Chapter 5. The Carboniferous rocks of the Southern District

Historical and general

The presence of the small tract of limestone in the south of the Island has received notice in most of the old topographical descriptions, on account of its economic importance in a country so generally devoid of calcareous rocks. The quarries in this rock have not only been the chief source of lime in the Island, but have also furnished its best building stone. The ancient and well-preserved Castle Rushen [SC 26548 67531] at Castletown, dating back at least to the 13th century, is built of this local limestone.

Of the early geological writers, Woods described the Carboniferous rocks of the south as "transition limestone" Berger classed them as "Floetz Rocks", and observed with regardto the fossils that Parkinson had noticed "that the whole much resemble those found in Westmorland, Cumberland, Durham, and, as far as he can judge, those of Kilkenny". Macculloch discussed at considerable length the relations existing between the stratified and unstratified portions of the limestone at Poolvash and elsewhere, and noticed the unconformability at the base of the conglomerate associated with the limestone on Langness. In the nomenclature of the period, he classed the slates as "Primary", and the limestone and associated strata as "Secondary". Henslow gave a more generally accurate account of the extent and stratigraphical relations of these deposits, and was the first to recognise the volcanic character of the breccias overlying the limestone on the coast between Scarlet and Poolvash.

When the term "Carboniferous" was introduced for the equivalent rocks of the mainland, the Manx limestones were relegated to this system without further question; and were thus shown on the map published by Conybeare and Phillips in 1822<ref>Frontispiece to "Outlines of the Geology of England and Wales". The map bears the date 1821, but the title page of the volume is dated 1822.</ref> Indeed, this classification had been adopted some years previously by William Smith in his manuscript geological map of England and Wales,<ref>"See Prof. J. W. Judd on "William smith's Manuscript Maps". Geol. Mag., dec. iv., vol. lv. (1897), p. 446.</ref> and under the title of "Derbyshire Limestone", in his published map of 1815.

Towards the middle of the century our knowledge of these rocks was greatly extended by the Rev. J. G. Cumming, whose painstaking investigations of the Limestone Series and its fauna supplied a wealth of careful and accurate detail upon which we shall draw extensively in the subsequent pages. As mentioned in a previous chapter (p. 18), this author divided the series into Old Red Sandstone and Conglomerate; Lower or Castletown Limestone; Upper or Poolvash Limestone; and Posidonia Schist or Poolvash Black Marble. Owing to the extremely limited superficial extent of the two latter of these divisions and to their peculiarly complicated outcrops, it has not been found practicable to show them separately from the Lower Limestone on the Survey Map, but they will be treated independently in the descriptions which follow.

The contributions to our knowledge of the Manx Carboniferous Limestone since Cumming wrote have been few and unimportant; they consist principally of incidental references to Manx fossils in works dealing with the palaeontology of the Carboniferous System (see Bibliographical Appendix, pp. 590–5). Our knowledge of the Carboniferous Volcanic rocks of Scarlet has, however, meanwhile been largely augmented by the labours of Messrs. Horne, Ward and Hobson, and Sir Arch. Geikie (see pp. 228–33); and in recent years the surmises of Cumming and others (see p: 280) that Carboniferous rocks might exist beneath the drift-plain at the northern extremity of the Island, have been verified by deep borings carried out by Messrs. Craine Bros., of Liverpool. These borings have, as yet, been too few in number to make clear the full extent and composition of the Carboniferous strata in this area, but are sufficient to prove their greater thickness and diversity than in any other part of the Island. We owe to Prof. W. Boyd Dawkins and Mr. J. Todd the first published information regarding these borings (see pp. 280–95).

Like the southern Limestones the little strip of Red Sandstone and Conglomerate on the western coast north of Peel has received notice in all the early topographical and geological accounts of the Island, as being the only " freestone" found therein. It was classed by Berger, Macculloch and Henslow with the Conglomerate which underlies the Carboniferous

Limestone at Langness, but was shown as 'New Red Sandstone' in the map of Conybeare and Phillips of 1822 (see p: 264). Cumming and the later writers on the subject were unanimous in considering it to be older than the Carboniferous Limestone of the southern basin, until 1894, when Prof. W. Boyd Dawkins in publishing a more detailed account of the deposit than had hitherto been attempted, claimed it to be of Permian ago (see pp. 266–7). While the insufficiency of the stratigraphical evidence leaves this question of age fairly open to debate, it has seemed to the present writer, as will subsequently be shown, that the weight of probability is still in favour of the older and long accepted view; and the rocks have therefore been classified on the map as Basement Beds of the Carboniferous.

In the following pages, the rocks of the three above-mentioned areas, being both lithologically and geographically distinct, will be separately described, in the following order

- The Conglomerate, Limestones, and Volcanic Rocks of the Southern Basin. (Chapter 5.)
- The Peel Sandstones. (Chapter 6.)
- The strata underlying the Drift of the Northern Plain (Chapter 7.)

The Carboniferous Basin of the south of the island

From the variety of its phenomena and their magnificent display in the coast-sections, this small tract of between 7 and 8 square miles in extent is of exceptional geological interest. It stretches from Cass-ny-Hawin [SC 29808 69153] (the mouth of the Santon River) on the east, to Bay-ny-Carrickey [SC 23169 68739] on the west, a distance of 4½ miles; and from Langness Point [SC 27755 65266] on the south, to Athol Bridge [SC 27315 71543] (where the Peel and Castletown highroad crosses the Silverburn) on the north, a distance of 4 miles, Castletown the ancient capital of the Island lying nearly in the middle of the basin. In outline, the basin is somewhat oblong, with the longer diameter running N.E. to S.W., or parallel to the hilly central axis of the Island. The limestones of which it is principally composed are fringed on the north-east and southeast sides by the basal conglomerate; are cut off by a fault on the north-west; and bounded by the overlying volcanic rocks and by the sea on the south. Its highest strata lie adjacent to the coast about a mile to the westward of Castletown, and are surrounded by the lower divisions on all sides except the south, where they pass beneath the sea.

In the interior the limestones occupy a low-lying undulating tract usually covered thickly with drift or alluvium, their exposures being almost limited to the valleys of the Silverburn and one of its tributaries north of Ballasalla [SC 28031 70163], and to certain large quarries west of that village. Under these conditions, the exact inland boundaries can be fixed at only a few points, and must be drawn more or less conjecturally across the intervening spaces and as small faults are numerous in the district, the dotted boundary shown on the map can be only approximately correct.

Basing our classification upon that of Cumming, we recognise in the basin the following divisions (here given in descending sequence, but subsequently described in reverse or ascending order):

4. Volcanic Series of Scarlet.

3. Posidonomya Beds.

3. Poolvash or Pale Limestones.

2. Castlotown or Lower Dark Limestones.

1. Basement Conglomerate.

Basement Conglomerate

In the south of the Isle of Man it is certain that the vast interval of time between the period of the Manx Slate Series and the earliest stage of the Carboniferous epoch is entirely unrepresented in the succession of the strata. In the north of the Island there remains the slight possibility that some portion of this interval may have its representative among the rocks

which lie hidden beneath the drift plain.

Before the beach-conglomerates were spread out, which in the southern district form the base of the Carboniferous System, the Manx Slates of the central massif, after having undergone the violent structural changes and igneous permeation described in the foregoing chapters, had been cut down to the core by denudation, whereby any intervening strata which may have existed in this quarter must necessarily have been destroyed.

The Carboniferous basement beds are seen to rest upon the denuded edges of the slates in the most conspicuous and striking manner in the coast-sections on Langness. The low cliff at The Arches [SC 28213 65666] on the western side of the promontory presents a magnificent illustration of this unconformability, which has been many times described and figured.<ref>Cumming's "Isle of Man", Plate at p. 88; Clifton Ward, Geol. Mag dec. ii., vol vii., p1. 1; W. W. Watts, "Geology for Beginners", Fig. 156, p. 223.</ref> The section is so instructive that no excuse is needed for again presenting it (Figure 49).

Equally or even more impressive are the exposures on the western side of Dreswick Point [SC 28285 65145], half a mile farther southward, where the base of the conglomerate is exactly at the level of the present foreshore, so that as the ancient beach material is loosened and removed by the waves of to-day, the tides once more ebb and flow across the old tidal flat of slate which they washed in Early Carboniferous times. We may tread this ancient feature from high to low water mark, and note how the harder ribs of quartzite and vein-quartz in the slates have formed ridges on the old shore, and how the narrow dykes of greenstone have rotted away into little gullies in the past, just as they still do. After many cycles of change, consuming an interval too vast for us to measure, the old conditions are renewed at this spot; and the sea, unaffected by time, returns once more to roll the Carboniferous shingle over the Carboniferous shore. But a lighthouse now stands guard above it!

That the Conglomerate has had its origin as a marine beach is proved not only by its general characters but also by its relation to the overlying limestones, into which it passes by gentle gradations. It is chiefly of a dull red colour, and this tint has stained the slates beneath it, to a varying extent, sometimes only superficially and sometimes to a considerable depth. Its pebbles are of all sizes up to a foot or more in diameter, but the majority are smaller than a clenched blind; they are usually well-rounded but occasionally subangular. They may all have been derived from the subjacent rocks,<ref>See W. Boyd Dawkins, "Vannin Lioar", vol. 1., p. 16, and Rep. British Assoc., 1896, p. 775.</ref> being chiefly of vein-quartz, quartzite and greywacke, with rarer fragments of diabase and slate. In this respect the deposit differs from the pebbly bands in the Peel Sandstone, which contain material not known to exist within the Island (see p. 263). The stones of the Conglomerate are set in a gritty matrix, and in places they are intercalated with lenticular beds of red sandstone. As usual in deposits of this character, the thickness is very irregular and the bedding impersistent. Prof. Dawkins has stated that in the bed of the Awin Ruy, north of Ballasalla, the conglomerate is "about 159 feet thick"; but this estimate certainly exceeds the thickness at other localities.<ref>"Vannin Lioar", vol. i. p. 17. The figures seem to have been arrived at by calculation from the dip and width of outcrop, as direct measurement is not practicable in ths exposure. Cumming was of opinion that "in no place where it can be observed is it more than 50 feet in thickness ['60 feet' in 'Guide Book'), being often not more than 4 or 6 feet".—Quart. Journ. Geol. Soc., vol. ii., p. 320</ref> A measurement across the foreshore to low water at the northern side of Derby Haven [SC 29126 68022] gives 55 feet of these beds (including 5 feet of gritty limestone marking the upward passage into the limestone), but the conglomerate is not exposed quite to its base in this locality: a mining trial on the western side of Langness passed through about 50 feet of conglomerate before reaching the slate (see p. 538. The only fossils known to occur in it are those recorded by Cumming from the uppermost calcareous layers at the back of the Abbey garden at Ballasalla [SC 27827 70209], where a rock consisting of "pebbles of white quartz in a gray matrix of limestone includes the characteristic fossils (particularly *Orthis Sharpei*) of the lowest limestone series as seen elsewhere in this basin".<ref>"Isle of Man", p. 44. Among Cumming's fossils preserved at King William's College, Castletown, there is a specimen showing *Spirifera glabra ?* Mart, in a matrix of limestone with small quartz pebbles. The label gives the locality "Ballahot", a place near Ballasalla where the topmost beds of the conglomerate are slightly exposed (see p. 197).</ref>

These transitional layers of the Conglomerate are of similar character wherever seen, consisting of thin bands of hard calcareous grit and of limestone with small pebbles. The conditions indicate that with the progressive subsidence, the deposition of limestone commenced in the quieter off-shore waters, while the beach-conglomerate was still creeping

upward on the flanks of the slowly sinking land; hence we find that the Lower Limestones are thin and flaggy, and intercalated with thickish partings of somewhat sandy Shale, and occasionally contain small isolated pebbles of quartz (see pp. 204, 244). The phenomena are, in fact, analogous to those which generally prevail at the base of the Carboniferous System around the northern part of the Irish Sea, in north-western England, south-western Scotland and eastern Ireland.

Further stratigraphical details of the Carboniferous Basement Beds

(*Six-inch Sheets* (Sheet 16) and (Sheet 19))

Cass-ny-Hawin

[SC 29800 69129] Commencing with the coast-sections at the north-eastern edge of the basin at Cass-ny-Hawin (eastern margin of 6 inch (Sheet 16)), we find the Carboniferous Limestone brought in suddenly against the slates by a fault striking W. 8 N. with a southward downthrow of approximately 120 feet. At low water of spring tides a narrow strip of conglomerate in proximity to dark gritty limestone may be seen along the line of the fault on the shore. The exposure is not sufficiently clear to show whether this is a wedge displaced between branches of the fault, or whether, as seems very probable, it represents a true emergence of the basement beds below the limestone. A patch of the same rock, mixed with fault-breccia, is seen to accompany the fault in the adjacent cliff. By this dislocation the main mass of the conglomerate is cut out of the coast section and shifted inland for about 300 yards, where its outcrop is exposed in some low crags in the field east of the road to Ballawoods<ref>As in the preceding chapters, the use of italics in these descriptions denotes that the place-name will be found only on the six-inch Ordnance map.</ref> farm, as well as in the road itself and on the western tip of the ravine which the Santon River has excavated in in the underlying slates. The upper boundary of the conglomerate is also fixed in this locality by the presence of dark blue fossiliferous limestone in some old quarries in the field to the westward of the above-mentioned road; and as the dips in these exposures are low, say from 5° to 8°, westward, the basement beds must here be comparatively thin.

In following the coast southward from Cass-ny-Hawin, though the limestone occupies the whole foreshore for the next ¾ mile, its base is probably never far below low water; and in the outer reef at Loch Skillicore [SC 29489 68447] the lowest limestone strata brought up by a slight anticline are of a gritty character. A little farther south a small branching fault elevates the crest of the above-mentioned anticline, so that the conglomerate occupies the lower half of the foreshore opposite Ronaldsway [SC 29129 68058]. At this place the following section was measured.

I.—Section of base of Carboniferous rocks on foreshore on northern side of Derby Haven opposite Ronaldsway.	Thickness	
	Feet	inches
Carboniferous Limestone, blue weathering pale, in lenticular and generally very lumpy beds 6 inches to 2 feet thick; fossils abundant (Productus, etc., corals, encrinites, etc.); thickness (up to low cliff at old limekiln) 38 to 40ft.	6	0
Thin lenticular limestone-courses, smoother and less dolomitized than below Blue limestone with dolomitized bands and irregular brecciated joints - about	13	0
Calcareous grit or gritty limestone, weathering with curious brecciated aspect (due to irregular dolomitization 1) about	5	0

Hard smooth grey calcareous grit, almost like quartzite, with rhomboidal joints	2	0
Pebbly conglomerate; thickening northward	1	0
Dark soft shaly sandstone with some pebbles about	5	0
Palish blue pebbly grit or quartzite, weathering dark; passes into conglomerate both ways along strike	6	0
Very coarse irregular yellow conglomerate, cross-bedded, with sandy streaks; containing boulders of up to 2 feet diameter about	12	0
Sandy yellow band, smaller stones	4	0
Alternations of sandy and coarse bouldery conglomerate, yellowish, stained red in places	8	0
Yellow conglomerate, in some places sandy in others coarse, with subangular stones over 1 foot diameter	6	0
Coarse red conglomerate	6	0
Lower beds visible beneath sea at low water.		

NOTE.—All the beds of conglomerate are very impersistent and changeable, so that the details vary from point to point.

Derby Haven

In crossing Derby Haven a slight depression reduces the Basement Beds to a narrow strip just visible at the lowest tides on the outer side of the Breakwater [SC 28928 67770]; hut they afterwards creep upwards again, so that 100 yards south of the Breakwater their base is exposed, resting upon an uneven surface of stained slate. The steeper dip, of about 30° towards W.N.W., at this place, in the vicinity of a fault, quickly brings on the overlying sandy limestone, the whole outcrop of the conglomerate having a width of about 40 yards. The foreshore is, however, so much obscured by beach-material and seaweed that only a small portion of the deposit can be studied.

Langness

The small fault just referred to has been taken possession of by an olivine-dolerite dyke; its effect is to bring the lowest beds of the limestone against the conglomerate in the middle of Derby Haven, and to shift the outcrop of the latter 100 yards eastward, where the rocks are for the most part hidden under beach-material. The S.S.W. prolongation of the anticline noticed at Skillicore and Ronaldsway is again intercepted by the coast on the southern shore of Derby Haven; and is succeeded eastward by a shallow syncline which brings in a small trough of sandy limestone flanked on both sides by the conglomerate. The most easterly exposure of the Basement Beds in Derby Haven is at high-water mark a few yards east of the gate across the road to St. Michael's Island, where coarsish conglomerate is seen in contact with stained slate; but whether the junction is normal, or slightly faulted, is not clearly shown. Crossing the isthmus of sand dunes, less than 200 yards in width, which separates Derby Haven from Castletown Bay, we find a broad flat foreshore on which the line of disturbance above noted can again be recognised, the anticline breaking into a small fault and uplifting a little pear-shaped inlier of pebble-beds, traversed by two small olivine-dolerite dykes, among the lowest limestones. The main belt of conglomerate is magnificently exposed 150 yards farther southward, being continuous thence along the shore nearly to the southern extremity of Langness. In these extensive surfaces, showing a confused admixture of large and small stones and pebbles, interspersed with seams of sand, its beach-like character is most impressive; and the interest of the scene is heightened by the presence of a plexus of black olivine-dolerite dykes

ramifying among the red conglomerate. Towards low-tide mark, the rocks are cut up by water-channels and obscured by a heavy growth of seaweed; but in spite of these difficulties it is possible to trace the sandy upper margin of the conglomerate passing up into gritty limestone, as far southward as Creg Inneen Thalleyr [SC 28094 66015], but south of this spot the conglomerate extends to low-water.<ref>The characteristic, differences between the foreshores formed respectively of limestones, conglomerates, and slates on the southern coast of the Island are expressed on the Ordnance maps by different ornamentation. This is on the whole well done, though the boundaries are often not quite correct. The larger olivine-dolerite dykes are also sometimes indicated.</ref>

One of the trial shafts of the Langness Copper mines [SC 284 659] (see p. 538), 300 yards S. of Langness Farm few feet above high-water mark on the Raised-beach platform, starting in the upper part of the Basement Beds, penetrated 50 feet of these beds and then entered the slates. A small fault brings up the slates, on the E., against the conglomerate, in the bank below the Langness farmstead; and a similar faulted junction occurs nearly on the same line 450 yards further southward, on the western side of the low cliff at the Copper Mine buildings. The main shaft of the mine was sunk in the slate at this place; but a level at a depth of 12 fathoms went N.W. to the fault, and reached the conglomerate and one of the olivine-dolerite dykes; a second level at 25 fathoms was entirely in slate (p. 538). South of the mine, the slates occupy the low cliff and the upper part of the shore for a distance of 400 yards, when the beds are again affected by a small fault which brings the conglomerate into the cliff-section at The Arches [SC 28185 65675], as shown in (Figure 49), p. 190.

The small dyke, supposed to be of the age of the Carboniferous Volcanic Series, which traverses the slate and the conglomerate on the shore immediately to the northward of The Arches, has been elsewhere described (see p. 325).

From this place to Port Bravag [SC 27940 65435] in the northern elbow of Langness Point, the picturesque cliff and foreshore arecomposed entirely of conglomerate; and a level had, in 1895–6, been driven eastward for 36 fathoms into the cliff at the southern end of The Arches without reaching the slate. At Bravag the base of the conglomerate again rises above the shore, and passing over the ridge of slate which forms Langness Point descends gradually on the southern side to low water at Dreswick Harbour [SC 28105 65274], where the main belt occupies a strip of the coast 160 yards wide, with several small outlying cake-like masses resting upon the upturned edges of the slate between high and low water marks. The chief features of these fine exposures have already received our attention (pp. 191–2, (Figure 50), (Figure 51)).

Port St. Mary

We do not again find the base of the Carboniferous rocks revealed on the coast. But at the western edge of the basin, 4½ miles W. of Langness, the calcareous top of the conglomerate is just visible in the outer harbour at Port St. Mary [SC 21178 67392] between tide-marks, at the edge of the fault which forms the landward boundary of the isolated patch of Carboniferous Limestone. The presence of the conglomerate in this locality was noticed by Macculloch<ref>"Western Isles", vol. II, p. 509.</ref> and Henslow<ref>Trans. Geol. Soc., vol. V., p. 492.</ref>, but was overlooked by Cumming<ref>"Isle of Man", p. 143.</ref> and subsequent writers. It occurs as a narrow strip parallel to the fault,.the following being the downward succession:

Black sandy limestone (extending up to the New Pier.)

Dark pebbly grit, 3 inches.

Brown sandy grit with pebbles, 1 to 2 feet.

Dark gritty limestone, 2 feet.

Fault — bringing in the Slates.

The same calcareous pebbly beds were found below low-water in preparing the foundations for the extension of the pier at this place in 1893. Mr. James Walker, C.E. informed the writer that the divers were at work here on a low submerged cliff, 6 to 8 feet high, the upper part composed of limestone and the lower of the pebbly rock. Specimens procured for the

Survey by the divers, under Mr. Walker's instructions, consisted of pebbly conglomerate of rounded fragments of vein-quartz set in a dark gritty calcareous matrix, the pebbles being somewhat larger than those in the outcrop on the foreshore. The rock resembles the topmost layers of the conglomerate exposed at Ballahot and Ballasalla in the interior.

The presence of the top of the Basement Beds in this quarter, together with other evidence mentioned below, seems to indicate that the boundary-fault which cuts off the Limestone-basin westward may owe its strong effect upon the stratigraphy, not so much to the amount of its vertical displacement as to its position near the base of the Carboniferous Series in its present line of outcrop.

Scarlet Point

[SC 25670 66158]. At Scarlet Point the disturbed mass of limestone adjacent to the Volcanic rocks contains, in one part, a seam of scattered pebbles of quartz, suggesting that it may include portions of the lowermost limestone beds. Its present anomalous relations will be subsequently discussed (p. 244).

Inland exposures

Along the north-eastern margin of the limestone-tract in the interior, the Basement Beds are well displayed at several points. In the road-cutting at Ballakewin, 200 yards south of Athol Bridge [SC 27345 71356], coarse red conglomerate is revealed, resting on stained slate. The ground to the westward of this exposure is covered with drift; but red conglomeratic rubble probably marking a weathered outcrop was noticed in the gutter adjoining the ruins of a cottage 350 yards W.S.W. of Ballavell [SC 26839 71167]; while in the same gutter about 70 yards farther north-westward the solid slate is reached. The soil in the S.W. corner of the next field westward seems again to indicate that the conglomerate is close to the surface; and on this evidence the westerly curve has been drawn in its boundary on the map. The facts suggest that at this place its limits have not been much curtailed by the boundary-fault.

Forty yards below Athol Bridge [SC 27344 71516] the conglomerate is visible in the bed of the Silverburn, with limestone above it in the eastern bank. In the adjacent field the decomposed limestone was formerly dug for the manufacture of umber<ref>A shallow excavation for this purpose was in progress in 1892, when the ground was surveyed.</ref>. These Carboniferous rocks form a small outlier cut off by a fault running approximately in the direction of the valley, or nearly at right angles to the main Carboniferous boundary-fault. As the ground to the eastward is drift-covered, the evidence in regard to this outlier is confined to the immediate neighbourhood of the stream-bed and that of a little tributary; and the mapping is therefore necessarily more or less conjectural. The complications extend down to the village of Ballasalla [SC 28011 70465]; the rendering of the ground finally adopted, after repeated examination, agrees closely with that given by Cumming. Gritty limestone and sandy shale is visible in the little tributary of the Silverburn on the eastern side of Ballashimmin [SC 28011 70465]; but there is no exposure of the outer belt of conglomerate indicated on the map at the north-eastern margin of the outlier, though the presence of conglomerate-rubble in the drift in a gutter 150 yards north-east of Ballashimmin supports the likelihood of its existence. The outlier appears to be bounded on the south-east by a third dislocation, having a N.E. course parallel to the principal boundary fault; the evidence being that at the sharp bend of the Silverburn 200 yards N.W. of Cregg Mill [SC 27530 71192], slate is exposed at the foot of the slope (close to the building used in 1893–4 as a Mineral-water Factory) and in the road leading down it, while gritty limestone dipping to south-west occurs in the bottom of the stream on the north-west side of the bend, and is succeeded downward by fine pebbly conglomerate and then by coarse conglomerate; and these rocks are replaced suddenly by quartzite belonging to the Manx Slates at the turn of the curve. Thence to Cregg Mill [SC 27617 71047] the stream runs in a gully carved out of quartzite and slate; but its course must lie very near the line of the N.W. and S.E. fault, as the following downward succession can be made out in the northern bank of the road up the slope east of the mill.

Dark Limestone (in place?) at bend at top of slope

**** (gap of several feet, not seen);

Fine-grained calcareous grit.

**** (gap of a few feet);

Bands of calcareous grit with layers of small pebbles of quartz.

**** (gap of a few feet);

Conglomerate with rounded and sub-angular stones up to 4 inches in diameter, (3 to 5 feet seen.)

**** (gap of several feet, not exposed);

Slate and quartzite (Manx Slate Series) forming the foundations of the bridge.

The fault crosses the stream 150 yards below the mill, where conglomerate and pebbly limestone are slightly exhibited in the bed of the stream while slate and quartzite are exposed in the western bank. A short level has been driven into the latter rocks in search of iron-ore (p. 484). A little lower down the valley there are a few exposures of limestone, to which later reference will be made.

Awin Ruy [SC 27963 70653], the tributary which falls into the Silverburn from the north-east at the northern end of the village of Ballasalla, flows at right angles to the strike of the main belt of Basement Beds and these rocks are revealed in several places in its bed. At the mainroad-crossing [SC 27985 70683] the stream is in dark limestone dipping gently towards S.S.W.; 100 yards farther north pebbly limestone is seen, followed by sandstone, marking the upper limit of the conglomerate; and another exposure 400 yards north of the mainroad shows pebbly sandstone interbedded with coarse conglomerate, resting upon or against purple-stained quartzite of the Slate Series<ref>See p. 192 and footnote, with reference to the supposed thickness of the Basement Beds in these exposures.</ref>. The altitude of the quartzite in the walls of the ravine just above the junction of this rock with the conglomerate suggests slight faulting, or otherwise considerable unevenness of the old surface beneath the conglomerate.

From these exposures to those in the vicinity of Cass-ny-Hawin [SC 29800 69179] already described, a distance of 1¼ mile, the outcrop of the Basement Beds is completely hidden by drift.

To the westward of the Silverburn only two outcrops remain to be noticed. Pebbly limestone and fine quartz-conglomerate are exposed in the bank on the western side of the gardens of Rushen Abbey [SC 27763 70142], at which place, as noted above, Cumming found fossils of the Lower Limestone series in the pebbly rock. Similar material crops up in the road at the farm of Ballahot [SC 27287 70338], ■ mile farther westward, furnishing evidence of the upper limits of the Basement Beds in this quarter.

Lower or Castletown Limestone

In extent and thickness the Lower Limestones constitute by far the most important division of the Carboniferous rocks of the south of the Island. They consist of flaggy courses of dark blue limestone, from a few inches to a few feet in thickness, separated by partings of black shale, which are thickest and most numerous towards the base of the division. Thin lenticular patches and nodules of chert are locally abundant at certain horizons, especially towards the top of the division on the coast west of Castletown Harbour. In the lower part fossils are plentiful, comprising many common Carboniferous Limestone forms (see table at end of chapter, pp. 257–62); the higher beds contain fewer fossils, but in them are found certain species like *Prolecanites compressus* (*Goniatites Henslowi*)and *Nautilus* (*Discitea*) *complanatus* which are of more restricted distribution.

