-westward across the shore 300 yards west of Derby Castle, appears to be of the 'newer 'greenstone' type, but its relations are ill-defined.

Near this place the discovery of pieces of graphite on the shore has led to the driving of an adit northward into the cliff 200 yards west of Derby Castle [SC 39479 77343], and it is said that a lode has been encountered which carries a small quantity of gold (see p. 548).

Southern side of Douglas Bay

On the southern side of the Bay the insulated Conister Rock [SC 38864 75538]furnishes good examples of the smaller greenstone intrusions, and shows the manner in which they are cut and displaced by minor faults. Similar dykes are seen both outside and inside the harbour in the rocks on which the New Pier is built; and again, on the opposite side of the Harbour, in the quarry on the hillside due south of the new Swing-Bridge. The extensive quarries [SC 38271 75036] which break the lower slopes of the hill in this quarter have supplied most of the building stone for Douglas. They are in slaty flags with some gritty bands, dipping W.N.W. at angles usually between 65° and 80°. Higher up the hill are the ruins of an abortive mining trial for lead (p 544.)

Douglas Head

On Douglas Head outside the harbour, a 6-ft. 'greenstone' is visible on the foreshore 30 yards east of the outer Pier [SC 38934 74970]. Close by, and possibly associated with it, there is a curious pale seam, an inch thick, among the Flags, like those noticed at Contrary Head and Dalby Point (p. 148).

Under the lighthouse [SC 39053 74734] the trough of a fold pitching N.E. is well exposed. It is interrupted by a line of fracture and crushing which can be traced in the face of the cliff south-westward for 700 or 800 yards. There are two broken greenstone dykes at the base of the section 80 to 110 yards S. of the Lighthouse; another below high-water mark at Fiddler's Green [SC 38538 74219] (6-inch map (Sheet 13)) 500 yards farther S.W.; two in the tramway cutting on the crest of the cliff between this point and Pigeon Stream: another in the rock-walls on both sides of Slack Indigo; and others on the coast and in the tramway cuttings farther westward.

An intrusion, 5 feet wide, of different type, occurs 200 yards W. of Slack Indigo [SC 37886 73963] (five-sixths of a mile from Douglas Head Lighthouse). It strikes N.W. up the face of the cliff, and is again revealed, in the condition of weathered ferruginous spheroids, in the tramway cutting above. Its field-characters suggest that it might be classed with the olivine-dolerite group, but its petrographical examination has thrown doubt on this correlation (see p. 329). In the cliff-section, a segment of this dyke, 8 feet in length is displaced 10 feet to the northward between two small parallel slides.

Little Ness

[SC 37087 73409]. At Port Walberry there are indications of a north and south fault of some importance, with a downthrow eastward. On the westward side, dykes make their appearance in increased numbers. One of these, 10 to 15 feet wide, is more or less continuous for about 200 yards, between Horse Leap [SC 36921 73332] and Purt ny Coan [SC 36694 73064], and an intrusion of similar aspect is seen at low water in the outer rocks of Little Ness. Some of the dykes on Little Ness [SC 36607 72875] seem to belong to the 'newer greenstone' group; but it must be acknowledged that while the differences between extreme examples of the older and the newer set are strongly marked, there are many individual dykes of intermediate character which one hesitates whether to assign to the one set or to the other.

On the extremity of Little Ness [SC 36610 72809] two threads of olivine-dolerite, respectively 3 inches and 3 to 4 inches in thickness, traverse the Flags. Other threads or the continuation of the last, 6 inches thick, are seen in the cliff on the western side of the Ness, 300 yards farther N.W. It is probable that these are fliers from a broader dyke of the same kind, though none such has been actually observed in the vicinity.

The westerly trend of the coast-line brings the Douglas Bay syncline once more into the cliffs at The Whing [SC 36025 73244], 700 yards west of Little Ness, where, owing to the distortion of vertical folds, the dip of the flags swings to and fro between the top of the precipice and the bottom, as shown in (Figure 40)

Port Soderick

[SC 34710 73022]. In the next recess and on the coast westward the general inclination is towards S.S.E., at an angle usually exceeding 60°. In the rocky spur of Coolebegad some thick bands of pebbly grit and quartz-veined quartzite make their appearance, amid confused faulting and partial brecciation of the adjacent flags. They probably represent the northerly extension of the rocks of Santon (St. Anne's) Head (see p. 46 and p. 184). They are seen again at low water on the opposite side of the Keristal inlet, and pass obscurely amid faults, into the cliff of the eastern shoulder of Port Soderick. The small 'greenstones' of this part of the coast are too numerous for detailed notice. In the centre of Port Soderick an olivine dolerite intrusion, only about 4 inches thick, strikes north-westward across a foreshore composed of contorted strongly banded flags which dip towards S.E. at about 35°.

We have now reached the southern edge of 6-inch (Sheet 13), the limit adopted for the Central division of the Island: the more southerly portion of the eastern coast will be described on subsequent pages (pp.182–4),

and we will now discuss the interior of the Central division.

Interior of the Central Division

(6-inch Sheets 9, 10, 11, 12 and 13.)

Interior north-west Peel

The description of the area bordering the west coast north of Peel (N.W. portion of <u>(Sheet 9)</u>), supposed to be underlain by the Peel Sandstone, will be found in Chapters 4 and 9 (p. 277 and p. 457). To the eastward of this tract the Slate Series rises up in a range of steep slopes suggestive of an ancient sea-margin. The crest of the slope, from Knocksharry [SC 27604 85784] south ward to Poortown [SC 26812 83150], seems from the debris in the soil to be occupied chiefly by thick-bedded quartz-veined grits, which are however actually seen only in a few places, in the corners of fields between Lhergydho [SC 27315 85099] and Rockmount [SC 27580 83086]. The grits are flanked on both sides by variable banded flaggy slates of the usual 'unseparated' type. Except for the intervention of another thin strip of grit, unsatisfactorily exposed around Ballavaish [SC 28729 84561] and Staarvey [SC 28242 84261] these slates extend eastward up to the belt of Barrule Slate through which the Neb has carved its canon-like valley. An isolated hillock of banded slate with gritty intercalations rises above the low drift-plateau to the westward of the railway near Peel Road Station, like an outstanding Stack of the old shore.

The chief interest of the district centres in the size and variety of its igneous intrusions. At Lhergydho (near the northern margin of (Sheet 9)), a quarry has been opened by the side of the road [SC 27469 85023] adjoining the farm in a mass of altered grit-like rock whose igneous origin was only recognised after careful petrographical examination of selected fragments (see p. 317). It seems to be a microgranite, but different from either the Dhoon or Foxdale types. As most of the ground in the district had, however, been surveyed before the true character of this rock was discovered, it is possible that slight outcrops in other places may have been overlooked or mistaken for grits. The intrusion appears to strike N.N.E. across the road, but its boundaries are obscure. It is probably older than the above-mentioned granites (see p. 319).

Poortown

[SC 26812 83150]. A mile farther south, we encounter the largest basic intrusion of the Island. Where best exposed, in a large quarry on the north side of the high-road at Poortown, 1/4 mile east of Peel Road Station, this is a handsome dark-green porphyritic rock crowded with augite crystals, which has attracted the attention of many previous observers (see p. 304). Two hundred yards farther east, in smaller quarries on both sides of the road, much finer-grained material is revealed, in contact with baked splintery flags; and this material has been considered, on petrographical grounds, to be a separate and newer intrusion<ref>seeB. Hobson, Quart. Journ. Geol. Soc., vol. xlvii., p. 449.</ref>, but the field-evidence is more favourable to the view that it is simply the more quickly cooled margin of the coarser mass. The igneous rock may be traced E.N.E. across the fields, by ploughed-up fragments and by small openings made for fencing material, in a belt 100 to 200 yards wide, extending for 700 yards from the guarries to within a short distance of the road to Lhergydho, 250 yards N. of Rockmount farm; and wherever seen it is fine at the margin and coarse in the interior as in the exposures in the guarries. Its extension northward from Poortown (see one-inch map) is somewhat problematical, the only evidence being the presence of rock-fragments in the ploughed fields, which cannot be explained by glacial agency. The westerly boundary of the intrusion is obscured by drift, but the coarsely crystalline character of the rock where last seen in this guarter indicates that it may once have extended for some distance farther, though now probably truncated by the prolongation of the eastern boundary-fault of the Peel Sandstone. Its easterly boundary is also obscure, and may be dependent upon another north and south fault, perhaps a branch of the above-mentioned, since in the road-cutting 300 yards S.S.E. of Rockmount the slates are shattered and decomposed as if by a line of dislocation; some pinkish ashy-looking felspathic bands in this cutting deserve remark, though too decomposed to yield much information. In its original shape the intrusion was probably a lens-like sheet inclining north-westward. There can be little doubt that the mass is connected with a chain of smaller intrusive bosses of nearly similar composition which ranges from N.N.E. to S.S.W. in this part of the Island. To the northward we find scattered links of this chain in some low slightly quarried outcrops, extending for about 100 yards, in the fields 600 yards N.N.E. of Ballavaish Moar (near the northern edge of (Sheet 9)) and in the exposures at Cronk y Voddee previously described (p. 137). The southerly prolongation of the chain, south of the Neb, will be subsequently noted.

A small quarry in a field 150 yards west of the road rather over half a mile north of Staarvey reveals a characterless rock which, if not a weathered grit may allied to that of Lhergydho. To the eastward of Glen Helen, of pale rock of felsitic aspect, almost certainly of igneous origin, are exposed close by the farmstead of Eairy Moar [SC 30268 84094], and in a small quarry 400 yards farther due S., just within the mountain-fence enclosing Beary Pairk [SC 30157 83665].

Basin of the Neb north of St. John's

[SC 28442 82448]. The Neb has no doubt at one time reached the central valley through the dry gap at Ballacraine [SC 28626 81779], where the high-road turns off to the northward. By the present westward deflection of the river at Ballig [SC 28513 82444], Cronk Grianagh [SC 28513 82444], a rocky hillock of Barrule Slate, is left between the old and new valleys, like Cronk Sumark at Sulby, to guard the entrance of the Glen. Above the bend, in the part of the valley known as Glen Moar [SC 28645 82739], we find good exposures of Barrule Slate in some extensive slate-trials on the western slope, while the eastern hill-side is drift-covered for more than a mile. In the crags to the westward of the approach to Glen Helen a small greenstone dyke is visible [SC 29408 84184]. The bottom of the valley in this and the higher portion of its course begins to show the banded unseparated rocks in places; and above the much visited waterfall of Rhenas [SC 30772 84668] (western edge of (Sheet 10)) the stream flows over striped rather sandy flags, with a general N.W. dip, resembling the more slaty portion of the Lonan Flags; but a mile farther up it again enters the Barrule Slates. Above Glen Helen [SC 30941 84739] the river receives no feeders on its western side, but on its eastern is joined by four important tributaries flowing W.N.W. in regular parallel courses. The beds of these streams for the most part show bare rock, and they afford practically the only opportunity for studying the upper basin of the river, the intervening moorland ridges being mostly drift-covered. In going eastward up Blabae River [SC 31265 84461] the more southerly of these streams, we continue for 500 yards on the striped slaty flags; then cross a belt of dull black welded slate 300 yards wide, perhaps a subsidiary infold of the Barrule Slate; then striped flags again for 300 to 400 yards; then flaggy grits, somewhat massive, with thick partings of slate; and finally striped flaggy slates once more; but n no case are the boundaries of these divisions well defined.

The same sequence is repeated in the next stream to the northward, which flows past Ballashimmin [SC 31873 85042]. This, however, reaches back farther east than the last, into a higher belt of grits; and then into the crush-conglomerate

described in the last chapter (p. 58). In the next two glens, Glion Gill [SC 32532 85779] and Rhenas River [SC 32408 86320], the exposures are not sufficiently continuous to reveal the succession. In all the streams, while the general dip is N.W. or W.N.W., local reversals to the opposite quarter are occasionally found, especially in the gritty rocks. This belt of 'unseparated' rocks seems to represent the prolongation of the beds forming the Sartfell and Slieau Curn ridge [SC 34062 88409]; and, as in that area, igneous intrusions, at any rate in a form recognizable as such, are of rare occurrence.

Hills between the basins of The Neb and Glass Rivers

Rocks of the same general character occupy the hills bordering the basin on the eastward, including Slieau Maggle [SC 34492 85924], Colden Mountain [SC 34347 84331], Lhargee Ruy [SC 33202 83232], Slieau Ruy[SC 32847 82404] and the greater part of Greeba Mountain [SC 31903 81674] (Sheets 7 and 10); and extend over the watershed to the heads of the streams draining into the River Glass, up to the principal belt of Barrule Slate on Beinn-y-Phott [SC 38117 86067], Garraghan [SC 36822 84892], and Creg Awhallan [SC 35290 83686]. On crossing this watershed, however, we come within the range of the intrusions which were conspicuous in the Crammag and Lhergyrhenny tributaries of the Sulby River (pp.138–9). These are well exposed in the bed of Injebreck River [SC 35070 85077], a feeder of the Glass, where examples of the Foxdale microgranites and of the altered greenstones are visible at several points, from 200 to 900 yards W. of the hotel. Fast and north-east of Injebreck, also, in the upper reaches of the Glass, small outcrops of altered actinolitic basic dykes are seen 60 yards below the old lead trial and 200 yards above it, and more extensive exposures in the banks of the side glen leading off to the eastward, 700 yards above the mine. At the head of the last-named little glen, there is a seam of soft clayey material which is probably a decomposed dyke; and another similar band occurs in the north fork of Colden River, where there are indications that the original rock was a microgranite. Other intrusions of the 'greenstones' were observed in the upper part of the crags of Garraghan overlooking the Glass Valley; in the bed of Colden River, 20 yards below the bridge of the mountain-road; in The Creg [SC 34736 83202], 400 yards S.W. of the old slate guarries, and on the rocky slope 300 yards farther W., above Awin ny Darragh ' in Braid ny Scarrag, at the head of the Awin; on the crest of Lhargee Ruy, 800 yards S. of the junction of the boundaries of the parishes of Braddan, Michael, and German on the Slieau Ruy, at points 150 and 250 yards N.E., and 450 yards W. of the summit; and on Greeba, 50 yards S., and again 250 yards E. of the cairn.

