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## Chapter 17 The Northern Belt — continued. Arenig, Llandeilo, and Caradoc formations in the district between Nithsdale and Loch Doon — continued.

### New Cumnock to Carsphairn

#### Volcanic area two miles E.S.E. of New Cumnock

In the tract lying to the north of the Knipe Hill, and extending from the north-west margin of the Sanquhar coal-field to the area of Carboniferous rocks south of New Cumnock, there is an important development of the Arenig volcanic group and associated radiolarian cherts. Here, as elsewhere, the rocks are brought to the surface by means of isoclinal folds, and in one instance, south-west of Polshill [NS 65104 13092], two miles east from New Cumnock, the contemporaneous and intrusive volcanic rocks are admirably seen. Indeed, of the various exposures of these rocks outside of the Ballantrae region, the Polshill tract ranks next in importance to that of Bail Hill, near Sanquhar.

The Burntonhill Burn [NS 64099 12433], a small streamlet about three-quarters of a mile south-west of Polshill, exposes an isolated outcrop of the volcanic rocks and radiolarian cherts. The upper reaches of the stream show greywackes and shales, together with conglomerate bands having a shaly matrix, and merging into shaly greywacke with scattered pebbles. At a point about seventy yards above the farmhouse of Burntonhill, the red cherts are visible, greywackes and shaly conglomerate passing underneath them with an inverted dip. A few yards lower down the stream a small exposure of fine-grained vesicular lava is to be seen on the right and left banks, overlain and underlain by cherts. Further down, opposite Burntonhill Farmhouse, the greywackes, grits, and shales appear. An isolated outcrop of the red cherts occurs in the field to the east of Burntonhill Farmhouse [NS 64128 12370]. In the Elder Burn [NS 64405 12506], about 200 yards to the east of Burntonhill, the basic lava rises at one point, and it also occurs in the adjoining field. Still further east, in a field [NS 64654 12581] adjoining the Gatelochside Burn, the lava is visible at many points within a small radius, forming smooth glaciated surfaces peering through a thin superficial cover.

**Gatelochside Burn.** — [NS 64696 12945] One of the best sections of the volcanic rocks in this area is met with in the course of this stream which joins the Nith, 400 yards east of Blackwood Farmhouse, just before it enters the Carboniferous area at Gatelochside. For a distance of 300 yards to the south of the fault bounding the Carboniferous area, the burn flows through a narrow gorge or wooded glen, showing excellent exposures of the igneous rocks. The lava is visible immediately to the south of the fault, and about 100 yards up from the fault, the red radiolarian cherts are seen in the gorge. Further up stream, at a point near a waterfall about 200 yards above the fault, the red chert and jasper are seen on both banks of the stream, underlain and overlain by the lava. Here, above a bend in the stream, the cherts are again visible on the right bank, forming an infold of the volcanic rocks.

The southmost exposure of the volcanic rocks in this stream, about 300 yards to the south of the Carboniferous fault [NS 64676 12772], displays the pillow-structure which is such a characteristic feature of the lavas in the Ballantrae region. The pillowy masses vary in size from a few inches to several feet across, and they display the concentric arrangement of the vesicles so common in the Ballantrae region. The lava is uniform in character, rather fine-grained and vesicular. A specimen of this vesicular lava No. (S6807) shows under the microscope "acicular microlites of felspar, chlorite, and magnetite". The original rock probably contained granular augite, but no trace of this mineral now remains. The microlites of felspar show a tendency to arrange themselves tangentially with respect to the amygdalules. They give approximately straight extinction, and are therefore presumably orthoclase. It is possible that a second felspar occurring in irregular individuals may also be present". The red cherts and jasper are seen resting on the lavas on the top of the bank at this locality.

In this volcanic area, as already noted elsewhere, intrusive igneous rocks are associated with the bedded lavas. A small intrusive patch of dolerite is seen to the west of Gatelochside Burn, measuring about 200 yards in length and about 60 yards in extreme width. The main mass of intrusive rocks, however, lies to the east of Gatelochside Burn, and runs nearly east and west for a distance of about half a mile, terminating westwards in the Garpool Burn close to the granite mass that stretches as a narrow belt from Meikle Westland to the Knipe Hill. This mass consists of a green coarse-grained

ophitic dolerite, well seen in various old quarries to the south of Polshill. It is probably intrusive in the lavas, for though the exposures are few, the contemporaneous slaggy rocks are to be seen at various points in the fields on the north side of the intrusive mass and at one or two points on the south side.

The cherts are seen at one point about 150 yards to the south of the road leading to Polshill Farmhouse. They are there close to the intrusive mass, while the slaggy lava is visible on a knoll close at hand. Along the northern margin of the bedded lavas neither the cherts nor the black shales are observable. Indeed, the evidence is obscured by drift, and the rock actually seen at the roadside near Polshill consists of greywacke. In like manner, round the southern margin of the mass, the cherts and black shales are concealed from view.

One interesting feature connected with this area of volcanic rocks south of Polshill is the contact alteration induced on the slaggy lavas by the granite intrusion, which is well seen at a point in the Garpool Burn about 500 yards south of the road leading to New Cumnock [NS 65589 12685], and also in the small tributary stream (see page 647).