The differentiation of the division from the higher portions of the limestone series, though grounded principally upon lithological characters, appears to rest also upon a sound palaeontological basis. An adequate investigation of the latter branch of the enquiry would however have consumed more time than could be allowed for the survey of this limited tract; so that we are still compelled to rely principally upon the previous work of Cumming for information m regard to the distribution of the fossils, supplemented by a few notes most kindly prepared for us by Dr. Wheelton Hind from his personal knowledge of the deposits (see pp. 254–6).

The following passages are quoted verbatim from Cumming, and contain his analysis of the subject as given in the notes which follow his lists of Manx Carboniferous Limestone fossils ("Isle of Man"Appendix Q, p. 358).

"In order to show a reason for the separation which I have made of the Carboniferous limestone series of the Isle of Man into three divisions of-1st, *Lower limestone;* 2nd, *Poolvash limestone;* 3rd, *Posidonian schist*, it will be sufficient to call attention to the following facts.

"Of the 222 species named and located in [the fossil list] we have only 30 common to 1st and 2nd; only 8 common to 1st and 3rd; only 11 common to 2nd and 3rd; only 3 common to 1st, 2nd and 3rd. Again, of the 76 species occurring in 1st, 40, or more than 50 per cent., are found in it only. Of the 153 species occurring in the 2nd, 117, or 76 per cent., are found in it only. Of the 39 species found in the 3rd, 20, or just 50 per cent., belong to it alone.

"The fossils characteristic of the lower limestone series seem to be *Orthis,Sharpei, Productus hemisphaericus, Caunopora ramosa, Favosites caetetes* and the larger variety of *Cyathophyllum fungites.*<ref>For modern terminology, see Notes and List at end of chapter.</ref> The localities for obtaining them are the little creek of Ronaldsway [SC 29092 68189], Strandhall [SC 23387 68722] to the westward of Poolvash, and Port St. Mary. At Scarlet, near the limekiln [SC 25852 66379], the specimens of *Ammnonites Hensowlii* and *Nautilus complanatus*, which are in the Woodwardian Museum, Cambridge, were obtained. I am not aware that the latter fossil has elsewhere been found".

In another part of the same volume (p. 241) Cumming makes the following statement in regard to the wider correlation of the Lower Limestone:

"On a comparison of the fossils of this division with those of the carboniferous series in other parts of the British Isles, we find them remarkably agreeing with the lower Northumbrian type, or still more closely with the series developed in the neighbourhood of Hook Point m the south of Ireland; they may very well be compared also with the Kendal beds" (see also p. 208).

The gradual downward passage of the Lower Limestone into the Basement Conglomerate has already been described. Its upward limits and relation to the Poolvash Limestone are ill-defined; they will be more conveniently dealt with in discussing that division (see p. 210). Cumming estimated the thickness of the Lower Limestones at not more than 160 feet <ref>Quart. Journ. Geol. Soc. vol. ii., p. 320. </ref>, but it will be subsequently shown that this is probably too low. These rocks occupy the whole of the southern Carboniferous basin within the rim of Basement Beds, except a narrow strip bordering the coast between Scarlet Point [SC 25685 66216] and Balladoole [SC 24012 68578], where alone are the higher divisions and the Volcanic series preserved.

Further stratigraphical details of the Lower Limestones

Cass-ny-Hawin to Derby Haven

From Cass-ny-Hawin [SC 29812 69199], where the basal beds of the Lower Limestones are faulted down against the slates under conditions stated on a foregoing page, To the division occupies the whole of the foreshore and low cliff up to Ronaldsway [SC 29092 68189]. Cumming has given a minute and accurate account of this part of the coast, with an enlarged ground-plan showing the system of small faults and flexures by which it is characterized.<ref>Quart. Journ. Geol. Soc. vol. pl. xvi. and "Isle of Man", pl. at end.</ref> The governing dip is towards W.N.W., but this is subject to incessant variation owing to the above-mentioned disturbances, the general effect of which is to throw the limestone into a succession of shallow basins and low domes, with steeper plications which occasionally break into actual faults. The flaggy character of the bedding brings out these features very clearly on the broad foreshore. The axis of disturbance alluded to in discussing the conglomerate runs S.S.W. from the vicinity of Cass-ny-Hawin, where it appears to be a true fault, to Skillicore [SC 29435 68469], where it takes the form of a sharp narrow anticline with some crushing of the limestone but perhaps without actual dislocation. Opposite Ronaldsway [SC 29161 68182] it enters the conglomerate and its course thence has already been traced. Other minor lines of crush and slight faulting, sometimes crossing each other with a rudely reticulate arrangement, strike in directions varying between W.S.W, and N.W. Dolomitization of the limestone has gone on extensively along these disturbances, and sometimes spreads out from them along the bedding-planes. Small veins of calcite, quartz and dolomite are common, and at Skillicore a mass of shattered and stained limestone has been recemented by vein-material into a belt of "beautiful variegated appearance", as noted by Cumming,<ref>Isle of Man", p. 106.</ref> who says that "some attempts to work it as a marble-quarry have been

defeated by the large admixture of quartz, and the fractured character of the rock".

A marked feature of these flaggy limestones is the lumpy lenticular character of the bedding, the upper surface of many of the courses being embossed with rounded protuberances, from a few inches to a few feet in diameter, often rising several inches above the general level. These are still more strongly developed at the same and higher horizons farther westward. They seem to be original structures of the beds, due to the presence of masses of coral or clusters of shells, though it is only occasionally that the organic remains are still preserved in them. The subject will be subsequently referred to in relation to some anomalous features in the Poolvash Limestones (see p. 250.)

The following section was measured in 1882 on the foreshore and foot of the cliff between Cass-ny-Hawin [SC 29822 69213] and the Skillicore disturbance [SC 29161 68182]. The measurement was rendered somewhat doubtful in places by the disturbances of the strata; but the section gives approximately the succession and the thickness of the beds above the conglomerate on this part of the coast. It will be seen that a thickness of about 150 feet of limestone and shale is represented.

II.—Section of Carboniferous Limestone on the shore between Cass-ny-Hawin and Skillicore.

	Thickness	
	Feet	**Inches**
Limestone courses with thickish shale partings, seen in foot of cliff N. of Skillicore; beds to southward much confused by small faults, but probably no higher strata exposed up to the Skillicore disturbance	8	0
Limestone courses, weathering rough, with thin partings of shale: small encrinites and large corals abundant: in reef and cliff N. of Skillicore	12	6
Alternations of rhomboidal — jointed flaggy limestone, and shale. Encrinites and other fossils abundant; reticulate corals plentiful in lower part	15	0
Limestone band with conspicious rhomboidal structure	1	0
do. weathering rough	1	6
Alternations of thin platy limestone and shale about	10	0
Beds hidden by shingle -probably about	10	0
Shaly beds with thin limestone. Productus, etc., abundant	5	0
Alternations of thin shaly limestone with thicker paler limestone courses. The shale bands contain curious nodule-like lumps of limestone. These beds form a reef in small bay S. of Cass-ny-Hawin	10	0
Thicker limestone-courses, very irregular; interrupted by small fault about	7	0
Dark-blue thin limestone bands with shale partings; bedding lumpy and lenticular; corals, encrinites, and other fossils	9	6

Shale	0	6
Thicker limestone courses	4	6
Lenticular lumpy limestone bands with shale partings	4	6
Shale with thin platy limestone	2	0
Thin irregular limestone bands with thin shale partings	4	0
Palish blue limestone, weathered with rough surface; forming top of reef on south side of Cass-ny-Hawin fault	2	0
Dark limestone in thin lumpy bands with shale partings	7	0
Dark greyish limestone	3	0
Dolomitized massive limestone, confused by fault, and thick ness doubtful, say	25–30	
Basement Conglomerate. Top just seen on beach near low water at Cass-ny-Hawin, S. of fault bringing up Manx		

The exact effect of the interruption at Skillicore has not been determined, but the amount of displacement is not likely to be more than a few feet, probably causing a slight repetition on the western side. Between this place and the Ronaldsway fault, which breaks the upward sequence by bringing in the lower beds again, the following details were noted, showing an additional 40 feet or so of higher strata, and thereby considerably exceeding Cumming's estimate for the whole thickness of the Lower Limestones.

III.—Section of Carboniferous Limestone on the shore between Ronaldsway [SC 29107 68199] **and Skillicore** [SC 29460 68496]**.**	**Thickness.**	
	Feet	**inches**
Thin limestone bands and black shale, with large Productus, etc.; on shore of Ronaldsway inlet and in cliff at north side seen, about	4	0
Thicker paler limestone bands, many fossils	3	0
Shale	0	6
Dark grey limestone, weathering pale; many small brachiopods	3	0
Shale with nodule-like lumps of limestone	0	6
Thin platy limestone-bands, lumpy and lenticular; many gasteropods in upper layer	4	0
Shale	0	6
Hard blue limestone in lumpy lenticular courses, with thick shale partings; many fossils	12	6
Hard limestone-course, with surface covered with 'fucoid' markings	1	0

Dark limestone courses with thin shale partings	8	0
Thinly-bedded shaly limestone seen below this at low-water S. of disturbance	10	0

The upper surface of the limestone in the low cliffs north of Ronaldsway is sometimes decomposed into brown 'umber'. A group of small branching olivine-dolerite dykes traverse the foreshore in a north-westerly direction at the northern termination of Loch Skillicore [SC 29526 68557] (see p. 330).

The details of the interesting section on the foreshore opposite Ronaldsway [SC 29140 68183] in which the lowermost layers of the limestone pass down into conglomerate have previously been given<ref>Cumming describes "a tabular mass of trappean conglomerate, or of quartz pebbles, apparently mixed up in a trappean matrix" as occurring in this section between the limestone and conglomerate, and colours it as an igneous rock on his published ground-plan. His description evidently refers to a dark pebbly crystalline calcareous grit which occurs in places in the position indicated.</ref> (see p. 194).

In the inner portion of Derby Haven [SC 28891 68008] the sandy foreshore is probably underlain in places by boulder-clay covering the limestone, but the latter rock crops up here and there in low scars. On the outer side of the Breakwater it is traversed by two small olivine-dolerite dykes, and by a third in the line of fault already described, 140 yards S. of the Breakwater [SC 28919 67758] (p. 330). The short infolded trough of limestone among the conglomerate on the southern shore of the Haven has been previously mentioned.

Castletown Bay

On the eastern side of Castletown Bay the lowermost portion of the limestone is exposed at dead low-water on Creg Inneen Thalleyr [SC 28106 66007], and from this point northward the outcrop expands until it occupies the whole of the shore, here over quarter mile wide at low tide, but much obscured by seaweed. The dip is usually about W.N.W. at an angle of 10° or under. A few dolomitized veins occur, mostly striking approximately E. and W., and are accompanied by slight crushing; while at low water in the bend of the Bay, 80 yards N. of Black Rock (6-inch map, (Sheet 16)) [SC 28210 67222], a good example of the domed arrangement of the bedding may be noticed; but the strata as a whole are much less disturbed than in our former sections. They are traversed by several small dykes of olivine-dolerite, having the usual northwesterly strike, which appear to occupy discontinuous parallel cracks or joints.

The Boes

The two islets bared at dead low-water about a half-mile off shore in this part of the Bay, known as Sandwick Boe [SC 27704 66988] and Boe Norris [SC 27453 66896], are composed of dark flaggy limestone. As seen from the shore at low water of spring tides, one would imagine that a good stretch of rock was exposed in these reefs, but the appearance is mainly due to the laminaria-weeds growing thickly on their submerged portion and rising up out of the water surrounding them; with a tide of about 19 feet only three narrow ridges of bare rock were found on Sandwick Boe, while on Boe Norris the rock exposure was confined to one small boss a few feet in diameter. A larger reef, Lheeah Rio [SC 26686 66292], half mile S.W. of Boe Norris, is shown on Cumming's map as limestone; but so far as I have been able to examine it, with an ebb-tide of 18 or 19 feet, the whole outcrop consists of dark basalt or olivine-dolerite (see p. 326).

The inner shore of Castletown Bay for five-sixths of a mile, from the N.E. corner at Sandwick [SC 28012 67580] (six-inch, (Sheet 16)) to within about 100 yards of the harbour [SC 26762 67523], is usually covered with sand and shingle; and when this is swept aside hard stony till is revealed. No evidence is forthcoming as to the depth to which the limestone lies buried in this gap, but it is not unlikely that the interval may conceal a preglacial or early-glacial rock-channel, perhaps that of the old Silverburn, filled in with drift. The embouchure of the Silverburn at Castletown Harbour [SC 26575 67498] is a narrow post-glacial notch excavated in the limestone; and as its valley as a whole is a pre-glacial feature, its present course here is evidently not that which it once occupied.

The solid rock reappears near high-water mark 70 yards west of Flukeing Pool [SC 26977 67643], and is more or less continuous thence to the harbour, though on the shore below about half-tide level boulder-clay was seen in several

places. To the westward of the Harbour the greater part of the tidal platform is composed of bare limestone, which is continuous thence to Scarlet [SC 25811 66728]. Above high-water immediately to the westward of the Pier, the strata are more thickly bedded and paler than is usual in the Lower Limestone. They are probably near the top of the division, and may foreshadow the upward passage into the pale Poolvash Limestone which was recognised by Cumming<ref>Quart. Journ. Geol. Soc. vol. ii, p. 334.</ref> 600 yards farther westward, in the field north of Knockrushen House [SC 26060 67205]. The dip of the beds, however, is variable and the rocks are intersected by lines of crushing and dolomitization in this vicinity, so that it is difficult to make out the true sequence; and though this limestone is presumably higher than any hitherto described, its actual position in the series cannot be directly determined. A systematic study of the fossils of the whole series might possibly yield this information, as some of them appear to be confined to definite horizons.

A branching group of small olivine-dolerite dykes is visible in the limestone in the outer harbour 25 yards N.E. of the Pier, and Cumming noticed "thin strings of galena" in association with the intrusion. Opposite Knockrush House the foreshore is traversed by a dyke of the same rock-type, from 18 to 24 feet wide, with several thin fliers in the limestone outside its margin it strikes W. 12 N. and is the broadest example of its class. One hundred and fifty yards farther south another of these intrusions, only a few inches wide, is encountered; another of similar small dimensions 80 yards beyond; and another, in a decomposed and scarcely recognizable condition, among disturbed limestone at the landing place opposite Scarlet House.

A more important but less accessible mass of igneous rock occurs in the lowest reef of the foreshore, E. 5 S. of Scarlet House and 320 yards south of Seal Rock. This reef<ref>The reef is not named on the Ordnance maps, but is known to the fishermen of Castletown as Creg Kermode.</ref> though shown on the Ordnance map as if continuous with the shore is only exposed at the lowest spring tides, and then eau rarely, if ever, be reached except by boat. Dark flaggy limestone constitutes the chief part of the reef, and into this is intruded a mass of dark basaltic rock somewhat resembling that of the insulated Lheeah Rio [SC 26680 66296] out in the Bay 500 yards to the south-eastward; it belongs either to the olivine-dolerite dykes, or to the Scarlet Volcanic group, the latter being the more probable (see p. 325). Owing to the heavy growth of seaweed with which the reef is covered, the limits of the intrusion are difficult to trace, but it seems to form a boss 20 or 30 yards in diameter, truncated by the sea, narrowing westward into a dyke a few feet wide, perhaps continuous with that above-mentioned at the landing place opposite Scarlet House.

Scarlet

[SC 25821 66703] Several dolomitized veins occur in the limestone between Castletown and Scarlet. The general inclination of the strata in this area is towards W.N.W., but with many local disturbances in which the rocks are often elevated into small domes with quaquaversal dips, having a flattened circular or oval summit. More or less perfect examples of this dome-structure are visible in the low-water reef of Seal Rock; near high-water in the recess opposite Scarlet House; and on the narrow foreshore between Scarlet House and Scarlet Point. We shall have occasion to revert to this structure in discussing the 'knoll-structures' of the Poolvash Limestone and of the Volcanic Series. The following section through one of these domes, in the low cliff 200 yards S.W. of the Scarlet Limestone quarry [SC 25825 66504] ?, reveals a slight thickening of each component stratum on the crest of the arch.

The quarry above-mentioned, which produces both building-stone and road-material, shows an excellent section in dark blue limestone-courses with black shaly partings, gently undulating as on the adjacent foreshore; and the upper surface is well-glaciated (see p. 465). These are probably the higher beds of the Lower Limestone; among the fossils which they have yielded (see list, p. 257) the most interesting are the rare cephalopods —*Prolecanites compressus* (*Goniatites Henslowi*), *Solenocheilus pentagonus, Ephippioceras bilobatum, Actinoceras giganteum, Pleuronautilus ? scarlettensis*, the last-named a new species recently described by Mr. F. R. Cowper Reed<ref>Geol. Mag. dec. iv. vol. vii. (1900), pp. 105–6. pl. vi. </ref>.

The same limestones extend for 300 yards farther southward, and are then broken off against the Volcanic Series, in a section which will be discussed on a later page.

Cumming states<ref>"Isle of Man ", p. 126.</ref> that he measured accurately the Lower Limestone in this vicinity and found that down to low-water mark the thickness amounts to 129 feet; and he would allow only 50 feet more (which is

probably insufficient) for the thickness below low-water mark to the base of the limestone, thus obtaining "in round numbers 180 feet for the dark limestones and shales at the Stack of Scarlet".

Bay Ny Carrickey

From Scarlet Point [SC 25652 66176] to Poyll Vaaish (Poolvash) [SC 24419 67448], a distance of 1¼ miles, the Volcanic Series occupies the coast; and from Poolvash for one-third of a mile westward, the Upper or Poolvash Limestone forms the principal constituent of the sections, though some patches of the Lower Limestone may possibly be intermingled with it (see p. 214). A N. and S. fault which ranges along the foot of the low cliff near Balladoole, south of the Castletown and Port St. Mary highroad, in crossing the broad scar to low-water opposite Poyll Richie [SC 24059 68167] brings up the Lower Limestones on its western side, and they are continuous thence on the shore to the westward for two-thirds of a mile, until let down against the slates by the boundary-fault at Kentraugh [SC 22977 68790]. The limestone strata of this tract resemble the beds between Ronaldsway and Cass-ny-Hawin both in composition and in fossil contents, and probably represent a similarly low horizon in the division. A rounded quartz-pebble, one-third of an inch in diameter, was observed in one of the limestone-bands a few yards to the westward of the fault.

The olivine-dolerite dykes traversing this part of the coast are evidently the prolongation of those of Langness and Castletown which have crossed the drift-covered interior between the bays. The largest among them, 18 feet wide, may be continuous with that of Knockrushen; it crosses the little bay at Strandhall from side to side in a north-westerly direction, first emerging at Poyll Breinn [SC 23882 68441] on the east and plunging inland again 100 yards west of the mill at Strandhall (six-inch map, (Sheet 16)). A smaller dyke west of Poyll Ritchie [SC 23912 68171] may be traced along the line of the fault above-mentioned for over 200 yards, this evidence apparently implying that the intrusion was of later date than the dislocation; yet on an adjacent part of the shore, other two small dykes of the same character, striking appear to be shifted several yards southward by the same fault.

On the beach opposite the place where the Castletown road turns inland, the limestone-scars are broken by a channel in which, when the recent shingle is denuded off, peat with trunks of trees is exposed and is said to be continuous to low water (see p. 413); this was evidently the channel of the Strandhall stream when the land stood higher than at present.

Between Strandhall [SC 23882 68441] and Kentraugh [SC 22664 69039] the general dip of the limestone is eastward, with broadly curving undulations; on this part of the shore the limestone has been quarried. The lumpy surface which often characterizes the bedding planes appears to be due mainly to large Producti and turbinate corals (*Zaphrentis*) embedded in the rock

In approaching the boundary-fault we find patches of till resting on a scratched surface of the limestone on the shore; and similar material forms the low cliff above. This suggests that the tidal rock-platform has existed in Preglacial times and is not yet completely laid bare again. The limestone may be traced to within about 20 yards of the slate, but the actual fault-line was not visible at the time of the Survey, being everywhere hidden by till and beach-material. The exposure of limestone nearest the fault is a patch of black gritty rock, visible at about half-tide level, possessing the characters of the lowest beds of the series and is probable that the lower part of the shore may contain the actual base of the limestones, as at Port St. Mary.

The Carrick

[SC 22693 67377] The Carrick is an insulated rock exposed at low-water in Bay ny-Carrickey, three-quarters of a mile off shore due south of Kentraugh; it is composed of dark flaggy fossiliferous Lower Limestone, with gently rolling dips forming a low anticline on an E.N.E. to W.S.W. axis.

Port St. Mary

The prolongation of the boundary-fault across the bay brings in an outlier of the limestone on the tip of the headland between Port St. Mary [SC 21357 67414] and. Perwick Bay [SC 20621 67046]. The lowermost portion of this outlier,<ref>Though always spoken of as an outlier, this is not strictly speaking correct, since the limestone is almost certainly continuous eastward beneath the sea with the main outcrop.</ref> in Port St. Mary Harbour, has already been

described. The upward succession on the outer side of the new pier is shown in the following section, measured on the foreshore; it reveals a thickness of 70 to 80 feet.

IV. Section of Carboniferous Limestone in the outlier at Port St. Mary.	Thickness.	
	Feet	Inches
Palish Limestone; many encrinites and 'fucoid' markings; highest bed visible on shore east of boundary-fault	3	0+
Lumpy courses of palish limestone with thin shale partings; in cliff opposite new houses	14	0
Lumpy irregular courses of limestone with very thin shale partings; fossils abundant; in cliff east of old limekilns	22	0
Palish Limestone with thin shale partings; corals abundant; on shore opposite old kilns - about	8	0
Calcareous shale with lumpy nodule-like structure; many corals	2	0
Dark limestone courses with lenticular bedding and very lumpy surface; thickish shale partings; large corals, etc.; in cliff south of new breakwater	10	0
Two bands of dark limestone, each 1 ft. thick, forming slope abutting on breakwater	2	0
Limestone hidden by breakwater and within harbour up to the band with quartz pebbles, see p. 196 probably about	20	0

In the upper part of this section the shale-partings are fewer and the limestone courses correspondingly thicker and also paler in colour than at the same horizon on the eastern side of the basin. The lumpiness of the bedding planes is very prominent, especially in the little recess due W. of Kallow Point [SC 21118 67018] (6-inch map, (Sheet 16)). The dips are undulatory, perhaps from the proximity, of the fault; but the dome-like arrangement so strongly marked in other parts of the limestone basin is only slightly developed in the outlier. The actual junction of the Carboniferous rocks with the slates at the fault is visible for a short space both in the outer harbour and on the shore at the S.E. extremity of Perwick Bay. In the latter locality the dislocation contains masses of fault-breccia, and the limestone is in places decomposed to brown earth or 'umber'.

Inland exposures

South-east of Ballasalla

The inland extension of the Lower Limestone lies wholly within (Sheet 16) of the six-inch map. Returning to the eastern margin of the basin, we find a shallow exposure in the old limestone quarries already referred to (p. 193) in the lowermost beds quarter of a mile inland from Cass ny Hawin [SC 29475 69301]. The next outcrop from beneath the drift is two-thirds of a mile farther west, where some hollows in a field 500 yards S.W. of Ballahick [SC 28482 69480], in which the soil-contains angular fragments of dark limestone, seem to indicate old quarries.

Similar appearances recur in another field 500 yards farther west, adjoining the Douglas and Castletown main-road 120 yards N.E. of the milestone ("Douglas: eight miles") [SC 28042 69572].To indicate these two small areas on the one-inch

drift map a continuous line has been drawn surrounding them; but there is probably a considerable thickness of drift in part of the ground between them. The little stream draining from Ballahick to Derby Haven is probably close to the surface of the limestone for the space of 300 yards to the southward of the bridge on the road to Ronaldsway. Bare limestone is revealed in its bed near the place where the sluice draws off the water for the Ronaldsway dam, 900 yards S. of the bridge. The rest of the country E. of the Castletown main-road is drift covered.

In the bed of the Silverburn between Castletown and Ballasalla there are at intervals slight exposures of dark flaggy limestone between 100 and 800 yards N.N.E. of the foot-bridge west of Creggans [SC 27511 69423]; and a small excavation on the E. side of the railway 600 yards N. of the bridge shows boulder-clay resting on a glaciated surface of the limestone. Creggans Hill [SC 27668 69210], S.E. of this place, though mainly a drift-feature, is probably moulded on a core of limestone. The same rock is exposed again in the shallow railway cutting 450 yards W.S.W. of Ballasalla Station [SC 27741 69630], and in both banks of the adjoining stream. It is seen at several places in the main street of Ballasalla; around the buildings at the northern end of the village N. of the old Crossag Bridge [SC 27999 70485]; and in the road at Ballatarrant [SC 27954 70738] and Ballavoddan [SC 28005 70942], W. of Awin Ruy.

In the bed of the Silverburn, at the weir 50 yards N. of the Crossag [SC 28001 70483], there is a good exposure of steeply-tilted limestone which Cumming believed to occur on the course of a fault striking N. 10° W. mag.<ref>"Isle of Man", p. 44.</ref> On the W. side of the river 150 yards N.N.W. of this exposure the limestone has been quarried. The outcrops in the higher portion of the valley and in the bed of Awin Ruy, and also that in the bank W. of Rushen Abbey have already been described (p. 197).

West of the Silverburn

West of the Silverburn, the principal and indeed almost the only exposures are in the large quarries around Ballahot [SC 26950 70248]. The first of these is on the north side of the mainroad leading from Ballasalla to Arbory, on the rise out of the Silverburn valley; the section showed (in 1893) fifty to sixty feet of dark flaggy limestone with shale partings, containing the usual fossils of the lower division, under a capping of eight to ten feet of red boulder-clay.

The largest quarries of the district are those less than half a mile farther west [SC 26848 70084], on the western side of the Castletown and Foxdale highroad between Ballahot and the cross-roads. They show irregular drift 3 to 20 feet thick on 20 or 30 feet of dark flaggy limestone with lumpy bedding-planes, in courses from 1 to 4 feet in thickness with shale partings, dipping mainly at about 6° towards S.S.W. The surface of the limestone is in places decomposed into 'umber,' and the same kind of weathering extends downward along the joints. The bottom of the quarries is below water-level, and is kept dry by pumping, partly by steam and partly by wind-power, the average annual discharge being estimated by the proprietor at about twenty-six million gallons.

Between these sections and the boundary-fault no further exposure is now visible to the northward of the Arbory road, though the top of the limestone has probably at one time been excavated in the shallow depression, 700 yards north of Booilevane, at the place marked Umber Pit [SC 26333 70399] on the six-inch map. The soil in the field to the westward of this place is full of fragments of decomposed limestone, and the till in the gutter above Umber Pit is full of limestone-rubble, which gives place to red conglomerate-rubble north of Billown farmstead [SC 26095 70687], and then to slate (see p. 196).

In the absence of further evidence, the boundary adopted on the tap for the limestone in this quarter has been based on the average direction of the boundary-fault where seen at Port St. Mary, Kentraugh and Athol Bridge; and is practically identical with that of Cumming's map.<ref>Q.J.G.S., vol. ii, pl xv., and " Isle of Man", Plate at end of vol.</ref> I was informed however<ref>My informant being Mr. T. Maddrell of Ballamaddrell.</ref>, that a well sunk seventy years ago behind the house at Ballamaddrell [SC 25156 70944] reached limestone after passing through 42 feet of clay, this place being one-third of a mile N.N.E. of Arbory, and half a mile beyond the boundary of the limestone as shown on the map. As slate is exposed immediately north of Arbory (Ballabeg), and again north of Billown (p. 196), the presence of limestone so far to the N.W. as Ballamaddrell could only be explained by trough-like cross-faulting. The drift in this quarter, especially towards its base, is full of limestone boulders, and the report that the well reached the limestone rock may have been based on this circumstance. The statement has been handed down verbally for two generations and is

scarcely sufficient grounds for the conjectural mapping which its acceptance would necessitate. It may nevertheless be pointed out that the transverse fault exposed on the shore between Balladoole [SC 24005 68574] and Strandhall [SC 23410 68767] (p. 204) would, if prolonged, intersect the main fault in the vicinity of Arbory [SC 24944 70443] and would have the effect of letting down the limestone to the eastward.