Exposures of the microgranite or elvan type occur at intervals throughout the same range, again in such manner as to suggest that most of the outcrops may represent the displaced segments of a single dyke. Coming S.W from the above described example in Injebreck River, we find the proximity of an elvan indicated by debris at the roadside, 800 yards due E. of the summit of Colden [SC 34931 84334] (at "Sheepfold" of 6-inch (Sheet 10)). The same kind of rock, 10 to 20 feet thick is visible at the source of the south fork of Golden River [SC 34769 83772]; and again, 600 yards farther to S.W., on the other side of the moorland ridge, at the head of a gully draining into Awin ny Darragh [SC 34141 83366]?. The next exposure is a mile distant, on the very summit of Slieau Ruy [SC 32829 82400], where the elvan is full of vein-quartz and is highly sheared, though not so greatly altered as farther south. A broad vein of quartz crops out on the hillside, 100 to 200 yards to the eastward, and there appear to be extraordinary complications in its vicinity, but the rock-exposures are scanty. Two hundred yards to the westward of the summit there is so much microgranite rubble in the old moorland path that we cannot doubt the presence of the elvan at this spot, though it lies quite out of the line of strike of the last exposure. On Greeba Mountain, 800 yards S.W. of the top of Slieau Ruy [SC 32167 82001], we can trace the elvan for some distance on the crest of the western slope of Braid ny Boshen. It is here from 15 to 20 feet thick, and has been crushed in places into a platy schist. Interesting mineralogical changes, including the development of secondary garnet and chloritoid, which appear to be due to the crushing (seep. 318), may be observed in it in this neighbourhood, especially in the strip which forms low crags 500 to 600 yards farther south, or about 150 yards S.S.E. of the cairn on the summit of Greeba [SC 31883 81529]. Farther southward on the mountain no exposures of the intrusion have been detected.

The mode of occurrence of the bands of Barrule Slate on both sides of Greeba Mountain have been sufficiently described in the previous chapter (pp. 51–2); as also the presence of a wedge of grits near Ballagaraghan [SC 29197 81525], between Greeba and St. Johns (p. 49).

Slopes north of Crosby

Continuing eastward on the same parallel, north of the central valley (six-inch (Sheet 10)), we cross the structural axis where the sloping ground near that valley is chiefly drift-covered, with scanty rock exposures at intervals. Sandy flags, dipping E.S.E., are seen in a quarry at Crosby 150 yards N. of the main road [SC 32659 79669]; and in a few places in the drainage channels on the slope north of the village; and again in the little gully 150 yards east of the church; and in a similar channel crossed by the high road, rather over half a mile farther east. The slope has been strewn in many places with large boulders of beautiful actinolitic greenstone and microgranite, which are now built into the fences; but it remains uncertain whether these denote concealed outcrops in the neighbourhood or have been transported across the intervening ridge from the Baldwin basin by glacial agency (see p. 454)

On the crest of the slope, where there are several craggy outcrops of the sandy flags, a tough altered 'greenstone', 10 feet wide, which would furnish useful road metal, is exposed on Cronk Breac 150 yards N.W. of Braid [SC 33681 81083], along with a second dyke, 6 feet wide, of similar material greatly sheared, 180 yards farther to N.W.

Valley of the Glass

In descending into the valley of the Glass or West Baldwin, above its junction with the Baldwin or East Baldwin stream, we cross the most southerly recognisable outcrop of the Agneash Grits on the steep slope north of Mount Rule [SC 35551 79365] (see p. 41). At the right-angled bend of the river north-west of this exposure we pass onto striped greyish sandy rocks with occasional grit bands, left as unseparated on the map, but much resembling the Lonan Flags; and the same type continues to predominate nearly up to Injebreck [SC 35621 84822], so far as one can judge from the places not covered by the drift and alluvium with which the valley is encumbered. The same conditions are also found in the lower portion of Awin ny Darragh.

At Ballachrink [SC 35181 80422], in the little ravine of a small feeder, 50 yards west of the main stream, a broad elvan of the Foxdale type, seemingly the prolongation of the great Crosby dyke (p. 168), is revealed; and is repeated in the same gully 80 yards farther westward a little below the high road; and again where bare rock is exposed at the farmstead just above the road. In the main glen three-quarters of a mile farther up-stream, 500 yards N. of the junction with the Darragh [SC 35486 81624] at Baldwin, a much crushed mass of pale felsitic rock occurs in the river-bed, but the identity of this material with the elvan has not been established.

Two smaller dykes of a more bathe type are visible in the stream within 100 yards north of this place; and above this there is little to see in the valley except drift and alluvium until we reach Injebreck [SC 35579 84746]. The old lead trial on the east bank at Baldwin is described at p. 543.

On the cultivated ridge between West and East Baldwin the only notable outcrop of solid rock is on Cronk y Keeill Abbain [SC 35579 84746], the site of the old Tynwald, north of St. Luke's Church. A small quarry 300 yards N. by E. of the Church [SC 36085 82522] is opened in dark blue spotted altered slate; while on the steep brow to the westward a crush-conglomerate of sandy slate is sparingly exhibited, and also a greenstone dyke, about 8 feet in width.

Valley of the Baldwin

The parallel valley of East Baldwin contains little that is noteworthy until we gain its upper reaches. As a rule the country-rock is more gritty than in the sister-stream, and above Adderry [SC 37138 82690] and in the Creg-y-cowin tributary [SC 37803 83787] quartz-veined grit-bands of the Agneash type are frequently exposed, with their slaty partings often speckled with secondary minerals and frilled with intersecting cleavages. The prevalent dip, as in West Baldwin, is usually to N.W. or W.N.W., but the beds are often nearly vertical. At Ballawyllin [SC 36646 82272] the dismantled "Ohio Mine" (see p. 543) adds one more to the list of abortive searches for lead in the central part of the Island.

Along the western edge of the Agneash Grits the metamorphism both of the country rock and of the basic intrusions reaches its maximum. Small highly altered greenstones are exhibited in three places in the bed of the main stream near the Dhoon farmstead [SC 37769 84429]; and again in the gully of the little feeders north and south of this place; and in Glion Feeagh [SC 37797 85010], the west branch of Baldwin River, 500 yards north of Dhoon. In the east branch similar outcrops are seen, 300 [SC 38102 84929], 400 and 800 yards above the fork, the last being distant only 200 yards from the exposure on the lower slope of Beinn y-Phott to which attention has already been called (p. 139).

Eastern rim of the Baldwin Basin

The high ground forming the watershed between the Baldwin and theLaxey basins in <u>(Sheet 10)</u> south of Mullagh Ouyr, including Carn Gerjoil(1,430 feet) and Slieau See (1036 feet), is mainly composed of the highly contorted quartz-veined Agneash Grits, in which we find a prevalent tendency of the bedding towards W.N.W., but with numerous local modifications. Except on Carn Gerjoil [SC 39281 84076] and Gob y Creggagh three quarters of a mile farther west, the exposures are not extensive; but there is no lack of minor outcrops. A small 'greenstone' intrusion is visible in one of these patches of bare rock, 1150 yards north of Balliargey. The south-eastern flank of the ridge is drained by the Abbey Lands or Little Sulby River. The sandy and slaty flags over which this stream flows are conterminous eastward with the Lonan Flags of the coast, and are shown on the one-inch map as part of that division. It must be acknowledged, however, that there is little or no difference to be noted between them and the 'unseparated' rocks of the West Baldwin valley (see p. 3n). The lower part of the stream nearly coincides with a sharp synclinal trough in the flags. In its higher portion the common direction of dip is to N.W. or W.N.W. at high angles; but the inclination of the cleavage is in the reverse direction, or toward E. or E.S.E., as usual on the eastern side of the central axis. In the rising ground between this stream and Groudle River wherever the flags are exposed, as at Gob-na-geay, Glendhoo, Cronk-ny-mona, etc., both their bedding and cleavage planes dip south-eastward.

Glen Roy and feeders

The deep hollow between Carn Gerjoil [SC 39281 84076] and Mullagh Ouyr [SC 39139 84528] is drained by a number of small streams which unite and flow into Glen Roy a mileabove Laxey. Above their union the beds of these strums usually reveal gritty flags, which though mapped with the Agneash Grits might with almost equal reason have been placed with the Lonan Flags, their smoothly waterworn and often moss-covered surfaces scarcely affording adequate evidence for discrimination between gritty flags and flaggy grits. The prevalent dips are towards N.W. or W.N.W.; but between the union of the rivulets at Ballachoan [SC 41052 84280] and the junction, a half-mile below [SC 41155 84354], of their combined stream with Glen Roy, the inclination of the greatly crushed and welded flags swings round to the exceptional direction of W.S.W., indicating'a westerly pitch of the composite folds of the central axis in this neighbourhood. Some traces of basic igneous intrusions may be detected in this quarter, but they are so crushed and altered as to be scarcely recognisable in the insufficient outcrops.

Better exposures of the dyke-rocks, including the Dhoon microgranite elvans, are found nearer the headwaters of the individual streams. In the most easterly of the streams these are visible in four places, in a distance of 400 yards between the head of the west fork and Close Mooar. A broadish dyke of tough 'greenstone' is revealed in the same stream, 250 yards due S. of Close Mooar [SC 41014 85263]. Other exposures of microgranite occur in the gutter descending from the col between Carn Gerjoil [SC 39165 84526] and Mullagh Ouyr, 200 to 400 yards east of the Douglas and Snaefell high road [SC 39400 84552]; and on the same hillside one-third of a mile farther east, at the corner of the fence of an old enclosure, 100 yards below the cross road to Laxey. These are the most southerly localities at which the elvans of this group have been recognised with certainty. If continued along the same strike they should be found in the same district as the Foxdale elvans in the Baldwin basin, but they have not yet been recognized there. Their discovery in this area might afford data for determining the relative age of the two granites (see p. 312); and a careful re-examination of the Baldwin valley with this point in view might possibly be successful, as dykes were observed in that locality, the relations of which have not seen definitely established (see *ante* p. 159).

In the upper part of Glen Roy only two or three small dykes of greenstone were noticed. A small quarry behind the buildings of the old mine [SC 41061 83460] (p. 529) exhibits an intrusion of greenstone 15 feet or more in width, and large blocks of the same rock are scattered on the steep hillside S.W. of this place. Below the mine the sedimentary rocks resemble in character and complexity of structure those already described in the lower part of the tributary glen. Four small greenstone dykes were observed below the junction of the valleys, at the distances, respectively, of 500, 900, 1,200 and 1,750 yards above the main-road bridge in Laxey village [SC 42418 84144].

District S.E. of Glen Roy

The watershed south of Glen Roy (Sheets 10 and 11) coincides roughly for some distance with the parish boundary between Lonan and Onchan.

It consists of a moorland ridge occupied by the weathered Lonan Flags generally thinly covered with rubble and wash, but with frequent exposures of bare rock. It is curiously channelled in places by transverse hollows excavated in the rock, probably by streams from the waning ice-sheet (see p. 363). On Slieau Meayl [SC 39863 82552], the westerly part of this ridge, there is a rather good exposure of an altered dioritic greenstone, about 10 feet wide, in the low crags a few yards beyond the mountain-fence 800 yards N.E. of the Craig-ny-Baa Inn [SC 39280 81918] on the Snaefell road, which may represent the same intrusion as that above-described at the Glen Roy Mine [SC 41061 83460]. Traces of other smaller greenstone dykes were observed farther east, on the moorland N. and N.E. of Injaign and in the old road down the ridge between Cooil Roi [SC 41733 80981] and Barroose [SC 42114 81369].

There are indications that in the neighbourhood of Caunrhenny [SC 41141 81699] ((Sheet 11)) one-third of a mile N.E. of Ennemona [SC 40681 81225], the outcrop of a more important intrusion, of somewhat unusual type, may be concealed by the thin drift and rubble. Blocks of a pinkish micaceous rock, perhaps a mica-trap like that of Port Groudle [SC 42071 78214], are common in the fences; while the soil in the cultivated land 120 to 200 yards duo S. of the farmstead is full of similar rubble which can scarcely have been derived from the glacial deposits of the neighbourhood, and probably denotes a subjacent outcrop.

Groudle River

The bed of Groudle River and that of its parallel tributary, the Ballacottier River [SC 39621 79851], lie entirely within the Lonan Flags. There is much drift in the upper part of the basin, but below the junction of the streams the valley-slopes are chiefly of rock. The prevalent dips in both streams, northward of Clypse [SC 39817 80675], are steeply north-westward; but from their junction to the sea the general inclination is equally steeply in the opposite direction, the beds being nearly vertically folded in a few exposures in the intervening belt. Two small greenstone dykes were noticed on the N.E. side of the valley, ½ mile above White Bridgewhere the main road from Douglas to Laxey crosses the stream.

The picturesque gully cut deeply in solid rock, in which a feeder from the north joins the main stream in the enclosed pleasure-ground near Groudle Tramway Station [SC 41769 77797], is a typical Manx post-glacial ravine. It might be made to afford a rough measure of the time which has elapsed since the disappearance of the ice-sheet. In the bed of this feeder, A mile above the junction, and in the adjacent tramway cutting there is an exposure of massive quartz-veined grits like those of the north side of Clay Head (p. 152); and the same belt appears to be continuous in the opposite direction, as shown on the map, to Port Jack (p. 153).

A peculiar dyke, unfortunately much decomposed, is exhibited in a cutting at Garwick 1½ miles farther north, just before the tramline crosses Glen Gawne [SC 42837 81723]; it consists of a pale yellowish-grey felsitic rock speckled with the short rods of a secondary chlorite (p. 317).

On Banks Howe [SC 41586 77976] ((Sheet 10) the cuttings of the same line reveal excellent sections of the Lonan Flags, with the rock-surfaces scored in many places by glacial stria. The intrusive mica-diorite of this locality has already been described (p. 152).

Lower part of the Glass valley

In the lower part of the valley of the Glass, in the neighbourhood of Tromode [SC 37151 77694] (Sheet 13), a thick mass of till has blocked the old channel in glacial times; and during re excavation, the stream has for a time missed its former hollow, and notched a new ravine for itself in the solid rock of the western bank 400 yards above Tromode Mills [SC 37203 78207]. Afterwards, erosion at this point not having kept pace with that in the drift-filled channel above and below, the river recovered its old course and abandoned the gap, leaving a steep isolated hillock of rock between its former bed and its present channel. As in several similar instances in the Island, this hillock was converted into a rude fort by the ancient inhabitants.

On the opposite or eastern side of the valley there is another dry channel of higher level and older date, probably dating back to the close of the Glacial period; this makes a larger loop under Ballanard and rejoins the present valley at Tromode.

In the striped flaggy slate immediately to the northward of the bridge at Tromode [SC 37185 77710], a small weathered basic dyke is exposed. Four hundred yards south of the bridge [SC 37231 77337], a little below the lodge of Cronkbourne House, a much broader intrusion is visible in the bed of the stream; though so much decomposed that most of its characteristics are lost, this probably belongs to the diorite group.

Another small greenstone dyke is revealed in the low outcrop of slaty flags where the stream impinges upon the base of the steep slope at the southern border of the alluvial flat opposite Purt-ny-shee.

The sloping ground above the valley on either side is smoothly drift-covered and under cultivation, with only a few isolated artificial rock exposures which need no comment.

The remaining portion of our central division lies to the southward of the Peel and Douglas valley, and this tract will be next described, commencing as before, in the west and working eastward.