**Nether Cairn (one mile east of Polshill).** — [NS 66709 13012] Eastwards from Polshill towards Marchburn Farmhouse, several arches of the radiolarian cherts occur. At the farmhouse of Nether Cairn the volcanic rocks appear, composed of typical slaggy lava, (diabase). The cherts are visible in a streamlet on the south side of the lava, followed by the "Haggis Rock" or fine conglomerate. They are also seen in the middle of the area occupied by the lava to the west of the farmhouse, here forming probably a synclinal fold.

**March Burn.** — [NS 67286 13001] In this burn which drains the northern slope of High Cairn Hill and joins the Nith near the county boundary, the red mudstones crop out a few yards above the bridge, followed by red grit becoming conglomeratic. A short distance up stream, where the rocks are sheared to some extent, blocks of stained diabase occur in red mudstones. Where the stream takes a bend at a right angle [NS 67122 12859], red greywackes and shales are seen on the left bank and red jasper in the channel of the stream. On the right bank red mudstone bands contain lenticles of a purple slaggy diabase, with small vesicles, well seen at the base of the cliff. The small tributary that joins the March Burn about 200 yards above the high road to Dumfries [NS 67045 12824], exposes purple diabase associated with the red chert and followed by grits.

**Dempster's Glenmuckloch.** — [NS 69156 13450] Again, at the edge of the Sanquhar coal-field, about a mile east from March Burn, Arenig lava appears in a burn that joins the Nith at Portland Place [NS 68602 13064].

The red cherts with radiolaria are met with on the south side of this outcrop. In the burn at Dempster's Glenmuckloch, on the north side of the Nith near the farmhouse, the cherts occur, associated with greywackes and grits, the latter being visible at the waterfall. Along the margin of the Silurian area, from Hillhead West to the Nith, occasional exposures of pebbly grit mark the position of the Haggis Rock.

### **Glenkiln–Hartfell Shales in Polmorchach and Polhote Burns**

**Polmorchach Burn.** — [NS 67946 11667] Having described the important volcanic area of Polshill, near New Cumnock, we may now consider the evidence for connecting the Arenig volcanic rocks and cherts of that district with the graptolite-bearing bands belonging to the Glenkiln and Lower Hartfell horizons. The Polmorchach Burn furnishes important information from certain fossiliferous bands which yield an assemblage of fossils characteristic of the Glenkiln group and of the lower zones of the Hartfell black shales. This burn is about half a mile distant from the county boundary between Ayr and Dumfries, and about two miles from the edge of the Carboniferous rocks east of New Cumnock. It rises on the slope of the High Cairn Hill, and after traversing the Silurian area for about a mile, enters the north-west corner of the Sanquhar coal-field. Above the limit of the Carboniferous rocks, greywackes and shales are seen, the former being rather massive. No fossils were obtained from any of the shale bands associated with these greywackes.

About a mile up from the road between New Cumnock and Sanquhar [NS 67808 11355], a band of igneous rock occurs as a lenticle in dark blue shales in the bed of the stream. It is about five feet broad, can be followed along the strike for about ten feet, and may be from fifteen feet to twenty feet in length. Under the microscope this rock No. [\(S6809\)](#) shows "numerous large chloritic or serpentinous pseudomorphs after augite. The matrix is too highly altered for determination,

but it is apparently non-fragmental. The rock contains irregular patches of calcite, and is traversed by veins filled with calcite. Pyrite is abundant". This lenticular mass probably represents the Lower Caradoc volcanic zone. A few yards above this point, flaggy shales dip to the S.S.E.; they consist of alternations of dark blue and grey sandy shales. The following fossils were obtained from the dark seams at this point:

*Dicranograptus* sp.

*Diplograptus foliaceus* (Murch.)

*Cryptograptus tricornis* (Carr.)

*Dicellograptus* sp.

*Glossograptus Hincksi* (Hopk.)

*Climacograptus caudatus* (Lapw.)

*Climacograptus Schärenbergi* (Lapw.)

*Corynoides calycularis* (Nich.)

*Acrotreta Nicholsoni* (Dav.)

A few yards further up, in dark blue-black seams alternating with grey seams the following forms were obtained:

*Amphigraptus radiatus* (Lapw.)

*Leptograptus flaccidus* (Hall.)

*Corynoides calycularis* (Nich.)

*Dicellograptus* sp.

*Dicellograptus moffatensis* (Carr.)

*Glossograptus Hincksi* (Hopk.)

*Diplograptus foliaceus* (Murch.)

*Cryptograptus tricornis* (Carr.)

*Dicranograptus ramosus* (Hall.)

*Acrotreta Nicholsoni* (Dav.)

At the places just mentioned, the sandy layers yield abundant worm tracks.

Still a third locality, which has furnished a similar assemblage of graptolites, occurs a few yards higher on the left bank, at a sharp bend of the stream about 70 yards above the last-mentioned exposure of igneous rock [NS 67711 11214]. Here the shales consist of alternations of blue and grey bands with dark seams. The annexed list of graptolites was here obtained:

*Dicranograptus ramosus* (Hall.)

*Diplograptus* sp. (probably a dwarfed) *foliaceus* (Murch.)

*Corynoides calycularis* (Nich.)

*Dicellograptus moffatensis* (Carr.)

*Dicellograptus elegans* (Carr.)