South of the Arbory and Ballasalla road, the rock exposures are few until we reach the vicinity of the coast. It is said that on Skybright Hill [SC 26686 69460], immediately to the westward of St. Lupus's (Malew) Church, the limestone lids only two feet beneath the surface, a statement supported by the abundance of limestone fragments in the soil. Like Creggans Hill, the aspect of this ridge is that of a drift-feature, and as such it was regarded by Cumming; <ref>"Isle of Man", p. 54.</ref> but if the limestone occur as stated, the drift must be only a thin veneer on a hillock of rock.

Dr. J. Clague of Castletown informed us that he remembered a small limestone quarry, now quite obliterated, in a field about a quarter of a mile S.W. of Ballanorris [SC 25172 69655]. On the rising ground north-west of Ballakeigan farm [SC 25568 68651], a little over half a mile S.S.E. of Ballanorris, the drift is very thin, and the soil full of limestone-fragments; and dark limestone in place is exposed and has probably been quarried under the fence at the north-eastern corner of the field, 300 yards W.N.W. of the farm-buildings. This is another example of a drumlin-like mound proving on examination to be a solid feature, and shows that the unevenness of the surface in this area is by no means due solely to the drift-deposits.<ref>Compare Cumming, "Isle of Man", pp. 52 to 57.</ref>

South of Ballakeigan, dark fossiliferous limestone dipping nearly west is visible in the bed of the little stream draining to Poolvash, a few yards above, and 100 and 250 yards below Maddrell's Bridge [SC 25649 68207], the crossing-place of the Castletown high road. A boss of cherty limestone may also be seen in the adjoining field about 100 yards south of the last of these exposures. To the southward, between Knockrushen [SC 26073 67199] and Poolvash [SC 24541 67574], and to the westward on the hummocky ground between the high road and the coast at Balladoole, there are numerous outcrops of massive pale limestone, apparently belonging to the Upper or Poolvash division (seep. 216). Rock of similar character is exposed in an old quarry in a field 150 yards north of the highroad at Cross Welkin Hill [SC 24668 68635] near Balladoole [SC 25464 67061]; but the soil at the foot of the hi is full of fragments of dark flaggy limestone, so that the junction of the divisions may lie between these points. A few hundred yards farther west, at 150 to 350 yards from the coast, dark limestone dolomitized in places is visible in both banks of the stream which reaches the sea at Strandhall [SC 23385 68741]. If the Balladoole fault (Figure 53) were prolonged in a straight line, this exposure would lie to its eastward or down-thrown side, and ought therefore to reveal the Upper Limestone; whereas it presents the characters of the Lower Limestone, so that it is probable the fault has an easterly curve and passes to the east of this section.

Between the last-mentioned stream and the boundary-fault no actual outcrop of the limestone was seen, but the soil in the fields adjacent to the by-road leading from Strandhall to Cronkmooar [SC 23723 69239], from 350 to 750 yards north of the shore, contains fragments of dark flaggy limestone in such abundance that the rock must lie near the surface, and has therefore been indicated on the map.

The Poolvash or Upper Limestone

This division as recognised by Cumming occurs in a series of remarkable exposures on the shore between the Balladoole fault and the outcrop of the Volcanic Series at Poyll Vaaish [SC 24441 67569], a space of about half a mile; and extends inland for about the same distance, in a strip running roughly parallel to the coast from Balladoole to the vicinity of the western shore of Castletown Bay.

Before entering upon the description of the very curious and exceptional stratigraphical relations of this limestone, we will take into consideration the general account given by Cumming in the following passages.

"The Upper Carboniferous limestone or Yoredale series, is only found at Poolvash to the west of the burn which comes down from Balladoole [SC 24036 68648]. It is of a light colour, made up almost entirely of fossils, of which nearly 200 varieties have been collected within the area of an acre. It has, comparatively speaking, few species (not more than 30 in 200) in common with the lower dark limestone series, and seems to have been originated under very different conditions: the sea had evidently become shallower. Its characteristic fossils are *Orthis resupinata*, *Terebratula excavata*, *Productus*

striatus, and *Goniatites crenistria*, all very abundant. It occupies a very small space of hardly more than half a mile in extent, rising up into a low hill to the west of Balladoole House [SC 24871 68010], and has been much dislocated and altered by the intrusion of trap dykes on the sea-shore south of Balladoole. Owing to these dislocations and to the covering of boulder clay, its passage into the lower limestone is hardly to be made out".

The above sentences contain Cumming's latest description of the deposit<ref>From "Guide to the Isle of Man" (1861), p. 181.</ref>. In his earlier writings the following additional details are given.

"The best place for tracing the connexion" [with the lower limestone] "seems to be at the edge of the fault at Poolvash, about 300 yards westward of the road running from Balladoole to the sea-shore, where some dark beds, which look like the commencement of the lower limestone, are brought up; but as not more than four or five feet appear, the few fossils contained in them are hardly sufficient to establish their identity. There can, however, be little doubt that a great and almost sudden change took place in the physical condition of the basin in the midst of the period of the deposition of the limestone strata, almost every species of mountain limestone fossils being crowded within a thickness of not more than sixty feet of limestone, and in an area of scarcely a mile across. Even here, however, we may remark, that the various beds of the series have individually their own more characteristic fossils. Thus I have found *Nautilus oxystoma* in the lower Poolvash beds alone, and the same species (but of much larger size) in the lowest dark limestone of Ballahot. The beds next above seem characterized by a *Natica* and by *Cyathophyllum basaltiforme.* In the next we have *Orthis resupinata* and *Goniatites crenistria*, extremely common and later still, *Nautilus sulcatus*. Some of these fossils range more or less through the whole series. The Orthoceratites are more common in the middle period, and so also is *Terebratula excavata*. Somewhat earlier we have *Producta anomala*, and a little crustacean, named by De Koninck *Cytherina Phillipsiana*, pervades both the earlier and middle beds. In the upper portion the larger corals disappear and give place to *Fenestella*, while in that part even the Encrinites are not abundant in proportion to other fossils".<ref>"Isle of Man", 1. 241</ref>.

In discussing these facts in his larger work<ref>Quart. Journ. Geol. Soc., vol. ii., p. 322.</ref> he remarks: "The light-coloured limestones… seem separately divisible into (so to speak) zones of life; and thus we see, even within the very limited area of this basin, that, as in the present day, so also in the palteozoic period, there were certain ranges of depth within which each animated species was confined, and that whenever, from any cause the sea-bottom was elevated or depressed, certain species died out, and others came in to take their place".

These statements as to the distinctiveness of the fauna of the Poolvash Limestone are of especial value for their bearing upon its stratigraphical relationship to the other divisions. The examination of a selection of the fossils by the paheontologists of the Survey in the preparation of the list given on p. 256 has somewhat modified, but on the whole supported, Cumming's results.

The curious mode of occurrence of the pale limestone on the coast westward of Poolvash did not fail to attract the attention of Maeculloch, who noted that pale grey or impure white unstratified limestone, often crystalline and refractory like primary limestone, " which accompanies the regular beds is found irregularly interspersed in detached masses throughout the whole calcareous tract of which it forms a part. It is neither placed above, nor, as might more naturally be expected, below the strata, but is irregularly intermixed with them, forming a portion of the common deposit"… "In almost every instance, its superior hardness and the greater resistance it offers to the sea and weather, cause it to project in rough masses, often many feet in height, above the surrounding stratified rock…. In some instances it decomposes by weathering into round honeycombed cavities separated by irregular ridges; resembling that limestone which occurs at Broadford and at Kilbride in Skye". He then goes on to discuss at considerable length the relations of the limestones to each other, with the object of proving that the unstratified limestone need not be "primary". <ref>"Western Isles", vol. ii., pp. 555–568, and vol. iii., pl. xxvii.</ref>

Henslow more briefly described the phenomena and illustrated them by an excellent section.<ref>Trans. Geol. Soc., vol. v., 1,p. 492–3, and pl. 35, fig. 6.</ref> In discussing the " change which sometimes takes place in the limestone, where its colour becomes reddish-brown and the texture crystalline [dolomitization]… slightly visible in Castletown Bay, but very plentiful to the south [? westward] of Poolvash", he adds— "Whether it forms a separate belt in the latter case or is merely a modification of the regularly stratified limestone is not so apparent. At one spot, however, near the black marble

quarries at Poolvash, two or three eminences occur of this nature rising through the regular strata, which are wrapped round and abut against them in a very perspicuous manner, the change being extremely sudden, the unstratified portion having a rugged appearance and being filled with fossils, the surrounding strata thin, slaty, and scarcely containing a trace of any".

Cumming seems to have regarded the features referred to in the above descriptions as part of the general disturbance and induration due to the intrusion of the olivine-dolerite dykes, to which he generally assigned greater importance than would now be acknowledged; and intentionally eschewed any particular discussion of the unstratified bosses. "Westward of Poolvash", he remarks, "the trappaceous deposits [*i.e.*, Volcanic series] do not appear, and the shore is so much intersected with trap-dykes and the rocks are so much altered, as to prevent all description of that neighbourhood".<ref>Quart. Journ. Geol. Soc., vol. ii., p. 333.</ref> In another place he says that "it is impossible to make out any order in the beds, though it is generally evident that in proceeding north-westward we are descending again into the lower series".<ref>"Isle of Man " p. 136.</ref>

No later discussion of the peculiarities of this limestone seems to have been attempted, until the present writer gave a brief description of the exposures in the Handbook prepared for the Liverpool meeting of the British Association in 1896 (p. 173), in which he suggested that the hummocks of pale limestone might be "Knoll-reefs" like "the bosses described by Mr. R H. Tiddeinan in the Carboniferous Limestone of the Skipton district of Yorkshire".

Description of sections

Coast at Poolvash

Starting from the north-western part of the exposure at the Balladoole fault, we from the dark flaggy Lower Limestones to the westward of the fault to a confused dolomitized mass veined in every direction with calcite and quartz. The line of the dislocation forms a shallow channel a few feet wide on the foreshore, more or less filled with shingle, but revealing here and there traces of a small decomposed dyke of olivine-dolerite among the fault-stuff. To the eastward for 450 yards, a shelving bank of shingle, probably in part belonging to the Raised Beach, extends above high-water mark and there is no cliff. The shore, a quarter of a mile broad at low water, is composed of low platforms of limestone, sprinkled over with shingle and boulders, and broken up by wide basin-like depressions in which the accumulation of shingle hides the rock. Some of these depressions are not drained at low tide, and in the summer they become choked with decomposing seaweed which renders this little area a most uninviting portion of the otherwise charming coast. Immediately to the eastward of the fault-channel, where rock is visible it consists of brown dolomite which appears to have soon shattered into small fragments and recemented by the segregation of white thread-like veins of quartz and calcite which make a delicate lace-like network on the weathered surfaces. This structure accompanies the fault down to low water and occurs again, in places, among the dolomitized rock 150 to 200 yards east.

The limestone for 20 or 30 yards to the eastward of the fault is completely dolomitized and defossilized; but at that distance, patches of less altered rock make their appearance towards low-water, forming islands in the altered mass; and a few yards farther E. we reach a larger unaltered tract of massive pale limestone of the Poolvash type, containing many fossils. The same features are repeated at high-water mark, but as the shingly hollow of Poyll Richie intervenes, the first actual exposure of fossiliferous rock which has been noted lies over 100 yards E. of the fault. By a rapid increase in the size of the undolomitized or only slightly dolomitized patches, we pass eastward out of the zone of conspicuous alteration in the vicinity of Ghaw Gortagh, about 500 yards. E. of the fault, where the dolomitization disappears rather suddenly, but without there being sufficient evidence to show whether it is arrested at a definite plane of bedding or faulting, or whether, as appears probable, it dies out laterally among the beds. The foregoing reduction from the working field map on the 25-inch scale will illustrate these features (Figure 53).

The general arrangement of the unaltered patches in the tract above described seems to imply that they have formed knolls of massive pale limestone surrounded, like those farther east, by darker flaggy beds; and that while the flaggy beds have undergone complete dolomitization, the less readily altered knolls have preserved an undolomitized core. Traces of flaggy bedding may still be detected in a few places towards the edges of the dolomitized masses, and afford evidence in favour of the supposition; but the absence of any indication of shale-partings among the altered rock tells

somewhat against it. As a rule no dip whatever can be discovered in this area, but there is a faint suggestion of a southward or S.S.W. dip in the larger unaltered tract at Skeir Lea at dead low-water, 150 yards N.W. of Ghaw Gortagh. From the gradual fading of the dolomitization in this quarter it seems probable that the alteration has not extended seaward much beyond low-water mark. Two small parallel dykes of olivine-dolerite, respectively 2 feet and 1½ feet thick, may with difficulty be traced at intervals in the altered limestone of the obscure ground from 50 to 100 yards S. of Poyll Ritchie; and are probably continuous with the corresponding though broader dykes at Ghaw Gortagh. Cumming, as we have seen, sought to connect the dolomitization of the limestone with the intrusion of these dykes<ref>"The very great alteration which has taken place in the [dolomitized] limestone here would seem to indicate that this was the grand focus of disturbance at the period of the trap-dykes, and this is further confirmed by the circumstance that the majority of the dykes which stretch over the area mem to converge towards this locality as a centre". "Isle of Man", p. 136.</ref>, but for this there is no evidence.

From the deep basin-like hollow on the shore due north of Ghaw Gortagh there gushes out, during ebb-tide, a strong spring of salt water (marked on the 6-inch map, (Sheet 16)), no doubt due, as Cumming suggests, to the existence of underground cavities which are filled by the sea at high tide.

To the eastward of this place the shore is occupied by huge cuboidal masses of pale crystalline limestone, often standing up above high-water mark with vertical walls formed by joint-planes, and thus constituting small islands when the tide is at full. In some places this rock is devoid of fossils, while in others it is crowded with well-preserved organisms, uncrushed and in excellent preservation, the interior of the brachiopod shells being sometimes hollow and lined with calcite crystals. Towards high-water mark, darker flaggy limestones with shale-partings enfold these masses and in places appear to dip beneath them, apparently occurring as huge lenticles among the massive beds. The shore at this spot terminates in a low cliff, which shows the preceding section under the cottage 230 yards N. W. of the road from Balladoole House (Figure 54).

One hundred and fifty yards S. of this section, opposite another cottage, the cliff has weathered down into a grassy slope, with a protruding crag on its brow which is extremely rich in fossils. This is perhaps the best place for collecting the Poolvash fauna though the bare rock-platform jutting out from the cliff-line 100 yards nearer Poolvash is also very prolific.

These platforms on the upper surface of the pale limestone-knolls are probably the remains of the shore-terrace of the Raised Beach period. As noticed by Macculloch, they are curiously weathered into a honeycomb of small pits, several inches to a foot or more in depth, separated by knife-edged ridges.

Continuing eastward towards Poolvash, we seem to reach a somewhat higher horizon in the succession, and find that the pale unstratified masses have been almost entombed and overlapped by the flaggy dark limestones, though here and there the crest of a knoll rises abruptly, sometimes with a steep cliff-like margin, above the encircling beds. Near high-water mark on the southern side of the little bay south of Poyllvaaish farmstead, the final stages are seen, in which the flaggy beds, constituting part of the "Posidonia Schist" of Cumming, sweep in a succession of smooth domes over the crests of the knolls, so that only where the flags are broken away is the inner core of massive limestone visible.

It is an important feature of these exposures that in juxtaposition with the knolls there in usually a band of limestone-breccia, consisting of subangular and rounded fragments of palish limestone in a (lark calcareous paste. This is best seen when the rock is wet, as when dry the bruised and battered surface produced by recent wave-action masks the distinction between matrix and inclusions. No rock except limestone has been observed among the "pebbles".

The breccia is usually developed only upon the steeper flanks of the knolls and in the flaggy layer immediately overlying their summits: but in a few places on the shore S.W. of Poyllvaaish farm, lenticles of the breccia occur among the limestone-flags in the intervals between the knolls. Fossils are often abundant in the breccia, particularly small compound corals and fragments of encrinites. Similar fossils occur plentifully in the enfolding Baggy beds, and corals are much more conspicuous in these dark limestones than in the massive pale rock of the knolls.

The following section on the shore of Poolvash 200 yards south of the farm-house illustrates the mode of occurrence of the breccia.

The knoll-structure is most beautifully exhibited, though not perhaps under the best conditions for study, on the northern foreshore of Poolvash inlet, opposite the farmstead. At this place, as indicated by the ornamentation on the 6-inch and 25-inch Ordnance maps, isolated masses of pale limestone, from 10 to 15 feet in diameter and from 5 to 15 feet in height, form an irregular chain running with a slight curve nearly east and west (see plan, (Figure 53)). This chain is terminated abruptly westward by the overlap of the volcanic ash occupying the lower part of the shore; but is prolonged eastward inland in the hillock of Cronk-y-Watch [SC 24648 67591] immediately north of the farm-house, and in bosses partly revealed in the field 100 yards farther east. A group of olivine-dolerite dykes (see plan, (Figure 53); also table on p. 331) traverses the shore between Poolvash and Ghaw Gortagh, cutting through knolls and flaggy beds alike; it is clear that these are as little responsible for the arrangement of the limestone at this place as for its alteration north of Ghaw Gortagh.

The most southerly exposure of the limestone bosses on the coast occurs just above high-water mark on the southern side of Poolvash inlet, only 30 or 40 yards south of the section figured above (Figure 55). The Posidonomya or Black Marble beds then completely overlap them to the westward and southward ccupying a little strip on the upper part of the shore while the lower part is composed of the overlying Volcanic Ash which is continuous southward from Ghaw Gortagh to Scarlet Point.

Cumming was inclined to think that the confused and brecciated mass of limestone, which is apparently overthrust upon the Lower Limestones at the edge of the Volcanic rocks at Scarlet, might correspond to the limestone of the Poolvash knolls, but this correlation is doubtful (see p. 244).

Inland Extension of the Poolvash Limestone

Balladoole

Within 150 yards of the coast to the north westward of Poyllvaaish farm, scattered hummocks of bare limestone rise above the drift-gravel; similar outcrops are seen in two or three places around the outbuildings of Balladoole House; and a bare ridge of limestone forms the rough ground on which stand the traces of the old chapel and burial ground, Keeill Vael [SC 24633 68168], 200 yards north-west of the last-named house. The ridge extends across the road leading to the house; and the same rock is exposed in small bosses in the fields on the eastern side of the road for 200 to 300 yards farther north. Similar exposures occur along the western and northern fences of the field north of that in which Keeill Vael stands, and extend thence north-westward along the fences of the adjoining fields to within 120 yards of the Castletown highroad. The exposure in an old quarry 150 yards north of the same road, on Cross Welkin Hill [SC 24668 68635], has been previously mentioned. All these outcrops are of pale greyish crystalline limestone of the Poolvash type, occasionally but not usually fossiliferous and from their mode of occurrence it is probable that they constitute a series of similar knolls to those seen on the shore.

East of Poolvash

Another chain of exposures extends south-eastward from Poolvash towards the western shore of Castletown Bay south of Knock Rushen [SC 26111 67131], running parallel to and not far distant from the inland margin of the Volcanic rocks. The outcrops take the form of low bosses of pale massive limestone in the cultivated fields, separated from each other by stretches of drift-gravel, each probably indicating the crest of a separate knoll. One of these bosses, on the southern side of the little stream at Poolvash, 120 yards inland, shows a patch of dolomitized limestone on its north-east Hank; another, in a similar position 200 yards farther to N.E., has some darker limestone and shale associated with the massive rock, like the knolls on the shore. Several other bosses occur in the fields bordering the Poolvash inlet, from 200 to 300 yards N.E. and N.E.E. and again 500 yards due east of the "Black Marble" quarry. These and other similar outcrops have necessarily been indicated on the published drift-map as if continuous with each other, the scale not permitting the individusj bosses to be shown.

The next exposures are about ¼ mile farther south and 370 yards southeast of the earthwork marked "Fort" [SC 24625 66873] on the one-inch map, extending east and west for about 250 yards, to within 130 yards of high-water mark. In these, pale massive limestone rich in fossils appears to project in a narrow tongue into the margin of the Volcanic Ash

(see p. 236). To the southward of the above, no actual exposures were seen; but from the shape of the ground and the character of the soil there appears to be a thinly covered boss in a field 550 yards W. 5 S. of Scarlet House. Eastward, massive bluish limestone, weathering paler, crops up in the uneven ground 50 yards north-west of the farmhouse rather over ¼ mile north-west of Scarlet House.

Knock Rushen

The last exposure to be described is that to which reference has already been made, on the hillock of Knock Rushen [SC 26010 67322], within 150 yards of the shore immediately south of Castletown, where massive grey limestone containing many fossils is seen around the outbuildings of Knockrushen House [SC 26066 67212], and in the field to the north-westward. In one part of this outcrop a south-easterly dip was observed, which if continued would carry the bed beneath the Lower Limestone of the coast-section; so that it is somewhat doubtful whether we are justified in including the exposure in the Upper Limestone. It may be merely a bleached and weathered outcrop of one of the thicker beds of the Lower Limestone; Cumming, in his earliest paper, seems however to have recognised it as belonging to the upper division, though the following passage is the only reference to it which he makes: "How far inland the Poolvash limestones extend, I have not as yet seen; the outcrop is seen at Knockrushen at the southeastern side of the basin, and they must have been denuded from the whole of Castletown Bay, if indeed they ever extended in that direction".<ref>Quart. Journ. Geol. Soc., vol. ii., p. 334. </ref> His later writings contain no mention of the locality, and moreover limit the Upper Limestone to the area west of the stream at Poolvash, thus excluding all the inland exposures described above, except those around Balladoole (see extract quoted on p. 208). There seems no likelihood of a fault of any magnitude coming between the Lower Limestone of the shore and the Knockrushen outcrop, and its correlation with the upper division, if it could be established, would afford better evidence than is elsewhere obtainable for the relationship of the two divisions, since the massive limestone of this place must be in direct contact with the undoubted Lower Limestone of the shore of Castletown Bay. If the same relationship be continuous to Poolvash, we might reasonably consider the dark flaggy limestone and shale there associated with the "knolls" as the direct upward continuation of the Lower Limestones, slightly modified by changed conditions. But Cumming apparently considered these Poolvash flaggy beds as forming part of his "Posidonia Schist", though it is by no means clear how much he intended to include in that division. A careful investigation of the fossil contents of the Knockrushen outcrop and a comparison of them with those of the Poolvash Limestone on the one hand, and of the Lower Limestone on the other, might serve to elucidate this matter.

The evidence as to relations of the Poolvash Limestone to the Posidonomya Beds and of both to the Volcanic Ash, which will be given in the subsequent pages, is essential to the discussion of the origin of the "knoll structures"; and we will therefore postpone the question until that evidence has been stated (see p. 248.)

Posidonomya Beds

Cumming's latest account of this unsatisfactory and difficult division is as follows:<ref>"Guide Book", pp. 161–2.</ref> — "Posidonia schist was the name given by the author, in a paper read at the meeting of the British Association in 1845, to a remarkable formation of black schistoze beds occurring at Poolvash… and locally known under the name of Poolvash black marble. The name was given from the occurrence therein of the characteristic fossil, *Posidonia Becheri*. It is used economically to some extent for tombstones, chimney-pieces and flagging, the steps of St. Paul's Cathedral having been obtained from these quarries and presented by Bishop Wilson".

"After the deposit of the beds of Upper Scar limestone [Poolvash Limestone<ref>The words in brackets are not in the original. </ref>] violent convulsions, accompanied with the protrusion of trap and outpourings of volcanic ash, appear to have affected this area in a remarkable manner, crumpling up the strata into folds… and forming a number of troughs or smaller basins and hummocks in the limestone. These phenomena may be seen more particularly in Poolvash Bay, between Scarlet Head [= ? Close-ny-Chollagh Point [SC 24495 67032], of 6-inch Ordnance Map] and the mouth of the stream from Balladoole [SC 23901 68630]. At periods of greater volcanic quiescence were formed the beds of Posidonia schist, in a shallow sea or estuary into which the rivers were bringing down the black mud of which the schist is composed. The proximity of land appears from the singular fact that in these beds of Posidonia schist we meet with plants of the coal strata, *Adiantum*, *Pecopteris*, *Sphenopteris*, *Lepidostrobus ornatus*, and *Calamites*. We meet at the

same time with truly marine organisins, such as *Goniatites* and *Orthocerata*, ….

"The Posidonia schist is sometimes found overlapping the felspathic ash, which had filled up the hollows, and resting directly upon the limestone. After a period of quiescence the volcanic action seems to have set in again,accompanied with violence and partial breaking up of the previously formed beds, producing a breccia in which we meet with fragments of the Posidonia schist, somewhat altered, and presenting the appearance of chert, and then a more quiet deposit of ashes, and the formation of other beds of the black carbonaceous mud; but on account of the dislocation of the strata, the exact sequence cannot readily be made out.

"It is extremely interesting to notice the formation of volcanic ash in the midst of the Carboniferous strata, containing Carboniferous fossils, and to compare it with similar formation in Silurian times".

In his earlier paper, Cumming gives further details regarding the deposit, describing it<ref>Quart. Journ. Geol Soc., vol. ii., p. 323</ref> as "a schist or plate, in some places ten feet thick, in others not so many inches. It is characterized by an abundance of very beautiful and perfect Posidonite, by several cephalopodous shells, not occurring elsewhere in the basin, and in one place by several varieties of Ferns, the nearest approach here to the Coal-measures. All the shales abound in iron-pyrites; and in one spot we find, a little to the east of a stream running from Balladoole into the sea, and parallel with a trap-dike, several extremely beautiful fossils of this material, consisting mostly of *Goniatites* and *Orthoceratites*".

In another place<ref>"Isle of Man", p. 359.</ref> he adds the information that " the ferns and *Favosites Gothlandica* may be met with in a hollow near three dykes, about 300 yards westward of the Balladoole stream" (see plan, (Figure 53)).

The last quotation is important inasmuch as it shows that Cumming included the flagay beds surrounding the "knolls" to the westward of Poyllvaaish in the "Posidoma Schist", though elsewhere he seems to confine the term to the "black marble" deposit of the eastern side of the inlet. But with this division as with the Poolvash Limestone, he avoids, and indeed deprecates, any attempt to define its limits accurately, aptly comparing the present arrangement of the whole Carboniferous series in this quarter to the frozen surface of a fresh-water lough just accessible to the sea, in which successive layers of ice have been partially broken up and tilted by the influence of the tide and partially overlapped by new ice.<ref>Ibid. pp. 134–5.</ref>

The only later published account is that of Mr. John Horne, whose brief notice of the deposit contains the following passages<ref>Trans. Edinburgh Geol. Soc., vol. ii., pt. iii. (1874), pp. 330. 331.</ref>:

"Lithologically, they ["The Poolvash Black Marble Beds"] are distinct from the underlying groups, and imply a change in the physical conditions which existed during the time of their formation. In the quarry of Poolvash, where they have long been worked, the consist of black shales and black calcareous flagstones, varying in thickness from 6 to 18 inches. They dip nearly west, but north and south of the quarry on the shore they roll about… . On the shore at the north of the Poolvash Burn they are interstratified with thin white limestones, which resemble the limestones of the underlying group".