Hills south of Peel

The hilly ridge of Niarbyl Flags bordering the coast south of Peel is simply the extension of the rocks seen in the cliffs (p. 146), and needs no further description. An excavation has been made into the west bank of the Neb, at the foot of the inland slope of Peel Hill a quarter of a mile south of Peel Railway Station, to obtain decomposed slate for brick-making. This material is covered by a variable thickness of rubbly drift; its rotten condition may be due to ordinary weathering, but is more probably connected with crushing or faulting alone the margin of the Flags. The interesting exposures of red conglomerate in and adjacent to the river-bed near Glenfaba Mills are described in Chapter 6., p. 278.

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Between these Niarbyl Flags and the Barrule Slates of Slieau Whuallian and Arrysey Hill we find a belt of 'unseparated' palish blue striped slates, phyllites, etc., like those of the coast south of the Niarbyl, with an apparent dip towards N.N.W. Associated with these rocks are many crushed lenses of basic igneous material, which occur in the same zone of intrusion and are similar in composition to the Poortown diabase, though differing from it in being usually highly sheared and less coarsely crystalline.

The chief outcrops of these intrusions are found on the steep slopes southward of Barnell [SC 24817 81839] and Ballacosnahan [SC 25343 81665] (Sheet 9), and appear to denote the existence either of a number of independent bosses or of a single mass broken up into disconnected blocks, the exposures as shown in the above reproduction of the six-inch field-map, being insufficient to determine the point.

The shearing of these bosses has, in some instances, produced a platy schist around their edges; while in others —for example, in a small quarry behind the farmyard of Ballacosnahan [SC 25392 81722] — the whole mass has become schistose by the development of shear-planes parallel to the cleavage of the surrounding rocks. Smaller dykes of similar composition and structure occur in several places east of the localities shown in the above plan, as for instance, in the old slate trial on the N, slope of Slieau Whuallian, yards south of the highroad at Glenaspet [SC 26652 81545], where two bands of greenstone-schist respectively about 4 and 6 feet in thickness are exposed.

The slopes between Ballacosnahan [SC 25302 81792] and Glen Meay [SC 23646 79691] are enclosed and cultivated, and although the rock is usually near the surface the actual out crops are few and limited. Indications of the intrusions may however be observed in two parallel roads 400 and 550 yards south of the more northerly houses of Rheabybeg, and in the bed of the gully draining thence westward to Rheabymoar [SC 23584 80184]. On the opposite or south side of Glen Meay, along the same strike, a mass of similar material of considerable thickness is just visible in an old quarry on the hillside above Ballachrink, 150 yards S.E. of the farmstead; and again a 'sheared camptonite' (p. 308) may be seen in the bottom of Ballelby Glen 600 yards east of the highroad (Sheet 12) [SC 22663 78560]. On the hill-top, mile farther

east, there is an outcrop of 'greenstone' in a field 150 yards east of Magherbane [SC 23333 78591]; while a little to the southward of Dalby other examples occur in the field-road leading up the hillside opposite Ballacain [SC 21819 78211], and in a little quarry by the side of the main road 300 yards farther south, behind an old cottage. The last-mentioned instance may however be of a different type from the others. In several other places, particularly in the upper part of Glen Meay, small dykes of obscure character were observed, but scarcely require special notice.

Andesitic breccia near Dalby

The small outcrop of andesitic breccia at Ballnalargy or Ballaquane, half a mile N.E. of Dalby Church, is especially interesting as furnishing the only known occurrence of true volcanic material in association with the Manx Slates (see *ante,* p. 38 and *post,* p. 323). The rock was first noticed, in the occupation road which adjoins the rivulet opposite Ballaquane farm stead [SC 22396 79182], 150 yards east of the highroad, and was then traced into the neighbouring field on the west, where it breaks above the surface near the ruins of a cottage, and has been recently better shown in a shallow excavation for stone. It seems to extend at least as far as the north-west corner of another field 100 yards south of the old cottage, but the scanty outcrops fail to reveal its further course, or its relation to the adjacent flags. There are some rather extensive rock exposures in Ballelby Glen, only 300 yards farther southward [SC 22479 78631]; but neither here nor in any other part of the district has the breccia been recognised. It unfortunately happened, however, that the survey of the Island had been completed before the true character of the rock was established, by the microscopic examination of fresh specimens from the above-mentioned excavation, so that there is a possibility of small outcrops having been overlooked which would now be recognised. Further search for it in Ballelby Glen and Glen Meay might prove more successful.

Glen Rushen

[SC 24212 76964]. The chief physiographical features of the Glen Rushen drainage system have already been discussed (p. 10). The precipitous walls of the ravine by which the river escapes to the sea at Glen Meay are composed of Niarbyl Flags. As previously stated (p. 148) a conglomerate is mentioned by Harkness and Nicholson as occurring in the "Skiddaw Slates" of this locality; but the only conglomerate now visible here is a fault-breccia in the southern wall of the ravine a little below the ruins of an old lead trial. A small outcrop of brecciated rock in the same bank above the mine, under the farmstead of Ballacrink [SC 23780 79460], which was at first thought to resemble the andesitic breccia above described, also proved, on microscopic examination, to be made up of crushed sedimentary material. Farther eastward, in the fine valley by which the stream crosses the outer belt of Barrule Slates, broad segregation veins of quartz are conspicuous. These have been dragged apart into discontinuous segments, after the manner of the intrusive dykes, their interrupted courses usually following the general strike of the country-rock. Determined attempts have been made to win roofing slate in this valley, and the slopes are deeply scored, especially on the S.W. side, by old quarries (see pp. 560 1). In following up the stream, we leave the Barrule Slates at the great bend above the quarries, the valley-floor above the bend consisting of slaty flags, changing gradually to flaggy grits which then continue nearly to the head waters.

The Barrule Slates meanwhile occupy the rounded ridge of Dalby Mountain [SC 23780 79460] on the west of the Glen, and also the elevated eastern and southern rim of the basin, forming the hill chain extending from Cronk ny Arrey Lhaa [SC 22426 74679], to South Barrule [SC 25772 75948]; and the manner in which the two belts converge at the higher levels toward the source of the stream suggests that they have formed a single mass overlying the flags and grits until separated by the erosion of Glen Rushen.

At Chleig-fheeiney [SC 23676 76472] (of 6-inch: Chleig Cheeiney of 1-inch map) there is a belt of massive coarse grit like that of the shore at Gob yn Ushtey [SC 21519 75653]; but usually the gritty flags of this valley bear more resemblance to the arenaceous portions of the Niarbyl Flags than to the quartz-veined grit of Agneash and of the south of the Island. N. to N.W. dips prevail throughout the valley.

The old mines on the eastern slopes of Glen Rushen [SC 24703 77733] were worked on the westward prolongation of the Foxdale lode and have yielded large quantities of silver-lead ore (see p. 504). In spite of numerous trials on the opposite slopes and on Dalby Mountain the lode has not been recovered among the Barrule Slates to the westward of the Glen; and it is noteworthy that there is no instance in the Island of the occurrence of profitable ore-bodies in this
division.

Foxdale Basin

[SC 27868 78116]. The chief belts of rock in Glen Rushen may be traced along their strike, over the ill-defined watershed, to the western side of Foxdale; but either because of the lbwer average level of the ground beyond, or perhaps from structural complications connected with the granitic intrusion, they cannot be followed with any certainty to the eastward of Foxdale.

In coming up this valley from St. Johns, we have the steep gable end of Slieau Whuallian on our right [SC 27555 81130], and a cultivated slope of much lower elevation on our left. A rocky hillock which breaks the latter slope opposite to Kennaa [SC 27834 80965] is composed of thick obscurely-folded bands of dark-bluish muddy pyritous grit with slaty partings, quarried for road-metal. These bands strike N.E. across the central valley and probably reappear on the opposite side in an old quarry 200 yards S.E. of Ballagaraghan [SC 29280 81351]?, and again in the bed of Greeba River. To the westward of Foxdale, however, they have not been identified Above Ballaoates [SC 28643 80202], two or three hundred yards farther up the slope, dark blue slates of Barrule type are exposed, and have been tested for roofing slate in a small trial. These slates also extend up to the central valley, occupying the hilltop at Kerrowgarroo (509 feet) [SC 29239 80187] [Kerrowgarrow?] and the lowermost part of Glion Darragh near Ballacurry [SC 29832 80598]. Though now interrupted by the central valley, they have probably been conterminous with the wedge which lies on the western slope of Greeba Mountain. Their extension in the opposite or south-westerly direction is more or less doubtful; but as shown on the one-inch map, there are rocks of this character in Foxdale around Ballanass, apparently wedging out rapidly westward. Some veins of quartz (with a little mica and chlorite) by which these slates are penetrated are of exceptional breadth; one example, 10 to 12 feet wide, has been quarried on the northern slope of Kerrowgarroo, 250 yards S. of the railway [SC 29378 80727].

To the southward of this tract of Pareule Slate there is an unsatisfactory area of 'unseparated' banded slaty rocks, broken by the Foxdale granite; and the same type extends thence, with minor variations, over the greater part of the interior south of the central valley and cast of the main hill-range of the Island.

Metamorphic area around Archllagan

In the Foxdale depression these rocks.do not show any greatly increased degree of alteration until they come into close proximity to the granite.

But on the higher ground to the eastward, around the heads of Glion Darragh (of <u>(Sheet 9)</u>; commonly known as Ballacurry Glen and Cooillingill [SC 30624 79358], and upon Archallagan hill [SC 29898 79026], although the visible outcrop of the granite is about a mile distant, the metamorphism is more excessive than in any other part of the Island, the slates being converted into garnetiferous mica-schists. These phenomena have already been discussed, in Chapter 3, pp.111–2, where the chief exposures of interest are indicated.

Upper part of Foxdale Basin

The western bank of the Foxdale stream opposite Ballamoore [SC 27706 79121] (Sheet 12), two-thirds of a mile north of Foxdale mines, reveals a 5 ft. dyke of microgranite, sheared to the condition of horny-looking schist; a similar exposure occurs on the opposite bank 400 yards farther up stream; and possibly a third, in an all but unrecognizable condition, 350 yards beyond. The rocks in these exposures differ in some respects from the usual Foxdale elvans (see p. 316); and it is possible that they may not be directly connected with the main mass of the Foxdale granite, but with the concealed intrusion which was encountered in the deeper levels of the old Cornelly or Townsend lead mine (marked 'Old Mines' on one-inch map) at the head of Glion Darragh [SC 29702 79485], 1¼ miles farther east (see p. 516). Two or three small elvans of similar character occurring in Glion Darragh may belong to the same group.

The exposures in the valley below the Foxdale mines are greatly obscured by the washing floors and spoil heaps; but the destruction of the natural sections is amply compensated by the artificial sections of the mines, which are elsewhere described (see pp. 504–12). In these mines the underground extension of the granite northward with a gradually shelving

surface is clearly demonstrated.

Foxdale Granite

The most northerly surface outcrop of the granite occurs in the bed of the stream 100 yards above the washing floors of the mine [SC 28160 77948]. Two hundred yards farther N. a short adit driven westward into the bank of the stream passes sharply from granite into slate through a crushed junction, perhaps a small fault, within ten feet from the entrance; and a few yards farther up the gully, a wedge of slate, traversed by an elvan, encroaches upon the granite, and occupies both banks of the stream. Hence we may conclude that the western hank of the hollow nearly coincides with the western boundary of the granite. Small quarries in the slate, combined with a natural section at a cascade in the stream close by, afford opportunities for studying the aforesaid elvan and the junction of the sedimentary rock with the granite. The slate is highly altered, but not to the same degree nor in the same manner as in the garnetiferous schists of the Archallagan track above described. Above the cascade the stream bed (Struan Barruleof six-inch map) is again composed of granite, but the solid rock is soon lost under a covering of rubbly wash and drift.

The main mass of the granite occupies the rounded hill to the eastward of the stream, named "Granite Mountain" [SC 28734 77208] on the ordnance maps, but known in the early part of the century, according to Henslow<ref>Trans. Geol. Soc., vol. v., p. 485.166 </ref>, as Slieau ny Clough (Clagh ?). The intrusion has a rudely oval outline, with the longer axis, five-sixths of a mile in length, extending E.-W. as in the Dhoon Granite, and its shorter diameter, quarter to half a mile, N.-S. Though its northern edge is nowhere actually visible, its position may usually be determined within a few yards by the character of the surface-rubble; and there is a small quarry in slate close to its margin, 600 yards E. of the stream. In this quarter a broad off-shoot of granite appears to strike N.W. into the slates, being slightly exposed by the roadside near the new cottages at the foot of the hill, and more clearly in the channel of the sluice 100 yards farther to N.W., having in the latter case a thickness of more than 20 feet. Following round the boundary south-eastward, we find a small opening, revealing much-altered slaty flags traversed by a thin elvan, close to the eastern margin of the granite 500 vards W. of Renshent [SC 29166 77027]. Then turning westward, we can follow only an approximate boundary across the boggy moorland north of Cloghwilly [SC 29274 76799] until we reach the top of the hill, where small outcrops are sufficiently numerous to allow the detail of the margin, with its fringe of apophyses, to be traced. Some old slate quarries on the western brow of the hill afford further opportunity for studying the alteration of the country rock adjacent to the intrusion. The edge of the granite 150 yards to the eastward of the larger quarry takes the form of a sloping plane, somewhat crushed and platy, and marked with slickensides, as though there had been a slight overthrusting of the slate upon it at this point.

Within its margin the granite presents many variations in texture, being seamed in places by thin bands of finer material resembling the elvans. This feature is referred to by Cumming, who seeks to explain it by supposing "a second elevation of the granitic mass, during which were injected into the cracks and fissures then formed those elvans or granitic veins which we find penetrating far into the schists round about this boss, three of which are cut through in the Foxdale mine".<ref>"Isle of Man" p. 175 and section on pl. I.</ref> But besides these veins of finer material, there are others of pegmatitic character, more coarsely crystalline than the surrounding mass. The granite is also traversed by gashes filled with quartz accompanied by small quantities of yellow mica and other minerals, which are considered by Harker to be of the nature of greisen<ref>A. Harker. Quart. Journ. Geol. Soc., vol. li., p. 143.</ref> (see p. 320). The more conspicuous of these quartz-veins have a N.N.W. strike; the largest, having a breadth of 10 to 15 feet, has been extensively quarried on the northern side of the hill 700 yards E. of Struan Barrule [SC 28799 77372]. Similar veins occur among the slates beyond the boundaries of the granite; a good example is exposed in a small quarry at Cloghwilly [SC 29277 76607] 300 yards S.E. of the S.E. corner of the granite. The petrographical description of the granite is given on p. 315.

Besides the main outcrop on Granite Mountain, a small outlier of the intrusion comes to the surface on the patch of moorland to the eastward of Renshent [SC 29945 77200], 500 yards E. of the edge of the principal mass. The intervening tract is occupied by slate which is exposed, in a much altered condition, in several places in the bed of the rivulet draining the eastern slope of Granite Mountain [SC 29496 77055]; and in Santon Burn [SC 29766 76984], the parallel stream, 200 to 300 yards farther east. The slate is of the striped flaggy description and its dominant planes (cleavage or bedding) in Santon Burn exhibit a somewhat unusual dip towards S.W. but swing round to S. and S.S.E. on passing away from the neighbourhood of the intrusion. The granite outlier is poorly exposed, and its actual boundaries are nowhere visible; but

its maximum dimensions seem to be about 300 by. 200 yards. It contains much vein-quartz, which is excavated in small quarries; the granite itself wherever seen is much decomposed, but similar in general characters to the main mass.