The shales at these various places have the same characters they are well-bedded, flaggy, and break in platy masses. From their graptolites, it is clear that they represent the lower bands of the Lower Hartfell black shales. Although the lithological character of these shales has completely changed from their normal type in the Moffat area, the assemblage of fossils is persistent. The sediment is more arenaceous, and the only representatives of the Hartfell black shales are the thin dark seams intercalated in the sandy layers.

About ten yards above the last-named locality, an outcrop of black shales is charged with a characteristic Glenkiln fauna. This short space is occupied by grey and blue shales with dark seams of the Lower Hartfell type peculiar to this section, so that we have here a perfect passage downwards to the Upper Llandeilo Rocks. This band of black shales also differs considerably from the normal type of Glenkiln Shales in the Moffat area and in the southern part of the Sanquhar district. It is a pure black shale, splitting with an even fracture and free from the black siliceous ribs. Its strata dip to the S.S.E., and are much cleaved in places. They have yielded the following characteristic list of fossils:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus surcularis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus perexcavatus* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Cryptograptus tricornis* (Carr.)

*Dicranograptus ramosus* (Hall.)

*Glossograptus Hincksi* (Hopk.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus moffatensis* (Carr.)

*Dicellograptus patulosus* var. *B.* (Lapw.)

*Dicellograptus patulosus* (Lapw.)

*Climacograptus bicornis* (Hall.)

*Climacograptus caelatus* var. *antiquus* (Lapw.)

*Climacograptus Schärenbergi* (Lapw.)

*Leptograptus flaccidus* (Hall.)

*Acrothele granulata* (Linnr.)

This assemblage of fossils, including twenty species, proves beyond all doubt that this band represents the Glenkiln black shales of the Moffat series. The most of the characteristic Glenkiln forms are here represented.

Unfortunately the radiolarian cherts are not exposed at this place, for as we ascend the burn these beds are faulted against greywackes and shales, the latter containing a band of felspathic grit, like the ashy grit in Kiln Burn, east of Bail Hill (p. 312). Crossing over the moor for a distance of three-quarters of a mile from Polmorlach Burn to the west branch of the March Burn, we meet with the green cherts with radiolaria (Arenig) at the head of the burn. A few yards down stream, beyond a blank in the section, a small exposure of black shales is to be seen in the bed of the stream. It is difficult to get material from these beds for examination. They yielded, however,

*Diplograptus foliaceus* (Murch.)

*Climacograptus bicornis* (Hall.)

*Cryptograptus tricornis* (Carr.)

*Dicellograptus sextans* (Hall.)

*Forchhammeri* (Gein.)

The Arenig cherts are thus associated here with the black shales, and though no well-marked zonal forms occur in this list of fossils, which evidently includes species common to both groups (Glenkiln and Hartfell), there can be little doubt that a portion of the band so well developed in the Polmorlach Burn is here represented.

**Polhote Burn.** — [NS 68867 11385] About half a mile to the south-east of the Polmorlach Burn, confirmatory evidence is obtained of the occurrence of a black shale which contains Glenkiln fossils and passes upwards into blue and grey shales, with dark seams resembling the beds in Polmorlach Burn. On the west branch of the Polhote Burn, a tributary of the Nith, an excellent section may be seen of the grey and blue shales with dark seams, all dipping to the S.S.E., from which the following forms, representing the Lower Hartfell horizon, were obtained: *Dicellograptus Forchhammeri*, *Diplograptus*, *Climacograptus*, and *Cryptograptus tricornis*. About 200 yards west of the fork, and 30 yards above the bend in the west branch of the Polhote Burn [NS 68479 10916], where it flows nearly east and west, an outcrop of black shales associated with greywackes represents the Glenkiln horizon, and resembles lithologically the Glenkiln Shales in Polmorlach Burn and the Glenkiln black shales in Back Burn near Corsebank, Crawick Water. Graptolites occur here freely, and in excellent preservation: in particular, *D. superstes* and *C. Schärenbergi*. *Caenograptus pertenuis* is also very abundant. The subjoined list gives the species collected at this place:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Glossograptus Hincksi* (Hopk.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus bicornis* (Hall.)

*Climacograptus Schärenbergi* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus patulosus* (Lapw.)

*Dicellograptus moffatensis* (Carr.)

*Dicranograptus ramosus* (Hall.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus euglyphus* (Lapw.)

*Acrothele granulata* (Linnr.)

At the bend in the stream just referred to, a band of pebbly grit, resembling a "Haggis Rock", is exposed on the right bank. The Glenkiln black shales reappear on the left bank, probably on a fold, and further down the stream displays a fine section of the flaggy blue and grey shales with dark seams, associated occasionally with greywackes. These rocks continue all the way down to the edge of the Carboniferous basin.

## **Dalmellington district**

### **Arenig rocks along the margin of the Silurian Tableland**

Along the margin of the Silurian Tableland in the neighbourhood of Dalmellington [NS 48056 05878], a narrow strip of radiolarian cherts, with occasional exposures of the underlying volcanic rocks, is traceable for a distance of about five miles. It is about a quarter of a mile in breadth, and on the published map (Sheet I4) has been coloured as part of the Old Red Sandstone formation. On the north side it is bounded by the fault which limits the Lower Old Red Sandstone, and on the south side it is truncated by the prolongation of the Glen App fault.