In discussing Cumming's statement that the Posidonia schist did not appear to have any exact equivalent in the British Islands, Mr. Horne remarks: — "From the manner in which the black shales and flags are interbedded with bands of white limestone, it occurred to me that they really belonged to the close of the white limestone group, though implying different physical conditions. If it be true, as Cumming infers from the nature of the fauna, that the white limestones were deposited in shallow water, then it might quite well have happened that the change from one set of conditions to the other was a gradual one. But, further, the fact that the black marble beds, which are in all probability estuarine, being inter-stratified with the white limestones, seems to point out an alternation of the conditions under which they were deposited. Slight elevations and depressions no doubt intervened".

"Mr. R. Etheridge, Jun., F.G.S., has kindly furnished me with the following note on the fossils found in these beds":

"Of the thirty-six species of animals mentioned by the Rev. J. G. Cumming as characteristic of his Posidonia schist, we may eliminate three species as undetermined, two of doubtful determination, and seven new species created by the author himself, and which from a stratigraphical point of view prove nothing. This leaves twenty-four good species, of

which twenty-two are characteristic carboniferous limestone forms. The two remaining species, *Posidonia Becheri*, Phill. and *Posidonia literalis*, Phill., are more particularly representative of the upper limestone shales and Yoredale rocks, that group of shales, grits, and fine sandstones which in central England intervene between the true Carboniferous limestone and millstone grit. It is to the horizon of the upper limestone shales that the Posidonia schist is probably referable. Some few of the above twenty-two limestone species have been met with in the Coal Measures, but only under exceptional cases and conditions".

Description of the sections

The Posidonomya Beds, as described in the above quotations, cannot be recognised anywhere excepting in the limited coast-exposure at Poolvash. Here they are typically developed only in a small patch about 200 yards long by 150 yards or less in width, on the upper part of the shore immediately to the northward of the fort. They are best seen in the "Black Marble" quarry,<ref>In most Manx topographical works one finds the statement that the steps of St. Paul's Cathedral were obtained from this quarry. Cumming notes that this event took place in the days of Bishop Wilson, i.e., early Pith century. ("Isle of Man", p. 132.) The rock is not particularly thimble, and the steps probably perished long ago; at any rate there are no steps of this character now in existence outside the cathedral.</ref> now no longer worked, 75 yards N. of the fort [SC 24612 67211], where they are traversed by one of the larger olivine-dolerite dykes. This dyke, though in one place only 9 feet, is for the most part from 15 to 18 feet wide, and in making an elbow on the "shore just outside the quarry, expands to a width of 39 feet; in its north-westward course it crosses the junction of the Posidonomya beds with the Volcanic Ash, and is prolonged among the Ash to near low-water mark, where it splits into several branches. In the quarry its effect upon the "black marble" is to render the deposit splintery and to destroy the Baggy character for a space of *7* to 9 feet from the contact on its northern side.

The quarry shows 24 feet of the Posidonomya Beds consisting of smooth dark regular limestone-courses, from 4 inches to 2 feet in thickness, with partings of black shale ranging from 2 to 6 inches thick, these partings being thickest in the upper part of the beds. A capping of coarse gravelly and clayey drift 6 to 12 feet thick, resting on a well-glaciated rock-surface, completes the section. The bottom of the quarry, being below high-water mark, is generally flooded; it does not seem to have reached the base of the flags. A greater thickness of the Posidonomya beds is revealed in this section than in any other exposure, and indeed it is greater than one would have estimated from the study of the outcrop on the shore.

As we have already seen, northward of the little stream in Poolvash inlet, the "knolls" of massive limestone approach the boundary of the Volcanic Ash, and the dark flags and shales which represent the Posidonomya Beds are confined to the flanks of the knolls and the hollows between them. Westward, the extension of the flaggy beds inland must be cut off within 150 yards of the low cliff by the chain of knolls previously described; while inland southward also, the massive limestone and the Volcanic rocks are nearly, if not quite, in contact within a short distance of the coast (see p. 217).

Cumming regarded the Posidonomya Beds as having been deposited in little basins and troughs between the hillocks of Poolvash Limestone, and this of course implies that the knolls of the latter were in existence prior to the deposition of the Posidonomya Beds. The partial interbedding of the two divisions, to which Horne draws attention, would not seriously impair this explanation, since it need indicate only a certain degree of contemporaneity between them during the transition from the earlier to the later set of conditions. Indeed, on the foreshore just opposite the quarry there seems, as shown in the above figure (Figure 56), to be direct evidence that the formation of knolls and flaggy beds has gone on, at any rate on a small scale, simultaneously.: and therefore that masses of the pale limestone may occur at different horizons in the flaggy beds.

It is, however, essential to this explanation that the knolls should be regarded as structures of original deposition; and though such has hitherto been my own opinion<ref>See "Outline of the Geology of the Isle of Man", British Association, Liverpool, Handbook, 1896, p. 174.</ref> and one which, after repeated re-examinations, I am still disinclined to relinquish, a powerful argument has recently been put forward by Mr. J. E. Marr<ref>Quart. Joum. Geol. Soc., vol. lv. (1899), pp. 327–358.</ref> to show that somewhat similar phenomena in the Carboniferous Limestone of north-western Yorkshire have been caused by complicated folding and earth-movement. Hence it becomes important that we should closely investigate the indications of disturbance in the rocks in question; and while I still fail to understand how any

combination of movement can have produced the Manx knoll-structure, it is undoubtedly the fact that intricate crumpling and overthrusting can be detected in this area at the junction of the Volcanic Rocks with the Posidonomya Beds.

Junction of the Posidonomya Beds with the Volcanic Ash

On the shore opposite the "Black Marble" quarry [SC 24511 67216] the smooth flaggy Posidonomya Beds have been thrown into a succession of steep ellipsoidal domes of variable size, with quaquaversal dips, as shown in the plan of a single example given above (Figure 57), resembling those already noticed in the Lower Limestone; and these undulations continue up to the boundary of the Volcanic Ash.

The Ash makes its appearance in the low cliff 60 to 80 yards south of the quarry, and it extends thence across the shore and encircles the Posidonomya Beds on the westward as already described (see plan, (Figure 53)). In approaching the junction, the crests of the undulations in the Baggy limestone become more acute, until where they disappear beneath the Ash they are pinched up into sharp ridges, which when seen in ground-plan at their narrowest part resemble dykes traversing the Ash.<ref>This peculiarity was commented on by Macculloch, "Western Isles, vol. ii., p. 564.</ref> In a few places, twisted and partly breceiated shreds of limestone occur in the Ash in such a manner as to suggest that they have been stripped off from the broken crest of the undulation. In the basins between the crests there is frequently two or three inches of pyritous platy material, forming a definite parting between the Ash above and the limestone below, not possessing the characters of a passage-bed but like the mylonitized material of a thrust-plane. The surface of the limestone beneath this layer is usually indurated, cherty and pyritous, and sometimes slightly brecciated. These features are exhibited in the section shown in (Figure 58).

In following the junction northward along the shore, the indications of sliding of the Volcanic Ash over the Posidonomya Beds become still stronger, brightly slickensided surfaces being visible in places in the shaly limestone near the contact, while the characteristic cherty induration, pyritization and partial brecciation of the limestone floor is very pronounced. These features are well seen at the base of an upstanding crag of Ash, 70 yards N.W. of the quarry. The slickensides indicate a movement at this place toward N. 15 W., but the strike of the undulatory ridges usually lies between a few points east and a few points west of north.

On the foreshore in the vicinity of this crag, shallow quarrying on an extensive scale has been done in the uppermost or indurated portion of the limestone, the Ash having apparently been stripped off in search of this layer, which probably furnished the hardest and best of the so-called "black marble".

To the northward of this place, the Ash gradually approaches the knolls of Poolvash Limestone, proportionately reducing the space occupied by the Posidonomya Beds. In the middle of Poolvash inlet the exposures are poor, the shore being wet and shingly; but wherever the base of the Ash is revealed, it is seen to rest on crushed shaly material with strong indications of overthrusting. Minor planes of movement may also be detected in the Ash several feet above the junction. To the S.W. and W. of Poolvash farm, where the boundary draws nearer to high-water mark, the Ash seems originally to have abutted directly upon the knolls; but in all except one doubtful case the sea has now denuded the material from their flanks, as shown in (Figure 59).

In the doubtful case just referred to, the Ash at one point is in actual contact with a knoll of pale limestone; but this junction may possibly be due to small faults, as indicated in the plan, (Figure 60).

Where the junction turns westward just before sinking to low-water mark on the S. side of Ghaw Gortagh, the suggestion of overthrusting at the base of the Ash is strengthened by the apparent truncation of some tilted shreds of limestone which lie among the volcanic material.

It is thus doubtful whether in any of these sections the original base of the Volcanic Series is revealed; nor can we tell for how far the Ash has been carried across the limestone by the overthrust, nor how much of the Posidonomya division is hidden beneath the Ash. As there is no admixture of volcanic material in the beds below the thrust-plane, it appears probable that the series is incomplete, and that higher calcareous beds showing an upward passage into the Ash may have been covered over or broken up by the displacement. We shall revert to this subject in discussing the Volcanic

rocks (see p. 237), and shall afterwards review the bearing of the overthrusting upon the question of knoll-structure.

The Carboniferous Volcanic Series of Scarlet

Historical and general

The magnificent exposure of the Carboniferous Volcanic rocks on the coast between Scarlet Point [SC 25656 66161] and Poyllvaaish [SC 24491 67406], a distance of 1¼ miles, possesses perhaps greater attractions for the geologist than any other portion of the Island, and occupies in consequence a prominent place in the literature. Berger described the eruptive material as an unstratified bed of Amygdaloid, overlying the limestone.<ref>Trans. Geol. Soc., vol. ii., p. 45.</ref> Macculloch referred to it as a breccia different from any rock with which he was acquainted, and compared it to rubbish formed on the surface by atmospheric agencies.<ref>"Western Isles", vol. ii., pp. 570–1.</ref> Henslow appears to have been the first to recognize its true character, pointing out that the greater part of the mass was not amygdaloidal trap as Berger had supposed, but trap-tuff of loose texture, traversed by dyke-like masses of amygdaloid near Scarlet, and intercalated with isolated bands of limestone in the opposite direction<ref>Trans. Geol. Soc., vol. v., pp. 495–6.</ref>.

Cumming demonstrated that the tuff must have been laid down beneath the waters of the sea, because of its close association with the limestones and the presence of marine fossils in its stratified portion<ref>Quart. Journ. Geol. Soc., vol. ii., pp. 322–3.</ref>. In reference to those fossils, he stated that towards the northern part of the exposure " we meet with organic remains regularly imbedded not only in the limestone, but in the trappean ash; they are chiefly corals and crinoidea,<ref>No separate list of these fossils is given, nor does there seem to have been any attempt since Cumininies time to collect them. Fragments of encnnites are by far the commonest forms, and indeed the only kind visible to casual examination. In the Cumming collection at King Williams College, Castletown, there is a specimen of *Posidonomya* in an ashy matrix labelled "Scarlet" (see also p. 236).</ref> and are the newest of the Palaeozoic fossils occurring on the Isle of Man; they are rather abundant than otherwise, though the eye does not readily catch the particular beds in which they occur".<ref>"Isle of Man", p. 129.</ref>

He regarded the eruption as having accompanied or followed the production of "an extensive crack or chasm running along an axis from the Stack of Scarlet, in a direction nearly N.W. by W."<ref>Quart. Journ. Geol. Soc., vol. ii., p. 322.</ref> His statements as to the relationship of the "Posidoma Schist" to the Volcanic Rocks are somewhat confused, inasmuch as while they usually imply that the former underlies the latter, his coloured section<ref>"Isle of Man", Section No. 2, plate vii. At first glance these sections, though published two years later, appear to be reproductions of those in his earlier paper in Quart. Journ. Geol. Soc., but on comparison numerous alterations will be found in them.</ref> and certain remarks in the letterpress seem to indicate the "Posidonia Schist " as being underlain as well as overlain by volcanic rocks. The following sentences are, perhaps, intended to reconcile these inconsistencies.

"Whilst, on the one hand, the more violent eruption seems to have been but of short continuance, it is evident also that the vent (wherever it might be) was kept open, and emitted for a lengthened period volcanic ash, which was carried by the currents and deposited quietly in different parts of this area… We find also a very interesting local deposit of black carbonaceous mud [*i.e.* the 'Posidonia schist'] going on at the same time, and mingled with the volcanic products, the prevalence of one or other in any particular locality depending, it would seem, on the relative distance of that locality from the sources of the respective ingredients there deposited… . At one period, indeed, the carbonaceous deposit seems to have entirely prevailed, perhaps the volcanic action entirely ceased, gathering strength for a subsequent eruption. The bed then formed has its own lithological character and fossils. It is the Posidonian schist… .

"This quiet and regular deposit was afterwards suddenly interrupted. The volcanic action was again exhibited with renewed violence, as at first. The lower beds of the first eruption, together with the beds of volcanic ash, of mixed trappean ash and calcareous deposits, and Posidonian schists, were contorted, broken up, reduced to a fragmentary condition, and enveloped in the outpoured deposits. There results a trap-breccia, in which the fragments of the older beds seem to have boon considerably influenced by heat. The Posidonian schist has become cherty, the limestone highly crystalline, and in some cases hardly distinguishable from amygdaloid".<ref>"Isle of Man", pp. 242–4.</ref>

The closing passages of the above extract show that the curious disturbances at the junction of the Ash with the limestone were duly recognised, and considered to be connected in some way with the volcanic outburst. With regard to the position of the orifice of the volcano, Cumming remarks: "I have never been able to make out with certainty where the volcanic vent was that emitted the trappean materials first deposited, though I have conjectured that it was a prolonged chasm extending from the Stack of Scarlet into Poolvash Bay" (op. cit., p. 123). Cumming's knowledge of the details of the deposits was so intimate that his statements, even when their meaning is at first obscure, deserve the closest attention; and his theoretical explanations will invariably be found to have been established upon a basis of accurate observation.

Quarter of a century later, Mr. Horne gave a careful account of the sections,<ref>Trans. Edinburgh Geol. Soc., vol. ii., pt. iii., pp. 12–15.</ref> describing anew and illustrating by several woodcuts the mode of occurrence of the limestone among the ash; he concluded with Cumming that they indicated intermittent volcanic discharges; he also draw attention to the "bedded porphyrite" occurring among the ash; and suggested that the vertical junction of the volcanic rocks with the Lower Limestone at Scarlet Point might indicate "the irregular edge of an old volcanic neck".

Clifton Ward, in 1880,<ref>Geol. Mag., dec. ii., vol. vii., p. 5.</ref> agreed in all essential points with the previous observers. With regard to the basalt forming the Stack of Scarlet and its dyke-like prolongation westward, he remarks: "There cannot be a doubt, I think, but that it represents an original line of eruption, the part nearest to the Stack being the spot where the volcanic fires first reached the surface, and where the vent became finally choked with large ejected blocks and scoriae, the basaltic liva welling up through a central fissure, and flowing over the volcanic breccia as it is seen to do upon the east side of the dyke. A little further west along the shore the greenish ashy material is less coarse, and becomes distinctly stratified, this representing the matter falling outside the vent, and becoming rudely bedded beneath the shallow sea. Just before reaching the bedded ash, other portions of the lava-flow may be seen overlying the ash, and exhibiting a very vesicular structure in bands. Nearer to Poolvash the ash is interstrati tied with limestone, both the grey and the black Posidonian band, so that there can be no doubt but that the eruption partook of a submarine character".

In 1889 Messrs. Dickson and Holland published some petrological and chemical notes on the Scarlet Rocks<ref>Proc. Liverpool Geol. Soc., vol. vi., pp. 128–130.</ref> (see Appendix II., p 576). Two veers later Mr. B. Hobson gave an account of the petrography of the series (see petrographical notes at p. 325), accompanied by a large-scale plan and sections of the coast from Scarlet westward for half a mile. His general conclusion, as stated in the following passages, aro similar to those of his predecessors. "The succession of events appears to have been as follows: During, or after, the deposit of the Poolvash limestone a vent was opened from which fine volcanic ashes were ejected and fell into the sea, forming bedded tuff At intervals between the eruptions the black, so-called Pool vash marble was deposited, and thus came to be interstratified with the tuff. Probably the vent became plugged up, and the violent eruption accompanying the blowing up of the plug provided the material for the agglomerate which overlies the tuff near Scarlet Point. Then lava welled forth and overspread the agglomerate. Finally the volcano became extinct, and by denudation the intrusive mass of the Stack, which I regard as a volcanic neck, was exposed"<ref>Quart. Journ. Geol. Soc., vol. xlvii, p. 449.</ref>.

There remains to be noticed the later description of the Volcanic Series given by Sir Archibald Geikie, the former Director- General of the Survey, in his "Ancient Volcanoes of Great Britain".<ref>Macmillan & Co., London. 2 vols. 1897. Vol. II. pp. 92–32.</ref> based on his personal examination of the sections in 1895. With the author's permission a considerable portion of this account will be quoted. verbatim. Sir Archibald Geikie's general description of the sections is as follows:

"It may be remarked at the outset that the last outcrop of the plateau-lavas of the Solway-basin occurs only 60 miles from the south end of the Isle of Man, at the foot of the hills of Galloway, the blue outline of which can be seen from that island. The distance from the Manx volcanoes to the nearest of the puys of Liddesdale is about 100 miles. Though the fragment which has been left of the ejections is too small to warrant any confident parallelism, there appears to be reason to believe that, alike in geological age and in manner of activity, the Manx volcanoes may be classed with the type of the puys "The volcanic rocks are… almost entirely confined to the range of cliffs and the ledges of the foreshore. Yet though thus extremely limited in area, they have been so admirably dissected along the coast, that they furnish a singularly ample- body of evidence bearing on the history of Carboniferous volcanic action.

"Unfortunately the bottom of the volcanic group is nowhere visible. At the east or lower end of the series exposed on the shore, an agglomerate with its dykes appears to truncate the Castletown Limestones. No trace of any tuff has been noticed among these lower limestones: We may infer that the volcanic energy began after they were deposited. The highest accessible portions of the volcanic gruito„ as Mr. Horne showed, are clearly exposed on the coast at Poyll Vanish, intercalated in and overlying the dark limestones of that locality… .

"Owing to irregularities of inclination the thickness of the Volcanic group can only be approximately estimated. It is probably not less than 200 to 300 feet. But as merely the edge of the group lies on the land, the volcanic rocks may reach a considerably greater extent and thickness under the sea… .

"The volcanic materials consist mainly of bedded tuffs, but include also several necks of agglomerate and a number of dykes and sills These Manx tuffs present many of the familiar features of those belonging to the pity-eruptions of Central Scotland, but with some peculiarities worthy of attention"

"Their colour is the usual dull yellowish green, varying slightly in tint with changes in the texture of the materials, the est bands consisting of the finest dust or volcanic mud reat differences in the size of their fragmentary constituents may be observed in successive beds, coarse and fine bands rapidly alternating, with no admixture of non-volcanic sediment, though occasional layers of fine ash or mudstone … may be noticed.

"The materials of the tuffs are remarkably uniform in character and conspicuously volcanic in origin. With the exception of occasional blocks of limestone, which range up to masses several feet and occasionally several yards, in diameter, the dust, lapilli and included stones consist entirely of fragmentary basic lava, so persistent in its lithological features that we may regard its slightly different varieties as merely marking different conditions of the same rock.

"The accumulation of pumiceous ash in this southern coast of the Isle of Man is one of the most remarkable in Britain. As Mr. Hobson has well shown, the matrix of this tuff consists of irregular lapilli, representing what may have been various conditions of solidification in one original volcanic magma. This magma he has described as an 'augite-porphyrite' or olivine-basalt. Some of the lapilli, as he noted, consist of a pumice crowded with vesicles which occupy more space than the solid part; others show nearly as many vesicles but the glass is made brown by the number of its fine dust-like inclusions; a third type represents the cells and cell-walls in nearly equal proportions. Tne same observer found that where the substance is most cellular the vesicles, fairly uniform in size, measure about a tenth of a millimetre in longest diameter.

"An interesting feature of the tuffs is the abundant occurrence of loose felspar crystals throughout the whole group up to the highest visible strata. These crystals, sometimes nearly an inch in length, appear conspicuously as whites pots on weathered surfaces of the rock. They are so much decayed, however, that it is difficult to extract them entire. On the most cursory inspection they are observed to enclose blebs of a greenish substance like the material that fills up the vesicles in the pumiceous fragments and in the pieces of cellular lava.

"I have not ascertained the original source of these scattered felspars. In ono of the dykes on the north side of the agglomerate at Scarlet Point, as was pointed out by Mr. Hobson, large crystals of plagioclase occur in the melaphyre, but the feh4pars in the tufts and agglomerates differ so much from these that we cannot suppose them to have come from the explosion of such a rock. I failed to detect any other mineral in detached crystals in the tuffs, but a more diligent search might reveal such, and afford some grounds for speculating on the probable nature of the inagma from the explosion of which the scattered crystals were derived. It, is at least certain that this magma must have Included a large proportion of plagioclase crystals.

"Between the lapilli and the minute pumice-dust that constitute the matrix of this tuff much calcite may be detected. Though this mineral may have been partly derived from the decay of the felspar in the lava-fragments I believe that it is mainly to be attributed to the intermingling of fine calcareous ooze with the ash accumulated on the sea-floor… .

"The stones imbedded in the tuff consist almost exclusively of slightly different varieties of the same rock—a pale, always vesicular rock, and sometimes pass into a coarse slag. They vary up to six feet or more in length; in many cases, they appear to have been derived from the disruption of already solidified lava, for their vesicles are not elongated or arranged

with reference to the form of the block, but have been broken across and appear in section on the outer surface. In other instances, however, the cavities are large and irregular in the centre of the block, while on the outside they are smaller and are drawn out round the rudely spherical shapes of the mass, as in true volcanic bombs.

"The limestone fragments enclosed in the tuff include pieces of the dark carbonaceous and of the pale encrinital varieties. In no case did I observe any sensible alteration of these fragments. They seem to have been derived from material disrupted and ejected during the opening of successive vents, and not to have been exposed for any considerable time to the metamorphic influence of volcanic heat and vapours".

Sir Archibald Geikie then discusses the dyke-like belts of basalt or diabase which traverse the ash and form an important constituent of the Volcanic Series, especially in the eastern portion of the exposure, between Scarlet Point and Cromwell's Walk. He observes regarding them, that "in their remarkably developed vesicular structure they look more like streams of lava than ordinary dykes. It is this structure which gives to these dykes their peculiar interest. Bands of vesicles, from an inch or less to several inches in breadth, run along the dykes parallel to the outer walls. Unlike the familiar rows of little amygdaloidal cells in ordinary basalt dykes, such *rs* those of the Tertiary series in Scotland, those vesicles, though small and pea-like in the narrower bands towards the margin of the dykes, become so large, numerous, and irregular, in the broader and more central bands that the rock passes there into a rough slag".

This resemblance to a lava-flow is again commented on in the description of the supposed sill at Cromwell's Walk, respecting which the following details are given:

"There is, however, a peculiarity about the development of the vesicular structure in this sill which I have not observed anywhere else. If we examine the southern side of the crag near its eastern end, we observe that the successive bands of vesicles are arranged in the same direction as the surface of contact with the underlying tuffs, precisely as they are ranged in the dykes parallel to the bounding walls. So far the structure is quite normal. But, moving a few yards westwards, we find that the bands begin to curve, and, instead of following the contact surface, strike it first obliqqely and then at right angles, until we have the structure shown in (Figure 63) The bands here vary from less than an inch to more than a foot in breadth and where broadest assume a slaggy texture".

After further discussion of the conditions of the eruption, which he believes to have taken place from several small vents between Scarlet Point and Poolvash, Sir A. Geikie concludes his description as follows:

"As the records of the earliest eruptions during the Carboniferous Limestone period in the district of the Isle of Man are concealed, so also those of the last of the series lie under the sea. Where the highest visible tuffs overlie the Poyll Vaaish limestones they show no change in the nature of the materials ejected or in the energy of eruption. They lie so abruptly on the dark calcareous deposits as to show that a considerable pause in volcanic activity was followed by a violent explosion. The same abundant grey-green pumice, the same kind of loose crystals of felspar, the same type of lava-blocks and bombs as had characterized the foregoing eruptions remained as marked at the end. But the further volcanic records cannot be perused, and we are left to speculate whether the coast sections reveal almost the whole chronicle, or if they merely lay before us the early chapters of a great volcanic history of which the main records lie buried under the waves of the Irish Sea".

Farther account of the Volcanic Series

The foregoing quotations will suffice to show the general character of the Carboniferous Volcanic rocks. Their exposure is practically confined to the coast line, the ground being cultivated up to the edge of the cliff and their inland extension probably nowhere exceeding more than 200 or 300 yards in breadth. The shelving rocky foreshore has a width varying from 100 yards at Scarlet to 170 yards near Poolvash, and this tract was mapped by Mr. A. Strahan and myself in 1892 on the scale of 25 inches to the mile. Some difficulties encountered at that time in the interpretation of the sections led mo to make several subsequent re-examinations, but it was not until an opportunity occurred in 1897 for investigating the rocks around Scarlet. Point with an exceptionally low tido that a clue to the unravelling of these difficulties was forthcoming.<ref>See Annual Report of the Director General of the Geological Survey 1887, p. 110.</ref> As mentioned on a pre4ious page, evidence was then found for overthrust movements of the volcanic rocks upon the Lower Limestone;

and on pursuing this line of enquiry it was ascertained that many of the phenomena which had hitherto been assigned to volcanic activity were more probably due to later disturbances by earth-movement. These results were confirmed during two subsequent visits to the outcrop under similar favourable conditions of tide, and a summary of my conclusions on the subject was brought before the Geological Society in 1899.<ref>"On some effects of earth-movement in the Carboniferous Volcanic rocks of the Isle of Man". Quart. Journ. Geol. Soc., vol. lvi. (1900), pp. 11–45.</ref> The disturbances were found to have affected every part of the outcrop, but were especially pronounced at the junction of the Volcanic rocks with the limestone at the eastern and at the western extremity of the exposure, and also in the vicinity of the dyke-like masses of vesicular basalt mentioned in the above-quoted description. Many of the intercalations of limestone with volcanic material, which have been supposed to denote intervals of quiescence between separate volcanic eruptions, I now believe to be displaced masses, dragged up along thrust-planes from the underlying limestone-floor; and most of the dyke-like bands of vesicular basalt I think may have originally been more or less horizontal lava-flows which have been tilted and sometimes broken into fragments during lateral movement of the whole mass. In the following pages the detailed evidence on which these conclusions are based will be presented.<ref>Mrs. M. Ogilvie-Gordon has called attention to the similarity between the structures produced by disturbance in these rocks and those similarly produced in the Triassic rocks of the Ennoberg area in South Tyrol, described in her papers in Geol. Mag., dec. iv., vol. i. (1894), pp. 1–10 and 50–60, and Quart. Journ. Geol. Soc., vol. lv. (1899), pp. 560–033. The phenomena in the Manx Carboniferous Volcanic Senes are, however, apparently of a simpler character, and are on a much smaller scale than those in the Tyrol described by Mrs Gordon (see letters in "Nature", vol. lxi. (1900), pp. 490 and 612, awl vol. lxii. (1900), p. 7).</ref>

In considering this evidence, we will commence at the northern boundary of the Volcanic rocks at Poolvash, where the junction with the limestone has already been described, and will work thence southward to Scarlet Point.