It is not clear whether this outlier represents the top of a boss rising up from the shelving surface of a concealed portion of the intrusion continuous underground with the mass to the westward, or whether it is a block which has been separated from the larger body by faulting, overthrusting or other effect of earth movement. The known inequalities of the surface of the granite as revealed in the shafts of the Foxdale mines favour the first supposition; while the absence of granite in the East Foxdale mine only 350 yards N. of the outlier [SC 30067 77737] (see p. 514), and from the other workings between this place and Foxdale (p. 513), along with the indications of disturbance in the belt of slate separating the outlier from the main outcrop give colour to the second view. Prior to the examination of the ground by the Survey the isolated character of this patch of granite does not appear to have been noticed.

Foxdale elvans south and west of the granite

Unlike the dykes from the Dhoon Granite, the chief elvans of the Foxdale type cannot be traced directly into the intrusion, but strike past it among the slates some distance to the southward; while those apophyses which are seen to spring from the margin of the intrusion appear all to die out within a short distance of their source. It is noteworthy, too, that although the granite has been proved in the mines to shelve down gradually northward, the exposures of elvan-material in that quarter are few and small, while to the southward they aro many and large. Thus, in going south from the main boss along the heather-covered moorland strewn with glacially transported blocks of the granite, we find indications of elvans at several detached points within ■ mile of the margin of the intrusion; though the chief examples occur near the end of the ridge, on Windy Common, a little more than ½ mile from the granite.

In their mode of occurrence these elvans resemble the other Pre-Carboniferous dyke-rocks of the Island, being arranged in short tapering segments which appear to represent the broken and displaced portions of individual intrusions. The rock of which they are composed is pale yellowish close-grained felsite or micro-granite, characterized by sparsely distributed hexagonal crystals of white mica, but otherwise not readily distinguishable in the field from the finer grit bands, with which indeed they have sometimes been confused<ref>Clifton Ward described the Crosby Dyke as "a thick bed of quartzite", Geol. Mag. dec. ii., vol. vii., p. 3. Henslow, however, though he considered the fine sheared greenstones to be greywacke, called attention to the granitoid character of these "quartz-rocks.'Trans. Geol. Soc., vol v (1821), p. 487.

Westward from Windy Common., an exposure of micro-granite appears to be indicated by the large loose blocks in the bed of Awin Ruy, 700 yards due N. of Gibdale farmstead [SC 28129 75064]. On the westward prolongation of the same belt, an intrusion, probably over 30 feet wide, is seen in the highroad 300 yards farther W., close to a milepost (Sheet 12), and is less distinctly indicated in the old road parallel to the former, 300 yards beyond; after which it is lost for two or three miles under the sheet of drift which covers the upper basin of the Silverburn.

Nearer the granite, a smaller elvan, about 9 feet wide, with platy slate-like cleavage, is exposed 70 yards E. of the highroad at the next milepost (6 miles from Castletown), in the gutter draining eastward into Struan Barrule, apparently striking N.W., in agreement with the local deflection of the slates in this locality. It may be this dyke which is again revealed in the large old slate quarries on the north-eastern spur of South Barrule [SC 27027 76919] (Barrule Beg of 6 inch map), over half a mile farther west, where an elvan having a thickness of 8 feet occurs in one of the entrances to the quarry, but is pinched along a thrust-plane in the interior of the excavation into a pale schist only one to two feet thick, some thin veins of quartz being also implicated in the crushing.

The description of these elvans at their reappearance in the hills on the western side of the basin of the Silverburn and in the cliffs of the west coast has already been given; and an account of their outcrops farther south, in <u>(Sheet 16)</u>, will be found on p. 171. The first point of their westerly reappearance seems to be in a small old quarry [SC 22679 74814] ? on the eastern slope of Cronk ny Arrey Lhaa, 500 yards S.W. of the fork in the old mountain road leading from Port St. Mary to Dalby.

Foxdale elvans south and east of the granite

Returning now to trace these elvans eastward from Windy Common [SC 28139 75340], we find the first exposure half a mile E. of that moorland in a gutter 120 yards S. of Tosaby farmstead [SC 29407 75814] (Sheet 12). At Campbell Bridge [SC 30232 76048] which crosses the Santon Burn at Ballanicholas, half a mile farther east, micro-granite has been penetrated in a small mining shaft; and from the abundance of this rock in the old fences of the neighbourhood it is probable the dyke has at some time been quarried at the surface. The next indication of the elvan is at Ballacallin Mooar [SC 30930 76433], half a mile farther to N.E., where some of the farm-buildings are composed of this material, said to have been obtained from a small disused quarry in the adjacent coppice. As these exposures lie nearly in the same line of strike, they may represent a single intrusion.

The first outcrop of a more northerly set is found in an occupation road 50 yards S. of the most northerly house of Ballachrink [SC 30498 76608], and only 300 yards W. of the granite outlier. The next indications are some small quarries, now overgrown, on the new enclosure on Dreem-lang, W. of Garth [SC 30628 77397], winch appear to have been in micro-granite. Thence the elvans may be traced at intervals N.E. down the slope towards Garth [SC 31612 77529], by loose blocks or low crags, the best exposures being in the rough ground 200 and 350 yards N.W. of Garth farmstead. A portion of the intrusion has also been cut in a mining level on the north side of the stream. The stones of the prehistoric monument, "St. Patrick's Chair" [SC 31656 77946], in an adjacent field, are detached slabs of this material. On the same strike, half a mile farther N.E., a single broad elvan is well seen in old quarries and in the roadway close to St. Runn's Church (Sheet 13) [SC 32101 78644]. There is a gap of 500 yards of cultivated ground between this place and the next exposure in the well-known quarries at the foot of the hill opposite to Crosby Station [SC 32540 79284] (Sheet 10), where the whole width of the dyke-20 to 30 feet—and the adjacent walls of slate are laid open to inspection (see p. 315)

Other more northerly shreds of micro-granite, of small size, perhaps emanating from the boss touched in the Comely Mine (see p. 516), were observed in Cooillingill stream, 1 mile due W. of Crosby (S.W. corner of <u>(Sheet 10)</u>) [SC 31231 79414]. On the moorland to the southward, near the E. corner of Archallagan plantation [SC 30819 78761]?, there seems to have been a small quarry, now overgrown, which has supplied similar material for the adjacent fences.

Slates around the Foxdale Granite

The sedimentary rocks in the vicinity of the Foxdale Granite show more indication of disturbance than do those adjacent to the Dhoon Granite, but it is not certain that their irregularities are due to the intrusion. The Dhoon Granite lies somewhat to the S.E. of the structural axis of the slates, whereas the Foxdale Granite breaks directly in upon this axis, where deviations from the usual strike are frequent even when the granite is not present. Hence the Foxdale mass may be coincident with rather than the cause of the deviations. At any rate the slates around the junction seem to have been already tightly folded before the igneous mass and its elvans were injected among them. At the same time, we have clear proof of later movement, which affected the granite and its elvans after their consolidation; so that it is very probable some minor local changes in the direction of the bedding and cleavage planes of the sedimentary rocks may have resulted from the yielding of the strata when pressed against the massive intrusion (see p. 316.) From whatever cause, the prevalent dips to the northward of the granite are towards N.W. or N.N.W. and to the southward of it are S.S.E.; while in its immediate vicinity they are much less regular, and show a general but by no means universal tendency to dip away from the intrusion on all sides.

Basic dykes nesar the granite/Southern slope of the Central valley

Greenstone dykes are not numerous in the neighbourhood of this granite, nor is the evidence so clear as in the case of the Dhoon granite to show that they are the older. Such is probably the relationship, however, as those which do occur are in the altered actinolitic condition. Three small examples in this state are exposed in the upper part of Glion Darragh (Ballacurry, (Sheet 9)), respectively 300, 350 and 500 yards N. of Cornelly Old Mines [SC 29714 79706], where they are very difficult to distinguish from the highly altered flags and garnetiferous schists with which they are associated. Toward the mouth of this glen the rocks are broken by N. and S. dislocations which may be faults of some magnitude. In Cooillingill, among altered country-rock dipping abnormally towards N.E. or E.N.E., a 3-feet dyke exhibiting beautiful sheaves of actinolite-needles crosses the stream 450 yards below the boundary-fence of Archallayan plantation [SC

30730 79115]; and a boss of somewhat different aspect crops out in the corner of a field on the hillside 350 yards to northwestward; and again, more obscurely, on the adjacent moorland 350 yards due south of Rhenny. A more extensive exposure is found in Creg y Whualliam [SC 31245 79963] overlooking the central valley S. of Greeba (Sheet 10), where an intrusion of actinolite-schist about 10 feet wide can be traced up the slope; and is seen again near the angle of the fence. bounding the craggy land, One of its rock faces bearing the inscription *"F. Moore baught this estet A.D. 1766.. 1770".* The upper part of these crags is composed of welded dark blue slate of the Barrule type, but towards the base we find a wedge of highly sheared grit-bands, with greatly-altered garnetiferous slaty intercalations. The locality lies upon the structural anticline; and the strata, as usual, strongly exhibit the deformation-phenomena of frilling, puckering, and stretching. The dark slates have a fissile shear-structure dipping towards N.E. like the "stripe" of the altered flags in Cooillingill; they appear to wedge out westward before reaching Glion Darragh [SC 29710 80134].

In Ellerslie Glen (Sheet 13), dykes of altered greenstone are visible in the west bank of the old dam [SC 32829 78264], and in the bed of the stream 200 yards south of the ruined lead mine [SC 32720 78130]. Another example occurs in the higher reaches of the same stream, 150 yards west of the bridge at Garth [SC 31766 77717].

To the southward of the granite, there are poor exposures of basic intrusions, in the highroad 200 yards west of Ballalhergy [SC 29452 75196] (Sheet 12), and in the gutter adjoining Booldoholly [SC 29429 75517], 300 yards farther north.

In the spoil from the East Foxdale Mine at Eairy [SC 29717 77715] (Sheet 12), we may observe blocks of olivine-dolerite, derived from a dyke of this type which was encountered in the deeper workings (see p. 515); affording another example of the association of olivine-dolerite dykes with metalliferous veins (see p. 488). Though there is no clear exposure of this dyke at the surface, loose weathered fragments occur in the pathway down the steep bank above the southern end of the old dam, 70 yards S.E. of the Chapel [SC 29809 77809], which may indicate an outcrop. No other dyke of this character is known in the Foxdale district.

Basin of the Silverburn

The broad shelving basin around the headwaters of the Silverburn, between South Barrule [SC 25766 75939] and Slieau Eairystane [SC 23625 73578], contains so much drift that the rock exposures are almost confined to the beds of the streams. In Geaylin ny Cregyn [SC 26494 76087] and other of the lower crags on the south side of South Barrule, especially on its eastern shoulder, striped slates with sandy bands are exposed which seem to lie below the level of the Barrule Slate which forms the summit of the ridge. These rocks are highly sheared and the sandy bands are broken up here and there into wisps of crush-conglomerate. These phenomena are also repeated in the low crags on the E. side of Cronk Fedjag 550 yards W.N.W. of Cringle [SC 24415 74985]. The prevalent dips in these slopes are towards N.N.W.; but the next exposures, in the streams farther southward, show the folded rocks with a general inclination to the opposite quarter, where not vertical.

The little side-gullies at Whallag [SC 25415 74544] and Reash [SC 25415 74544], 600 yards E.S.E. of Cringle, are close upon the structural axis of the Island; and the intensely sheared rocks which they reveal show a high degree of mineral alteration. This is particularly noticeable in the softer slates adjacent to certain massive bands of quartz-veined grit exposed in this locality, the prolongation of those seen on the Carnanes [SC 20845 71557](p. 45). In places the slates with thin sandy layers are converted into true mica-schists with a gneissose fluxion-structure. As these altered rocks are over two miles distant from any known outcrop of the granite we can scarcely assign their metamorphism to the influence of that intrusion (see p. 113). On the other hand, the occurrence if similar phenomena, though usually in a less extreme form, in the axial belt throughout the Island, points to the alteration being in some way connected with the forces which have produced the general structure. The quartz veins associated with these crushed and altered rocks have been implicated in the movements; and whether from this cause or from their original composition, they are full of yellow mica and fibrous tourmaline. Indications of a normal fault striking N.N.W., of later date than the other movements, are also visible in the above-mentioned gullies.

The more northerly ravine, which contains one of the reservoirs of the Castletown waterworks, has intersected a seam of ochreous earth 1½ feet wide, visible in both banks, 100 yards below the highroad; it strikes N. 40°W., and appears to

represent a decomposed dyke of olivine-dolerite. A broader band of similar material occurs a mile to S.W.' on the opposite side of the basin, in a little glen on the north side of Garey Mooar [SC 24122 73524] 40 yards below the main road; and has been opened up by a short adit. The substance, like the decomposed dyke at Maughold Head (p. 556), might be useful as a colouring material.

In all the upper branches of the Silverburn, southward of the belt of grits described in the previous chapter (p. 45), the predominant rock-type appears to be palish grey and blue flaggy striped slate with sandy intercalations, bearing a general resemblance to the Lonan Flags of the sections farther eastward, and indeed perhaps forming part of that division though left as 'unseparated' on the map. The outcrops, however, are not sufficiently numerous to justify any general statement. These remarks also apply to the country (in 6-inch (Sheet 16)) southward up to the edge of the Carboniferous basin. Among the few dykes observed in this area, we may mention a greenstone 10 feet wide, in the bed of Awin ny Reash near Grenaby [SC 26845 72667], 250 yards above its junction with the Silverburn; and some minor intrusions of similar material in Awin Ruy about three-quarters of a mile S. of St. Mark's [SC 29071 72849]. The latter stream in this part of its course is for some distance bordered by curious knolls of slate, carved out in post-glacial times through the river having been temporarily diverted from its ancient channel. The wedge of flaggy grit or quartzite in the lower part of this valley has already been described (p. 42).

Basin of the Santon River

Below Campbell Bridge [SC 30232 76048] (p. 167), the Santon valley repeats the features of the Silverburn, and scarcely needs separate description. The spoil-heap of a small trial-shaft near the W. bank, close to the cross-road 400 yards N. of Ballacorris [SC 30937 73964], contains beautiful examples of the cleavage-frilling of slaty bands among sandy flags, S.W. and the same structure is well seen in a quarry on the slope 700 yards to W of this spot near Ballakew [SC 30314 73860]. Some interesting facts in regard to the distribution of tie boulders of Foxdale granite in this area are given in Chapter 9, pp. 367–70.

