Chapter 9 The Central Belt — continued. Black shale bands between the Cree and the Mull Of Galloway

In the broad belt of Tarannon Rocks stretching from the mouth of the Cree across the low grounds of Wigtownshire to the shores of Luce Bay, the representatives of the Moffat series come to the surface along various anticlines. Of these, the most important is the series of bands that extend from Drumblair by Glenling and Crailloch to Ballaird. (Sheet 4 of Survey Map.)

Glenling, Crailloch, and Ballaird Black Shale Bands. — This series of outcrops is traceable from Drumblair [NX 28202 50522], on the east shore of Luce Bay, 5½ miles N.W. of Port-William, to Ballaird [NX 36633 54494], 5 miles W. from the mouth of the river Bladenoch. Near the western termination of the bands, the radiolarian cherts are visible at three localities, and from this horizon there is an ascending sequence to the *M. gregarius* zone. The outcrops of the black shales are extremely irregular; there are no continuous cross-sections in streams, the exposures being met with in fields and on moorland.

Drumblair. — [NX 28202 50522] The section on the hill-face north of Drumblair shows grey, massive, and nodular radiolarian charts, some of the beds measuring two feet thick. In the core of the arch there is a fine-grained felsitic rock which may probably represent some member of the Arenig volcanic series. The cherts are visible in a knoll in the field, but their relations to the surrounding rocks are not visible. A few yards to the north, debris of black shales is seen, and still further north greywackes appear. To the south of these radiolarian cherts the black shales appear at Drumblair, and in the road leading to the house. They are visible at various localities in the neighbourhood of Drumblair, but the horizon of these shales has not been proved.

Garheugh. — [NX 27600 50160] The by-road leading to Garheugh from the main road at Alticry, half a mile west of Drumblair, furnishes sections of the members of the Moffat series (Figure 34). About 300 yards north of the main road the cherts appear, with the black shales on both sides. On the north limb of the fold, and in the field adjoining the road to the east, the following forms were obtained: *Climacograptus bicornis, C. tridentatus, Cryptograptus tricornis,* and *Diplograptus foliaceus.*

For a short distance there is a blank in the road section, but to the northwards an exposure of black shales yields *Diplograptus foliaceus, Dicellograptus,* and *Climacograptus.* Next we find, for about 30 yards, the Barren Mudstones, which are succeeded by the Birkhill Shales. It is probable that the whole sequence of the Lower Birkhill group is here represented, but the only fossils obtained belong to the *M. gregarius*zone, as given in the following list:

Monograptus gregarius (Lapw.)

Monograptus tenuis (Portl.)

Monograptus leptotheca (Lapw.)

Monograptus Hisingeri (Carr.)

Diplograptus tamariscus (Nich.)

Climacograptus normalis (Lapw.)

Dawsonia campanulata (Nich.)

The Barren Mudstones come to the surface at the roadside for a distance of 30 or 40 yards, while in a quarry at a sharp bend in the road, 200 yards from Garheugh, a thin seam of black shales has yielded *Diplograptus foliaceus.* This outcrop of Barren Mudstones, after crossing a narrow hollow, is succeeded by grits and greywackes, the latter being probably brought into conjunction with the Moffat series by means of a fault. This hollow runs in a north-east direction by the Black

Loch, and is bounded on the north by a line of cliff composed of grits, greywackes, and shales. The probable fault-line is oblique both to the Moffat series and to the greywackes and shales to the north. North-eastwards along the hollow occupied by the fault, within 100 yards of the quarry just described, a cliff of greywacke rises on the north side of the feature and the black shales appear on the south side. These shales here form one limb of an arch, and dip generally to the south about 70°, the lowest zone occurring nearest the fault. The Barren Mudstones are seen at the base of the slope underneath the black shales with a south-east dip, followed by the *Diplograptus acuminatus* zone. This outcrop of the Moffat series can be traced north-eastwards by the Black Loch for two-thirds of a mile. At a point about 300 yards south-west from the Black Loch [NX 27801 50663], the black shales contain *Diplograptus vesiculosus, D. tamairiscus, Dimorphograptus elongatus, Climacograptus normalis,* and *Monograptus.* On the south bank of the Black Loch the following forms were obtained: *Diplograptus acuminatus, Monograptus attenuatus, Climacogrwptus* sp., and *siculae* of graptolites. Not far to the north-east of the Black Loch the foregoing band of black shales is truncated by the fault already referred to, the overlying greywackes and shales appearing along the strike to the north-east (Figure 35)

Near Loch Doon, about 300 yards E.S.E. of the Black Loch [NX 28431 50933], there is a nearly parallel fold of black shales which has been traced for a distance of two-thirds of a mile, with the Barren Mudstones in the centre and the Birkhill Shales on both sides (Figure 35).

The folds of the Moffat series, forming numerous though isolated exposures between Drumblair and the Black Loch, as already described, disappear within half a mile to the north-east of Drumblair, and are succeeded by the overlying greywackes and shales. Along the line of the two most northerly folds (Black Loch and Loch Doon bands) the Moffat Shales have not been observed on the Drumblair Moor to the north-east. To the south-east, however, the Moffat series reappears near Kirwan Plantation [NX 28892 50875] (Figure 35). From this point to the road near the farmhouse of May — a distance of about a mile — the members of this series occupy a belt of ground about a quarter of a mile wide. The exposures are confined chiefly to the cultivated ground and the rocky knolls scattered through the fields. The evidence is, therefore, imperfect, and, indeed, we seldom find here two of the main groups of the Moffat series in conjunction. The lowest beds exposed are the radiolarian cherts, which occupy the crest of a small knoll in a field about half a mile W.S.W. of May Farmhouse and about 100 yards from the public road. The cherts are here followed by black shales, from which the following forms have been collected: *Diplograptus foliaceus, Cryptograptus tricornis, Climacograptus bicornis,* and *Dicellograptus.* The grey Barren Mudstones form the main portion of the rock exposures, and indeed it is highly probable that they underlie a large part of the narrow belt, from the abundance of mudstone debris in the cultivated soil between the knolls of rock.

May Farmhouse. — [NX 30158 51507] The Birkhill Shales are also exposed in numerous places, and often enclose boat-shaped masses of greywacke, which form the most prominent rock-knolls. At two localities on the public road, from 150 to 200 yards northeast of May, these beds have supplied *Monograptus gregarius* and *Monograptus attenuatus,* indicating that the *M. gregarius* zone is represented. Following this line of outcrop eastwards from May Farmhouse as far as the Water of Malzie, we find numerous exposures of the Moffat series covering an area about half a mile wide. These exposures are isolated, and the evidence is more defective than in the area above described. Notwithstanding this fact, there is confirmatory evidence of the rapid plication of the Moffat series. About 500 yards east of May Farmhouse [NX 30598 51558] the black shales have supplied the following Birkhill forms: *Monograptus, Dimorphograptus,* and *Climacograptus normalis.* The Glenkiln–Hartfell Shales are exposed in a ditch about 100 yards north of Culshabben School, and about *a* mile further to the north-east the radiolarian cherts appear on a knoll on the west bank of the Water of Malzie, where it takes *a* sudden bend to the east. Indeed, along the belt of ground north of the road between Culshabben and the Water of Malzie, debris of black shales and Barren Mudstones is exposed in the cultivated ground, while occasional rocky knolls, formed of grit, project here and there through the surrounding tilled patches.