It is curious to note that towards this boundary with the limestone, the ash presents in places a tendency to the dome-like arrangement so conspicuous in the underlying limestones. Near low-water-mark W.S.W. of Poolvash farm, 30 yards N. of the larger olivine-dolerite dyke, the following perplexing section is revealed in the steep edge of a gully in the rock-platform. (Figure 64).

The limestone in this exposure is obviously not in its original position. The plane which defines the surface of the dome is probably an oblique section through a curving plane of slip or overthrust, along which a shred of limestone has been caught up and crumpled. In the crags on the opposite side of the gully, 30 or 40 yards N.W. of the above, the ash, which in this neighbourhood is of medium texture and not often distinctly bedded, shows some well-defined planes, along which there is an inch or two of fine crushed material resting on an even, indurated surface of cherty ash. These are also probably lines of movement.

Most of the lenticles of limestone in the ash are free from any ashy admixture; and I have always found it difficult to understand how this could have occurred if they had been deposited, as supposed, in separate little basins a few feet or yards across, surrounded on all sides by ridges of pumiceous volcanic detritus. To the westward of the above section, however, at extreme low-water between Ghaw Gartagh [SC 24251 67672], and Poyll Vaaish [SC 24411 67395] of the six-inch map (see plan, (Figure 53)), on a rock-platform much obscured by marine growths, there are some shreds of dark ashy limestone among the volcanic tuff In only two or three other instances has limestone been observed with ashy fragments actually incorporated in it, though little wisps of ash between separate surfaces of limestone are not uncommon.

The margins of the included limestone-masses, both great and small, are usually characterized by cherty induration, probably from chemical reactions tending to silicification induced along the surfaces in contact with the ash. In the isolated limestone blocks embedded in the coarser volcanic agglomerates, the silicification generally extends through a deep outer crust which surrounds a less altered or unaltered interior;<ref>See "Ancient Volcanoes", op. cit., pp. 25 and 26.</ref> but the thin contorted strips in the fine ash are altered throughout.

The evidences of overthrusting which are everywhere visible as we follow the junction of the Volcanic rocks with the limestone south-eastward across Poolvash Bay have already been described (pp.224–5, (Figure 58), (Figure 59) and (Figure 60)). The section on the foreshore south of the "black marble" quarry (Figure 58) is especially instructive in

showing how the top of the limestone-flags (Posidonomya beds) has been rucked up by the movement into sharp ridges, the crests of which have been bent over towards the north and sometimes pinched off and carried up into the ash.

At Close ny Chollagh Point [SC 24462 67044], about 50 yards S. of this section, there appears to be a lenticular band of dark flaggy limestone embedded in the ash. But when followed down along 'the foreshore, this band Of limestone is found to be continuous with one of the anticlinal ridges shown in (Figure 58), p. 223 and its curiously irregular outline, cherty surface, and lack of continuity are at once explained when we recognise that it has been pinched up from below.

In the little bay on the south side of Close ny Chollagh Point [SC 24610 66986], 100 yards S. of the old fort, the cliff-section reveals a lenticular cake of grey fossiliferous limestone, about 40 yards long and six or eight feet in maximum thickness, underlain and overlain by ash, and dislocated midway by a small fault. Fossils occur here in the ash close to base of the limestone, including *Glyphioceras* (*Goniatites*) *striatum*, Sow., and *Spirifera* probably *bisulcata*.<ref>These specimens were obtained by Mr. J. A. Howe during our recent visit together to the sections, and have kindly been presented by him to the Survey (L. 1743 and 1744).</ref>

This limestone-lenticle in general aspect differs from all the adjacent strips, bearing a closer resemblance to the pale Poolvash Limestone than to the dark Posidonomya flags. It is difficult to believe that this isolated patch, differing lithologically from the other patches and yet similarly unmixed with ash, is in its original position. The likelihood that it is a slice which has been ridged up and shaved away from below, is further supported by the indications of crushing which are visible around its margin. There appears to be some connection between this mass and the tongue of pale limestone which, as previously described (p. 217), juts out into the volcanic rocks in the field 200 yards inland south-eastward.

The ash on the shore to the Westward and south westward of this section is frequently fine in texture and well bedded;. and contains marine, fossils; chiefly bits of the stems of encrinites. The finer beds occasionally pass into calcareous and sometimes nodular ashy flags; and regularly interbedded with these we find cherty layers of dark limestone, rarely more than an inch or two in thicknek evidently of contemporaneous deposition. These strata possess the true characters of passage-beds; and we should probably have found rocks of this kind forming a transition between the limestone and the ash in all the sections if the junction had been undisturbed. The surfaces of these laminated ash-beds are generally beautifully tessellated by close-set rectangular joints, sometimes not more than an inch apart; while in many places small faults break the continuity of the beds at intervals of a feet feet, or even inches; and sooner or later the stratification beTmes crumpled and confused, and the laminated series is Merged into a mass of ash or agglomerate with twisted shreds of limestone, possessing only a rude platy structure which is 'probably of secondary origin. Though on a smaller scale, and among 'rocks very different in their present lithological condition,. these; phenomena recall structures common in the Borrowdale Volcanic Series pf tile Lake District, in such sections as those under the Sty-head Pass to which my: attention was directed by Mr. Marr and Mr. Harker.

The accompanying copy of a photograph (Plate 4.2) taken by the former Director-General of the Survey during his later visit to the Island, illustratei the stratification and step-faulting in the ash between Close ny Chollagh Point and Cromwell's Walk. In this photograph, the pale layer in the middle of the section has been artificially whitened; this band is faulted down four times towards the right. In the upper right-hand corner, the stratification becomes Confused and lost.

A little to the southward of Close ny Chollagh Point, we find, besides the interbedded calcareous layers, two much larger lenticular masses of black flaggy limestone 25 to 50 yards apart, extending from high-water mark across the foieshore, to below half-tide mark in bold curves more or leis parallel to each other. If prolonged inland in the same direction; these strips would meet the protruding tongue of pale limestone mentioned in a receding paragraph. At their junction with the tuff we find the usual indications of relative displacement, the bedded ash a little above the junction presenting the following section (Figure 66), in which disruption of the original stratification by lateral movement is clearly exhibited.

Disturbances of this kind become more acute as we proceed southward; until at the little cliff at the end of a field-fence 450 yards south of the old fort at Close ny Chollagh Point, we roach a curious vertical wall of coarse agglomerate, made up of large blocks of vesicular basalt., apparently- bursting through fine ash, and in places mined with and overlain by similar ash, but associated with and probably passing into a solid mass of the basalt on the inland side of the section. This has been described as the site of a small volcanic vent. Like the similar agglomerate between Cromwell's Walk and

Scarlet Point, presently to be discussed, there seems however much reason to believe that it may be a sill or lava-flow which has been displaced and brecciated.

Forty yards south of the above section, the base of the cliff reveals a little dome of black cherty limestone 10 to 12 yards in diameter, with its convex upper surface singularly crumpled up among fine structureless ash, and its under surface resting in places on an obscurely exposed mass of basalt into which it appears to be pinched or folded.

Another and larger dome occurs at high-water mark 220 yards farther south. It shows the same peculiarities of structure, and contains, besides, some pebble-like inclusions of pale fossiliferous limestone, resembling in this respect the dark "pebbly" bands around the Poolvash knolls. One of the newer olivine-dolerite dykes bisects this dome.

It is characteristic of these limestone lenticles that they are almost invariably arched upwards, and not downwards as should have been the case if they had been deposited in hollows of the tuff on the sea-floor.

Between the last-mentioned section and Cromwell's Walk [SC 25234 66292], the shore is constituted of broad bare platforms of ash, mostly of medium texture, with a platy structure suggesting incipient cleavage, but occasionally fine and well-bedded. At several places in these sections, indications of normal faulting may be observed; but the evidence is insufficient to prove the amount of throw, and the stratigraphy does not seem in any instance to be seriously affected by these fracture-lines. On the south side of an E.–W. dislocation due S. of "Burial Ground" (6 inch, sheet 16) a dyke-like ridge of vesicular basalt, varying from 2 feet to 7 feet in width, strikes S.S.E. across the foreshore; and 75 yards farther E. there occurs a smaller parallel vein of similar material about 4 inches wide. These bands are much jointed, and some of the joints form small step-faults like those in the laminated ash already described. The larger band is trenched near half-tide mark by a deep gully, and the cross-section therein exposed reveals a sharp to ■-shaped curve, which is probably an incipient fold. This plication dies out towards low-water mark.

At Cromwell's Walk [SC 25234 66292] we reach the broad mass of basalt which presents the anomalous features commented on by Sir Arch. Geikie in passages above quoted.

Between low- and high-water, this basalt rises with steep walls through the ash like an ordinary dyke; but in the crags above high-water mark it rolls over north-eastward, and lies almost flat in a shallow trough of coarse agglomerate, with a little outlier of agglomerate upon its upper surface, here bearing more resemblance to a lava-flow than to a dyke. It is in this tabular portion that we find the exceptional arrangement of the vesicular structure described by Sir A. Geikie (see p. 232, (Figure 61), (Figure 62) and (Figure 63)). Other peculiarities about this basalt also deserve close attention. Its steep south-western face, which is beautifully revealed in the cliff, has a curiously wrinkled surface, suggestive of a lava-flow; and is broken towards the base by a ledge, where a little crushed ash and agglomerate comes in between two nearly parallel surfaces of the massive rock, with indication's that there has been some degree of relative displacement between these surfaces.

Again, in the detached tabular mass just behind the crest of the cliff, we find that where the truncated stream-lines of vesicles occur, the margin of the solid basalt is fractured and gapped by sharp indentations from which irregular blocks have evidently been plucked, these indentations being now filled in with the ash and coarse agglomerate; and immediately beneath the basalt, the agglomerate is crushed and streaky. These features are illustrated in (Plate 3), fig. 2, and (Plate 4), fig. 1, which are reproduced from photographs taken by Sir Arch. Geikie.

In the dyke-like ridge, the basalt is flanked on the south-west by ash of medium texture in which large blocks are rare; while the opposite or north-eastern side it is bordered by coarse agglomerate composed of subangular and rounded blocks of vesicular rock like that of the solid mass, with numerous small wisps, and large rounded blocks of dark limestone with a cherty exterior. Towards low-water, inclusions of limestone increase in size and numbers; and at low tide, 'a dome-like mass of black limestone several yards in diameter is exposed among the agglomerate adjoining the ridge (see plan, (Figure 68)). The character of the agglomerate a little above the principal limestone-dome is shown in (Plate 3), fig. 1, from a photograph by Sir A. Geikie; finer ash overlies the agglomerate in the background.

It is equally difficult to conceive either that the dome of limestone at this place could have been ejected from the volcano, Or that it could have been originally deposited in its present position. But when the evidences of disruption and

rearrangement in the vicinity are taken into account, it appears not improbable that the mass may have been pinched from the crest of a fold and carried along a thrust-plane, like the strips; previously described. This explanation of course implies that the agglomerate now surrounding the limestone must also have undergone great deformation; and it becomes a matter for consideration how much of the structure 'of this agglomerate is due to the volcanic eruption, and how much to the breaking up of the rocks during the movement. That some part should be assigned to the latter cause is, I think, evident from the fractured condition of the margin of the basalt as well as from the relative abundance of blocks of this rock near the solid mass, and of limestone near the dome of limestone. But, of course, in rocks of this character a brecciation-structure might readily be superinduced upon an original pyroclastic structure; and I must confess my inability to distinguish between the one and the other where both are represented in the same section.

I think, however, that the phenomena of this part of the coast, as a whole, may be best explained by regarding the vesicular basalt as a lava-flow which has been tilted on end and partly folded and driven forward among the surrounding ash by lateral pressure; and during the movement it appears probable that portions of the mass were brecciated, and thrust-planes developed along which wedges of limestone were dragged upwards from the underlying floor. This view is expressed in the following diagram.

From Cromwell's Walk the ridge of basalt probably extends towards W.N.W. for some distance, roughly parallel to the cliff-line, at from 30 to 50 yards inland, as there are low bosses of similar rock here and there along this direction in the field in which a mound occurs, marked **Burial Ground** on the six-inch map [SC 25022 66520]. In the next field also there are similar bosses, along the line of a demolished fence; and if these indicate the further prolongation of the ridge it may possibly be conterminous with the shattered basalt and coarse agglomerate already described, which just touches the cliff 450 yards south of Close ny Chollagh Point. On the published one-inch geological map these outcrops have been indicated as if definitely continuous, this being the only practicable method of representing them on so small a scale.

To the eastward towards low-water, the coarse agglomerate at Cromwell's Walk terminates suddenly against finer ash, along a plane which is probably in connection with the overthrust movement, though it has been interpreted as a normal fault by Mr. B. Hobson and as the wall of a small vent by Sir A. Geikie.

From Cromwell's Walk [SC 25264 66293] to the Stack of Scarlet [SC 25653 66077], a distance of about 600 yards, the coast exposure reveals an exceedingly complex mass of ash and agglomerate, broken into by ridges and irregular partially-brecciated masses of vesicular basalt; and among these rocks, as we approach the junction with the Lower Limestone, shreds and patches of dark flaggy limestone are again intricately mingled. As previously mentioned, this part of the outcrop has been carefully studied and mapped by Mr. B. Hobson<ref>Quart. Journ. Geol. Soc., vol. xlvii., pp. 437–438.</ref> who, though chiefly concerned with their petrographical characters, noticed in several places the tilting and disturbance of the rocks.

In all essential particulars, these sections repeat the phenomena already described; and may be similarly explained. A massive belt of vesicular basalt has been ridged up and crushed in among less coherent ashy material and thinner bands of lava, causing general disruption and rearrangement. The plan ((Figure 68), p. 243) of this part of the coast has been copied from the 25-inch working map.

It has hitherto been commonly held that the principal vent of the volcano lay in this quarter, Clifton Ward, B. Hobson, and Professor Boyd Dawkins<ref>British Assoc. Rep. Liverpool, 1896, p. 778.</ref> considering the great block of columnar basalt which forms the Stack [SC 25657 66084] to mark the actual orifice, while other observers have thought that the site of the neck was indicated by the coarse agglomerate. But it is clear that lateral displacement has been rife in these rocks and has given rise to at least some of the phenomena which have been regarded as proving the proximity of the vent, so that I am now inclined to doubt whether the eruptive focus is anywhere revealed in the section. As at the western extremity of the outcrop so also at this place, it is in the relation of the limestone to the volcanic rocks that the most important evidence for this displacement is forthcoming. Between the smooth undulating scars of Lower Limestone on the northern side of Scarlet Point [SC 25663 66170], and the rugged outcrop of the Volcanic Series, there intervenes a little shingly recess (indicated in (Figure 68) by the absence of shading), in which above half-tide level the solid rocks are for the most part hidden, though some low crags of brecciated vesicular basalt drop out near high-water mark. Immediately to the southward, abutting upon the volcanic rocks, we find a huge jagged mass of apparently unstratified

limestone, about 100 yards long by 50 yards broad (xb. of (Figure 68) and (Figure 70)), rising with steep sides several feet above the highest tides; and when closely examined the lower part of this mass is seen to be composed of recemented limestone-breeds. The shingle in the recess narrows towards low water; and during an exceptionally low ebb (of 21 feet) I have traced dark flaggy limestone right across the inlet, save for a gap of only 9 feet, which probably marks the position of an olivine-dolerite dyke, eroded out at this place, but still visible hitcher up the recess, where it traverses the Lower Limestone and strikes directly for the gap. Mr. Hobson suggests that the "melaphyre dyke" (a^2 of (Figure 68)) which borders the Volcanic Series near the 'spring' 75 yards farther west may also occur in the gap, but I failed to find this rock or any other portion of the volcanic group in the lower part of the recess. The limestone on the southern side of the gap appears to correspond in every respect and to be identical with the Lower Limestone of the shore to the northward. These dark flaggy beds at low-water are thence continuous southward up to the steep margin of the massive limestone-breccia above described, and are then seen distinctly to pass beneath it in a well-defined platform, at the surface of which the flag layers are in places truncated. On this platform rests the thick bed of recemented limestone-breccia, quite free from volcanic admixture, which forms the basement of the unstratified mass. It is clear that we are dealing at this point with a thrust-plane, and this plane can be traced at the lowest tides around the eastern or seaward edge of the unstratified limestone. In the opposite direction, if we follow the gully to high-water mark we find the Lower Limestones apparently truncated by a fault of low hade, above which volcanic breccia is obscurely exposed. In the grassy ground above high-water mark, the ash and agglomerate terminate suddenly at a more steeply dipping plane which truncates the limestone. It has been suggested by Mr. Horne that this Junction may indicate the actual wall of the crater, while Mr. Hobson seeks to explain the facts by supposing that a normal fault follows the line of the gully; but the phenomena are all compatible with the view that the junction is everywhere an overthrust.

That Cumming was aware of the essential facts in regard' to the unstratified limestone is shown in the following passage:

"The upper portion of the isolated and altered patch of limestone nearest the Stack appears by the included fossils, so far as they can be made out, to belong to the light coloured Poolvash limestone, but the lower ertion may readily be observed as being the same with the black a to the northward of the protruded amygdaloid and trap which have isolated this limestone boss. It is very unfortunate that at this point… the rocks should have been so much altered frcm their ordinary character".<ref>"Isle of Man", p. 126. </ref>

It may be doubted however whether there is sufficient evidence to bear out the correlation of the unstratified limestone with the Poolvash Limestone. Cumming gives no list of the fossils on which his view was based; and as organic remains other than bits of encrinites are rare and fragmentary, it is probable that he truusted mainly to the pale colour and massive appearance of the rock. The presence, first noticed by Henslow,<ref>Trans. Geol. Soc., vol. v., p. 496. </ref> of abundant rounded quartz-pebbles in the massive limestone around its north-western margin tells against this correlation, such pebbles being elsewhere extremely rare except only towards the base of the Lower Limestone (see p 193). These pebbles seem to indicate that the overthrust mass has been derived from beds lower than those on which it rests. Cumming may have had this pebbly limestone in mind in referring to rocks which " present appearances of a passage from true limestone into true trap"<ref>Isle of Man", p. 124.</ref>, as the material bears a superficial resemblance to some portions of the amygdaloidal lavas.

Though the limestone-mass appears to have been more or less brecciated throughout, the upper part, where least obscured by recrystallization, dolomitization and cleavage-like jointing, sometimes shows traces of crumpled bedding forced up into domes, as represented in the following sketch (Figure 69) of a small exposure in the heart of the boss.

The recognition of the overthrust at the base of the massive limestone affords the key to the interpretation of the rest of the section. Great blocks of vesicular basalt and agglomerate, confusedly intermingled with shreds of limestone, abut against the southern and western flank of the mass, and are continuous thence up to the Stack. The following section shows the principal facts of these exposures and their theoretical interpretation. (Figure 70).

At extreme low-water, pinched-up ridges of dark flaggy limestone are visible hero and there in deep crannies worn into the volcanic rocks in this space right up to the northern flank of the Stack, and the coast is skirted by tabular reefs, covered at the lowest tides by only a few feet of water, which from their shape are moat probably of limestone. The whole evidence strongly suggests that the platform of Lower Limestone underlying the major thrust-plane is continuous at least

as far as the northern edge of the Stack, dipping gently southward beneath the volcanic rocks. In the coarse agglomerate, rounded and spindle-shaped pieces of cherty limestone are rather abundant, but no fragments of the Carboniferous Basement Conglomerate nor of the Manx Slates were observed, though these strata probably exist within 200 or 300 feet of the surface and must have been perforated if any volcanic orifice had opened up in this quarter. In the confused ground to the north of the Stack a little arch of dark flaggy limestone, 10 to 15 yards in diameter, with bedding well preserved, apparently resting upon a sloping plane of basalt (see Figs. 68 and 70), has always constituted one of the most difficult problems of the section, and one for which no satisfactory solution hits been afforded in the previous literature of the subject. But it is in all respects similar to the lenticles which have previously been described, and like them is probably the portion of a fold torn off and carried forward along a thrust-plane. It seems to be connected with the pinched-up ridge which occupies the cranny running south-eastward from it.

The Stack [SC 25657 66084] itself consists of a mass of basalt which, on all sides except the north, goes steeply down into deep water; the less coherent ash and agglomerate in which it was no doubt once embedded having been stripped away by the sea. It exhibits a rude columnar structure, best seen on its summit, the columns being nearly vertical. Such columns are formed perpendicular to the cooling surfaces, so that if the Stack had been, as supposed, the core of a vertical orifice in which lava has cooled, the columns should have been horizontal, and not vertical. The rock has an indistinct platy structure, suggestive of rude cleavage, which strikes N. and S. and traverses the columns. A little strip of baked cherty limestone, 2 to 3 inches thick, apparently a fragment caught up by the molten material in its flow, lies embedded in the igneous rock on the western side of the Stack.<ref>See Hobson, op. cit., p. 436.</ref>

Lheeah Rio [SC 26691 66298].—Reference has previously been made (p. 202) to the fact that Lheeah Rio, the insulated reef in Castletown Bay nearly three-quarters of a mile E.N.E. of Scarlet Point, is largely if not entirely composed of massive basic igneous rock. I examined the reef during a 19-feet ebb, and found every part then above water to be of only one kind of igneous rock. As seen afterwards from the shore at the time of an exceptional ebb of 21 to 22 feet, there appeared to be much more bare scar than I had gained footing upon; and the reef might repay further examination during such an ebb, though probably much that seems from a distance to be rock would he found to show only the tops of the tall laminarian seaweeds, growing in a few feet of water. The reef has a length of about 150 yards, with an extreme breadth of 50 yards, and, even in that portion which I examined, presents the largest homogeneous outcrop of intrusive material within the Carboniferous basin. Its position and dimensions associate it with the Volcanic Series, but petrographical examination seems to indicate that its affinity is with the olivine-dolerite dykes rather than with the diabase of the Stack (see p. 326). Unfortunately the circumstances of its exposure leave its stratigraphical relations entirely conjectural. Except for the petrological evidence, I should have regarded it as part of the Volcanic Series and as an indication that the portion of the series concealed by the sea was of great extent and thickness.

Concluding notes on the Southern Carboniferous Basin

In concluding this chapter I propose briefly to restate the general deductions drawn from the observed facts.

The indications of overthrusting at the junction of the Volcanic Series with the limestone imply that the on sequence between these rocks may not anywhere be preserved. The laminated character of the least disturbed portions of the tuff, and the presence of marine remains in it, show that the products of the eruption must have fallen into the sea, even if the volcano were not wholly submarine. But the absence of volcanic material from any portion of the limestone below the mass of eruptive rocks indicates that the volcanic episode took place after the deposition of the mass of the limestones. The first invasion of tuff seems, however, to have followed immediately upon the deposition of the Posidonomya Beds at the top of the limestone-sequence; and the thin crumpled shreds of ashy limestone among the disturbed ash above the overthrust are probably the remnants of beds which once existed at the true base of the Volcanic series. The preponderance of tuff in the lower part of the series probably signifies that the present outcrop lay at some little distance from the centre of eruption, and that the strip now above sea-level occurred on the flank of the volcano. As the eruption continued, basic lava flowed out over the ashes and became interbedded with them; and at a later stage some dykes or sills of similar composition, including the "melaphyre dyke" near Scarlet, seem to have been injected into them. During subsequent overthrusting, the rigidity of these sheets of basalt gave rise togreat relative displacement between them and the softer deposits with which they were associated; they were snapped into huge blocks, which ploughed through the ash and were tilted and partly brecciated during the process. Owing to the unequal pressures impinging on the

limestone-floor during these movements, the limestone was ridged up into steep shallow folds the crests of which were sometimes torn off and involved in the superincumbent moving mass.

By the northward overthrusting of the Volcanic Series, the Posidonomya Beds have probably been in great part overridden and concealed. Owing to the lack of inland exposures there is much uncertainty as to the manner in which the overthrusts from higher to lower horizons in the limestone when pass eastward from Poolvash to Scarlet, but they appear to cross the strata obliquely, cutting the Posidonomya Beds at Poolvash, the Poolvash Limestone in the vicinity of Close ny Chollagh Point, and the Lower Limestone farther eastward. There is also difficulty in explaining the absence of the displaced portion of the limestone above the thrust-plane in the vicinity of Scarlet if, as seems necessary, we reject Cumming's supposition that this portion is represented by the mass of limestone-breccia at the margin of the Volcanic rocks. It has not, indeed, been absolutely proved that the black flaggy beds underlying the Volcanic rocks on the southern side of the little recess north of Scarlet Point belong to the Lower Limestone; and there is a bare possibility that they may represent the Posidonomya Beds brought in by a fault against rocks of similar aspect belonging to the Lower. Limestone on the north. But, as already stated, I could find no evidence for this fault at low water, and Cumming was also of opinion that the Lower Limestone extended across the recess.

The probable explanation is that the movement was everywhere as complex as in the sections which have been described and figured above, and that the displacement was effected by the development of numerous minor planes throughout the mass of the volcanic rocks rather than by movement *en bloc* above single plane.

The general tendency of the movement seems to have been towards the production of an anticline along an E.S.E. to W.N.W. axis, ranging from Scarlet Point to Poolvash. If the beds had been of more homogeneous and pliant composition it is probable that the requisite lateral shortening would have been attained by a system of simple folds. But the rigid sheets of basalt, lying among softer material and under no great superincumbent weight, were incapable of more than incipient folding, and were broken and overthrust all along the crest of the anticline. The general effect has been to roll forward the Volcanic series, as it were, piecemeal upon the limestone. The localisation of the more intense results of the disturbance to the Volcanic rocks is thus the direct consequence of their lithological characters.

While in the crush-conglomerates of the Manx Slates, described in a previous chapter, there are indications of great super-incumbent pressure and shearing in every particle of the mass, the Carboniferous Volcanic rocks seem to have suffered disruption and rearrangement comparatively near the surface, where pressure was not severe and the fractured strata were comparatively free to move. Under such conditions, brecciation has been produced without any trace of deformation in the intimate rock-structure, and the separate blocks have been pushed along with as little interstitial alteration as the boulders in and under a glacier.

Brecciation of this type may be described as "brecciation-without-crushing", as distinguished from the "brecciation-with-crushing" which is seen in the slate-rocks.

Returning now to the discussion of the knoll-structure in the Poolvash Limestone, it will be observed that the knolls curiously encircle the northern margin of the volcanic area. As mentioned on p. 210, my first opinion was that these knolls were original structures, due to the accumulation and rapid consolidation of limestone-reefs on the Carboniferous sea-floor; but since observing how severely the volcanic rocks had been affected by earth-movement, I have felt less assured on this point. Mr. J. E. Marr has recently claimed<ref>"On Limestone Knolls in the Craven District of Yorkshire and elsewhere", Quart. Journ. Geol. Soc., vol. lv. (1899), pp. 327–358.</ref> that somewhat similar though much larger limestone-knolls in Yorkshire and Lancashire have been formed by earth-movement; and though Mr. Marr's hypothesis of cumulative overthrusting could scarcely apply to knolls so small 'as those of Poolvash, it must be acknowledged that these are very likely to have been in some degree modified during the overthrusting of the Volcanic rocks, since they lie partly within and partly along the borders of the zone of disturbance- in which the production of dome-like ridges is not unusual. On the other hand, there seems to be clear evidence of different stages of unequal accumulation among the limestones, beginning in the hummocky surfaces so common in the Lower Limestones (p. 199), increasing in the small bosses among the Posidonomya Beds like those described and figured on p. 227, and still further expanding in the lenticular swellings of limestone-bands as shown in (Figure 54), p. 213. The difference between the fauna of the knolls and that of the surrounding strata, strongly insisted upon by Cumming: the great abundance of fossils in the knolls, and

their uncrushed condition: and the scarcely less excellent state of preservation of those in the enfolding flaggy beds: are circumstances difficult of explanation if we regard the structures as due solely to earth-movement. We are hampered in the discussion by the lack of definite information as to the upward sequence from the top of the Lower Limestones, and especially as to the original thickness of the Poolvash Limestone and of the Posidonomya Beds. A patient re-examination and correlation of the faunas of these different divisions is also needed; and until such data have been accumulated it is perhaps advisable to leave the matter *sub judice.*

The structure of the Southern Carboniferous Basin as a whole, with its Basement Conglomerate outcropping at Port St. Mary on the western edge, as well as at Langness on the eastern and at Athol Bridge and Cass ny Hawin on the northern, fully justifies Cumming's observation that its Volcanic rocks occupy the centre of a trough. It is true that the trough is wide and shallow, but none the less it is in the bottom of the basin that lateral pressure would be developed most forcibly by the inward tilting of the sides.