At the north-east end of this strip, the red cherts and mudstones are visible in a small knoll, near the sheep-ree about half a mile E.N.E. of Mosssdale Farmhouse [NS 49359 04198]. Here they are pierced by a dolerite dyke running W.S.W. and E.S.E. In a little side stream, named the Trough Burn, about 400 yards east of Mosssdale, the red cherts and mudstones occupy the watercourse for a short distance, rising from underneath the grey mudstones of the "Tappins group" <ref>This term is applied to a group of strata, which, at Portandea, north of Glen App and in the valley of the Stinchar above Barr, overlie conformably the Arenig cherts and volcanic rocks.</ref>. They also form small knolls on the north bank of the stream. The fault which truncates the red cherts and mudstones on the south side is visible in the Trough Burn. Further south in this stream, the strata exposed consist of shaly greywackes and shales. The fault that bounds the red cherts and grey mudstones on the north side is exposed in the Mosssdale Burn, about half a mile above Mosssdale. Here the grey mudstones are brought into conjunction with an intrusive felsite, the rocks on both sides being much shattered. To the north-east of this point, it is probable that the red cherts and mudstones extend for some distance, since numerous fragments of cherts occur in the drift.

In Glen Muck, just south of Mosssdale Bridge [NS 49345 04131], the green mudstones overlying the red mudstones occupy a strip about 150 yards broad. At the bridge across the Muck an exposure of Lower Old Red conglomerate is seen in a quarry, but the fault which brings the conglomerate in contact with the mudstones is not visible. On the south side these green mudstones are succeeded by the greywackes and shales of the Mosssdale Craigs [NS 49624 03691].

South-westwards along the margin of the Silurian area, the rocks are concealed under drift for some distance. The cherts reappear, however, in a small burn that drains into the Doon below the Glen of Ness, near Dalfarson. At a point in this burn about half a mile from its junction with the Doon, about two feet of a porphyritic slaggy lava (Arenig) may be detected in the midst of the red alerts. The rock is purple, contains much decomposed porphyritic felspar, and resembles externally some of the Arenig porphyritic lavas at Ballantrae. About 70 yards north from this small exposure, another small mass of Arenig lava which appears in the slope, is like the ropy lava about a mile to the south-west of Berbeth. Various knobs of red cherts and red mudstones are to be found on the south slope of the Well Hill. At one point the red mudstones occur not far from the Lower Old Red Conglomerate, the position of the fault between the two being indicated by a well-marked feature. The Old Red Conglomerate is vertical, and its pebbles are composed almost wholly of greywacke.

**Berbeth to Knockdon.** — [NS 46778 03900] South-westwards from the Ness at Dalfarson to Knockdon, on the river Girvan, several exposures of the Arenig cherts may be observed associated at one locality with characteristic lavas. The red cherts and mudstones are to be seen in the policies of Berbeth, on the east side of the mansion house, where they form a prominent knoll. They are visible also in the Glessel Burn, to the south of Berbeth. In this stream up to the waterfall above the old gasworks [NS 47118 02416], shattery grey mudstones and greywackes are laid bare which resemble the "Tappins group" of the Stinchar valley. The red cherts and mudstones reappear, however, on another fold three-quarters of a mile south-west of Berbeth Mansion-house, near a prominent bend of the Glessel Burn. The crags about a quarter of a mile to the south-west of Berbeth [NS 46707 03642]? display a fine development of shattery green and grey mudstones and greywackes of the "Tappins series". It is obvious that the section along this part of the margin of the Silurian. Tableland bears a close resemblance to that in the Stinchar valley near the Tappins (see p. 464).

Still further to the south-west, in one of the branches of the Glessel Burn, fed by streamlets which drain the northern slopes of the Big Hill of Glenmount, about a mile from Berbeth Mansion-house [NS 45903 02552]?, red and grey cherts and mudstones are laid bare, succeeded northwards by green mudstones and greywackes, seen at intervals in the stream, the general dip being to the southeast.

In the same south-westerly direction, green and grey mudstones and greywackes are exposed in several knobs, with an occasional outcrop of red cherts and mudstones. On the slope, immediately to the north of the Wee Hill of Glenmount [NS 45048 02187], and not far from the alluvial flat formed by one of the branches of the Glessel Burn, a section shows the relation of the Arenig volcanic rocks to the cherts. The lavas are seen in several knobs, bounded on the north side by the red cherts and mudstones. In one of these exposures, where the rock is less decomposed, it is vesicular, and contains porphyritic feldspars set in a dark micro-crystalline matrix, and shows traces of the pillowy structure already noticed. To the south of this mass a pink intrusive igneous rock occurs, which is largely developed in the immediate neighbourhood to the north. The red cherts and red mudstones can be followed south-westwards at intervals to near the Knockdon Craig [NS 44327 01270], which is the last exposure of them to be met with in the direction of the Girvan valley.

It might be contended that some of these red cherts and mudstones, formerly mapped as part of the Lower Old Red Sandstone, may have been stained by the members of the Old Red Sandstone which formerly covered them. But such a supposition is improbable, because the Old Red Conglomerate immediately in contact with the cherts is grey in colour and charged with greywacke pebbles. It is further of interest to note that the acid intrusive rock which pierces the Arenig cherts and the overlying mudstones and greywackes south of the Wee Hill of Glenmount is identical in character with that which cuts the Lower Old Red Sandstone strata to the north. It also bears a close resemblance to the acid intrusive rocks which surround the Criffel and Dalbeattie granite mass.