Crailloch and Low Glenling. — [NX 04106 58947] About four miles inland from the east coast of Luce Bay the neighbourhood of Crailloch and White Dyke is occupied chiefly by peat mosses, with intervening cultivated knolls. Recently the Water of Malzie and its tributaries have been artificially deepened, and where the cuttings exposed the Moffat series, numerous graptolites have been obtained from the Glenkiln–Hartfell and Birkhill Shales respectively.

One of the best exposures in the area is seen on the south of the Water of Malzie, on the by-road to Crailloch Farmhouse, [NX 32517 51935] which branches from the main road half a mile west of Low Glenling (Figure 36). Here the

radiolarian cherts appear in the bank on the south side of the road, and are succeeded by a mass of black shales which contain the following Glenkiln forms: *Diplograptus euglyphus, Leptograptus flaccidus, Dicranograptus formosus, Dicellograptus,* and *Climcograptus.* These strata are followed by debris of platy black shales, crowded with *Leptograptus flaccidus* and *Dicellograptus,* together with *Diplograptus foliaceus* and *Dicranograptus ramosus,* probably representing a portion of the *D. Clingani* zone of the Lower Hartfell black shales.

A few yards to the north, where a cutting has been made in these Moffat Shale beds for the purpose of deepening the river, a search was made in the debris thrown out from the river bed, and the following typical Glenkiln forms were obtained, chiefly from large slabs of a dark coarse-grained shale:

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Didymograptus superstes (Lapw.)

Lasiograptus bimucronatus (Nich.)

Diplograptus foliaceus (Murch.)

Thamnograptus scoticus (Lapw.)

Climacograptus bicornis (Hall.)

Climacograptus caelatus var. *antiquus* (Lapw.)

Dicellograptus sextans (Hall.)

Dicellograptus intortus (Lapw.)

Dicellograptus patulosus (Lapw.)

Dicellograptus moffatensis (Carr.)

Dicranograptus ramosus (Hall.)

Cryptograptus tricornis (Carr.)

Glossograptus Hincksi (Hopk.)

In certain seams the *Caenograpti* occur in great abundance; *Didymograptus superstes* is very plentiful, and the specimens of *Lasiograptus bimucronatus* are remarkably well preserved. Though the road-cutting does not expose the black shales on the north limb of the fold of radiolarian cherts, yet by following the river course westwards, debris of Glenkiln–Hartfell Shales may be observed, which may be regarded as evidence that the sequence on the north limb extends to the horizon of the Lower Hartfell group.

South from the road-cutting, the Barren Mudstones are observable at intervals at the roadside. Near the main road there is a small exposure of black shales in a quarry, and debris of black shales occurs along a footpath running west from the road. These strata are followed southwards by greywackes.

To the east of the artificial cuttings in the Water of Malzie and adjoining road, the lower members of the Moffat series extend along the river as far as a point north of Low Glenling, a distance of three-quarters of a mile. The same shales and overlying Barren Mudstones are likewise exposed in the knolls that rise out of the peaty flat through which the stream flows. In a knoll 600 yards north of Low Glenling, the Barren Mudstones are succeeded on their northern edge by a black shale containing *Rastrites peregrinus, Monograptus spiralis, M. Sandenoni, Climacograptus normalis,* and *Diplograptus* sp. This assemblage indicates the occurrence of the *Monograptus gregarius* zone, and perhaps a part also of a higher

zone.

In the fields to the south of Crailloch, and in quarries by the side of the road from Crailloch eastwards to the Water of Malzie, the Barren Mudstones and black shales belonging to the Glenkiln–Hartfell divisions are exposed. Round Crailloch Farmhouse, and for some distance along the strike to the N.E. and S.W., the Birkhill Shales appear. At a point 300 yards E.N.E. from Crailloch, where a ditch has been cut through one of these outcrops, the following forms were obtained from the debris — an assemblage which suggests that the various sub-zones of the Lower Birkhill group are here represented:

Diplograptus acuminatus (Nich.)

Dtmorphograptus Swanstoni (Lapw.)

Diplograptus vesiculosus (Nich.)

Climacograptus normalis (Lapw.)

Climacograptus rectangularis (M'Coy.)

Climacograptus nov. sp.

Monograptus gregarius (Lapw.)

Monograptus tenuis (Portl.)

Monograptus attenuatus (Hopk.)

Monograptus leptotheca (Lapw.)

Dawsonia campanulata (Nich.)

One feature which characterises the system of folding in the area just described between Garheugh and Low (ilenling is worthy of note, viz.: that the sharpest folds, revealing the lowest strata, occur along the southern margin of the, area, even though these folds do not run along the same axial line. They are arranged in *echelon,* the long axis of each successive deep fold being a little to the south of the preceding one as we pass towards the north-east.

Crows Burn, Ballaird. [NX 36443 54822]— Owing to the pitch of the folds the Moffat Shales bury themselves underneath overlying sediments to the east of the area just described. For a distance of nearly two miles to the E.N.E., only greywackes are met with, save at one locality, where a small patch of black shales is visible near the "White Dyke Spa" — a chalybeate spring [NX 34555 53486], rather more than half a mile north by east of White Dyke Farm. The black shales reappear, however, to the north, near Ballaird, about half a mile to the west of Ballaird Farmhouse, where they occupy a considerable breadth of ground, along the line of the Crows Burn to the east of Crows Moor. This outcrop of Moffat Shales in the Crows Burn is bounded on the west by a cliff-like feature named the Cat Craigs, which forms the east margin of the Crows Moor. That this feature is due to a fault may be surmised from the fact that the black shales strike persistently at the greywackes of the escarpment.

This area, about a mile long and about 200 yards broad, stretches from the feature just mentioned to the road a little to the north-east of Ballaird Farmhouse [NX 36873 54771]. The most conspicuous beds in it are Barren Mudstones, but the Lower Hartfell black shales are also exposed, sometimes in the knolls, but chiefly in ditch-like cuttings in the course of the Crows Burn, about 800 yards W.N.W. of Ballaird Farm, where they have yielded *Diplograptus foliaceus, Climacograptus caudatus, Glossograptus Hincksi.* From another exposure, a little further down stream, *Diplograptus foliaceus* and *Climacograptus tubuliferus* were collected. In a field about 400 Wards north of Ballaird, black shales occur next greywackes, from which *Monograptus leptotheca* was obtained, proving that part of the Birkhill Shales are here represented. In a quarry in a field close to the road, about 400 yards north-east of Ballaird, the Barren Mudstones occur with a mass of Hartfell black shales, the latter being much cleaved and shattered, and enclosing imperfect specimens of *Diplograptus foliaceus* and Climacograptus *bicornis.* To the east of these outcrops, the black shales do not reappear

throughout the area lying to the west of the estuary of the Cree.