It is clear from the undisturbed manner in which the Carboniferous Basement Conglomerate rests upon the Manx Slates that the Post-Carboniferous movements have had little or no effect upon the rigid floor of these previously folded rocks; and the displacements within the boundaries of the Carboniferous seem to have attained their greatest intensity at some distance above this unyielding base, the strata resting immediately upon the rigid floor being less disturbed than those higher in the series where the freedom of movement was greater.

In the south of the Island the evidence merely shows that the movements were Post-Lower-Carboniferous; but in other quarters a narrower time-limit is indicated. In the deep borings in the north of the Island, (see Chapter 7. p. 280), Triassic and so-called Permian strata were found to rest nearly horizontally and undisturbed, in sharp unconformability, upon the eroded upturned edges of Lower Carboniferous rocks tilted at a high angle and much disturbed, proving severe movements of Pre-Permo-Triassic age. The same Post-Lower-Carboniferous but Pre-Triassic movements (Stage 6. of the classification in Chap 3 p. 72) seem also to have affected the Peel Sandstones of the western coast (see pp. 272–3).

Paleontology of the Carboniferous rocks

As previously mentioned, though a few Manx fossils have been described in special monographs since Cumming's list was issued in 1848, no later work on the subject as a whole has yet been published. It was not found possible during the present survey to devote much time to the collection of the Carboniferous fossils, but an attempt has been made in the list which follows to illustrate the palaeontology of the deposits, by using the material available in several private collections generously placed at our disposal by the owners.

Cummmg's list included 222 species, of which 13, considered by him to be new, were denoted by MS. names without figures or description. His collection is still preserved in the museum of King William's College at Castletown, but has unfortunately fallen into disorder, so that the majority of the specimens are now either without labels, or with labels insufficient for their identification. By permission of the authorities of the College, we were allowed to pick out the labelled specimens, in which species equivalent to about one half of Cumming's list were represented, and these were re-determined in the Pala ontological Department of the Survey and returned to the College. It was at first intended to work out Cumming's synonymy in regard to these species, but the old nomenclature was in some instances so erratic that the intention was abandoned, as it was suspected that the labels had in some cases been shifted from their original specimens. Those fossils from the Cumming collection, along with a few collected during the course of the Survey and others previously contained in the Jermyn Street Museum, were arranged under the stratigraphieal divisions adopted by Cumming, and became the basis of the present list, which was then augmentei to its present length by the examination of the collections of Miss C. Birley, Mr. R. Law, F.G.S.,<ref>Mr. Law's collection of the Manx Carboniferous fossils, especially of those of the Poolvash Limestone is of the most extensive character. The cephalopods and lamellibranchs alone have been laid under contribution for the present list, as time did not permit the examination of the whole.</ref> and the Woodwardian Museum of Cambridge, and by the addition of species recorded in the special monographs mentioned at the head of the list. Dr. Wheelton Hind has also supplied us with a list of the Manx lamellibranchs and a few other forms contained in his own and other collections which he has personally examined. To him and to the owners of the collections above-mentioned our hearty thanks are due for their unstinted assistance. These sources are indicated in the Table by initial letters, and in the fourth column the authority for the determination is given.

The list contains a total of 237 species, as against the 222 species recorded by Cumming; but from the method in which it has been compiled, it is necessarily of unequal value for the different branches of the fauna. It is especially rich in Lamellibranchs, owing to Dr. Hind's assistance; in Cephalopods and Brachiopods is adequate but not exhaustive; while in Gasteropods. Trilobites and Corals it is poorer than Cumming's list and is frankly insufficient. Cumming also records three species of fish from the Lower Limestone and one from the Posidonomya beds; and five plants (*Adiantum, Pecopteris, Sphenopteris nervosa*, Brongn., *Lepidostrobus ornatus*, Brongn., and *Calamites*) from the last-mentioned beds; all of which are now unrepresented among the labelled specimens preserved in the College Museum collection at Castletown. Stratigraphically, it is in regard to the Posidonomya beds that our present list is most deficient as compared with its forerunner, Cumming having paid especial attention to this division, whereas most later collectors have been chiefly attracted to the more prolific Poolvash and Lower Limestones.

In the Lower Limestones the most conspicuous fossils are the larger corals, Z*aphrentis*, etc.; *Productus giganteus*, and other brachiopods; and large cephalopods, including *Prolecanites compressus* (better known as *Goniatites Henslowi*) (Figure 71), *Solenocheilus*, *Temnocheilus*, etc.

The Poolvash Limestone, as already described, is in many places a mass of beautifully preserved shells, brachiopods predominating in one spot, cephalopods in another, while corals are comparatively rare, though they abound in the dark flaggy and shaly beds which surround and overlap the knolls of this limestone (see p. 214).

The characteristic fossil of the *Posidonomya*-beds is the lamellibranch *Posidonomya Becheri (Figure 73)*, but as Dr. Hind remarks, it is only found in certain bands.

The fossils in the Volcanic Ash have been much neglected, and those at present known are not sufficiently numerous to be worth showing in a separate column in the table. Fragments of encrinite sterns are the most common remains; in the Cumming collection there is an example of *Posidonomya Becheri* in an ashy matrix; and, as mentioned on p. 235, during our recent visit to the sections Mr. J. A. Howe found a dorsal fish-spine *Sphenacanthus* (*Ctenacanthus*)5 inches in length in the ash near low-water mark at Poolvash, and *Glyphiocerus* (*Goniatites*) *striatum* and *Spirifera* (probably *bisculata*) in the same material in the low cliff at Close ny Chollagh (see p. 286).

[**Postscript, August, 1902**.—Reference has been made above to Cumming's discovery of plant-remains in the Posidonomya Beds, and to the absence of the original specimens from the Cumming Collection in the College Museum, Castletown. We have, however, been informed recently by Dr. Wheelton Hind, that fresh specimens of these plants have been obtained by Mr. D. Tait while collecting at Poolvash for the 'Carboniferous Zones Committee' of the British Association. The specimens were found in a band of black shale among the hummocks of limestone containing marine fossils, and included the following plants: *Adiantites Machaneki*, Stur.; *Adiantites antiquus* Ett.; *Sphenopteris pachyrachis*, Göpp.; *Sphenopteris pachyrachis*, var. *stenophylla*, Göpp.; and *Sphenopteris* allied to *Sph. bifida*, L. and H., or *Sph. subgeniculata*, Stur.

The bed also contained the following *mollusca: Posidonomya Becheri; Aviculopecten papyraceus* (thus proving the existence of this species in the Island and settling the doubt expressed in a footnote on p. 259); *Orthoceras morrisianum; Orthoceras sulcatum;* and *Glyphioceras* resembling *Glyph. crenistria* or *Glyph. reticulatum.*]

As Dr. Wheelton Hind is at present engaged in a critical study of the British Carboniferous fauna, and has personally investigated the Manx deposits with this object in view, he has at our request kindly prepared the following notes on the general aspect of the Manx fauna and its relations with the Carboniferous faunas of the mainland:

"In reviewing, as a whole, the Carboniferous fossils of the Isle of Man, it cannot be said that the fauna is in any way local or peculiar, except in the number of individuals present. One shell, *Allorisma monensis*, Hind, may prove to occur only in the island, and this shell does seem to be characteristic of the Lower Limestones, only being found with *Edmondia sulcata*, Phill.sp. and *Prolecanites compressus*, Sow. (*Gon.Henslowi*), at Scarlet and Ballasalla. The fauna of the Poolvash Limestone may be said to be identical with the faunas which are found in the shelly limestones of the Craven district of Yorkshire, Clitheroe, (Lancashire), Castleton, Park Hill, and Thorpe Cloud (Derbyshire), and Wetton, Narrowdale, and Gateham (Staffordshire), though individuals of the Cephalopoda aro much more numerous in the Isle of

Man.

"In my opinion, in S.W. Yorkshire, Derbyshire, and Staffordshire the lower beds are rarely exposed, and, consequently, to a very large extent we are ignorant of any special fauna they may contain; but at Clitheroe the Carboniferous Limestone consists of a series of bedded limestones at the base, much resembling the Scarlet and Ballasalla limestones in appearance, and an upper series of obscurely bedded, white, richly fossiliferous beds, which probably represent the Poolvash beds, and accumulated under similar conditions. The fauna of the lower part of the limestones, as exposed at Kendal Fell, Westmoreland, appears to me to closely resemble that of the Lower Limestones of the Isle of Man, and, amongst others, *Edmondia sulcata* and *Prolecanites compressus*, which are not met with in the upper beds of either the Midlands or the Isle of Man, are found there. The Knife Scar limestones of Shap also have a very similar fauna, and this bed is supposed to belong to the Melmerby Scar series, the northern representatives of the Great Scar Limestone: The limestones of the Furness district appear to have a series of bedded limestone at the base, with massive limestone above, but fossils are not present in any large number, but corals are, as in the Isle of Man, only found in numbers in the lower beds, and *Productus giganteus* appears to have lived during the whole of the deposit of both upper and lower beds, as in the Isle of Man, and to pass upwards in the Furness district into a thin band of limestone which is separated from the main mass by a hundred feet or so of shales, which is the limit at which this fossil occurs. I doubt whether *Edmondia sulcata* can in any way be claimed to be characteristic of the lower limestones, except that I have not yet seen it in any of the shelly white limestones either of the Isle of Man or north central England. But this shell occurs at, at least, two horizons in Wensleydale, in the shales below the Hardraw Scar, and in the Middle Limestone.

"In the Isle of Man it seems impossible to make out the exact relationship of the shelly limestones to the well-bedded or Lower series. It is at present impossible to determine whether or no the isolated masses of shell limestone were original local structures, or were due to the denudation of a sheet, which was cut up into masses by exposure to the usual weathering agents, or by exposure on a foreshore, some slight horizontal movements subsequently complicating their stratigraphical arrangement.

"The *Posidonomya* beds are of interest, from the peculiar fossils they contain, and from their local character.

"The beds are found over a very small area only, and appear to be due to a local more or less estuarine phase in the upper part of the series of bedded limestones, and their relation to the white shelly limestone is very questionable. All previous observers have considered the *Posidonomya* beds to be stratigraphically above the white shelly limestones, and to represent the last phase of the Carboniferous deposits in the south of the Island, but the section at the black marble quarry can hardly be interpreted in this way.

"The fauna of these beds consists of flattened casts of an ovate lamellibranch, *Solenomya costellatus*, McCoy, which I have also obtained from the 4 Laws Limestone of Northumberland, wo cephalopods, *Orthoceras sulcatum*, Flem., and *Discites sulatus (?)*, Sow., and the well-known *Posidonomya Becheri* itself, also always flattened. I fancy the three forms, *Pos. Becheri, Pos. lateralis*, and *Pos. gracillima*, Cumming, will turn out to be all one species. This fossil is always found in shale, and is by no means common, though, when it does occur, individuals are plentiful. It occurs at Venn, near Barnstaple, in beds considered to be Upper Culm, associated with *Orthoceras*; and some shales which have been baked by contact with a volcanic dyke at Budle Bay, Northumberland, also contain *Posidonomya Becheri* in abundance, associated with *Lingula squamiformis*, a lamellibranch of doubtful genus, *Bellerophon Urei* and *Chonetes laguessiana.* I have this year [1900] obtained *Pos. Becheri* at three localities in S. W. Yorkshire, in shales immediately above the massif of limestone, and from the extremely narrow horizon in which this species occurs, I have hope that its presence may indicate a definite zone. It will thus be noted that the fauna which occurs with *Pos. Becheri* in each case is a peculiar one, and contains none of the species so common in the Carboniferous Limestones. Von Koenen has noted the occurrence at Herborn of the special Kulm Fauna, which occurs with *Pos. Becheri* (Neues Jahrbuch far Min. Geol. u. Palwont, 1879, p. 309), and I am of opinion that the change of fauna is entirely due to a change of environment, the organisms which inhabited the clearer sea bottom being unable to survive in the muds of the Posidonomya shales, and in no way due to the dying out of a previous fauna and the coming on of new types".

List of Carboniferous Limestone fossils from the south of the Isle of Man based on material in the following collections:

Miss Birley's collection, marked B.; the labelled specimens in the Cumming collection (*see* above), marked c.; Dr. Wheelton Hind's collection, marked H.; Mr. H. Law's collection,* marked L.; the Geological Survey collection, marked s.; the Cambridge Woodwardian Museum collection, marked w.

The addition of a to the initial indicates that doubt exists as to the horizon from which the fossil was obtained.

The letters in the fourth column denote the authority for the determinations, thus: D. = Davidson, Monog. Brit. Carb. Brach., Pal. Soc.; F. = Foord di Crick, Cat. Foss. Cephal. Brit. Mus.; J. =Jones, Kirby & Brady, Monog. Carb. Ostracoda., Pal. Soc.; B. Determined by Dr. Wheelton Hind; s. = Determined or verified by the Palaeontological Department of the Survey; cit.—Determined by Mr. G. C. Crick

*Mr. Law's collection contains several examples of a small spindle shaped organism from the Poolvash mitotte which Dr. W. Hind thinks is probably *ftoitditia.* Unfortunately no internal structure is apparent in the specimens..

	Lower or Castletown Limestone (1)	Poolvash Limestone	Posidonomya Beds.	Authority.
COELENTERATA.				
Amplexus coralloides, Sow.	H	B	—	S H
Cyclophyllum fungites, Flem.	B		—	B
Dania sp.	—	S	—	A
Dibunophyllum sp.	B	—	—	S
Favosites parasites, Phill.	—	—	C ? S	S
Lithostrotion basaltiforme, Con. & Phill	—	W		
Lithostrotion caespitosum, Mart.	B	—	—	S
Lithostrotion irregulare, Phill.	W	—	—	S
Lithostrotion junceum, Flem.	C	—	—	S
Michelinia favosa, Goldf.	B	—	—	S
Michelinia megastonta, Phill.	B C	—	—	S
Monticulipora tumida, Phill.	S C	—	—	S
Zaphrentis (Campophyllum) cylindrica, Scouter	B	—	—	S
Zaphrentis patula ? Mich.	W	—	—	S
Zaphrentis sp.	B	—	—	S
ECHINODERMATA				
Crinoidea.				
Actinocrinus?		H	A	S
Poteriocrinus crassus, Mart.	B	—	—	S
Poteriocrinus sp.	B	—	—	S
Echinoidea.				

Archaeocidaris Urei, Fleet.	B	—		S
ANNELIDA.				
Serpulites carbonarius, M'Coy	B	—		(2)
CRUSTACEA.				
Ostracoda.				
Cyprella chrysalides, de Kon.	—	S C ? J	—	S J
Cypridellina Burrovi, J. & K.	—	B	—	S
Cypridinella Cummingi, J. K. & B.	—	S J	—	S J
Cypridinella Cummingi, sp.	C?	—	—	S
Cypridina primaeva, M'Coy	—	C ? W	—	S J (3)
Cypridina phillipstana ? Jones	—	W	—	S
Cypridina sp.	B	—	—	S
Entomoconchus orbicularis, ?J.K.&B.	—	J	—	J
Entomoconchus Scouleri, M'Coy	—	C ? H	—	J
Polycope simplex ? J. & K.	—	—	—	J
Polycope Burrovi, J. & K.	—	B	—	J

(1) The specimens in the first column (Lower Limestone) were chiefly from the Scarlet and Ballasalla quarries and from the shore at Roualdsway, Castletown and Balladoole.

(2) Determined at British Museum.

(3)"Probably Cyprina ovalis of Cumming". (J. K. & B.)

	Lower or Castletown Limestone	Poolvash Limestone	Posidonomya Beds.	Authority.
CRUSTACEA —continued.				
Trilobita.				
Griffithides seminiferus, Phill.	—	C ? W	—	S
Phillipsia derbiensis, Mart.	C ? H	C ?	—	S H
Phillipsia Eichwaldi, Fisch.	C ?	C		S
POLYZOA				
Fenestella membranacea ? Phill.	C ?		—	S
Fenestella plebeia, M'Coy	C ?	C ? H	—	S

Fenestella polyporata, Phill (multiporata, M'Coy).		W	—	S
Glauconome grandis, M'Coli		C ?	—	S
Rhabdomeson sp.		C ?	—	S
BRACHIOPODA.				
Athyris ambigua, Sow.	—	B	—	S D
Athyris expansa, Phill.	C ?	—	—	S
Athyris globular's, Phill.	—	—	—	D
Athyris planosulcata I Phill.	—	B	—	S
Athyris Royssi, Lev.	—	—	—	D
Camarophoria crumena, Mart.	—	—	—	D
Camarophoria globulina, Phill.	—	C ?	—	S
Chonetes buchiana, de K^{r} on.	—	H	—	H
Chonetes laguessiana, deKon.	—	—	—	D
Chonetes papilionacea, Phill.	B C ? D	—	—	S D
Dielasma (Terebratula) hastata, J. de C. Sow.	—	C ? B S		S D
Dielasma (Terebratula) sacculus, Mart.	—	B		S D
Orthis Michelini, Lev.	C ?	C ?		S D
Orthis resupinata, Mart.	B C ?	S C ? B		S D
Orthis resupinata var. gibbers, Portl.	—	H		H
Orthotetes crenistria, Phill.	C	H		S D
Productus aculeatus, Mart.	—	S W D		S D
Productus Cora, d'Orb	C	D		S D
Productus costatus, J. de C. Sow.	—	B		S D
Productus fimbriatus, J. de C. Sow.	C ?	B C W D	—	S D
Productus giganteus, Mart.	C B	H		S D H
Productus giganteus var. hemisphaericus, Sow.	C	—	—	S
Productus latissimus, Sow.	H	—	—	H D
Productus longispinus, Sow.	—	S D	—	S D
Productus mesolobus, Thin.	—	H D	—	H D

Productus proboscideus, de Vern.	—	—	—	
Productus punctatus, Mart.	W B D	S B D	—	S D
Productus pdaulosus, Phill.	—	—	—	D
Productus scabriculus, Mart.	—	C? W S D	—	S D
Productus Thireticulatus, Mart.	C	B S D	—	S D
Productus var. Martini, Sow.	—	C W		S
Productus spinulosus, Sow.	—	—	—	D
Productus striatua Fisch.	—	C ? W	—	S D
Productus tessellatus, de Kon.	—	—	—	D
Productus undatus, Defr.	—	B W D	—	S D
BRACHIOPODA—Continued.	Lower or Castletown Limestone (1)	Poolvash Limestone	Posidonomya Beds.	Authority.
Rhynchonella acuminata, Mart.	—	C7 B	—	S D
Rhynchonella angulata, Linn.	—	S B	—	S D
Rhynchonella flexistria, Phill.	—		—	D
Rhynchonella pleurodon, Phill.	—	B S	—	S D
Rhynchonella pugnus, Mart.	—	B S	—	S D
Rhynchonella reniformis, J. de C. Sow.	—	—	—	D
Rhynchonella trilatera, de Kon.	—	—	—	D
Spirifera convoluta, Phill.	C ?	—	—	S
Spirifera duplicicosta, Phill.	B	B S D	—	S D
Spirifera glabra,. Mart.	C^1 D	B S C	—	S D
Spirifera integncosta, Phill.	—	B	—	S D
Spirifera (Rencularia) lineata, Mart.	B	S B H	—	S D
Spirifera (Rencularia) lineata var. elliptica, Phill.	—	H	—	H
Spirifera ovalis, Phill.	B C	S B	—	S D
Spirifera pinguis Sow.	C ?	—	—	S D
Spirifera planate; Phill.	—	—	—	D

Spirifera rhomboidea, Phill.	—	—	—	D
Spirifera striata, Mart.	—	B	—	S D
Spirifera triangularis, Mart.	—	—	—	D
Spirifera trigonalis, Mart.	B (?sp) C	S B	—	S D
Spirifera trigonalis var. bisulcata Sow.	B	S	—	S
Spinferina cristata ? Schloth.	—	C ?	—	S
Spinferina insculpta, Phill.	B (? sp)	—	—	S D
Spinferina laminosa, M'Coy	—	—	—	D
Streptorhynchus (see Orthotetes).				
Strophomena rhoniboidalis, Wick.,var. analoga, Phill.	D	S W D	—	S D
Syringothyris cuspidata, Mart	—	—	—	D
Syringothyris distans, J. de C. Sow.	—	B	—	S
LAMELLIBRANCHIATA.(2)				
Allorisma monensis, W. Hind,	H L B	—		H
Avicula (Leiopteria) informis, M'Coy	—	W	—	S
Avicula (Leiopteria) laminosa, Phill.	—	H	—	H
Avicula (Leiopteria) lunulata, Phill.	—	H	—	H
Avicula (Leiopteria) squamosa, Phill	—	C ?	—	S
Aviculopecten arenosus, Phill.	—	C ?	—	S
Aviculopecten coelatus ? M'Coy	—	W	—	S
Aviculopecten docens, M'Coy	—	W	—	S
Aviculopecten dumontianus de Kon.	—	C ?	—	S
Aviculopecten incrassatus, M'Coy	C ?	—	—	S
Aviculopecten Murchisoni M'Coy	C ?	—	—	S
Aviculopecten planoradiatus, M'Coy	C ?	S	—	S
Aviculopecten variabilis, M'Coy	—	—	C ?	S

(1) In limestone with quartz-pebbles, labelled "Ballahot". (Cumming coll.)

(2) The Cumming collection contained specimens of *Aviculopecten Papyraceus* and *Nuculana attenuata*, but the labels do not state the locality, and Dr. W. Hind informs us that the fossils are probably not Manx.

LAMELLIBRANCHIATA — continued	Lower or Castletown Limestone (1)	Poolvash Limestone	Posidonomya Beds	Authority.
Cardiomorpha Egertoni, M'Coy (dwarf form).	—	H	—	H
Cardiomorpha obliqua, W. Hind	—	H	—	H
Cardiomorpha oblonga, Phill.	—	H	—	H
Cypricardella Annae, de Ryckholt	—	H	—	H
Edmondia laminata, Phill.	C ?	—	—	H
Edmondia Lyelli, W. Hind	—	L	—	H
Edmondia primaeva, Portl.	—	H	—	H
Edmondia rudis, M'Coy	B	H	—	S H
Edmondia sulcata, Nall.	B L	—	—	H
Edmondia unioniformis, Phill.	—	H W	—	S
Lithodomus lingualis, Phill.	—	C ?	—	S
MyalinaFlemingi, M'Coy.	—	L	—	H
Myalina peralata, de Kon.	—	L	—	H
Multalimorpha (Goniophora) rhombea, Phill.	—	H	—	H
Parallelodon bistriatus, Portl.	—	L	—	H
Parallelodon cancellatus, Mart.	—	L	—	H
Parallelodon decussatus M'Coy	—	H	—	H
Parallelodon fallax, de Kon.	—	H	—	H
Parallelodon Fraiponti, de Kon.	—	H	—	H
Parallelodon Geinitzi, de Kon.	—	L	—	H
Parallelodon obtusus, Phill.	—	H	—	H
Parallelodon reticulatus, M'Coy	—	L	—	H
Parallelodon squamiferus, Phill.	C ?	H	—	H

Parallelodon verneuilianus, de Kon.	—	C ?	—	H
Pinna flabelliformis, Mart.	C ?	L W	—	S H
Pinna spatula, iirCoy.	—	L	—	H
Posidomella pyriforms, W. Hind	—	L H	—	H
Posidomella vetusta, J de C. Sow.	—	L	C ?	S H
Posidonomya Becheri Bronn	—	—	S C W	S
Protoschizodus aequalis, de Kent.	—	L	—	H
Protoschizodus axiniformis, Portl.	—	H	—	H
Protoschizodus fragilis, M'Coy	—	H	—	H
Protoschizodus subtruncatus,M'Coy	—	H	—	H
Protoschizodus trigonalis, de Kon.	—	L	—	H
Sanguinolites augustatus, Phill.	—	L	—	H
Sanguinolites luxurians, df; Kon.	—	H	—	H
Sanguinolites striatolamellosus, de Kon.	—	H L	—	H
Sanguinolites striatogranulosus, Hind	—	H	—	H
Sanguinolites subcarmatus, M'Coy	—	H	—	H
Sanguinolites tricostatus, Portl.	C ?	H L	—	S H
Scaldia benedeniana, de Kern.	—	H	—	H
Scaldia visetensis, de Kon.	—	H L	—	H
Solenomya primaeva Phill.	—	L	—	H
Solenomya costellata, M'Coy	—	—	H	H
Tellinomorpha cuneiformis, de Kon.	—	H	—	H
GASTEROPODA.				
Aclisina sp.	—	W	—	S
Bellerophon hiulcus, Mart	S	C ?	—	S
GASTEROPODA—continued.				
Bellerophon recticostatus, Portl.	C ?	—	—	S

Euomphalus crotalostomus, M'Coy	C ?	—	—	S
Lepetopsis retrorsa, Phill.	—	C ?	—	S
Loxonema constrictum, Mart.	—	C ?	—	S
Loxonema rugiferum, Plat	—	C ?	—	S
Loxonema scalaroideum PAW.	—	W	—	S
Loxonema sulcatum ? de Kon.	—	C ?	—	S
Macrochilina acuta J. de C. Sow.	W	H W	—	S
Macrochilina rectilinea ? Portl.	C ?		—	S
Metoptoma pilaus, Phill.	—	L H	—	S H
Microdoma serrilimba, Phill.		C ?	—	S
Murchisonia ?	C ? B		—	S
Naticopsis ampliata, Phill.	—	C ?	—	S
Naticopsis plicistria, Phill.	S C	B W	—	S
Natiria lirata, Phill.	—	C ?	—	S
Platyceras angustum, Phill.	—	C ?	—	S
Platyceras trilobus ? Phill.	—	C ?	—	S
Platyschisma helicoides, J.de C. Sow.	B	B	—	
Platyschisma ovoideum ? Phill.	—	W	—	S
Pleurotomaria (Luciella) eliana, de Kon.	—	C ?	—	S
Pleurotomaria (Mourlonia) conica ? Phill.	—	W	—	S
Pleurotomaria (Baylea) Léveillei, de Kan..	—	B	—	S
Pleurotomaria (Ptychomphalus) sculpta, Phill.	—	—	C ?	S
Pleurotomaria (Baylea) Yvani, Lév.	—	C ?	—	S
Porcellia Puzo, Lév.	—	B	—	S
Portlockia parallela, Phill.	B	—	—	(1)
Straparollus exaltatus, de Kon.	C ? B	—	—	S
Straparollus pileopseus, Phill.	—	W	—	

PTEROPODA.	—	—	—	
Conularia quadrisulcata, Sow.	—	L	—	H
CEPHALOPODA.	—	—	—	
Actinoceras Breynii, Mart.	—	B C S L	—	S
Actinocerasgiganteum, Sow.	B L	L	—	S Cr.
Actinoceras Sowerbyi, M'Coy	—	L	—	S
Actinoceras sp.	L	L	—	S
Coeonautilus bistrialis, Phill.	—	B W	—	S
Coeonautilus cariniferus, J.de C. Sow.	—	L	—	S
Coeonautilus derbiensis, Foord	—	H L	—	S F
Coeonautilus subsulcatus, Phill.	—	C ? H L	—	S Cr. F
Cyrtoceras Gesneri, Mart.	—	L	—	S
Coeonautilus verneuilianum, de Kon.	—	S	—	S
Discites (Nautilus) complanatus, Sow.	C	V	—	M Coy (2)
Discites (Nautilus) bisulcatus, de Kon.	—	W	—	S
Discites (Nautilus) discus, Sow.	—	H L	—	S

(1) Determined by Mr, B. B. Newton. (2) Brit. Pal. Foss. 1855, p. 557.