The fault that bounds the belt of Arenig cherts and overlying mudstones between Knockdon and Glen Muck can be of no great magnitude, because the conglomerate in contact with the Arenig rocks is apparently the basal conglomerate of the Old Red formation which throughout Ayrshire is composed mainly of greywacke pebbles.

**Connel Burn to Benty Cowan Hill (south-west from New Cumnock).** — About a mile from the margin of the Silurian Tableland west of the Afton, the Arenig volcanic rocks and radiolarian cherts and mudstones come to the surface along another line which stretches from the Connel Burn [NS 59902 10706] to Benty Cowan Hill [NS 57906 08295] (Sheets 14 and 15 of the Survey Map), a distance of about one and a half miles. The Arenig cherts are not traceable the whole distance, being succeeded by pebbly greywackes and grits along the line of strike.

Ascending the Connel Burn from the point where it is crossed by the fault that brings the Carboniferous rocks into contact with the Silurian strata, we find two outcrops of pebbly grit or "Haggis Rock" inclined to the south-east. Not far to the south of these exposures, the cherts and mudstones are to be found on two folds; the more northerly one shows only red cherts and mudstones on both banks of the stream, succeeded immediately by greywackes; in the second fold, visible in a streamlet on the east bank of the Connel Burn, the red, green, and grey cherts are met with.

Along the line of strike to the south-west of the Connel Burn, volcanic agglomerate crops out on the Connelburn Rig [NS 59402 09166], at a point about 500 yards from the exposures of the cherts in the Connel Burn. This rock forms small rounded knobs on the hill slope, and at one spot there is a small opening as if it had been quarried. The rock is

decomposed, but it seems to have a fragmental matrix of crystalline igneous material, through which are scattered fragments of black, red, and grey cherts. In a little grass-covered opening, which may have been a small quarry, the red cherts are seen in contact with the volcanic rock. They are also visible in drains on both sides of the agglomerate. About 40 yards down the slope pebbly grit of the "Haggis Rock" type, with mudstones, appears in a small scar.

South-westwards along the hill slope, at a distance of a quarter of a mile, various exposures of the radiolarian cherts may be observed above the level of the 1250-foot contour line; and on the crest of the ridge between the Connel Burn and the Blarene Burn, small knobs of vesicular basaltic lava of Arenig age are seen peering through peat. About a mile still more to the south-west, the red cherts crop out on the slope of the Benty Cowan Hill [NS 58097 08440], along a fold which must lie slightly to the north of the strike of the arches referred to in the foregoing paragraphs.

A noteworthy feature in connection with the exposures of Arenig volcanic rocks and cherts between Connel Burn, and Benty Cowan Hill, is the absence of the peculiar mudstones and greywacke bands of the "Tappins group" in the Stinchar valley. Representatives of that series, as already indicated, crop out near Berbeth in association with the radiolarian cherts at the margin of the tableland. Their absence here may indicate a slight unconformability; at anyrate, the "Haggis Rocks", which rapidly succeed the cherts in the Connel Burn, contain abundant fragments of chert and fragmental material derived from the disintegration of volcanic rocks.

Beyond the watershed the Dalleagles Burn [NS 57289 08496], on the west side of Benty Cowan Hill, has laid open a good section of well-bedded flaggy shales and greywackes, dipping generally to the southeast. These beds resemble those seen in part of Glen Muck.

**Pochriegavin Burn.** — About a mile to the south of the strike of the Connel Burn and Benty Cowan Hill band of radiolarian cherts and mudstones, another anticlinal fold which reveals the cherts and overlying black shales with graptolites, is traceable for about a mile from the Pochriegavin Burn, a tributary of the Dough, north-eastwards to a small stream which drains the south slope of the Stony Knowes Will. About 300 yards to the west of the point where the Prickeny Burn joins the Pochriegavin Burn [NS 55518 04075], grey cherts with radiolaria appear in the bed of the latter stream, with dark blue shales on the south side. The shales, though crushed, yield fragments of graptolites. The general dip is to the south-east. Higher in the stream, in the intervals between gaps in the section, occasional exposures of flaggy grits, greywackes, and shales may be seen; till at a point about 150 yards west of the radiolarian cherts, flaggy dark blue and grey shales, finely striped with dark seams with fragments of graptolites are met with. In dark blue sandy shales exposed in the bed of the stream, the following fossils were obtained:

*Climacograptus bicornis* (Hall.)

*Climacograptus Schärenbergi* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Dicranograptus ramosus* (Hall.)

*Diplograptus foliaceus* (Murch.)

*Dicellograptus* sp.

*Corynoides calycularis* (Nish.)

*Lasiograptus margaritatus* (Lapw.)

In a small burn that drains the Stony Knowes Hill and joins the Pochriegavin Burn about half a mile north-west of Lochmaharb shepherd's house [NS 56726 04091], the radiolarian cherts appear about 200 yards from the foot of the streamlet. The grey cherts are first seen where a fence crosses the burn. A few yards further north the grey cherts are typically developed, and enclose abundant radiolaria. They are associated with mudstones and dark blue shales, the latter occurring in two synclinal folds. Again on the north side of the cherts, after an interval of several yards, grey sandy



shales are met with, followed by greywackes and shales.