Eldrig Loch. — [NX 25353 69370] About two miles to the south of the bands at Low Glenling, the Moffat series reappears at Lochhead, by the roadside east of Eldrig Loch, in Mochrum Parish, and again about a mile to the W.S.W., in a quarry, where the black shales form the back of an anticline. From the latter locality, fragments of *Monograpti* have been obtained, and from the former some Birkhill forms have been collected.

Culroy. — [NX 25714 53962] About two and a half miles to the north of the band at Garheugh the black shale series reappears near Culroy to the west of Castle Loch, Glenluce Parish. This band has been traced for 2½ miles, the best sections being visible in the Gillespie Burn (Figure 37). At a point about 400 yards east of Culroy Farmhouse, this stream changes its course at a right angle and plunges into a rocky gorge, where the burn flows along a nearly vertical outcrop of Hartfell black shales. The following fossils were here gathered: *Diplograptus quadrimucronatus, D. foliaceus, Climacograptus caudatus, Cryptograptus tricornis, Climacograptus bicornis, Dicranograptus ramosus, Dicellograptus, Retiolites, Corynoides calycularis.*

On the north side of this exposure of the Hartfell Shales a small development of Barren Mudstones is succeeded by a thin band of blue-black shales, containing *Climacograptus normalis, Diplograptus,* and *siculae* of graptolites, belonging to the Birkhill group. These strata are followed by greywackes and shales, with a thin black shale containing fragments of graptolites.

On the south side of the main exposure of Hartfell Shales the stream flows across Barren Mudstones. The Hartfell black shales reappear at two localities — one 50 yards (Locality B in ground-plan, (Figure 37)), the other about 100 yards down stream (Locality C) from the main Hartfell outcrop (Figure 38). The fossils from Locality B include *Diplograptus foliaceus, Climacograptus bicornis,* and *Dicranograptus;* those from Locality C, at the bend on left bank, comprise *Diplograptus foliaceus, Climacograptus bicornis, Corynoides calycularis,* and *Dicellograptus.* Some of the seams are crowded with specimens of *Diplograptus foliaceus.*

Descending the burn, the observer notes the radiolarian cherts and black shales on the right bank a few yards back from the stream. North-east of the stream, the red mudstones and black shales are visible in the cultivated fields, and are traceable for a distance of 700 yards from the burn section. To the north of the arch of red mudstones, the cherts appear on another fold, probably on the line of strike of the band B in the Gillespie Burn (see (Figure 37) and (Figure 39)). This zone of cherts is also associated with black shales. Both these anticlinal folds are apparently truncated by a fault running in a north-east direction. Still further to the north, a third fold reveals the Hartfell black shales containing the following forms: *Diplograptus foliaceus, Climacograptus bicornis, Dicellograptus,*, *Dicranograptus ramosus.*

Proceeding to the north-east, we find that the fault already described truncates these three folds in succession. At a distance of three-quarters of a mile north-east of Gillespie Burn, the Hartfell Shales on the northmost anticline are seen crossing the road leading to Barhaskine; a little further north, on the same road, dark shales in greywackes yielded the following forms: *Diplograptus acuminatus, D. tamariscus, Monograptus tenuis, M. attenuatus, M. gregarius, Climacograptus normalis.* A little further to the north-east, on the footpath, in blue-black shales in greywackes, the fossils obtained were *Monograptus gregarius* and *Climacograptus normalis.* Here, then, it is clear that the representatives of the Birkhill Shales are enclosed in other sediments. A little over a mile and a half east-north-east of Gillespie Burn, the Birkhill Shales appear in a little quarry, beside a footpath about 100 yards W.S.W. of a small loch in peat. Here in a blue-black platy iron-stained shale, fine specimens of *Diplograptus acuminatus* have been got, together with specimens of *Climacograptus normalis and Monograptus attenuatus.* The fault just mentioned gives rise to a prominent feature traceable eastwards to the little loch in the peat, and even beyond that point. At a point in the high road, about 300 yards N.N.W. from that loch, two folds of black shales appear, of which the most northerly yielded *Diplograptus acuminatus* and Climacograptus *normalis.*

In a little tributary of the Gillespie Burn east of Culroy [NX 25643 53987], on the right bank, dark seams in blue shales embedded in greywackes contain *Diplograptus vesiculosus, Monograptus attenuatus, &c.* To the west of Gillespie Burn fragments of black shales may be seen in the fields, and even knolls of black shales and Barren Mudstones occur. But the folds of these strata appear to be gradually becoming narrower. In a burn, due west of Culroy Farmhouse, where a

by-road or footpath crosses the burn, fragments of *Monograptus* were found in blue-black shales similar to those near Culroy. Again, by the roadside near Machermore [NX 24355 54860], at a point about half a mile south-east of Whitefield Loch, fragments of indeterminable graptolites were obtained from similar beds.

The evidence given in the foregoing paragraphs indicates that in the Culroy band of Moffat Shales the representatives of the Birkhill division have to a large extent disappeared, and that the graptolites of the *D. acuminatus* zone occur in dark seams, interleaved in coarser sediments. This change becomes still more apparent as we approach the northern margin of the Llandovery and Tarannon area near Glenluce. A section exhibiting these features stretches along the east shore of Luce Bay, about a mile south of Glenluce, between the Fish-house and the Crow's Nest. Beginning near the Fish-house and advancing southwards, the observer finds rusty mudstones resembling the Barren Mudstones, and calcareous bands with beds of greywacke, several feet in thickness. These are followed by greywackes and blue micaceous shales and mudstones, with dark bands and streaks sometimes calcareous. All the beds are nearly vertical or dip at high angles to the south. At a point about 200 yards south of the Fish-house two thin dark seams, ten yards distant from each other, yield graptolites sparingly. The more northerly layer encloses fine specimens of *Climacograptus normalis,* together with *Diplograptus acuminatus, Climacograptus* sp., and the *siculae* and the young stages of a *Dimorphograptus.* The southerly one yields *siculae* of graptolites and the same attenuated form of *Climacograptus.* These are followed by massive grey greywackes with thin bands of blue shales.

About 250 yards south of the foregoing fossiliferous localities certain thin bands in the greywackes yielded *Climacograptus* abundantly. About half a mile south of the Fish-house, beyond a series of massive greywackes with thin shales, dipping sometimes to the north and sometimes to the south, fossiliferous shales occur on the shore which closely resemble the *D. acuminatus* band already described near the Fish-house. Similar graptolites are obtained in great abundance in certain layers. These strata are followed southwards by mudstones, resembling lithologically the Barren Mudstones, and dip to the N.N.W. at high angles. About 100 yards south of the latter exposure, after traversing massive greywackes, we come again upon the blue shales with Lower Birkhill graptolites, which are followed southwards to the Crow's Nest by greywackes, grits, and thin shaly partings. About nine miles to the E.N.E. of the section here referred to, in the Tarf Water at Waulk Mill, about one quarter of a mile south of Kirkcowan [NX 33276 60212], *Climacograptus normalis* is found in a thick dark seam in greywackes, thus confirming the disappearance of the Moffat type of the Birkhill Shales towards the northern margin of the Llandovery and Tarannon area.