The ridge bordering the valley on the eastward shows tracts of grey sandy and bluish slaty flags on Slieau Chiarn [SC 31621 76548] (635 feet) and Mount Murray (726 feet) [SC 32252 75454], with only an irregular superficial covering of rubble and similar though smaller outcrops extend thence at intervals southward' to the coast. On the western side of Mount Murray narrow 'greenstone' dykes are visible in a slate-quarry 500 yards S.W. of the summit [SC 31890 75208] and in other places; and on the eastern side of the hill, in a small excavation on the parish boundary between Braddan and Marown, 300 yards S.W. of Rosehill [SC 32689 76006], a 9-ft. intrusion of a somewhat different type is exposed.

Crogga River

Though at present discharging to the sea in a rocky post-glacial ravine at the edge of the Carboniferous rocks at Cass ny Hawin [SC 29805 69325], the Santon River has probably once reached the coast at Port Soderick [SC 34671 72646], 3½ miles farther north-eastward, through the deep Crogga Glen [SC 33255 72424], which is now partly dry and partly occupied by the Crogga rivulet, draining the eastern side of Mount Murray. The bed of this stream lies wholly within the Lonan Flags; it reveals a broadish (about 8 ft.) dyke of tough dioritic 'greenstone' in the deep gully 100 to 150 yards south of the railway; and smaller greenstone intrusions are exposed on the eastern margin of the pond below Crogga Bridge [SC 33599 72862]; at the side of the high-road behind Crogga House; and a mile farther north, in a rocky outcrop at the farmstead south of the high-road at Mount Murray [SC 32959 74195].

Middle River and adjacent slopes

The next stream eastward, known as Middle River, which at first runs parallel to Crogga River and then turns at right angles northward [SC 35446 74115] into a new course to join the Glass near Douglas [SC 36875 75571], shows but few rock-exposures, and these of no great interest. In the upper part of its basin, however, near Ballabunt, a boss of porphyritic igneous material of unusual composition crops out, in a low exposure surrounded by drift-covered cultivated land (for petrographical description see p. 322). The rock is exposed in a disused quarry 300 yards south of Ballapaddag, in a field on the western side of an occupation-road. It is seen only in the quarry, and as no indication of its margin is visible in the excavation we have no means of judging whether it is likely to be a dyke or merely a boss. Blocks of this

material, presumably transported by glacial agency, are scattered over the steep slope of Richmond Hill [SC 34552 74564] on the opposite side of the valley. The road leading to Speke Farm, at 200 yards N.W. of the main-road between Richmond Hill and Mount Murray [SC 33467 74504], shows some decomposed ferruginous rubble which may indicate a basic dyke; and blocks of rock like that of Ballabunt [SC 33885 76195] are plentiful in the adjacent fences.. But the rubble in the roadway is too rotten to show the original character of the rock; and the blocks, like those previously mentioned, may have been glacially transported to this place from Ballabunt.

On the top of the hill south of the cross-roads [SC 35463 75221] above Pulrose the soil is full of splinters of slate. The rock is slightly exposed in the adjacent roads, and must be near the surface in many places in the fields; but the slaty soil is apparently due to an irregular gravelly cover of re-arranged fragments of the country-rock mixed with a few far-travelled pebbles, constituting a local drift perhaps modified by Late-glacial flood-waters (see p. 371). Similar rubbly deposits are of frequent occurrence on the lower slopes of the slate-massif; and it is well to note that a soil full of sub-angular slaty debris does not necessarily imply the presence of solid rock immediately beneath the surface.

The Lonan Flags are exposed in many places on the slopes of the central valley southward and westward of Douglas, but the sections call for no special remark. The thick bands of quartz-veined grit seen in the vicinity of The Nunnery [SC 36668 74677] have already been mentioned (p. 46).

Southern Division (Six-Inch Sheets 15 to 19)

Western Coast

Cliffs near Fleshwick

The cliffs for some distance on both sides of Fleshwick [SC 20177 71434] exhibit complex masses of flaggy quartz veined grits and highly-sheared dark striped slates intricately folded together, as described in the previous chapter (p. 44, (Figure 4)). The composition of the lower cliff rarely corresponds to that of the precipitous slopes above, for although the rock-bands appear to plunge down almost vertically from the summit they are frequently bent sharply back upon themselves several times before reaching the shore. On the southern side of Gub ny Traie Ruy [SC 20555 72588], and again on Kione Beg [SC 20064 71651] the western boundary of Fleshwick, a crush-conglomerate has been locally produced in the slates in the vicinity of the grits.

A small dyke of olivine-dolerite occurs in the cliff north of The Boe [SC 20465 72395] three-quarters of a mile north of Fleshwick another of the same type in a little recess on the east side of Fleshwick, 200 yards south of Raclay [SC 20301 71673] (Sheet 16); a third, accompanying a small vein with traces of copper, on the west side of Lhoob ny Charran [SC 19301 71522] (Sheet 15), 800 yards west of Fleshwick; and a fourth on the north side of Bradda Head, at the old mines, exhibiting a main branch striking W. 35° N. across the shore and a flier following the N.–S. course of the lode in the cliff.

These dykes with the examples a little farther north described on p. 150, probably represent the emergence, on the west coast, of the group seen around Castletown Bay [SC 25903 66611] on the opposite side of the Island. There are doubtless others concealed in the drift- or talus-covered bays and ghaws of this part of the coast, as the intrusions weather more quickly than the country-rock, and are liable to be hidden in the recesses.

The most southerly and westerly point to which any of the Foxdale elvans have been traced occurs in the upper crags of the cliff on the south-west side of Bradda Hill [SC 19281 71252]. Here we find a strip of pale microgranite, 2 feet wide which is seen at intervals extending thence northward, in disjointed segments, across Ghaw Doo [SC 19469 71462]; and, increasing somewhat in thickness, into the lower cliff at Kione Meanagh [SC 19917 71690] 200 yards west of Fleshwick, where it might readily be mistaken for a crushed quartz-vein. It reappears on the opposite side of the bay in the cliff under Raclay [SC 20436 71851], where its sheared and broken condition is excellently displayed. Its course thence up the long steep slopes above the true cliff is indicated only by a few scattered blocks; until we reach an outcrop of the dyke in the upper range of crags? 500 yards N. of Raclay [SC 20460 72312]. Although the exposures beyond this point indicate a rapid increase in the thickness of the intrusion, there seems to be no reason to doubt that we are following the same dyke, Its position relative to the outcrop on the shore at. Raclay appears to show some displacement, possibly due to

overthrusting; or it may be that the intrusion has swerved northward to avoid the adjacent crumpled mass of grit. (See (Figure 4), p. 44.) From the crest of the declivity the segments of the elven hold an easterly course across the plateau until lost beneath drift at the foot of its eastern slope, 150 yards N.W. of Kirkill farm [SC 21614 72308].

At the head of the Raclay Ghaw we encounter a 10-ft. dyke of greatly sheared 'greenstone' which is probably intercepted by the elvan, though the section is not sufficiently clear to show the contact. Shreds of a similar dyke are visible in places on the steep seaward slope of Carnanes [SC 20661 71450] 150 to 250 yards farther southward. A more peculiar dyke, with large crushed felspars, crops out in places among the quartz-veined grits on the southern shoulder of Carnanes 300 yards S. of Ballarock [SC 21744 71433]. The position of this and the other intrusions mentioned in the foregoing sentences, is indicated in the ground-plan (Figure 4), p. 44. Numerous examples of the ordinary sheared greenstones may be observed on the eastern slopes of Bradda Hill [SC 19843 70571] between Fleshwick and Port Erin Bay, but call for no special remark. They are rarer in the cliffs on the opposite side of the Hill.

Bradda Head and Port Erin

The chief feature in the coast section at Bradda Head is the great N.–S. metalliferous vein so magnificently displayed in the cliffs on both sides of the headland, said by Sir W. W. Smyth to be the finest surface exhibit of its kind in Europe.<ref>"Metallic Mining" in "British Manufacturing Industries", ed., 1876 pp. 304–6.</ref> This vein and the workings on it are described in Chapter 12., pp. 529–32. [SC 18761 70586] to [SC 18634 69683]

The complicated contortions of the grits and slates in the western face of the promontory may be taken as typical of the general structure of this part of the Island. Northerly or N.N.W. dips., at angles generally above 60°, prevail on the coast as far south as Port Erin, after which the dominant tendency of the contorted strata is usually towards the opposite quarter. The change of direction is first seen in a narrow belt of folded flaggy grit or quartzite in the N.E. corner of Port Erin Bay [SC 19379 69663]. The dark striped slates on the northern side of this belt of hard rock are reduced in places to the condition of crush-conglomerate, though owing to a later cleavage the structure is not well seen excepting in water-worn slabs. In the middle of the bay the drifts probably extend to low water mark beneath the sandy beach.

Cliffs south of Port Erin

From Port Erin [SC 19586 69197] southward to the extremity of the Island the cliffs are composed of striped slates, rather sandy in places, of the characterless 'unseparated' type. Sheared and disjointed dykes of 'greenstone', including examples both of the dark green and the paler types, are very numerous, scarcely any section being free from them. The largest of these occur in the cliffs around Aldrick (Sheet 15), where, in Half-way Rocks [SC 17674 67706] on the N. side of the recess, one of the diabases has a thickness varying from 8 to 16 feet; 60 yards farther S. there is a boss or dyke, with a diameter of 18 feet, showing porphyritic structure; and in the cliff adjoining Clet Aldrick [SC 17406 67219]another example 30 feet wide. Sixty yards S. of the last-mentioned spot, one of the rougher 'diabase' intrusions 8 feet wide seems to have been penetrated by smaller dykes of the paler intermediate type. South of Aldrick the clips again show a northward tendency which is continued across the Sound into the islet of the Calf [SC 17084 66606]. In Bay Fine [SC 18177 67926] a fracture striking N.N.W., accompanied by fault-breccia and vein-stuff, is seen in the cliff, cutting off several small greenstone dykes; the same fault probably emerges on the opposite coast, a mile distant, at the old mining level at Rheboeg [SC 18825 66473] in Bay Stacka, and may be the cause of the truncation of the grits of Mull Hill and The Chasms [SC 19199 66398].

In Aldrick a similar fracture strikes nearly N. and S. into the cliff, and is revealed again on the opposite shore 600 yards farther S., at Carrick Nay [SC 17371 66510] in the Calf Sound; this also has been explored by the minors, who consider it to be identical with the Bradda Lode (p. 532), though the northward prolongation of its strike would lie some distance to the westward of Bradda Head. Other fractures parallel to these are indicated by the narrow water-channels separating the islet of Kitterland from the mainland on the one hand and from Thousla Rock [SC 16812 66534] and The Calf on the other.

On Kitterland [SC 17037 66594] (Sheet 18), which at low tide has an extreme length of 380 yards, thirteen small 'greenstone' dykes were counted, mostly under 3 feet in width, striking E. or E.N.E. with the strata, like the majority of the

intrusions on this part of the coast.

The Calf of Man

The Calf [SC 16812 66534] (Sheet 18) is composed throughout of slates similar to those of the adjacent mainland. A little basin of shallow drift occurs in the central and southern part of the islet; and in a few other places there are small patches of drift-gravel; but elsewhere the solid rock is at or near the surface. A narrow wedge of thin flaggy grits, in nearly vertical folds, strikes inland from Fold Point on The Sound, and may be traced to the top of the slope overlooking Gibbdale Bay [SC 15914 66233], where it is probably broken by a N. and S. fault which appears to traverse the Island to its southern shore at The Puddle [SC 15731 64605]. The striped slates which occupy the remainder of the Island are frequently sandy and flaggy, resembling and perhaps being identical with the thin-bedded portion of the Lonan Flags. They frequently possess a tough fibrous structure, like the rocks of Spanish Head [SC 18208 65763]. Small dykes of greatly sheared greenstone of various types, frequently in the condition of talc-chlorite-schist, abound in every part, being often in clusters of several individuals running parallel within a few yards of each other; though this appearance may sometimes be simulated by the crenulation of a single dyke. At the N.E. of the Calf these clustered intrusions may be studied at low water on the shore off Cow Harbour [SC 16617 66444]; on Kione Beg [SC 16309 66486]; and on both sides of Gibbdale Bay [SC 15949 66278]. In its western cliffs they are exposed around the Stack; at Culbery [SC 15004 65140], where they are cut off at the foot of the precipice by a thrust-plane; and around Caigher Point. On its south coast they occur on both sides of Rarick [SC 15647 64799], where the sections are less difficult of access than in most places; and on the E. coast we find them on Kione Roauyr [SC 15647 64799]; in the adjacent Ghaw Yiarn [SC 16674 65586]; and in the cliff opposite to The Clets [SC 16833 66024]. They are usually less than 4 feet but occasionally as much as 8 feet or more in width. The largest example observed is 10 to 18 feet wide, and like many of the others, is scarcely recognisable as of igneous origin without (or even with) petrographical examination; it occurs on the foreshore 350 yards N.N.E. of Burrow, and resembles the dyke seen on the opposite shore of The Sound in the cliff near Creg y Jaghee [SC 17926 66242] on the W. side of Spanish Head, and also that of The Chicken Rock [SC 14312 63932] (see p. 304).

The numerous fractures filled with breccia, quartz and other vein-stuff which traverse the slates of The Calf, sometimes, as on the main Island, exhibit slight metalliferous indications. Thus, traces of lead and copper were observed a little to the northward of Caigher Point [SC 15138 64686]; Cumming records a small vein of copper pyrites in the vicinity of The Puddle [SC 15596 64768] <ref>"It runs S. 60° E. mag. and dips S.W. by S at an angle of 70°". "Isle of Man", p. 151.</ref>; and similar traces are said to have been found in the veins on the N. side of Fold Point [SC 16824 66257].

Rock-benches slightly above the reach of the tides, and ghaws or deep narrow gashes cutting the cliff-line, in which the sea at its present level is ineffective for erosion, betoken the Raised-Beach period. A ledge of tufa and cemented beach-stuff in a cave at Bay yn Ow [SC 15171 66051], 450 yards N.E. of The Stack, may also be referred to this period.

The Chicken Rock [SC 14246 63955] is a dangerous low-water reef of striped somewhat sandy slate traversed by greenstone dykes, one large and one small, the larger, 12 to 18 feet wide (p. 304).

Southern and South-eastern coast

From the south-western extremity of the Island we will now follow the coast round to the eastward and north-eastward up to the Carboniferous Basin.

The banded fibrous slates of the broad low foreshore bordering Calf Sound are seamed with small dykes of the same character as those on Kitterland [SC 17066 66527]. These are especially abundant in Carrick Nay to the westward of the fault mentioned above, and in Baih Breechyn [SC 17761 66442], the next recess eastward. On the intervening headland of Barroo Ned [SC 17576 66371] a belt of vertically folded gritty flags, like those of the opposite Calf shore, occupies a portion of the cliff, flanked on both sides with thin-bedded rocks of the 'unseparated' type. On the W. side of the promontory a small vein shows brilliant blue and green staining from decomposed copper-ore. In Baih ny Breechyn, an isolated crag exposed at low water contains a boss of igneous material 20 to 30 feet in diameter, like that of the adjacent dykes, perhaps representing one of the conduits from which the smaller intrusions have drawn their supply. The broad dyke 15 feet wide already mentioned in connection with a similar dyke on The Calf (p. 173) is exposed at the base of the

high cliff 100 yards S.E. of this crag; as frequently happens to these intrusions, it is sliced off by a thrust-plane so that only a short segment is visible.