The zonal graptolites characteristic of the Glenkiln Shales have not been obtained as yet from the beds in immediate contact with the cherts of the Pochriegavin band, the dark blue shales next the cherts being too much crushed to yield graptolites in that stream. About a mile to the south, however, on another anticlinal fold, a section in the Deugh of part of the Moffat series, has furnished a large suite of graptolites. This section closely resembles that in Polhote and Polmorlach Burns in Sheet 15, north-west of Sanquhar (p. 368).

## Carsphairn district

### Black shale bands in the basin of the Deugh, Water

**Hillend, Water of Deugh (Sheet 14 of the Survey Map).** — On the east bank of the Deugh, about 500 yards south of the mouth of the Pochriegavin Burn [NS 56713 03204] at the shepherd's house of Hillend, the graptolite-bearing beds are exposed at intervals for a distance of about 60 yards. The fossils obtained at one point in the section show that the strata belong to the Glenkiln group; but it is probable that some of the other bands, yielding forms common to the Glenkiln and Hartfell groups, may be the passage beds between these two horizons.

The north end of the section presents alternations of grey and dark blue or black shales, finely striped, in a band of black shales alternating with the grey seams, from which the accompanying list of fossils was obtained:

*Dicranograptus ramosus* (Hall.)

*Dicranograptus* var. *spinosus* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus Forchhammeri* (Gein.)

*Leptograptus flaccidus* (Hall.)

*Climacograptus* sp.

*Cryptograptus tricornis* (Carr.)

*Dicranograptus ramosus* (Hall.)

*Diplograptus foliaceus* (Murch.)

abundant in some of the seams.

About twelve yards down stream on the same bank, dark blue or black shales, alternating with greywackes, contain *Dicranograptus ramosus* abundantly in certain layers, *Cryptograptus tricornis* abundantly, *Climacograptus Schärenbergi*, and *C. bicornis*. Lower, on same bank, in black sandy shales, *Dicranograptus ramosus* and *Cryptograptus tricornis* have been found abundantly; also *Diplograptus foliaceus*, *Dicellograptus sextans*, and *Corynoides calycularis*.

At a point on the east bank about 54 yards below the first exposure, black or dark blue flags or shales afford graptolites characteristic of the Glenkiln group in abundance and fine preservation. The lithological characters of the Glenkiln Shales, as here developed, differ widely from those in the typical Moffat region. Instead of alternations of black cherty ribs and black shales, flaggy dark blue or blue-black sandy shales occur here, like the band of Glenkiln Shale in Polhote Burn northwest of Sanquhar. The fossils are well defined, but owing to the presence of iron pyrites in the shale they ultimately disappear. The following list was here obtained:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus bicornis* (Hall.)

*Climacograptus Schärenbergi* (Lapw.)

*Climacograptus peltifer* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Dicranograptus* var. *spinosus* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Diplograptus foliaceus* (Murch.)

On the same slab with *Climacograptus peltifer* occur *Dicellograptus sextans*, *Dicranograptus ramosus*, and a fragment of *Caenograptus pertenuis* and *Climacograptus Schärenbergi*. Minute seams of grey shale are interleaved in the foregoing black flaggy shales. Down stream greywackes appear, with alternations of dark shales seamed with grey shales. From the manner in which bands of greywacke are intercalated in these graptolite-bearing shales, it is probable that the Glenkiln or Upper Llandeilo Rocks are here partly represented by graptolite-bearing shales and partly by greywackes.

**Petillery Hill.** — About half a mile to the south of the graptolite bands just described, grey cherts with radiolaria appear in association with greywackes and grits on the west slope of the Petillery Hill, on the east side of the valley of the Deugh. They form a series of rocky knolls peering through heather and turf, named on the six-inch map (Kirkcudbright 2, S.W.) the Shiel Knowes [NS 56153 02113]. The peculiar feature of these exposures is the alternation of grey radiolarian cherts with bands of greywacke, which measure in some instances several feet across. At one spot the rock next the chert is a grit with minute fragments of radiolarian chert. No graptolite shales are associated with the cherts at this locality.

**Brownhill Burn.** — [NS 54949 00525] At the point where this stream joins the Dough, in the bed of the latter stream, black shales with grey seams and red cherts are exposed, which can be traced for a short distance down the river when the stream is low. On the west bank the strata are pierced by a dyke of porphyrite.

Not far from the foot of the Brownhill Burn, and a few yards south of the footbridge, crushed and shattery black shales are intercalated in blue shales. Graptolites are abundant in certain layers, and though the shales are very shattery the fossils are in good preservation. The following Glenkiln forms were obtained:

*Dicranograptus ramosus* (Hall.)

*Dicranograptus* var. *spinosus* (Lapw.)

*Diplograptus mucronatus* (Hall.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus perexectiatus* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus* sp.

*Dicellograptus sextans* (Hall.)

About 150 yards further up stream [NS 54935 00636], in flaggy dark blue shales, among other forms *Climacograptus bicornis*, *Diplograptus foliaceus*, and *Dicellograptus* were found. In a small stream that joins the Brownhill Burn on the west side (the Polgavin Burn), black shales occur. No fossils except graptolite fragments were here obtained.