In the long narrow tongue of land which stretches south from the sands of Luce Bay to the Mull of Galloway, various folds of the Moffat series appear in the midst of the overlying Llandovery strata. (Sheets 1 and 3 of Survey Map.)

Clanyard Bay, West Coast of Rhinns of Galloway. — [NX 10135 37961] Important sections of the Moffat Shales, ranging from the Barren Mudstones to the *M. spinigerus*zone of the Birkhill division, are laid open in this bay, which is about a quarter of a mile wide, measured from north to south. The exposures are confined to the north and south limits of the bay the central portion being covered with sand and gravel or other marine alluvial deposits (Figure 40).

Beginning with the section at the north end of the bay, the observer finds, as he proceeds northwards, that an excellent exposure of Barren Mudstones occupies the shore for a distance of 20 yards across the strike. These are the first rocks met with, and are apparently the lowest visible beds in this section. They consist of red, green, and grey mudstones with nodules of manganese or pisolitic ironstone, which lie along the bedding planes, and measure from one to three, and in some instances six, inches across. The variation in colour of the mudstonas from red to green and grey is purely local, and is not confined to separate bands. The strike of the beds is a few degrees to the north of east, the dip being sometimes to the north and sometimes to the south.

At their northern limit alternations of dark and green mudstones may be observed. The junction line between the top of the Barren Mudstones and the overlying Birkhill Shales is traceable along a ridge of rock through the gravel of the beach. About a foot below the base of the Birkhill Shales a seam of dark or black shales about half an inch thick furnishes good specimens of *Diplograptus truncatus* and *Dicellograptus anceps.* In the band of black shales in contact with the Barren Mudstones specimens of *Monograptus tenuis* and *M. attenuatus* were obtained. This zone is succeeded by black shales containing the following forms:

Diplograptus acuminatus (Nich.)

Dimorphograptus elongatus (Lapw.)

Diplograptus vesiculosus (Nich.)

Monograptus tenuis (Portl.)

Monograptus attenuatus (Hopk.)

gregarius (Lapw.)

Climacograptus normalis (Lapw.)

Climacograptus nov. sp.

To the north of these shales the Barren Mudstones reappear with a north-west dip. They here show a blue colour in fresh fracture, but weather brown or yellow. They are pierced on the north side by an intrusive dyke 29 feet broad. This dyke is succeeded by a mass of the Lower Birkhill Shales, visible at low tide. A few feet from the junction with the igneous rock the following forms were obtained from these shales:

Diplograptus vesiculosus (Nich.) in abundance and in excellent preservation.

Monograptus triangutatus (Hark.)

Monograptus tenuis (Ports.)

Diplograptus confertus (Nich.)

Diplograptus tamariscus (Nich.)

Measured from the north edge of the dyke there are 26 feet of black shales. Northwards a change takes place in the character of the sediments, for the succeeding 16 feet of strata consist of alternations of blue and black shales and clays, with nodules of ironstone and limestone. From, the following assemblage of graptolites obtained from them, there can be little doubt that these strata represent the *M. gregarius zone.*

Monograptus gregarius (Lapw.)

Monograptus tenuis (Portl.)

Monograptus attenuatus (Hopk.)

Monograptus leptotheca (Lapw.)

Diplograptus tamariscus (Nich.)

Climacograptus normalis (Lapw.)

Monograptus cyphus (Lapw.)

Monograptus triangulatus (Hark.)

Petalograptus palmaeus (Barr.)

Rastrites peregrinus (Barr.)

Dimophograptus Swanstoni (Lapw.)

Diplograptus confertus (Nich.)

A fault occurs along the northern margin of the *M. gregarius* zone.

To the north of the outcrop just described, a succession of blue-black shales and clays represents a portion of the Upper Birkhill division. The *Diplograptus comets* zone has not been noted, but a rich assemblage of forms occurs here in the *M. spinigerus* zone, those obtained being in excellent preservation:

Monograptus spinigerus (Nich.) in great abundance.

Monograptus spiralis (Geinitz.)

Monograptus attenuatus (Hopk.)

Monograptus leptotheca (Lapw.)

Monograptus Hisingeri (Carr.)

Rastrites maximus (Carr.)

Rastrites distans (Lapw.)

Petelograptus folium (His.)

The distance of the *M. spinigerus* zone from the fault is 10 feet, so that the dislocation is evidently of no great magnitude. To the north of this zone two dykes make their appearance. East of the northmost dyke jointed greywackes and shales occur, with a thin dark seam about a quarter of an inch thick, yielding fragments of graptolites.

At the south side of Clanyard Bay (Figure 40) the black shales of the *Diplograptus vesiculosus* zone are seen at low tide dipping at high angles to the north-west. Specimens of this zonal graptolite have been collected here, together with *Climacograptus normalis.* These strata are underlain by a fine display of the Barren Mudstones, which occupy the beach for a distance of 41 feet. At a distance of 29 feet from the northern limit of the mudstones, a narrow band of black shales appears, probably an infold of the *D. vesieutosus* zone.

To the south of this compound arch of Barren Mudstones the shales of the *D. vesiculosus*zone succeed, followed by the black shales and clays of the *M. gregarius* zone, which in turn give place to blue-black shales, mudstones, and clays of the Upper Birkhill division, that graduate outwards into greywackes and shales. The general dip of the strata is to the north-west, so that the Moffat beds here form an isoclinal fold inclined to the N.N.W.

Drumbreddan Bay. — [NX 07771 43631] Proceeding northwards across the strike of the beds, we meet with the next exposures of the Moffat series in Drumbreddan Bay at the southern limit of Sheet 4 of the Geological Survey Map. This bay, which is about 300 yards wide, has a promontory of rock in the centre, dividing it into two portions. The section which it affords is not continuous, for a large part of the beach is occupied with sand.

The ridge of rock that runs seawards in the centre of the bay is bounded to the north and south by a broad expanse of sand. On the south side of the rocky promontory at low tide a small arch of black shales occurs in a series of blue-black shales, with seams of clay, peering through the sand. From the black shales *Monograptus gregarius, M. triangulatus, Rastrites peregrinus, Climacograptus normalis,* and *Diplograptus* have been collected.

These strata are succeeded on the north side by grey clayey shales, dipping south at about 80°, with dark seams in thin leaves, from which the following forms were obtained: *Rastrites peregrinus, Monograptus tenuis, M. attenuatus, M. Hisingeri, Climacograptus,* and *Diplograptus.* They are followed northwards by grey shales, which enclose grey limestone nodules varying in size from a few inches to a foot across, and alternate with bands of flaggy greywackes that become thicker and more gritty as they are traced outwards from the Birkhill Shales. The section is interrupted by small faults.

South of the promontory an expanse of sand stretches for a distance of 80 yards. At the southern limit of the bay grey shales with dark seams occur, containing limestone nodules varying in size from a few inches to a foot or two across. These shales are interleaved with greywacke bands, the series graduating southwards into massive grits and shales. The grits enclose limestone nodules which weather out. The beds dip to the S.S.E. at angles of about 80°.