Spanish Head

[SC 18226 65754]. South of the high broken precipice under Cronk Mooar [SC 18041 66207], the dips, after several sharp rolls, come over at the unusually low angle of about 10° towards S.S.E., and the banded slates acquire a peculiarly fibrous structure from the relationship of the planes of shearing to the bedding. The same axis of low dips strikes across the extremity of Spanish Head and reappears in the recess of Slea ny Bery [SC 18441 65865], between Spanish Head proper and Black Head (Sheet 18). The rock has at one time been guarried both at the top and at the base of the -great precipice, the quarryman's old trail down the broken face of the cliff still affording (in 1895-6), a possible but very dangerous means of descent to the shore. This is doubtless the locality referred to by Bishop Wilson, <ref>Bishop Wilson's "Description " in Camden's "Britannia" op. cit., 4th ed., p. 392.</ref> and afterwards by Macculloch,<ref>Macculloch, "Western Isles", etc., vol. ii., p. 532</ref> where " long beams of tough stone, 12 to 15 feet long" were wrought "fit for mantle-trees and strong enough to bear the weight of the highest stack of chimnies". Macculloch states that trials of its flexibility showed that a beam 15 feet long and 2 inches thick was forced 5 inches out of the straight line before it broke.' In Castle Rushen at Castletown, there is a fine floor and also a roof made of these beams laid side by side from wall to wall, 15 feet clear across without support; and it is said the full length of the beams is 23 feet. From the mode of occurrence of similar structure in the slates on the hill-side east of Ballaugh (described on p. 132), it is probable that the low dips on Spanish Head where the fibrous rock is found, mark a synclinal trough. The flaggy grits of The Chasm [SC 19263 66386] and Kioney Ghoggan [SC 19931 66426] on the opposite side of Bay Stacka have a similar low dip and appear to overlie the slates; but as stated in the last chapter (p. 43), these strata are probably portions of an overturned fold, in which case their original order has been reversed.

We find evidence in favour of this reading of the structure, in the presence of small recumbent folds, traceable in the thin sandy layers of the slates in the eastern corner of Bay Stacka north of The Sugarloaf pinnacle [SC 19464 66238]; and in the rapidity with which both slates and grits resume their high dips when followed inland from the coast. Similar recumbent folds arc still better seen in the prolongation of these grits north-eastward in Perwick Bay [SC 20376 67226], as shown in the opposite figure (Figure 42) The origin of the curious and much-visited Chasms has been previously discussed (p. 43).

On Spanish Head and in Bay Stacka a few small sheared greenstone intrusions of the ordinary type may be observed. The great cliff on the W. side of Slea ny Bery [SC 18448 65866] affords an interesting illustration of the manner in which these dykes are torn asunder by later movement, as shown in the above figure (Figure 43)

A crag known as Horse Rock, visible only at low tide, under the cliff 250 yards S.W. of Kioney Ghoggan [SC 19768 66297], is composed of coarse diabase studded with porphyritic augite, not unlike the diabase of Poortown (p. 304). At its outer edge and along certain planes within the mass, the rock is greatly sheared and altered by crushing, but in other places it shows scarcely any trace of movement. A small schistose 'greenstone', 1 foot to 3 feet wide, is seen in the adjacent cliff; but the coarse rock is confined in this locality to the isolated crag.

An interesting dyke of mica-trap of a type uncommon in the Island (p. 302) occurs in the cliff at the head of a little gullet on the N. side of Kioney Ghoggan [SC 19908 66435]. Its thickness in the coast-section is from 6 to 8 feet, but it seems to be twice this width in the field above, where it forms a low crag. Farther westward, though somewhat difficult to distinguish on account of its schistose structure, we find it in one or two small exposures in the fields between Kioney Ghoggan and the Chasms [SC 19199 66398] and at the latter place, both at the top of the cliff and in the sides of the' more easterly fissure near the corner of the field-fence overlooking the precipice; and once more, 80 or 100 yards farther west, in the crags on both sides of the slipped ground on which are the remains of a prehistoric stone circle. Where last seen, it is in proximity to a smaller dyke of different composition and direction of strike, but the point of intersection is not revealed. Though the cliffs north-west of Spanish Head lies athwart its westward course, the mica-trap has not there been recognised.

Perwick

[SC 20333 67260]. In turning into Perwick Bay from westward we find the cliffs composed of quartz-veined grits, with here and there a small schistose dyke, up to 300 yards N of Traie Vane [SC 20115 66907] where these rocks are replaced by smooth banded sericitic slate or phyllite with occasional sandy layers, which occupy the interior of Perwick Bay. An old shaft and level of the Glenchass mine, on a vein striking N.N.W. (see p 536), are seen at the foot of the cliff west of Ippney [SC 20092 67116]. The slates are greatly disturbed, sheared and veined with quartz; but their prevalent dip is towards S or S.S.E at angles rarely exceeding 30°; they are traversed by numerous small greenstone dykes some of which are in the 'talc-chlorite-schist' condition. The flaggy guartz-veined grits reappear on the E side of the bay, in highly contorted bands with crushed schistose slate between them; a seam of coarse breccia, marking a fault or overthrust at their junction with the main mass of the slate, is well exhibited in the isolated Shag Rock [SC 20572 66909] and on the S.E. side of the little bay W. of Towlfoggy [SC 20639 67143] (Sheet 18). Accompanying this fracture, in the cliff, is a much decomposed basic dyke or boss 10 to 20 feet wide, with coarse crystals of augite, like that of the Horse Rock [SC 19768 66297] (p. 304). The easterly prolongation of this dyke seems at one time to have been exposed in Port St. Mary Bay on the opposite side of the headland, as described by Henalow<ref>Trans. Geol. Soc., vol v., pp. 401–2. See also B. Hobson Quart. Journ. Geol. Soc., vol xlvii., p. 434. The loose block referred to by Mr. Hobson on the inner side of Port St. Mary New Pier is, however, probably a transported boulder.</ref>, but is now no longer visible. One hundred and fifty yards farther south, on the foreshore due E of Shag Rock, we reach the fault striking N.E which brings in the patch of Carboniferous Limestone forming the tip of the headland S of Port St. Mary [SC 21250 67285] (see p. 205).

Port St. Mary Bay

Crossing into Port St. Mary Bay [SC 21173 67408], to the northward of the fault we find a repetition of the features of the Perwick shore, except that the bands of grit are subordinated to the more argillaceous beds. Dykes are numerous and mostly in the schistose condition, but two distinct types seem to be represented; the one crushing down to a smooth pale greenish grey or slightly ferruginous schist which is softer than the country rock, while the other forms tough darker gritty-looking bands thicker and more resistant than the surrounding strata. A good example of the latter type, 8 to 10 feet thick, occurs in the low ridge jutting out from the cliff immediately to the N of the Cliff Hotel.

Gansey Point [SC 21496 67942] and Carthure Rocks [SC 21784 67915] contain much flaggy grit, folded among striped somewhat sandy slates, along with several small dykes, two of which on the E side of Chapel Bay seem to belong to the mica-trap group (p. 303), while the others are of the types above described. Between Gansey [SC 21509 68231] and Rhenwyllan [SC 21460 68569], the low rocky foreshore reveals a broad belt of grit, probably the continuation of that which forms the craggy ground on Cronk Skibbylt [SC 20552 67910] to the westward of Port St. Mary; and similar rocks are exposed in the gutter of the little stream both above and below the corn-mill at Rhenwyllan [SC 21435 68543].

Bay of Carrickey

For over half a mile to the east of this place the broad sandy foreshore of Bay ny Carrickey [SC 21947 68754] is probably everywhere underlain by drift or alluvium; but in the Black Rocks [SC 22568 68642] opposite Kentraugh the slates again crop out and occupy the whole breadth of the tidal platform. The low water reef of Cronnag [SC 22526 68359] is composed of folds of pale grit or quartzite, like that near Rhenwyllan; while the higher portion of the shore contains sheared banded slates, with the dominant planes dipping towards S.S.E. Small Pre-Carboniferous dykes are abundant, especially in the eastern part of the exposure, some of which are in the schistose condition while others are of the less altered type. We also find three examples of the Post-Carboniferous olivine-dolerites; one near the western end of the rocks, 350 yards east of the mouth of Colby River; and the second and third, respectively 340 and 420 yards farther east (far other details see Table on p. 331). Opposite to the cottages at Grenea [SC 22980 68733] (six-inch (Sheet 16)), the boundary fault of the Carboniferous Limestones. The slates may be traced with some difficulty to within a few feet of the fault, but the actual line is concealed, partly by beach-material and seaweed, and partly by patches of boulder-clay which towards high-water mark have not yet been entirely removed from the Pre-glacial rock-platform.

Leaving the details of the Carboniferous rocks for description in a later chapter, we pass now to Langness [SC 28644 66124], on the eastern edge of the Carboniferous basin, 4 miles distant, where the Manx Slates again emerge.

Langness

[SC 28644 66124]. The exceptional interest of the sections on Langness has long been known to geologists through the work of Cumming and other observers. The shores of the promontory present so much complicated detail that it was found impossible to render the facts on the 6-inch map, and the 25-inch scale was therefore adopted for this part of the coast. [6-inch, Sheets 16 and 19; 25-inch, Sheets 16 (of 6-inch 16) and 4 (of 19).1 The instructive phenomena accompanying the overlap of the Carboniferous Conglomerate upon the Manx Slates are described in the chapter following (see p. 195). The Langness sections show clearly that the slates, with their greenstone dykes, had acquired their pressure-structures long anterior to the earliest stages of the Carboniferous; and that the relative resistance of their constituent beds to the attack of the waves on the Carboniferous shore was not different from what it is on the present shore. (See (Figure 50), (Figure 51), pp. 191–3.)

On the western side of Langness the most northerly point at which the slates are seen is in a low bank 50 yards north of Langness farmstead [SC 28635 66448], where they are brought up against the Carboniferous Basement Conglomerate by a small fault. They consist of thinly-bedded rather flaggy slates, dipping S.S.E. at about 45°, stained to the purplish tint which they usually show when in contact with the red Conglomerate. They are again brought in by another small fault in the low section near the Langness Copper Mine [SC 284 659] 500 yards farther south (see p. 538); and are continuous thence southward, for 350 yards, in the cliff and the upper part of the foreshore, to The Arches [SC 28213 65665], where the unconformable position of the Conglomerate upon them is magnificently displayed (see (Figure 49), p. 190). They are traversed in this interval by several small Pre-Carboniferous dykes and by an intrusion of less usual character, probably connected with the Carboniferous Volcanic series, which after intersecting the slates in the low cliff is seen also to penetrate the Conglomerate on the shore a few yards north of The Arches (see p. 325). In the rough ground 70 yards inland from the cliff, 200 yards south of the mine buildings, there is a small exposure of an olivine-dolerite dyke in the slates, probably one of the group which traverses the Carboniferous Conglomerate on the shore below the mine (p. 195).

South of The Arches for 400 yards, the sections are composed entirely of the Conglomerate; but at Port Bravag [SC 27931 65434], under the shelter of Langness Point [SC 27681 65254], the stained slates reappear from beneath it, and the unconformable junction may be followed thence across the narrow neck of land to the outer shore at Dreswick Harbour [SC 28069 65250], the Carboniferous rocks thus isolating the little peninsula of slate which forms Langness Point and the low-water reef of Skerranes [SC 27715 65204] (Sheet 19). In this tract the slates are traversed by a plexus of dykes and bosses of 'greenstone', mostly of the 'camptonite' type (see p. 300), striking generally E.N.E. with the stratification; and the slates are also gashed by a set of north and south fractures, worn into 'gullets' by the sea, and filled with water at high tide. In at least two instances these fracture-lines cut off or displace the greenstone dykes; but as the intrusions are everywhere irregular, the amount of faulting cannot be deduced. One of the gashes is occupied by an olivine-dolerite intrusion, 1 to 2 feet wide, accompanied along part of its course by a narrow vein of copper-pyrites which has been tested by a mining shaft and cross-cut.

On the eastern side of Dreswick Harbour, under the Lighthouse [SC 28228 65210], the sections again show the emergence of the slates from beneath the Carboniferous Conglomerate (for descriptions see p. 191, Figs. 50,151). Thence northeastward, the whole of the outer coast of Langness is composed of the slate rocks, varying in their lithological characters but not perhaps to a greater extent than we find in the southern portion of the Lonan Flags bordering the Carboniferous basin farther north, to which as a whole they bear much resemblance; and it is questionable whether these Langness rocks should not have been mapped as part of that division instead of being left in the 'unseparated' class. But as strata of similar type also occur to the westward, in The Calf and the coast adjacent to it, closely associated with and inseparable from rocks devoid of the characteristics of the Lonan Flags, it was not thought advisable, in the present state of our knowledge, to carry that division south of the Carboniferous basin.

From Dreswick Point [SC 28376 65111] to Tarrastack Rock [SC 28568 65358], dark striped slates predominate; farther north the proportion of sandy material increases, and flaggy layers of grit are sometimes numerous; north of Martha Gullet (northern edge of <u>(Sheet 19)</u>), and especially in the vicinity of Morse Gullet and Scottean, arenaceous strata in the form of thin flaggy grits or imperfect quartzites with argillaceous partings are in the ascendency; while beyond Claberry there is a change in the reverse order, the rocks becoming more thinly bedded and more slaty again in going northward to St. Michael's Island. The prevalent dip throughout is towards S. or S.S.E., though with local variations tending

frequently to swing the direction some degrees W. of S. The angle is usually high, ranging between 50° and 70°. Lines of crushing and faulting, apparently often marking small overthrusts, are of constant occurrence, and are generally accompanied by more or less vein-quarts. The general structure is illustrated in the opposite section (Figure 44), in which, however, the folds are less strongly isoclinal than usual.

In the thinly-bedded sandy slates, 'worm-markings' are in places abundant they may be best studied in weathered crags a little above high-water mark in the cliffs on both sides of Martha Gullet [SC 28928 66187]; on the northern side of Horse Gullet [SC 29090 66521]; and in the vicinity of Gullet Buigh [SC 29220 66788]. The indications of shearing are not so strong as is usual in the Manx Slates; and the strain-slip cleavage is often only visible where brought out by weathering. The direction of this cleavage is approximately that of the bedding, but often at a different degree of inclination; in which case the intersection of the two sets of planes at the edge of the flags when weathered, gives the 'corded' structure described in the last chapter (see p. 73, (Figure 17)).