CEPIIALOPODA—Continued.

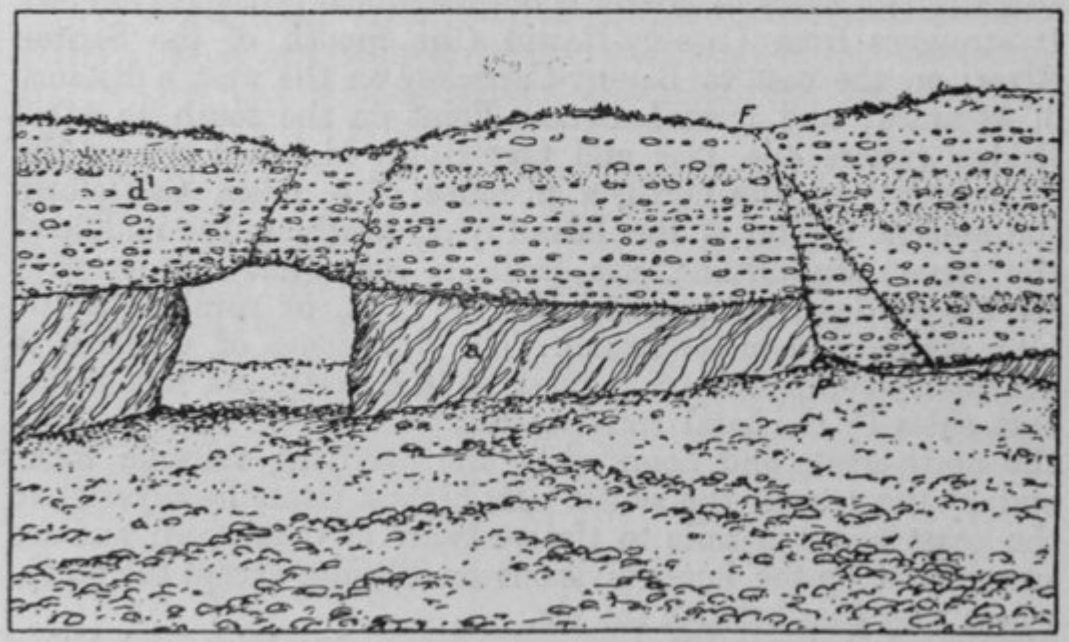
Discites (Phacoceras) oxystomus, Phill.	—	C L	—	S
Discites planotergatus, M'Coy	—	B H	—	S Cr.
Discites sulcatus: J. de C. Sow.	—	L	H ?	S
Ephippioceras bilobatum, Sow.	B L	—	—	S Cr.
Glyphioceras crenistria, Phil.	—	B L	—	S
Glyphioceras implicatum, Phill.	—	S W	—	S
Glyphioceras micronotum ? Phill.	—	B	—	Cr.
Glyphioceras obtusum, Phill.	B ?	—	—	S Cr.
Glyphioceras sphmricum, Mart.	—	S	C ?	S

Glyphioceras striatum, Sow.	—	S	—	S
Glyphioceras truncatum, Phill.	—	B L S	—	S Cr.
Glyphioceras vesica, Phill.	B	—	—	Cr.
Gyroceras Luidi, Mart.	—	W	—	S
Gyroceras ornatissininm, de Kon.	—	H	—	S
Gyroceras sp.	L	L	—	S
Nautilus globatus ? Phill. (non Sow.)	L	—	—	Cr.
Nautilus sp.	L	—	—	S
Orthoceras cf. acre, Foord	—	L	—	S
Orthoceras affine ? Portl.	—	L S	—	S
Orthoceras idoneum ? de Kon.	C ?	—	—	S
Orthoceras cf. martinianum, de Kon.	—	L	—	S
Orthoceras cf. salvum, de Kon.	—	L	—	S
Orthoceras sulcatum, Flem.	—	L	H	S
Orthoceras (several forms undetermined)[1].	L	L	—	S
Pleuronautilus ? scarlettensis, Reed.	W	—	—	Reed
Poterioceras cordiforme, Sow.	L	—	—	S
Poteriocerasfusiforme, J. de C. Sow.	—	C L	—	S
Prolecanites compressus, Sow. (Goniatites Henslowi, Sow.)	B C L S W	—	—	S Cr F
Solenocheilus dorsalis, Phill.	B	L	—	S Cr.
Solenocheilus pentagonus, Sow.	B L	—	—	S Cr.
Subclymenia evoluta ? Phill.	—	L	C ?	S Cr.
Temnocheilus Cricki, Foord.	L	—	—	Cr.

(1) Mr. Law informs us that he obtained from the Poolvash Limestone an Orthoceras 4 feet in length and 29 inches in circumference. This specimen lay flat in the limestone and was not distorted; it is probably an *Actinoceras.*

FIG. 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 49) Sketch-section of the most northerly of The Arches, Langness, showing unconformability at base of Carboniferous Rocks. Height, about 18 feet. d[1] Carboniferous Basement Conglomerate. a Manx Slates, with red staining. F Small fault.

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

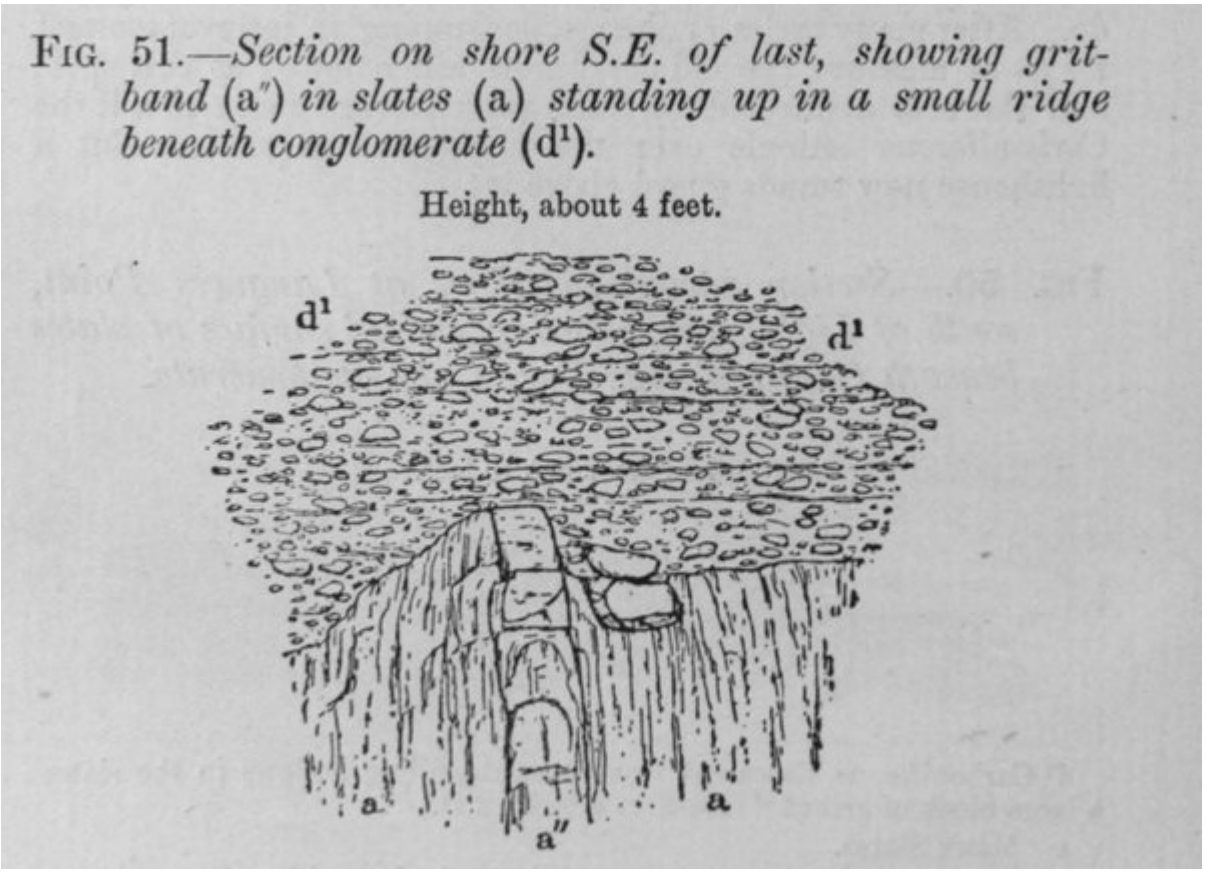
Height about 10 feet.

d¹ Carboniferous Basement Conglomerate, filling hollows in the slates: a large block of grit at * measures 4 ft. by 2 ft.

a Manx Slates.

B⁶ Pre-Carboniferous greenstone dyke, 8 inches wide, along which a gully 3 feet wide and 2 feet deep has been eroded on the Carboniferous shore. This is prolonged into a similar gully on the present shore.

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



(Figure 51) Section on shore S.E. of last, showing grit-band (a■) in slates (a) standing up in a small ridge beneath conglomerate (d^1). Height, about 4 feet.

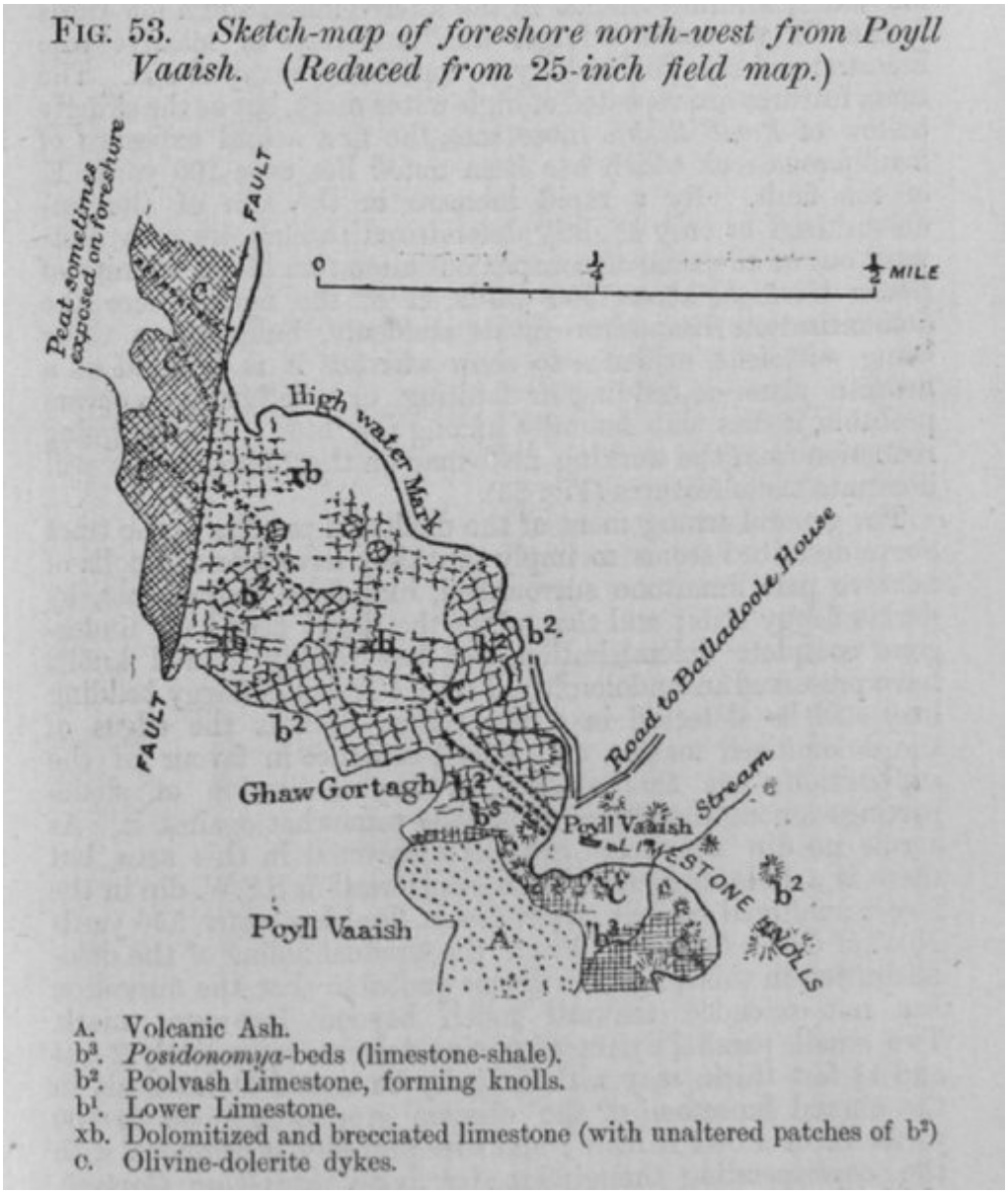


FIG. 53. *Sketch-map of foreshore north-west from Poyll Vaaish. (Reduced from 25-inch field map.)*

(Figure 53) Sketch-map of foreshore north-west from Poyll Vaaish. (Reduced from 25-inch field map.) A. Volcanic Ash. b^3. Posidonornya-beds (limestone-shale). b^2. Poolvash Limestone, forming knolls. b^1. Lower Limestone. xb. Dolomitized and brecciated limestone (with unaltered patches of b^2) e. Olivine-dolerite dykes.

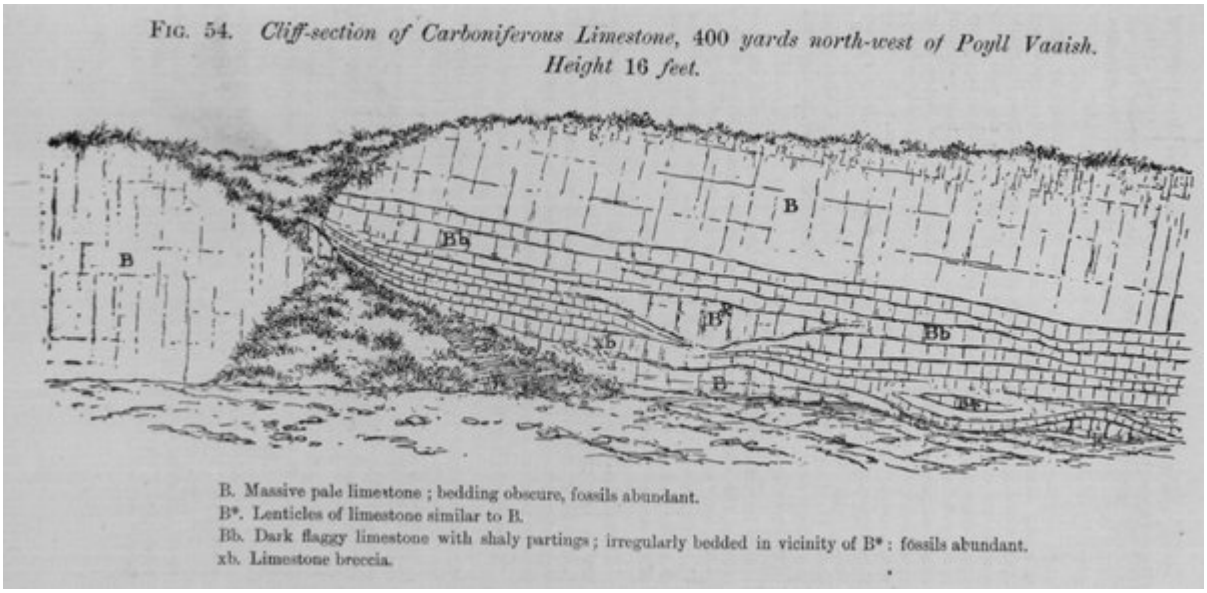
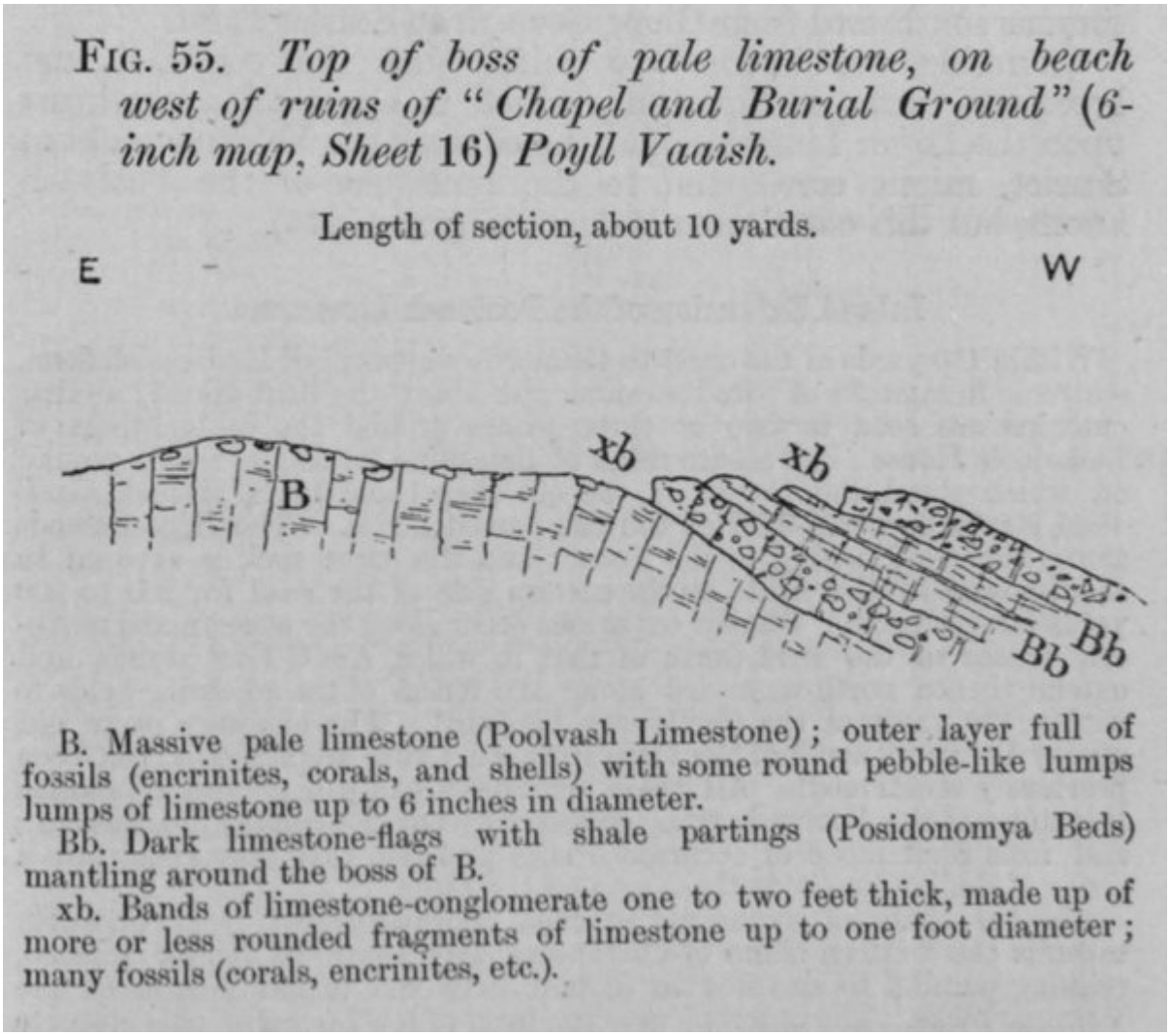


FIG. 54. *Cliff-section of Carboniferous Limestone, 400 yards north-west of Poyll Vaaish. Height 16 feet.*

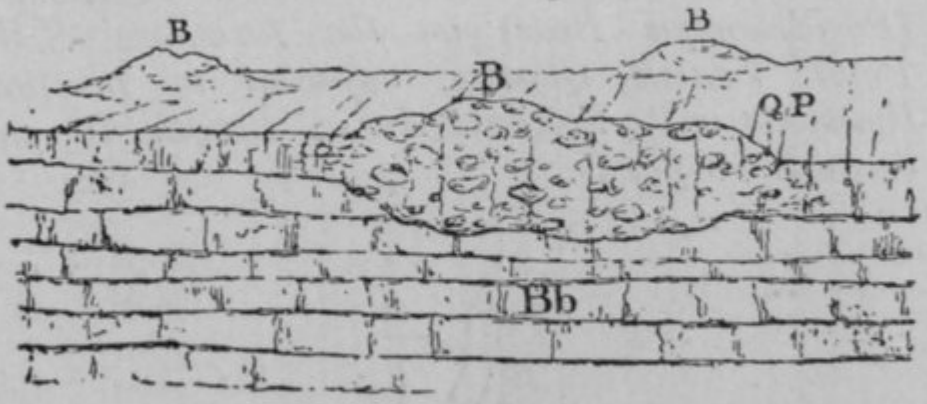
(Figure 54) Cliff section of Carboniferous Limestone, 400 yards north-west of Poyll Vaaish. Height 16 feet. B. Massive pale limestone; bedding obscure, fossils abundant. B. Lenticles of limestone similar to B. Bb. Dark flaggy limestone with*

shaly partings; irregularly bedded in vicinity of B: fossils abundant. xb. Limestone breccia.*



(Figure 55) Top of boss of pale limestone, on beach west of ruins of "Chapel and Burial Ground" (6-inch map, (Sheet 16)) Poyll Vaaish. Length of section, about 10 yards. B. Massive pale limestone (Poolvash Limestone); outer layer full of fossils (encrinites, corals, and shells) with some round pebble-like lumps lumps of limestone up to 6 inches in diameter. Bb. Dark limestone-flags with shale partings (Posidonomya Beds) mantling around the boss of B. xb. Bands of limestone-conglomerate one to two feet thick, made up of more or less rounded fragments of limestone up to one foot diameter; many fossils (corals, encrinites, etc.).

FIG. 56. *Section on shore slightly below high-water mark opposite Poyll Vaaish Quarry. Height about 3 feet.*



Bb. Dark limestone-flags with shale partings (Posidonomya Beds).
B. Boss of paler limestone, 6 feet diameter and 1½ feet thick, crowded with shells, principally *Productus*. A quartz-pebble, 1½ inches in diameter, was embedded in it at Q.P.
BB. Bosses similar to B protruding above the same bedding-plane ; not in the line of the section.

(Figure 56) Section on shore slightly below high-water mark opposite Poyll Vaaish Quarry. Height about 3 feet. Bb. Dark limestone-flags with shale partings (Posidonomya Beds). B. Boss of. paler limestone, 6 feet diameter and 1½ feet thick, crowded with shells, principally Productus. A quartz-pebble, 1½ inches in diameter, was embedded in it at Q.P. BB. Bosses similar to B protruding above the same bedding-plane; not in the line of the section.

FIG. 57. *Plan of a dome in dark limestone-flags (Posidonomya Beds) on the foreshore S.W. of Poyll Vaaish Quarry, adjacent to junction of limestone with Volcanic Ash. Length 40 yards ; breadth 10 yards.*

The arrows indicate direction of dip.

(Figure 57) Plan of a dome in dark limestone-flags (Posidonomya Beds) on the foreshore S. W. of Poyll Vaaish Quarry, adjacent to junction of limestone with Volcanic Ash. Length 40 yards; breadth 10 yards. The arrows indicate direction of dip.

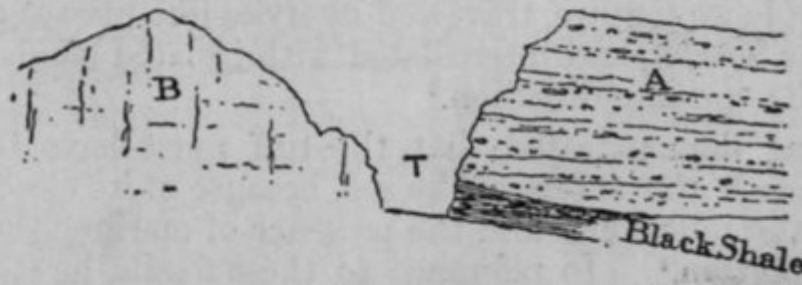
FIG. 58. *Section across the foreshore on the northern side of Close ny Chollagh Point, Poolvash; showing the rucking up of the Upper Limestone beneath the Volcanic Series. Length of section about* 120 *yards.*

(From Quart. Journ. Geol. Soc., vol. lvi.)

A. Volcanic ash of medium texture, with (b) contorted strips and fragments of cherty limestone.
B. Dark flaggy limestone (Posidonomya Beds); platy, indurated and pyritous in the uppermost layer, with signs of shearing (= thrust-plane); rucked up into short domes, the crests of which are in places pinched into the ash and brecciated.

(Figure 58) Section across the foreshore on the northern side of Close ny Chollagh Point, Poolvash; showing the rucking up of the Upper Limestone beneath the Volcanic Series. Length of section about 120 yards. (From Quart. Journ. Geol. Soc., vol. lvi.) A Volcanic ash of medium texture, with (b contorted strips and fragments of cherty limestone. B. Dark flaggy limestone (Posidonomya Beds); platy, indurated and pyritous in the uppermost layer, with signs of shearing (= thrust-plane); rucked up into short domes, the crests of which are in places pinched into the ash and brecciated.

FIG. 59. *Section across gully on shore at half tide W.S.W. of Poyllvaaish farmstead. Height* 10 *feet.*



A. Volcanic Ash, apparently overthrust upon black shale. B. Knoll of pale limestone and limestone-breccia. T. Thrust plane?

(Figure 59) Section across gully on shore at half tide W. S. W. of Poyllvaaish farmstead. Height 10 feet. A. Volcanic Ash, apparently overthrust upon black shale. B. Knoll of pale limestone and limestone-breccia. T. Thrust plane?