Proceeding now to the section north of the central promontory, where alternations of grits and shales form the last visible rock-exposures, the observer, after crossing a belt of 50 yards of gravel on the beach, finds another fold of the Moffat Shales at the north limit of the bay. Here, at low tide, at the base of the rocky cliff, black shales in grey clayey bands have yielded the following forms belonzina to the *M. gregarius* zone:

Monograptus gregarius (Lapw.)

Monograptus tenuis(Portl.)

Monograptus leptotheca (Lapw.)

Monograptus fimbriatus (Nich.)

Monograptus triangulatus (Hark.)

Rastrites peregrinus (Barr.)

Petalograptus palmaeus (Barr.)

Climacograptus normalis (Lapw.)

Climacograptus innotatus (Nich.)

Dawsonia campanulata (Nich.)

Siculae of graptolites.

These beds are succeeded at the base of the cliff by grey shales with dark films, like those on the south side of the central promontory, and then by sandy greywackes and shales.

Grennan Bay. — [NX 07485 43808] Round the headland of Grennan Point, brown-crusted grits, greywackes, and shales occupy the shore section — as far as Grennan Bay, where a fine section of Birkhill Shales is exposed. At the south limit of the bay massive grits and shales dip south-east, the beds immediately in contact with them consisting of black shales with clayey seams. These black shales yield graptolites in excellent preservation, belonging apparently to the *M. gregarius* zone:

Monograptus gregarius (Lapw.)

Monograptus tenuis (Portl.

Monograptus attenuatus (Hopk.)

Monograptus leptotheca (Lapw.)

Monograptus triangulatus (Hark.)

Monograptus lobiferus (M'Coy.)

Rastrites peregrinus (Barr.)

Climacograptus normalis (Lapw.)

Dawsonia campanulata (Nich.)

These strata contain limestone nodules from three inches to a foot across, and are traversed by a fault with a downthrow to the south. The black shales with limestone nodules yield *Diplograptus confertus* and a form like *Monograptus runcinatus.* Further north, black shales of the *Diplograptus vesiculosus:* zone contains *D. vesiculosus, Monograptus gregarius, M. attenuatus, M. tenuis, Climacograptus normalis, Dimorphograptus elongatus,* and *Diplograptus tamariscus.*

A constant repetition of the Lower Birkhill black shales, chiefly of the *D. vesiculosus* zone, may be traced northwards till an arch of Barren Mudstones is reached with flinty bands from seven to eight yards broad. On the north side of this arch there is a seam of black shale about one inch thick, followed by the Birkhill black shales. From the flaggy black shales the following forms were collected: *Climacograptus normalis, Monograptus tenuis,* and *Diplograptus tamariscus.* The next strata are black shales alternating with grey clays, succeeded by greywackes and shales. There seems, however, to be a line of fault at the north edge of the black shale series. This fine exposure of the Birkhill Shales occupies the coast line for a distance of about 70 yards.

Section near Float Bay. — [NX 06256 47269] About 4 miles to the north of the Grennan Bay band of black shales, another exposure of some members of the Birkhill division may be seen about a quarter of a mile to the north of Float Bay. Grey-blue shales with dark micaceous sandy seams occur on the north side of the bay, succeeded northwards by greywackes, grits, and shales. In the Dove Cave Bay [NX 05880 47400], representatives of the *M. gregarius* zone are met with, as shown on the accompanying ground-plan (Figure 41).

At A, on the cliff section, a zone of dark sandy shales contains *Monograptus tenuis, M. attenuatus, Diplograptus tamariscus, Climacograptus normalis,* and *siculae* of graptolites. These beds seem to be thrown by a fault to the south side of the bay, for at B they have yielded *Monograptus gregarius, M. tenuis, M. attenuatus, Climacograptus normalis.* They contain limestone nodules from a few inches to a foot thick. In the centre of the shales at B a synclinal fold of grit maybe observed to be marked with holes formed by the weathering out of calcareous nodules. Another exposure of shales with limestone nodules, probably on the same horizon, is seen on the shore a short distance to the north (White Laird's Loup, *&c.*).

Slunkrainy. — [NX 05639 47669] In the bay about 300 yards south of Slunkrainy, fossiliferous beds appear, which probably occupy the horizon of the *M. gregarius* zone. They consist of blue shales with black strains, dark sandy shales with limestone nodules and interleaved with greywackes. The sandy shales have yielded *Climacograptus, Monograptus,* and *Dawsonia campanulata.*

Immediately to the north of Slunkrainy Point [NX 05443 47779] a good development of blue-black shales with limestone nodules may be seen. In a cave at this part of the coast a black shale forms the roof, from which were obtained specimens of *Climacograptus normalis, Monograptus,* and *Diplograptus tamariscus.* To the north, these fossiliferous zones are succeeded by a great development of grey shales and mudstones. The general dip of the strata is to the S.S.E., but it is certain that these shales with greywacke bands, though they extend along the coast line for some distance, are isoclinally folded.

At a point where a burn falls over the cliff into the sea [NX 04835 48326], about a quarter of a mile south of Money Head, a band of black shales affords specimens of *Monograptus gregarius, M. tenuis, M. attenuatus, M. cyphus, M. leptotheca, Climacograptus normalis,* and *Dawsonia campanulata,* and probably represents the *M. gregarius* zone. It is the most northerly exposure of any recognisable fossiliferous zone representing the Birkhill Shales on the coast line between the Mull of Galloway and Portpatrick. Northwards this band is followed by shales, greywackes, and grits, occupying the cliffs at Money Head and Scarty Head towards Cairnsgarroch Bay.

From the evidence supplied by the various exposures of the Moffat series on the shore between the Mull of Galloway and Money Head, we may deduce the following conclusions. The lowest visible beds are the Barren Mudstones, and the highest belong to the *M. spinigerus* zone of the Upper Birkhill division. The type of mudstones representing the Upper Hartfell group closely resembles that in the Moffat area; while the dark band near the top, with *Dicellograptus anceps* and *Diplograptus truncatus,* is still met with. The lower division of the Birkhill group, with its subordinate zones of *Diplograptus*

acuminatus, Diplograptus vesiculosus, and *Monograptus gregarius,* is clearly recognisable, resembling closely the Moffat equivalents both in lithological characters and fossil contents. Further, it seems clear that in Clanyard Bay at least, and probably in the Grennan Bay arch, representatives of the Upper Birkhill division occur, including the *Cephalograptus cometa* and *M. spinigerus* zones. No trace, however, of the *M. spinigerus* zone has been recorded to the north of the Grennan Bay anticline in Sheet 3.

It is further observable that a marked change has supervened in the lithological characters of the strata between Clanyard Bay and Drumbreddan Bay to the north. The beds representing the *M. spinigerus* zone in Clanyard Bay, as already indicated, consist of blue-black shales, mudstones, and clays; while in Drumbreddan Bay this zone seems to be represented by grey shales with dark seams containing limestone nodules, followed immediately by flaggy greywackes and shales. In like manner the beds included under the *M. gregarius* zone consist in Clanyard Bay of black shales and clays; while several miles to the north, near Slunkrainy, the fossils of this zone appear in dark sandy shales interleaved in greywackes.