In no part of the Island are the basic igneous intrusions more numerous and more diverse than on Langness, though the granitic elvans are absent. The majority belong to the camptonite group of greenstones (see petrographical description and other details in Chapter 8, pp. 300–4), and these, along with the diabases and diorites, are of Pre-Carboniferous age; but there are, besides, many of the Post-Carboniferous olivine-dolerites, as well as the supposed Carboniferous dyke mentioned on p.177. The Pre-Carboniferous intrusions are, on the whole, much less crushed and altered than in the area to the westward of the Carboniferous basin; indeed, between Langness and Douglas Head these dykes are fresher and leas crushed than in any other part of the Island, probably because the compressive forces acted with less intensity on this flank than in the central zone of the massif. The smaller dykes usually strike about E.N.E. with the bedding, but the larger bosses are less influenced by the stratification, and frequently have N.E. or N.N.E. courses.

Starting again from the southern extremity of the peninsula, we find everywhere between Dreswick Point [SC 28366 65110] and Spire Gullet [SC 28687 65689] greenstone intrusions of small size striking obliquely across the craggy foreshore. To the northward of Spire Gullet they are of less frequent occurrence until we pass Creg Custane [SC 28887 66021], but are present in numbers again in the vicinity of Martha Gullet [SC 28890 66175] and between Bailie [SC 29006 66337] and Horse Gullets [SC 29056 66491]. In the craggy ground at the top of the cliff between The Cooill and Scottean ((Sheet 16)) the first of the broader dioritic dykes, 10 to 20 feet wide, is encountered, arranged as usual in interrupted lenticular segments. In a similar position north of Gullet Buigh [SC 29213 66793] another or possibly the continuation of the same mass may be traced northward for nearly 200 yards. To the seaward of it there is a plexus of smaller disjointed intrusions, as shown in the foregoing plan copied from the 25-inch map (Figure 45); and the manner in which they are broken and displaced vertically as well as horizontally is seen at the same place, in the section exposed in the walls of Claberry Gullet [SC 29244 66853] (Figure 46).

Another boss or segment of diorite crops up in the field opposite Gullet Creagh Moainee [SC 29388 67013], 70 or 80 yards due N. of the last exposure; and again farther north, 50 yards E. of the S. end of the causeway to St. Michael's Island, where it is seen in a crag above high-water mark and also on the foreshore. This intrusion has been described by Mr. Hobson.<ref>Quart. Journ. Geol. Soc., vol. xlvii., p. 447. </ref> Detached masses of similar material also occur on the west shore of the above-mentioned Island, N. of the causeway.

The following plan of a small dyke exposed near high water mark on the shore 50 yards S. of Gullet Creagh Moainee [SC 29388 67013] illustrates the extent of the deformation of the rocks through shearing even in this comparatively little disturbed area, and the difference in its effect according to the position of the dyke in regard to the direction of movement.

On Hango Broogh [SC 29448 67128], 200 yards farther N. (not to be confounded with the better known hillock of drift of the same name opposite the College at Castletown), the chief dyke is a porphyritic camptonite, about 12 feet wide, which is described on p. 303. Segments of the same or a similar dyke are exposed on the opposite foreshore of St. Michael's Island [SC 29522 67232], along with many of smaller dimensions.

St. Michael's Island

The most noteworthy intrusion on St. Michael's Island is a mass of green schistose rock, 30 feet wide, apparently a highly sheared diabase different in structure from any other of the Langness dykes, which strikes N.N.W. from near low-water to some distance above high-water mark S.S.E. of the roofless ancient Chapel [SC 29531 67321]. On account of its slaty fracture, this intrusion might easily be passed over without recognition; it has been quarried, and largely used in the walls of the old Fort [SC 29484 67351] (dating from about 1650<ref>See Cumming, "Isle of Man", p. 94.</ref>) where it has resisted the weather remarkably well. A small dyke of the paler 'camptonite' type, with the usual E.N.E. strike, can be traced up to the flank of the larger mass and reappears in the same line on the opposite side; but although it is most probable that the smaller dyke is continuous across the diabase, the exposure at this point is unfortunately not sufficiently clear to place the matter beyond doubt. The more highly altered and schistose condition of the larger intrusion, though to some extent explicable as the result of its abnormal strike athwart the cleavage, is further evidence for its greater antiquity.

The olivine-dolerite dykes of Langness preserve the accustomed N.W. or W.N.W. trend, whether they traverse slate, conglomerate, or limestone. An example 2 feet wide occurs on the N. side of Dreswick Point [SC 28375 65266], striking into the cliff near the S.E. corner of the Lighthouse yard [SC 28276 65258]; another, still smaller, on the N. side of Spire Gullet [SC 28698 65709] a group of branching and interlacing strings, intersecting a 'greenstone', between The Goayr [SC 28748 65811] and Creg Custane [SC 28884 66015], 220 yards farther N.; a similar but broader group, in the recess on the S. side of Martha Gullet [SC 28906 66150], with a flier in the Gullet itself; after which there is an interval of three-quarters of a mile before we reach the next, on the S. side of the inlet isolating St. Michael's Island, wherein a thin branching dyke may be seen strugghng in a sinuous course across the S.W. side of Hango Broogh [SC 29441 67076] and the shore to the westward, reappearing on the beach at the N. end of the causeway on St. Michael's Island.

On the shore of Derby Haven [SC 28515 67675] west of St. Michael's Island the slates with their associated small intrusions, though much obscured by seaweed and beach-materials may be traced up to the edge of the Carboniferous rocks which occupy the interior of the Haven. In the middle of the inlet, 50 yards south of the Breakwater Lighthouse [SC 28838 67634], a little patch of the stained slates unconformably overlain by the Carboniferous Conglomerate is brought upby a small fault just above the level of the lowest tides. A dyke of olivine-dolerite accompanies the fault.

South-eastern coast, north of the Carboniferous rocks

The Carboniferous rocks end off against an east and west fault (see p.199) which brings up the slates on the coast at Cass ny Hawin [SC 30246 70331] (eastern edge of <u>(Sheet 16)</u>). Besides the boundary fault, there is at this point, as Cumming observed,<ref>"Isle of Man", p. 109 </ref> a cross-fracture striking N.N.E., which shows as a broken fold and crush-belt in the Limestone, but makes a more definite fault in the Slates, bringing down stained rocks on the eastern side against unstained beds on the western. As already remarked, the slates north of this place, though recognized as forming part of the Lonan Flags, do not greatly differ from those of Langness, being chiefly thinly-bedded strongly striped pale grey and blue flaggy rocks, greatly crumpled and folded, with a prevalent dip towards S.S.E. at high angles. In places they contain hard concretionary nodules, sometimes pyritous, sometimes with cone-in-cone structure in their outer portion. Pseudo-ripple-marking (see (Figure 18), p. 74), pseudo-cross-bedding and other deformation structures are in places beautifully developed. Small sheared disjointed dykes, chiefly of the 'camptonite' type, are as abundant as on Langness, and present the same general characters.

Cass ny Hawin

[SC 30246 70331] The sections differ from those of Langness, however, in the presence, in places, of massive bands of coarse pebbly grit and quartzite of peculiar character. Conspicuous among these is a bed of quartz-veined quartzite, 15 to 20 feet thick, which abuts against the boundary fault on the shore at dead low water at Cass ny Hawin, and strikes thence N.N.E. into the cliff on the S. side of Cass ny Hawin Head ((Sheet 17)). Like the dykes, this band is broken off into disjointed segments which are arranged *en échelon*, being apparently shifted bit by bit northward by faults or thrusts; and it also often simulates an intrusion by breaking across the bedding planes of the softer strata in contact with it, as elsewhere described (p. 40). It is here and there accompanied for a short distance by small dykes which have found vent along its margin.

This quartzite may be traced in the cliff for about 200 yards and is then lost; but reappears 300 yards farther N., on the S. shore of the inlet of Port Soldrick [SC 30329 70517] (not to be confounded with fort Soderick, 3½ miles distant).

It seems then to be shifted southward to near low-water on the opposite side of the inlet; whence its segments may be traced, as before, for over 300 yards, until cut off in the cliff by another fault and lost, the line of fracture being occupied by an olivine-dolerite dyke striking N.W.

In the last-mentioned cliff-section there is evidence that the band is sharply folded, and that its apparent thickness is thereby increased, as shown in the following figure; a greenstone dyke (B) has been intruded near the junction of the grit with the slate, apparently after the folding took place.

The massive quartzite of the isolated outcrop in the N.W, of the Island near Skerestal ((Sheet 6)), described on a previous page (p. 137), bears much resemblance to this band.

On the shore near low-water mark south of Cass ny Hawin Head [SC 30211 69390], to the seaward of the quartzite, we reach the most southerly exposure of the pebbly grits of Banton Head whose main development farther northward was discussed in the foregoing chapter (pp. 46–7). Off the headland, these grits disappear and are not again seen above low-water mark for nearly 1½ miles. Between Port Soldrick [SC 30338 69683] and Port Grenaugh [SC 31650 70427] and thence to Traie ny Sloat [SC 32178 70283] thin-bedded sandy slates and flags prevail in the cliff, with harder thicker greenish-grey flags of the more typical Lonan type at low-water and in places reaching the cliff line. This part of the Island is so thoroughly riddled with the greenstone dykes that six or eight of these intrusions may frequently be counted between high and low water on the broader tracts of foreshore. They fall into two ill-defined classes, possibly of somewhat different age; one group consisting of fine-textured somewhat pale greenish-grey rocks of the camptonite type, probably the older; and the other, of dark newer-looking diabase, weathering with a roughish surface; but minor differences and intermediate variations are common (see p. 298). Instances of small dykes intersecting others of previous consolidation may be observed in several places, *e.y.*, in the cliff 600 yards west of Port Grenaugh [SC 31650 70427].

This part of the coast is also traversed by a group of the olivine-dolerite intrusions; of which the most southerly is that occupying the fault referred to above; while four others occur between that spot and Port Grenaugh; and two more between Port Grenaugh and Purt Veg (see list, p. 330), of which the more westerly accompanies a line of fault striking N. 20 W. into the cliff on the east side of Traie ny Sloat [SC 32178 70283], 700 yards east of Port Grenaugh.

Coast West of St Ann's Head

[SC 33273 70236] Thick-bedded fine-grained splintery flags make their appearance in the cliff on the eastern side of the last-mentioned fault, and are associated with bands of pebbly grit like those of Cass-ny-Hawin Head. These pebbly bands are well seen in Purt Veg [SC 32543 70319], where they extend inland for at least 200 yards, being exposed in the craggy ground on the S. side of Mary Voar farm. They are lost in the projection of the coast to the E. of Purt Veg [SC 32543 70305], which is composed of the thick splintery flags in wide folds; but reappear in the recess on the west side of St. Ann's (Santon) Head, and are continuous thence eastward for 200 to 250 yards until they 'nose out' in the cliff on the eastern flank of the headland through the pitching of the folds, as described on p. 47, (Figure 5)

North of St. Ann's head

The northerly trend of the coast beyond St. Ann's Head carries us gradually out of the region of the thick-bedded sandy flags, which about half a mile N. of the headland begin to alternate with more thinly bedded rocks with a larger proportion of argillaceous material, like those of Port Grenaugh. At Pistol Castle [SC 33965 71392] and thence to Staiden [SC 34568 72347] this latter type predominates; but is replaced by thicker flags again at the next headland and in the cliffs beyond, up to the southern margin of Port Soderick ((Sheet 13): see p. 155).

Though not again well seen on the coast, the coarse grit and quartzite crop cut in low broken ridges, probably the crests of folds, at Ballacregga [SC 34216 72226], a quarter of a mile inland from Staiden.

The character of the folding in these sections suggests that the synclinal trough of Clay Head and Douglas Head (see pp.151–3) is prolonged under the sea and skirts this part of the coast not far below low-water, so that the more salient points like Gob Lhiack [SC 34735 71892] (S. of Port Soderick) and St. Ann's Head [SC 33320 70250] come nearly into the bend of the trough.

To this cause we may perhaps assign the deflection noticeable in the greenstone dykes between Purt Veg [SC 32509 71102] and Port Soderick [SC 34754 73008] which rarely pursue the customary E.N.E. strike, but are usually coursed E. 10° to 30° S. We have already noticed a similar deflection in the dykes of Clay Head and parts of Douglas Head, and have discussed the probability that the change of direction is in some way connected with the synclinal axis.

Certain of the thicker diabases in this area, of fresher aspect than the rest, may be of newer date than the majority of the greenstones.

Of the numerous dykes of this coast it will suffice to enumerate the following, which are much above the average in thickness: a diabase of 9 feet: on the eastern side of Purt Veg; a similar dyke of 10 to 15 feet, in the cliff 300 yards N. of Pistol Castle; and another of 10 feet or more in a low-water crag at Staiden [SC 34568 72347]. The olivine-dolerites are represented by a small example in the cliff 350 yards N. of Staiden; the elvans seem to be absent

Interior of the Southern Division

An account of the stratified rocks of the interior of the peninsula between Port Erin and Port St. Mary (<u>(Sheet 15)</u> and <u>(Sheet 18)</u>) has been given in the previous chapter (p. 42–3. see also (Figure 20), p. 76); and also of those of the high ground N.E. of Fleshwick (<u>(Sheet 16)</u>: p. 44, and (Figure 4)). Of the igneous rocks of this area not already noticed, the only one requiring individual mention is a small band of somewhat peculiar character, obscurely exposed on the southern slope of Mull Hill a few yards N.W. of the highroad at the edge of the moorland at Cregneish [SC 18937 67389], and again on the hillside E.N.E., of The Chasms [SC 19199 66398], which may possibly be of volcanic origin (see p. 324).

Colby River Basin

The upper waters of the Colby River (Sheets 12 and 10) cross the strike of the Carnanes quartz-veined grit bands (p. 43), but these rocks are not so well exposed in the stream as on the steep ridge of Slieau Eairystane [SC 23624 73621] to the eastward of it (p. 45). The grits are again slightly exposed on the lower cultivated ground to the westward of the river, near the houses 400 to 500 yards S. of Lhingague [SC 22295 71762 ?, and at Cronkedooney [SC 22579 71304] (Sheet 16). In the remainder of the stream-course, down to Colby [SC 23092 70306] where the solid rocks are lost beneath drift and alluvium, we find alternations of thinly-bedded slaty and sandy flags, like those of Langness; and similar strata are seen in the scanty exposures which occur amid the cultivated slopes extending thence eastward to the margin of the Carboniferous rocks and the valley of the Silverburn (see p. 169). The dominant dip of the stratification throughout this district is towards S.S.E., but sharp isoclinal folding is often visible.

A dyke of 'greenstone' 10 feet wide occurs in the main stream at the weir above the mill at Colby, and a quartz-vein adjacent to it has yelded indications of lead-ore. A similar intrusion, 600 yards W.S.W. of this, in the bed of the Bellabbey tributary 40 yards above Ballasherlocke [SC 22671 70422], is probably the prolongation of the same dyke. A smaller example is exposed in the channel of the little feeder flowing S.W. from Greyney Mooar, 350 yards above its junction with the main stream.