**Knockingarroch (Water of Deugh, Sheet 8 of Survey Map).** — About a quarter of a mile below Knockingarroch, and about two miles north of Carsphairn, black shales which yield a fine assemblage of Glenkiln graptolites are laid bare in the Water of Deugh [NX 55636 96738]. At the southern limit of the section, on the east bank of the stream, grey and dark blue shales are inter-stratified with thin leaves or seams of black shales, an eighth of an inch thick, which yield traces of graptolites mostly indeterminable. These beds, occupying about 12 yards of the section, are succeeded by shattered black shales, certain bands of which yield graptolites in profusion, including *Dicellograptus sextans*, *Lasiograptus bimucronatus*, *Diplograptus mucronatus*, *D. foliaceus*, *D. perexcavatus*, and *Cryptograptus tricornis*. Northwards these black shales are followed by blue flags, shales, and greywacke bands, which, after a blank, are in turn succeeded by a fine development of black shales, visible on the eastern bank and in the bed of the stream. The platy shales are crowded with graptolites, some of the seams yielding well-preserved specimens of zonal forms of the Glenkiln group, the examples of *Didymograptus superstes* being especially perfect. A few yards up stream, on the east bank, gritty greywacke is observable, but no continuous section to the north or south of the foregoing black shales reveals their relation to the overlying sediments.

**Bridge-End.** — [NX 55688 94586] Not far above the bridge across the Deugh, about a mile north of the village of Carsphairn, black shales much crushed and shattered are visible, where they dip to the east of south, on the left bank of the stream, and are succeeded by blue greywackes.

**Garryhorn, Cairnsgarroch, and Carlin's Cairn.** — [NX 54700 93418], [NX 54719 93430], [NX 49497 88832] A series of compound folds of the Moffat series and associated sediments in the neighbourhood of the Woodhead Lead Mines, west of Carsphairn, is specially interesting, from the contact metamorphism superinduced on the radiolarian cherts by the Loch Doon granite mass. It exhibits a further notable feature in the marked deflection of the strike of the beds as they approach the margin of the igneous mass. For example, in the Garryhorn Burn, the strike of the strata is, generally speaking, about E.N.E., but traced westwards to the slope of the Kells range, it is deflected to the S.S.W., and runs roughly parallel with the granite boundary for several miles. Owing to contact metamorphism, many of the exposures are of little service in determining stratigraphical horizons by means of fossils; certain sections, however, prove that the Arenig cherts are succeeded by black shales yielding Glenkiln graptolites, and that the highest fossiliferous zone underlying the Carsphairn grits and conglomerates belongs to the Lower Hartfell black shales.

The Garryhorn Burn above its junction with the Halfmark Burn [NX 55274 92937] flows over a series of greywackes and shales, with grits and fine conglomerates, till at a point about 150 yards south-east of Garryhorn Farmhouse Arenig cherts and black shales make their appearance. Here the grey nodular and banded cherts are crowded with radiolaria. On the south limb of the fold, the black shales, with a south-east dip, enclose the following Glenkiln forms: *Caenograptus pertenuis*, *Dicellograptus sextans*, *Climacograptus bicornis*, *C. peltifer*, *Lasiograptus bimucronatus*, *Diplograptus foliaceus*, *D. euglyphus*, *Acrothele*, &c. A few yards further down stream, on the same side, shattered and brecciated black shales occur, containing graptolites in some of the jointed masses. Here *Corynoides calycularis* appears in profusion in some of the seams, together with *Siphonotreta*.

Further down on the north side of the burn, and a few yards above the footbridge, the Glenkiln black shales reappear, charged with *Didymograptus superstes*, *Cryptograptus tricornis* in profusion, *Dicranograptus ramosus*, &c. A fault traverses the bed of the stream at this point, the direction of which is indicated by fault-breccia. On the north limb of the fold, shattered black shales appear, but too much crushed to yield graptolites.

About 400 yards south-west of Garryhorn Farmhouse [NX 54343 93256], the Arenig cherts and black shales appear, the latter being considerably crushed and corrugated. On the south limb of the fold, the black shales on the north bank yielded *Diplograptus euglyphus*, *D. foliaceus*, *Dicranograptus ramosus*, *Cryptograptus tricornis*, *Climacograptus*, *Dicellograptus*, and *Corynoides*. Still further west, at the lower end of the alluvial flat below the Woodhead smelting-houses, radiolarian cherts crop out, but their relations to the surrounding rocks are not visible. About 130 yards to the south of them, the following graptolites were obtained from debris of black shale lying near an old trial pit: *Diplograptus foliaceus*, *Dicranograptus*, *Climacograptus*, *Corynoides calycularis*, &c. The surfaces of some of the slabs are crowded with specimens of the last-named form.

In the strike of this series of compound folds, the Arenig cherts and black shales appear on the Black Craig [NX 52166 92545], which forms the termination of the north-eastern spur of the Cairnsgarroch Hill. The latter eminence lies on the south side of the Garryhorn Burn, and two miles south-west of Woodhead Lead Mines. The north-east face of this crag exposes the black shale series. A small outcrop of the cherts is faulted on the south side against greywackes and pebbly grits. Northwards black flinty ribs, with thin partings of black shales, succeed, which afford *Caenograptus gracilis*, *Lasiograptus bimucronatus*, *D. foliaceus*, *Dicellograptus sextans*, *Climacograptus bicornis*, and *Cryptograptus tricornis*. At the top of the crag, due west of the arch of cherts, the black shales yield *Dicranograptus ramosus* in abundance.