This gradual change in the character of the sedimentation of the Birkhill group, as we proceed northwards, is a feature which, as already indicated, is characteristic of the whole Silurian Tableland. It is one which has occasioned considerable difficulty in drawing a base line for the northern limit of the Llandovery and Tarannon Rocks.

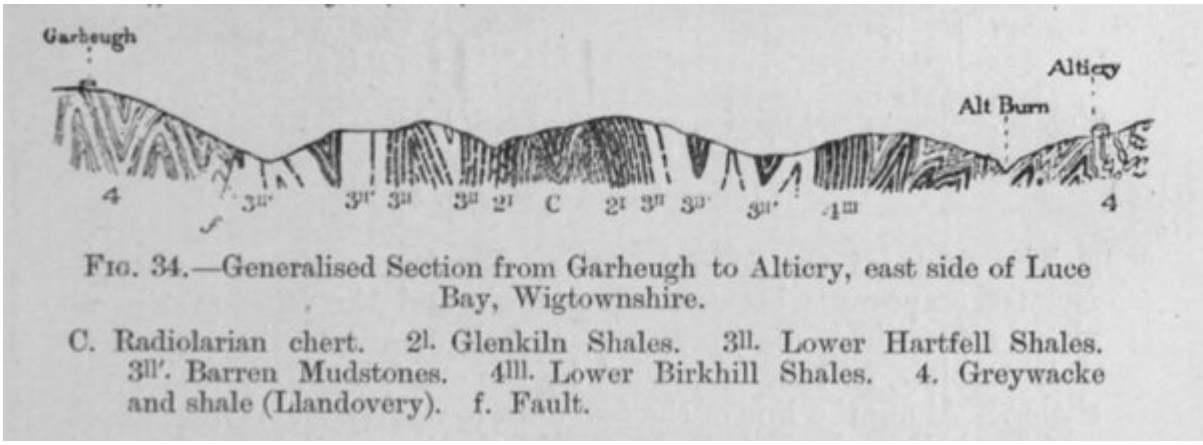

Fig. 34.—Generalised Section from Garheugh to Alticry, east side of Luce Bay, Wigtownshire.

C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3II′. Barren Mudstones. 4III. Lower Birkhill Shales. 4. Greywacke and shale (Llandovery). f. Fault.

(Figure 34) Generalised Section from Garheugh to Alticry, east side of Luce Bay, Wigtownshire. C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Harden Shales. 3II′. Barren Mudstones. 4III. Lower Birkhill Shales. 4. Greywacke and shale (Llandovery). f. Fault.

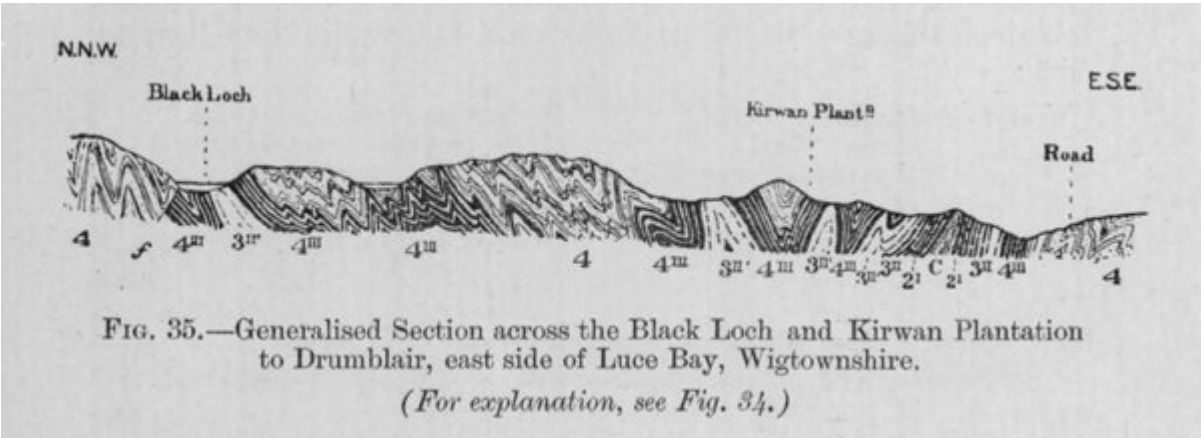

Fig. 35.—Generalised Section across the Black Loch and Kirwan Plantation to Drumblair, east side of Luce Bay, Wigtownshire.

(For explanation, see Fig. 34.)

(Figure 35) Generalised Section across the Black Loch and Kirwan Plantation to Drumblair, east side of Luce Bay, Wigtownshire. (For explanation, see (Figure 34).)

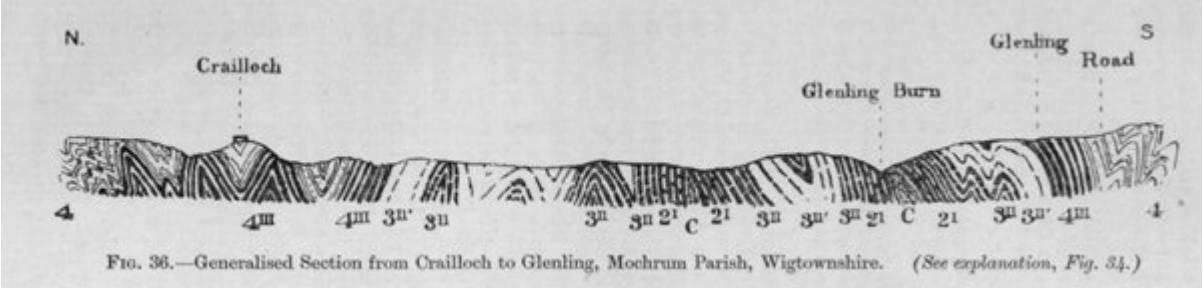

Fig. 36.—Generalised Section from Crailloch to Glenling, Mochrum Parish, Wigtownshire. *(See explanation, Fig. 34.)*

(Figure 36) Generalized section from Craigloch to Glenling, Mochrum Parish, Wigtownshire. (See explanation (Figure 34))