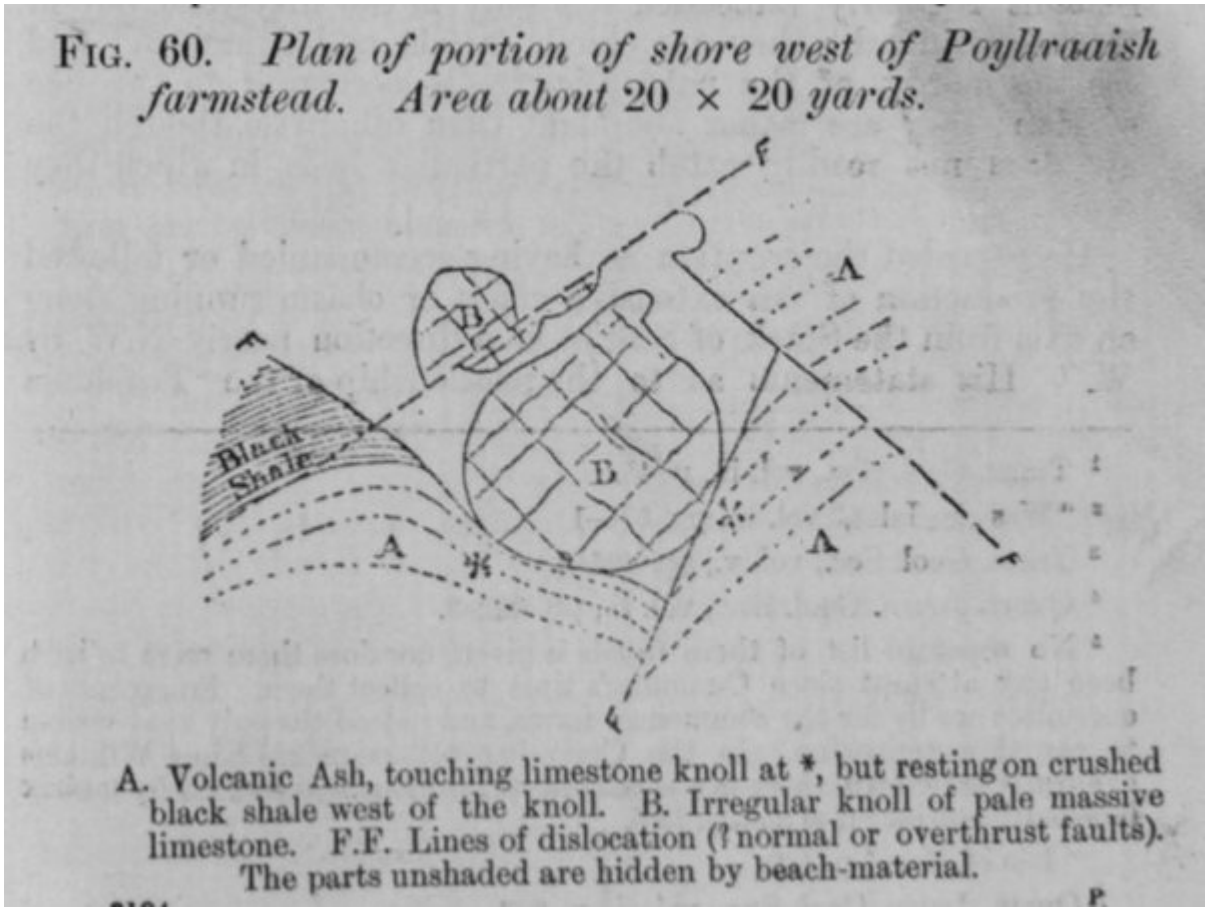


FIG. 60. *Plan of portion of shore west of Poyllvaaish farmstead. Area about 20 × 20 yards.*

A. Volcanic Ash, touching limestone knoll at *, but resting on crushed black shale west of the knoll. B. Irregular knoll of pale massive limestone. F.F. Lines of dislocation (? normal or overthrust faults). The parts unshaded are hidden by beach-material.

*(Figure 60) Plan of portion of shore west of Poyllvaaish farmstead. Area about 20 x 20 yards. A. Volcanic Ash, touching limestone knoll at *, but resting on crushed black shale west of the knoll. B. Irregular knoll of pale massive limestone. F.F. Lines of dislocation (?400 normal or overthrust faults). The parts unshaded are hidden by beach-material.*

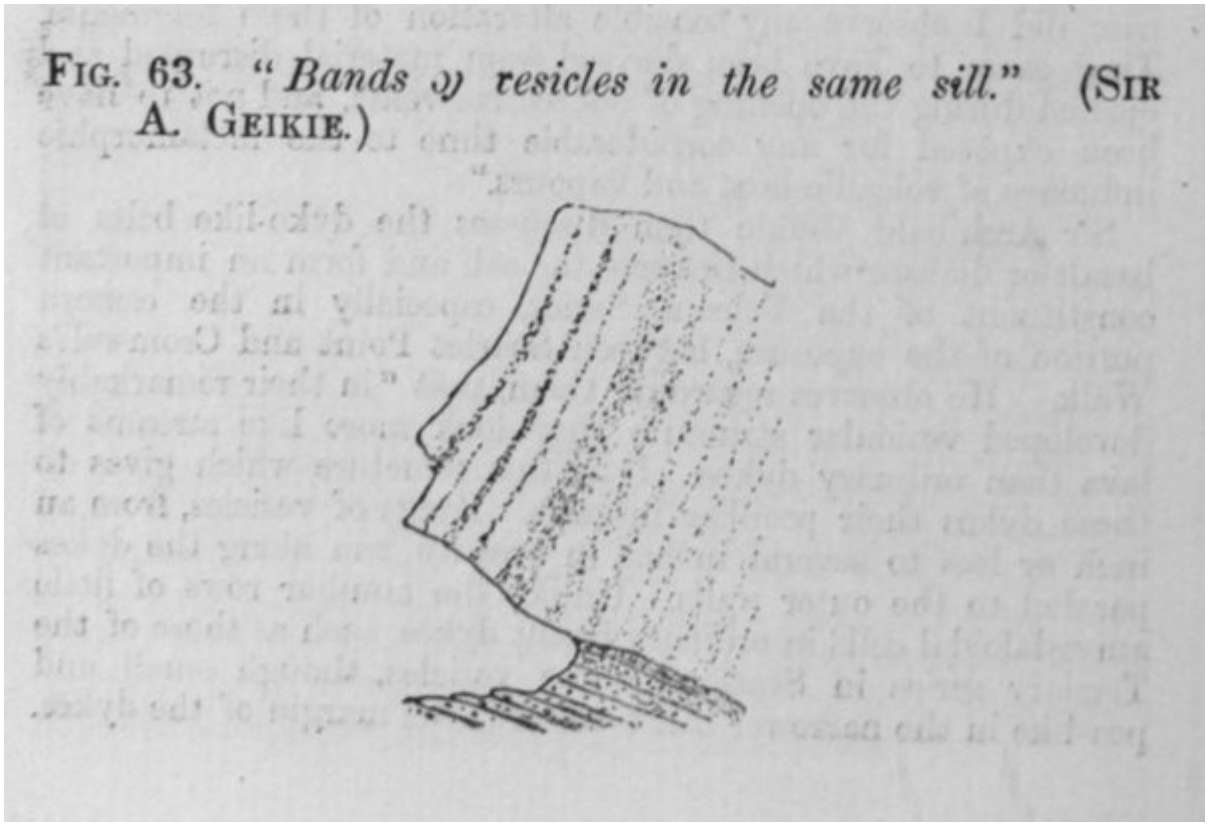


FIG. 63. *"Bands & vesicles in the same sill."* (SIR A. GEIKIE.)

(Figure 63) "Bands 41 vesicles in the same sill". (Sir A. Geikie)

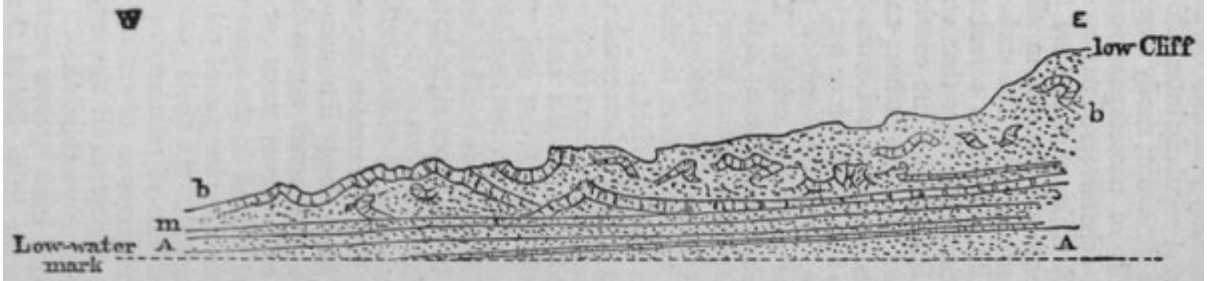
FIG. 64. *Section in crag on shore near low-water W.S.W. of Poyllvaaish Farm. Height about* 10 *feet.*

A. Volcanic ash.
b. Dark cherty limestone and shale, with pyritious fossils; wisps of ash, one to three inches thick, are apparently pinched in between folds of the strip of limestone.
T. Curving plane, probably overthrust. A dorsal fish-spine (*Sphenacanthus*) was found in the ash a foot or two below the right-hand lower corner of the section (see p. 236).

(Figure 64) Section in crag on shore near low-water W.S. W. of Poyllvaaish Farm. Height about 10 feet. A. Volcanic ash. b. Dark cherty limestone and shale, with pyritious fossils; wisps of ash, one to three inches thick, are apparently pinched in between folds of the strip of limestone. T. Curving plane, probably overthrust. A dorsal fish-spine (Sphenacanthus) was found in the ash a foot or two below the right-hand lower corner of the section (see p. 236).

FIG. 66. *Section across the foreshore* 250 *yards S. of Close ny Chollagh Point, showing the disturbance of bedding in volcanic ash and limestone. Length about* 100 *yards.*

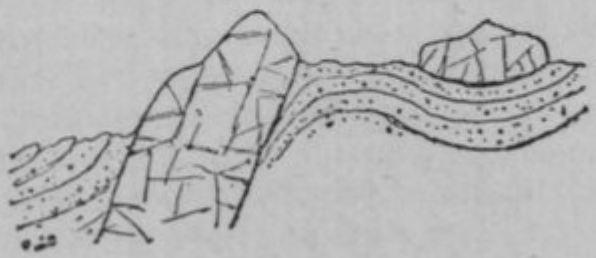
(From Quart. Journ. Geol. Soc., vol lvi.)



A. Evenly-bedded fine calcareous ash and thin cherty impure limestone-bands (6 feet seen).
b. Ash and limestone, like that below, but crumpled, broken and confused.
m. Small thrust-plane separating the broken from the unbroken beds; shifting to higher bands in going eastward. The ash is indurated for 2 or 3 inches beneath this plane.

(Figure 66) Section across the foreshore 250 yards S. of Close ny Chollagh Point, showing the disturbance of bedding in volcanic ash and limestone. Length about 100 yards. (From Quart. Journ. Geol. Soc,, vol lvi.) A Evenly-bedded fine calcareous ash and thin cherty impure limestone-bands (6 feet seen). b. Ash and limestone, like that below, but crumpled, broken and confused. m. Small thrust-plane separating the broken from the unbroken beds; shifting to higher bands in going eastward. The ash is indurated for 2 or 3 inches beneath this plane.

FIG. 61. "*Section of dyke and sill in the tuffs west of Scarlet Point, Isle of Man.*" (SIR A. GEIKIE.)



(Figure 61) "Section of dyke and sill in the tuffs west of Scarlet Point, Isle of Man". (Sir A. Geikie.)

FIG. 62. "*Section of south side of vesicular sill west of Scarlet Point.*" (SIR A. GEIKIE.)

(Figure 62) "Section of south side of vesicular sill west of Scarlet Point". (Sir A. Geikie.)

1. Coarse agglomerate below Cromwell's Walk, with included mass of Cherty Limestone.

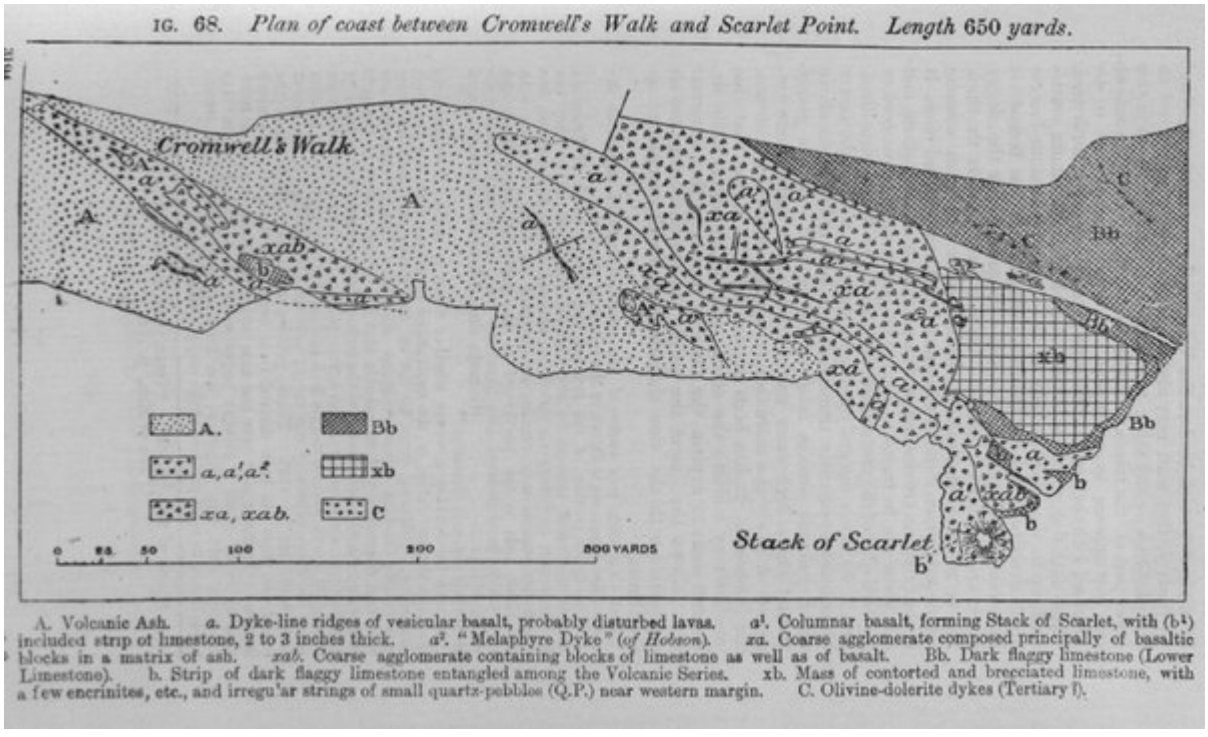
2. Tabular mass of Basalt at Cromwell's Walk, with lower margin fractured, and vesicular bands vertical.

(Plate 3) 1. Coarse agglomerate below Cromwell's Walk, with included mass of Cherty Limestone. 2. Tabular mass of Basalt at Cromwell's Walk, with lower margin fractured, and vesicular bands vertical.

1. Enlarged View of Gaps in lower margin of Basalt at Cromwell's Walk.

2. Laminated Ash, with close-jointing and step-faulting; 800 yards south of Close ny Chollagh Point.

(Plate 4) 1. Enlarged view of Gaps in lower margin of basalt at Cromwell's Walk. 2. Laminated Ash, with close-jointing and step-faulting; 800 yards south of Close ny Chollagh Point.



IG. 68. *Plan of coast between Cromwell's Walk and Scarlet Point. Length* 650 *yards.*

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

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

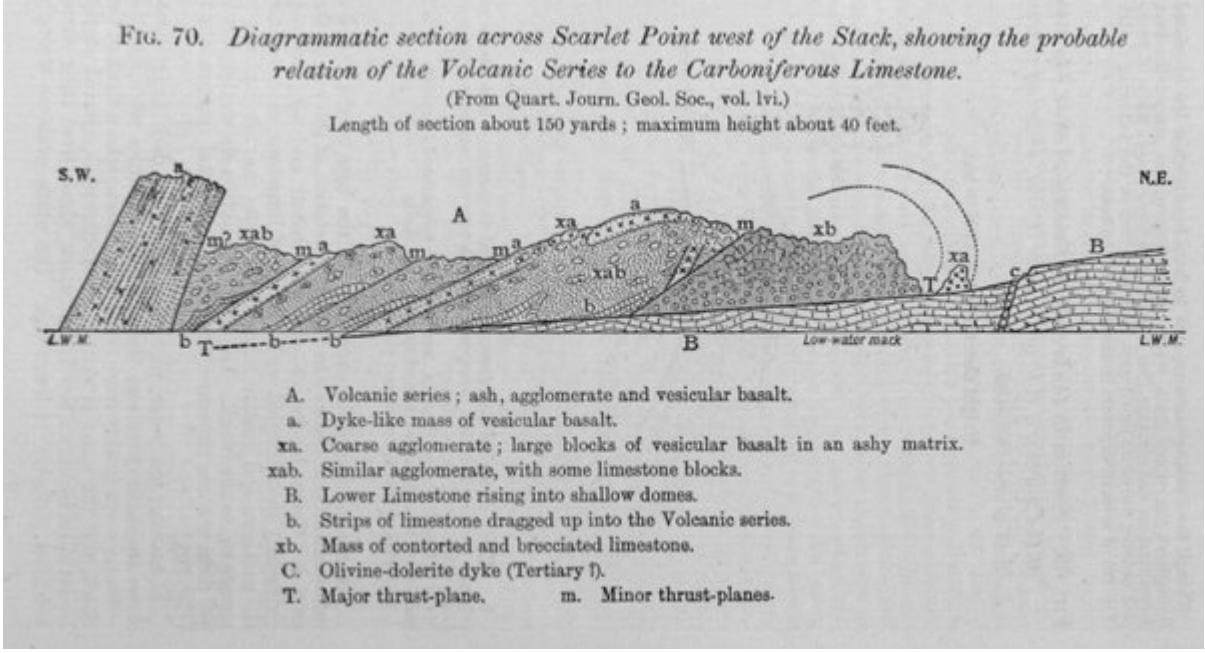


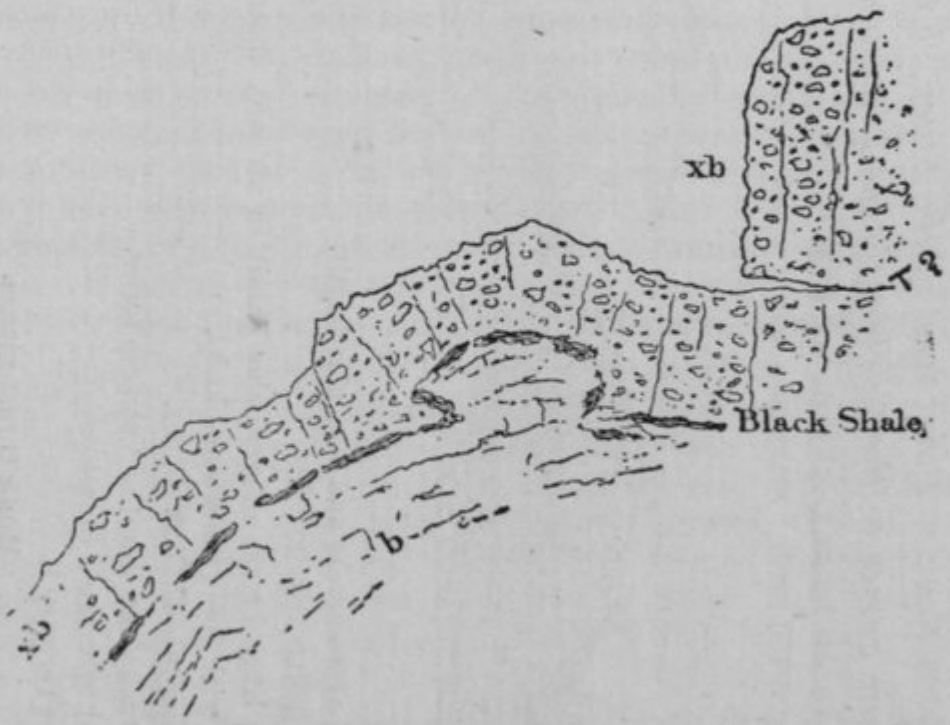
FIG. 70. *Diagrammatic section across Scarlet Point west of the Stack, showing the probable relation of the Volcanic Series to the Carboniferous Limestone.*
(From Quart. Journ. Geol. Soc., vol. lvi.)
Length of section about 150 yards ; maximum height about 40 feet.

A. Volcanic series ; ash, agglomerate and vesicular basalt.
a. Dyke-like mass of vesicular basalt.
xa. Coarse agglomerate ; large blocks of vesicular basalt in an ashy matrix.
xab. Similar agglomerate, with some limestone blocks.
B. Lower Limestone rising into shallow domes.
b. Strips of limestone dragged up into the Volcanic series.
xb. Mass of contorted and brecciated limestone.
C. Olivine-dolerite dyke (Tertiary ?).
T. Major thrust-plane. m. Minor thrust-planes.

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

FIG. 69. *Section in the brecciated limestone (xb of Fig. 68) at the northern side of Scarlet Point, showing traces of original bedding.*

Height about 6 feet, length 10 feet.

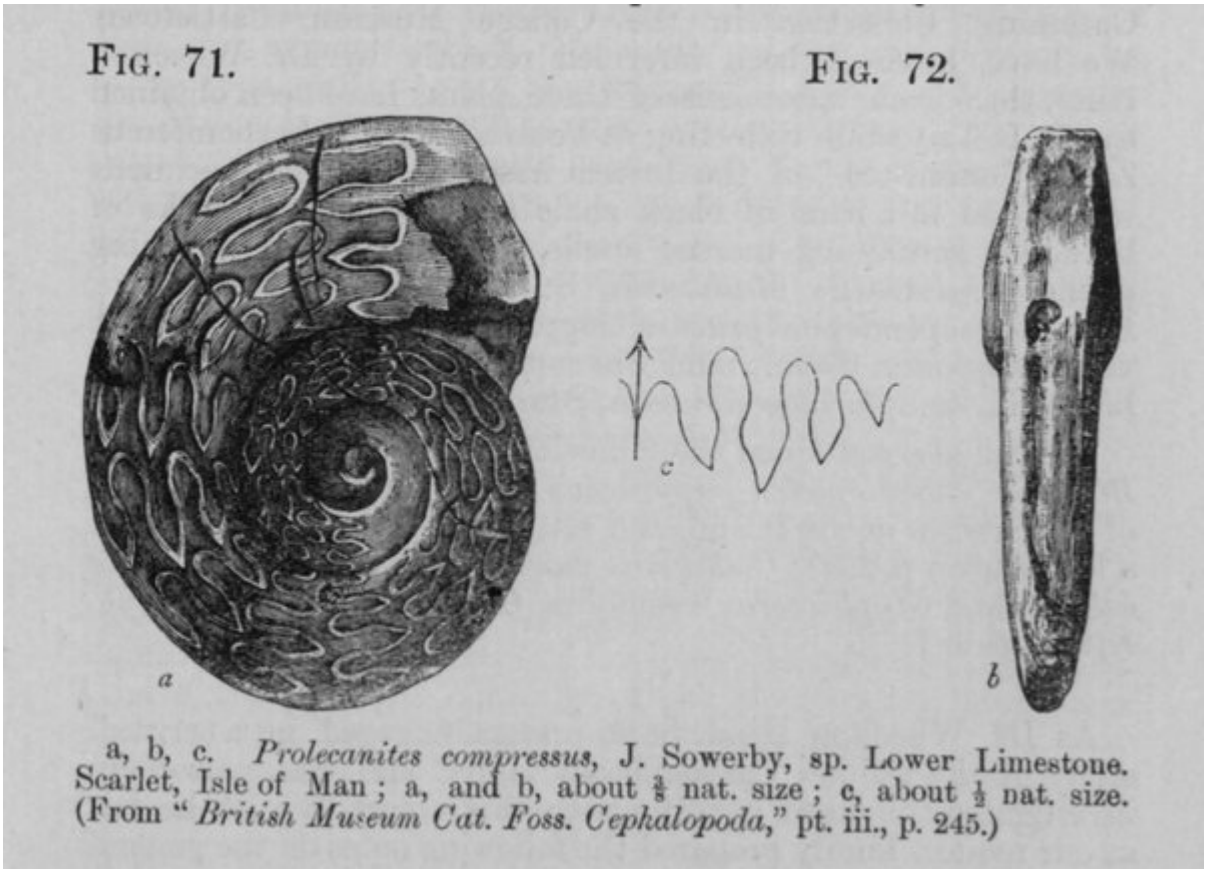


b. Much disturbed limestone, dolomitised in places; with traces of original bedding here and there, capped by a torn and interrupted strip of black shale 1 to 2 inches thick.

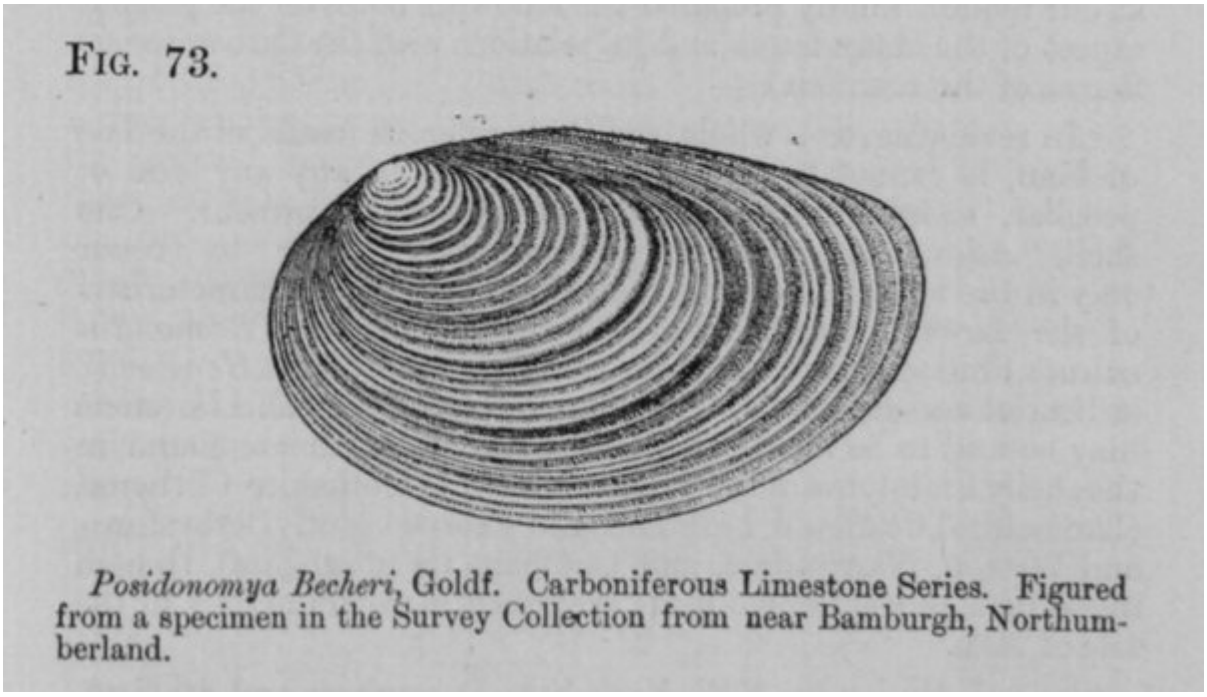
xb. Grey limestone-breccia, made up of recemented fragments of all sizes, with bits of encrinites and fragmentary shells.

T. ?. Probably a minor thrust-plane.

(Figure 69) Section in the brecciated limestone (xb of (Figure 68)) at the northern side of Scarlet Point, showing traces of original bedding. Height about 6 feet, length 10 feet. b. Much disturbed limestone, dolomitised in places; with traces of original bedding here and there, capped by a torn and interrupted strip of black shale 1 to 2 inches thick. xb. Grey limestone-breccia, made up of recemented fragments of all sizes, with bits of encrinites and fragmentary shells. T. ?. Probably a minor thrust-plane.



(Figure 71) a, b, c. Prolecanites compressus, J. Sowerby, sp. Lower Limestone. Scarlet, Isle of Mau; a, and b, about ■ nat. size; c about ½ nat. size. (From British Museum Cat. Foss. Cephalopoda", pt. iii., p. 245.)



(Figure 73) Posidonomya Becheri Goldf. Carboniferous Limestone Series. Figured from a specimen in the Survey Collection from near Bamburgh, Northumberland.