An olivine-dolerite dyke, about 10 feet wide, in which the olivine crystals are unusually well preserved, crosses the bed of the Colby due W. of Ballacannell [SC 22650 72749], not far from its source (N. edge of <u>(Sheet 16)</u>). Another of these supposed Tertiary intrusions is revealed about 30 yards below the bridge at the Corn Mill in Colby village [SC 23070 70396]; and again on the W. side of Bellabbey Glen nearly opposite to Ballasherlocke where a mining level has been driven into the bank [SC 22563 70402]. In the Ballacorkish lead-mine [SC 21884 70478], 500 yards farther west, from which a considerable quantity of lead-ore has been raised, a similar dyke accompanies the metalliferous lode and has been penetrated for some distance in the galleries of the mine. The lode has a general N.–S. course, but is displaced by E.–W. faults or "slides". (See further details, pp. 532–4.)

In the same district the relics of unsuccessful mines may be seen 250 yards north of Ballasherlocke [SC 22621 70652], and again half a mile east of Colby, 300 yards north of the main road [SC 23915 70429] ?(p. 535).

South-eastern area

To the north-eastward of the Carboniferous basin (Sheet 17), the country is occupied by the thinly-bedded slaty and sandy Lonan Flags excepting in the vicinity of the coast, where the grits and quartzites already described are locally developed. The lower ground is usually heavily encumbered with drift; but on the rise between the valley of the Santon Burn [SC 30823 74211] and Glen Grenaugh [SC 31465 71608] there is a tract in which rock, more or less weathered, is generally near the surface; and similar conditions recur in the vicinity of the dry Crogga Glen [SC 33261 72418] (p. 170).

Oatland Granitite

A boss of igneous material different from any of the other intrusions of the Island crops out in the northern part of this area, near the farm of Oatland [SC 32573 72490] ((Sheet 17) and extending into (Sheet 13)). The chief exposures occur in a series of low crags, which are quarried for road-metal by shallow excavations in a field 300 yards west of the farmhouse. The rock at this place is a palish grey close-grained granitite (see p. 321), but this material is fringed on the westward, northward And eastward by a narrow rim of dark green diabase full of augite crystals. This diabase crops out in the same field, in the crags near the N.W. fence; in the next field north-east ward, 60 yards from the fence; iu front of the house and in the farmyard at Oatland; in the field on the S.E. side of that containing the granitite quarries; and in the field adjoining the last-mentioned on the west. The actual contact of the granitite with the basic rock was not visible in 1896–7; but that they are conterminous is beyond doubt, since in its northerly outcrop close to the N.E. fence of the quarried field the granitite is full of angular or partially rounded fragments of the basic rock, while the latter in Oatland farmyard is veined with thin strings of the granitite. These facts also indicate that the acid rock is of later consolidation than the diabase. Further particulars respecting the relationship of these rocks, along with an account of their petrographical structures, are given in Chapter 8., pp. 320–2.

The northern and southern margins of this complex intrusion are hidden by drift; but on the east, in front of Oatland farm-house, baked splintery flags are seen close to the contact, and on the western side there is, in a small quarry, a still better exposure of similar flags, traversed by a basic dyke 2 feet wide. Altered splintery flags are also revealed in a quarry by the side of the road, 200 yards due south of Oatland. The total length of the intrusive boss from N.E. to S.W. is probably about 900 yards, and its width from N.W to S.E., 300 yards.

It is possible that a small boss of diorite may exist immediately beneath the surface in a field (on which 'Wells' is engraved on six-inch (Sheet 17)) nearly half a mile west of Santon Church or 250 yards W.N.W. of Ballacrine farmstead [SC 30501 71051], as the soil near the N.W. fence of the field is full of angular fragments of this material. A thickish greenstone dyke, perhaps a continuation of that in the bed of Crogga River previously described (p. 70), crops out on the steep hillside, 60 yards north of the railway, at the W. entrance to Crogga Glen [SC 33042 72704] (Sheet 17). Smaller dykes of similar character occur in the railway cuttings respectively 600 yards and half a mile east of Santon Station but considering the manner in which the adjacent coast-line is permeated with dyke-material, it is remarkable how few of the intrusions are visible in the inland exposures. The wore rapid decomposition of the igneous rock, together with the difficulty in distinguishing the dykes from the flags, especially in small outcrops, may perhaps be the reason for the discrepancy.



(Figure 92) Diagram showing replacement of stratified shelly drift by local boulder-clay in the cliff-section near Gob ny Creggan Glassey, Kirk Michael. Scale, for both Figs.: 1 inch = 100 feet, hor. and vert. Explanation (for both sections). 5. Stratified slaty platform-gravel, probably passing into (4) at foot of slope. 4. Upper local rubble-drift. 3. Stratified extra-insular drift; cross-bedded and confused in places; composed of sand, silt, gravel, with a few shell fragments, and thin patches of red clay, 3a, towards the top; the gravel, a mixture of local and foreign material. 2. Dark grey or blue local till, with a few foreign stones. 1. Slaty rubble passing in places into dark slaty till (2). x Manx Slates.



(Figure 93) Diagram at right angles to the above, showing general arrangement of the drift deposits on the lower slopes of the hills; based on sections in Glion Thoar and Glion Shellan. Explanation (for both sections). 5. Stratified slaty platform-gravel, probably passing into (4) at foot of slope. 4. Upper local rubble-drift. 3 Stratified extra-insular drift; cross-bedded and confused in places; composed of sand, silt, gravel, with a few shell fragments, and thin patches of red clay, 3a, towards the top; the gravel, a mixture of local and foreign material. 2. Dark grey or blue local till, with a few foreign stones. 1. Slaty rubble passing in places into dark slaty till (2). x Manx Slates.



(Figure 33) Section at base of cliff on south side of Gob y Deigan. B^G- Crashed and torn greenstone dyke traversed by quartz strings. Thickness about 4 feet. T. Thrust-plane, with brecciated slate, passing into crumpled slate below.



(Figure 27) Belts of strain-slip traversing crumpled slate and producing an appearance resembling stratification. From specimen in the Survey Collection from the Barrule Slates near Snaefell. About half natural size.



(Figure 13) Folded flags at margin of Crush-conglomerate at Ballanayre Strand. Cliff capped by glacial drift. Height about 60 feet.



(Figure 14) Coast on northern side of Gob y Skeddan, showing broken and folded greenstone dykes traversing dark slate and Crush-conglomerate. Height of undercliff at * = about 40 feet. S. Dark slate, greatly sheared, but still occasionally showing traces of bedding. Quartz veins abundant. C. Crush-conglomerate. B^G.Palish 'greenstone' dykes; the upper and lower bands of BG in the foreground unite on the farther side of the nearer headland.



(Figure 91) Cliff-section south of Ballure Glen, Ramsey, showing interbedding of local and foreign drift-material. Scale, horiz. and vert., 1 inch = 100 feet. 11. Rough semi-stratified clayey slate-rubble and gravel: =, Local rubble-drift: capped in places by thin silty wash. 10. Irregular band of red clay with a few pebbles:= Extra-insular drift: appears to thin southward into underlying gravels. 9. Fine slaty gravel and silt, with a few foreign pebbles; thin streaks of red clay in upper part at N.W. part of section. 8. Streaks of red clay among slaty gravel and silt, probably represented by red boulder clay farther north. 7. Cross-bedded sand, loam and fine gravel; pebbles partly of local slate and partly of foreign material thins rapidly southward. 6. Irregular band of stony red clay, fading out in places:= Extra-insular drift. Probably continued southward (6 ?) among local till (4). 5. Dark slaty gravel and sand with a few foreign pebbles. 4. Bluish slaty till:= Local drift. 3. Stratified cross-bedded yellow sand and gravel, contorted in places; pebbles chiefly local but foreigners abundant, including Ailsa Craig riebeckite-rock. 2. Grey slaty till, with an occasional extra-insular stone:= Local drift, with foreign admixture., 1. Coarse rubble of slate-fragments, banked against old cliff and in small hollow on top. x. Manx Slate forming pm-glacial cliff. NOTE. — Unshaded portions of section not seen; dotted boundaries obscure.



A faint cleavage parallel to the stratification in the limbs of the fold crosses the beds in the upfold, diverging somewhat in the gritty bands. (Figure 2) Cliff section 700 yards S.S.E. of Maughold Head, showing recumbent fold in striped slates with thin grit bands. Height, about 15 feet. A faint cleavage parallel to the stratification in the limbs of the fold crosses the beds in the upfold, diverging somewhat in the gritty bands.



(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.



(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.



(Figure 37) Section of grits and slates, showing torsion; in crag on hillside S.E. of GlendItoo Farm, in Glen Dhoo, Ballaugh. (From Quart. Journ. Geol. Soc. vol. li.) Length, about 2 feet. A, A, A. Grit bands in sheared slates, broken by strain-slip (y—y) and each segment partly turned on its axis.



(Figure 7) Section across the zone of Crush-conglomerate on the eastern side of Sulby Glen. (From Quart. Journ. Geol. Soc., vol. li.) Scale, horizontal and vertical: 6 inches = 1 mile. The section is not drawn strictly vertically, as it combines all the outcrops of the hill-side which slopes at about 40°.



(Figure 24) Crag of strongly-banded sandy slate in eastern bank of Sulby River below Snaefell, (450 yards north of "Lead-mine" of six-inch map, <u>(Sheet 7)</u>). (From Quart. Journ. Geol. Soc., vol. li.). Length, about 5 feet. A, A. Grit-band, about ½ inch thick, crumpled and partially broken, among puckered slates. B, B, B. Isolated pebble-like fragments of grit, apparently squeezed out from the band A. y, y. Strain-slip planes, cutting and displacing the bedding. z, z. Later 'shear-cleavage', with the same strike as the bedding (N. 40° W.) but a different degree of dip (about 30°).



(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.



(Figure 21) Puckerings on bedding-plane of fine-grained flags (Niarbyl Flags); from specimen in the Survey Collection obtained on the coast near Dalby Point. About one-third natural size.



(Figure 22) Tessellated puckering on bedding-plane of Niarbyl Flags; from specimen in the Survey Collection obtained on the coast near Dalby Point. About one-third natural size.



(Figure 23) Crest of fold in Niarbyl Flags in cliff at northern side of The Ladder, Contrary Head. (From Quart. Journ. Geol. Soc., vol. li.). Length, 4 feet. A, A. Pale band in slaty flags, pulled apart into pebble-like lenticles 1 to 2 inches in length. y, y. Faintly-developed planes of strain-slip.



(Figure 3) Cliff-section in contorted Niarbyl Flags at Ballaquane Strand, near Dalby. Height. about 20 feet. Faint cleavage crossing the folds.



(Figure 30) Section in Lonan Flags at foot of cliff on north side of the North Pier at Laxey, showing agreement between axial plane of folds and cleavage. x—x. Obscure cleavage in same direction as bedding but at a steeper angle. y—y. Axial plane of small fold.



(Figure 40) Diagram of cliff at The Whing, north-east of Port Soderick, showing varying inclination of bedding-planes of gritty flags between summit and base of section. Height about 300 feet. Note.—The tramway cutting is indicated in the upper part of the cliff.



(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.



(Figure 42) Recumbent fold in flaggy grits in cliff on east side of Perwick Bay, Port St. Mary. Height (maximum); about 60 feet.

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.



(Figure 50) Section across foreshore at Langness Point, south of Lighthouse, showing eroded surface of slates beneath Carboniferous Basement Conglomerate. Height about 10 feet. d¹ 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 51) Section on shore S.E. of last, showing grit-band ($a\blacksquare$) in slates (a) standing up in a small ridge beneath conglomerate (d^1). Height, about 4 feet.

FIG. 49.—Sketch-section of the most northerly of The Arches, Langness, showing unconformability at base of Carboniferous Rocks.

Height, about 18 feet.



(Figure 49) Sketch-section of the most northerly of The Arches, Langness, showing unconformability at base of Carboniferous Rocks. Height, about 18 feet. d¹ Carboniferous Basement Conglomerate. a Manx Slates, with red staining. F Small fault.



(Figure 44) Section on north side of Horse Gullet, Langness, showing thrust-planes and accompanying plication of thinly-bedded sandy slates. Height about 12 feet. B^D. Greenstone dyke, 2 feet thick. T. Thrust-plane, with Q, quartz-veins.

FIG. 17. Section in crag on western side of Sulby Glen, west of bench-mark 137' 6'' (six-inch map, sheet 4), showing method of production of pseudo-ripple marking by strain-slip-faulting.

> (From Quart. Journ. Geol. Soc., vol. li. Compare Fig. 18.) Length, about 2 feet.



A A A. Bands of grit 1 to 3 inches thick, cut displaced and lengthened by (y-y) oblique strain-slip planes. Dark slate, much sheared, between the grit-bands.

This pseudo-ripple-marking is commonly developed in the thin sandy bands among the striped slates, but may occur in any hard seam traversing softer beds. Thus, the example represented in Fig.19 shows the structure, on a small scale, in a thin segregation-vein of quartz.

Hence, although the rocks are in many places of a character in which ripple-marking may once have existed, it is doubtful whether

(Figure 17) Section in crag on western side of Sulby Glen, west of bench-mark 137' 6" (six-inch map, sheet 4), showing method of production of pseudo-ripple marking by strain-slip faulting. (From Quart. Journ. Geol. Soc., vol. B. Compare (Figure 18)) A A A. Bands of grit 1 to 3 inches thick, cut displaced and lengthened by (y—y) oblique strain-slip planes. Dark slate, much sheared, between the grit-bands.



(Figure 45) Ground-plan in vicinity of Claberry Gullet, Langness, showing plexus of greenstone dykes in contorted sandy slates. Scale, 25 inches = one mile. The numbers indicate the thickness of the dykes in feet: * shows position of section given in (Figure 48)

FIG. 46. Cliff-section on south side of Claberry Gullet, Langness, showing small greenstone dykes (B^D) cut and shifted in segments along horizontal planes of dislocation.



(Figure 46) Cliff section on south side of Claberry Gullet, Langness, showing small greenstone dykes (B^D) cut and shifted in segments along horizontal planes of dislocation. Height about 35 feet.


(Figure 18) Rock-rippling of thin gritty layer in slate by earth-morement. From a specimen in the Survey Collection obtained on the foreshore at Cass-ny-hawin. About half the natural size.



(Figure 5) Idealized sketch of cliff showing pitching of folds, based on structure seen on northern side of St. Ann's Head.

FIG. 20. Corrugated surface of grit-band in flaggy slate, in west bank of gully south-west of Fistard village near Port St. Mary.

Dimensions, 12 inches by 8 inches ; the finger-like ridges are from $\frac{1}{2}$ to $1\frac{1}{2}$ inches broad.



(Figure 20) Corrugated surface of grit-band in flaggy slate, in west bank of gully south-west of Fistard village near Port St. Mary. Dimensions, 12 inches by 8 inches; the finger-like ridges are from ½ to 1½ inches broad.