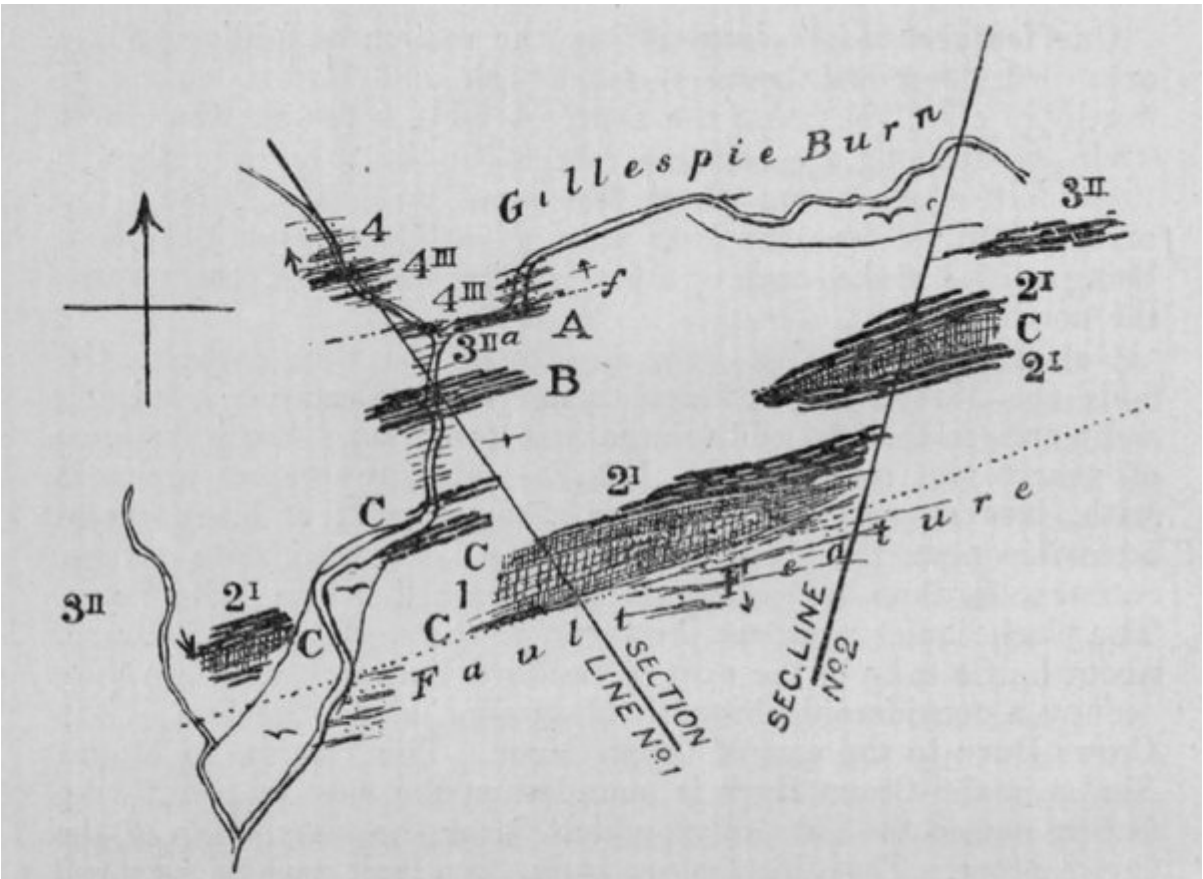

Fig. 37.—Plan of Gillespie Burn, Culroy, Glenluce Parish, Wigtownshire.

1. Mudstones (Arenig). C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3IIa. *Linearis*-zone. 3II'. Barren Mudstones. 4III. Lower Birkhill Shales. 4. Greywacke and shale (Llandovery). f. Fault. ~ Recent alluvium.

(Figure 37) Plan of Gillespie Burn, Culroy, Glenluce Parish, Wigtownshire. 1. Mudstones (Arenig). C. Radiolarian chart. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3IIa. Linearis-zone. 3II'. Barren Mudstones. 4III. Lower Birkhill Shales. 4. Greywacke and shale (Llandovery). f. Fault. [Symbol alluvium] Recent alluvium.

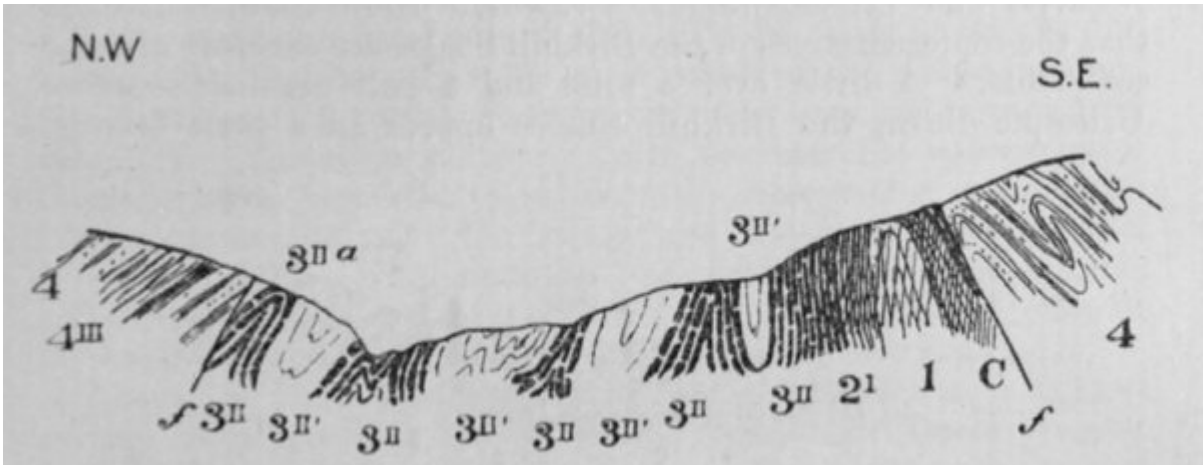

Fig. 38.—Section across Gillespie Burn (No. 1 in Fig. 37).

(Figure 38) Section across Gillespie Burn (No. 1 in (Figure 37)).

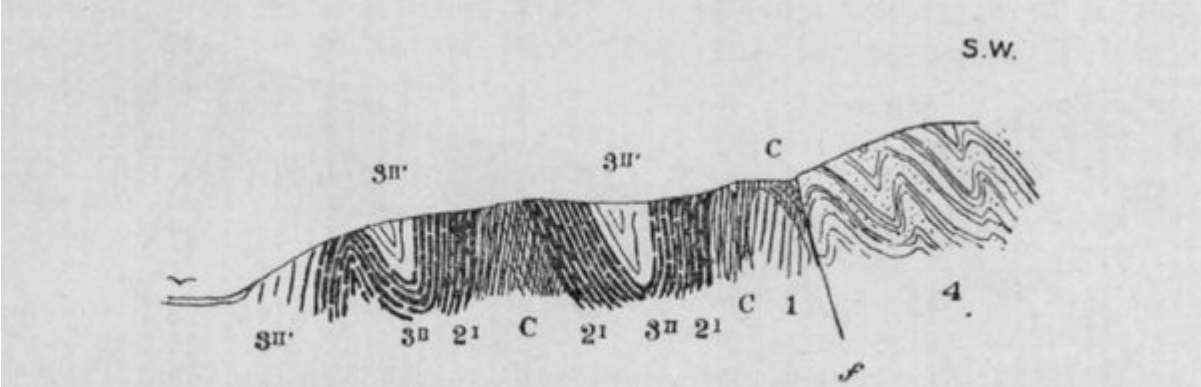

Fig. 39.—Section across Gillespie Burn (No. 2 in Fig. 37).

(Figure 39) Section across Gillespie Burn (No. 2 in (Figure 37)).

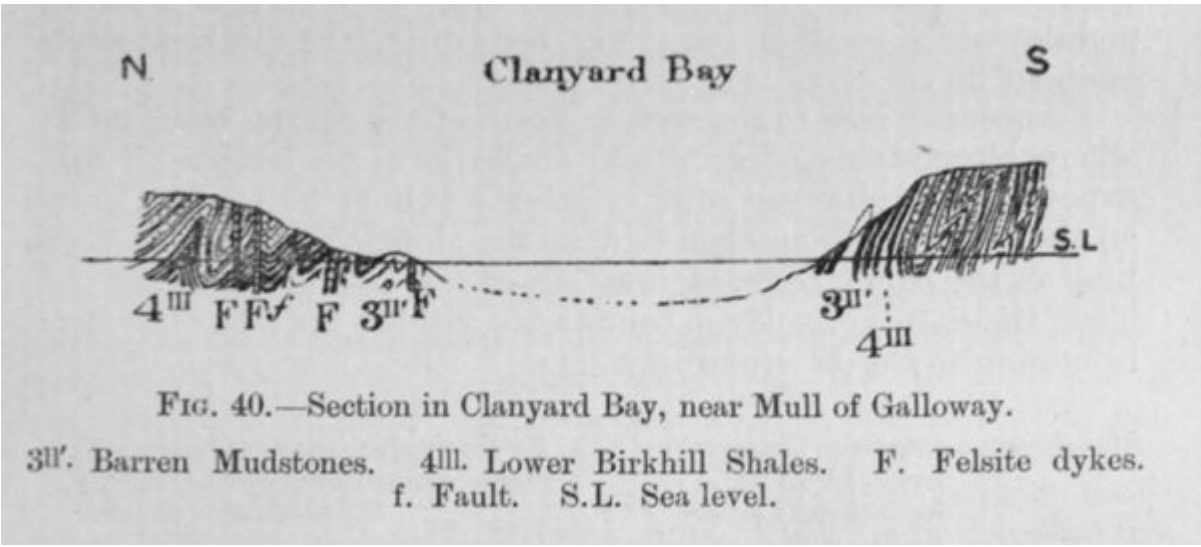

Fig. 40.—Section in Clanyard Bay, near Mull of Galloway.

3II'. Barren Mudstones. 4III. Lower Birkhill Shales. F. Felsite dykes. f. Fault. S.L. Sea level.

(Figure 40) Section in Clanyard Bay, near Mull of Galloway. 3II'. Barren Mudstones. 4III. Lower Birkhill Shales. F. Felsite dykes. f. Fault. S.L. Sea level.

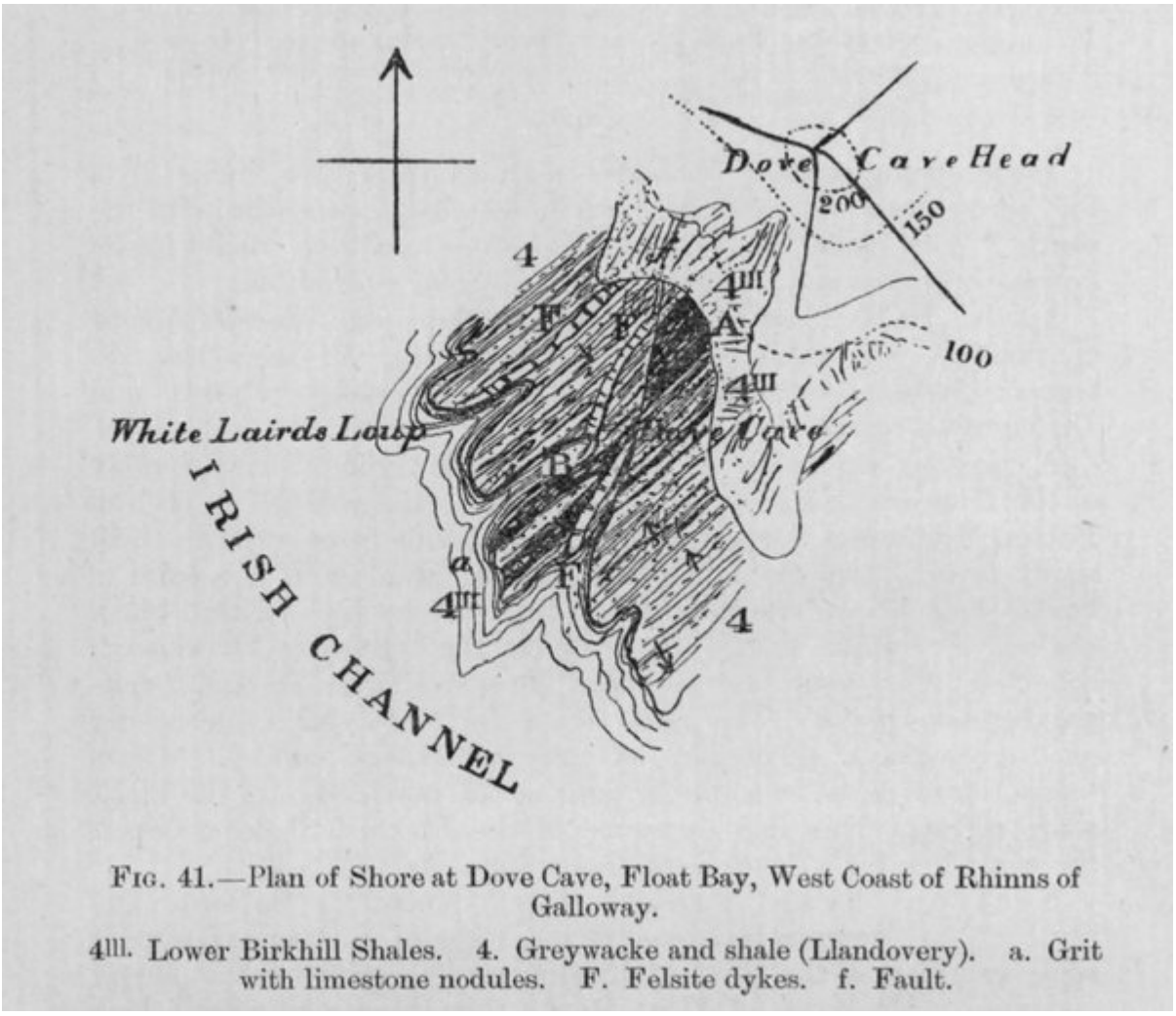

Fig. 41.—Plan of Shore at Dove Cave, Float Bay, West Coast of Rhinns of Galloway.

4III. Lower Birkhill Shales. 4. Greywacke and shale (Llandovery). a. Grit with limestone nodules. F. Felsite dykes. f. Fault.

(Figure 41) Plan of Shore at Dove Cave, Float Bay, West Coast of Rhinns of Galloway. 4III. Lower Birkhill Shales. 4. Greywacke and shale (Llandovery). a. Grit with limestone nodules. F. Felsite dykes. f. Fault.