Further to the south-west the radiolarian cherts reappear, and are truncated on the south-east side by a fault which brings them in contact with the overlying greywackes and shales. On the north-west side they are followed by corrugated black shales, the junction between the two groups being a line of fault. The only fossils obtained from these twisted bands are *Corynoides calycularis*, *Diplograptus foliaceus*, and *Climacograptus Schärenbergi*.

Three-quarters of a mile to the south-west a broad exposure of the Arenig cherts, black shales, and overlying sediments rises into a prominent crag on the north slope of Cairnsgarroch [NX 51462 91762] about two miles to the south-west of Woodhead Lead Mines. This declivity is drained by two streams, of which the most westerly one is named on the six-inch map, the Lumps Burn. About 200 yards east from this streamlet, and near the centre of the section, a well-marked arch of radiolarian chert, though about a mile distant from the granite boundary, is slightly granulitised. The black shales and dark flinty ribs near the cherts on the north-west side yield *Lasiograptus bimucronatus*, *Cryptograptus tricornis*, *Dicranograptus ramosus*, and *Dicellograptus*. About ten yards from the charts, on the same side, the following forms were obtained, viz.: *Dicranograptus ramosus*, *Climacograptus bicornis*, and *C. tridentatus*; while at a distance of 45 yards *Dicellograptus* and *Dicranograptus* are found crowding the slabs of black shale, together with *Climacograptus Schärenbergi* and *Diplograptus foliaceus* — forms which indicate the basal zones of the Lower Hartfell black shales.

On the south-east limb of the arch, the cherts are brought by a fault immediately into contact with the overlying grey sandy shales of Lower Harden age. The relations of these sandy shales to the black shales are clearly defined in the eastern portion of this crag (see ground plan, (Figure 92), Section (Figure 93), and one-inch Geological Map, Sheet 8), for as we proceed eastwards along the escarpment we find an arch of black shales running up the slope to the top of the crag and plunging underneath the grey sandy shales to the north-east and south-west. In the seams of black shale immediately in contact with the grey sandy shales, a characteristic assemblage of Lower Hartfell fossils was obtained. Beautiful examples of *Dicranograptus Nicholsoni* (wide-angled variety) were collected, and near to this locality the slabs of black shales are crowded with well-preserved shells. Moreover, in thin leaf-like seams interleaved in the overlying grey sandy micaceous shales, *Climacograptus bicornis*, *Dicellograptus*, and *Diplograptus foliaceus* occur, which indicate a natural passage upwards from the lower zones of the Hartfell black shales into the coarser shaly sediments and overlying pebbly grits and conglomerates.

Eastwards along the crag, the grey sandy shales are abruptly truncated by a fault which brings them in contact with the black shales and cherts to the south-east. Disregarding minor flexures, it is obvious that, on Cairnsgarroch Crag, the Arenig charts and black shales come to the surface along two main anticlines, and that the grey sandy shales lie in small intervening troughs.

These outcrops of the Moffat series are traceable south-westwards to the southern slopes of the Meaul (2279 feet) [NX 50176 90670] and the head-waters of Pulmaddy Burn [NX 50293 88331], where highly corrugated and granulitised cherts are associated with black shales which still yield graptolites. In a tributary of the Goat Burn, that drains the south-east

slope of the Meaul, an outcrop of black shales yielded the following Glenkiln forms: *Didymograptus superstes*, *Dicranograptus minimus*, *D. ramosus*, *Dicellograptus sextans*, *Diplograptus perexcavatus*, *D. foliaceus*, and *Cryptograptus tricornis*. Graptolites are, however, difficult to obtain within half a mile of the granite, and they disappear close to the boundary line. Perhaps the finest examples of the extreme alteration of the Arenig cherts are to be found in the band (Sheet 8 of the Map) which has been traced along the western slope of the Meaul for a distance of a mile and a half close to the margin of the granite.

**Half-mark Burn and Craighessie.** — Rather less than half a mile to the south-east of the Cairnsгарroch band of black shales, another outcrop of the Moffat series is distinguished by the presence of certain zonal Hartfell graptolites in the shales that underlie the sandy shales and conglomerates of that region (Carsphairn Grits). On the eastern slope of Cairnsгарroch Hill, three rivulets unite to form the Half-mark Burn. Near the head of the middle streamlet [NX 52305 91519], abundant debris of black shale occurs, which affords graptolites in good preservation: *Diplograptus euglyphus*, *D. foliaceus*, *Climacograptus peltifer*, *Dicranograptus ramosus*, *Cryptograptus tricornis*, *Acrothele granulata*, &c. On the slope above, the Arenig cherts appear, but unfortunately owing to the covering of turf the prolongation of their outcrop is concealed from view for some distance to the northeast and south-west. The members of the Moffat series reappear, however, about a mile to the south-west, on Craighessie [NX 51110 90551], which forms the southern spur of Cairnsгарroch. Here the cherts, including the black and grey, nodular and ribbed varieties, come to the surface on an isoclinal fold. Near the 1850-foot contour line they dip E. 40° S., and further down the slope the direction is E. 20° S. Debris of black shale occurs underneath the turf close to the cherts, but owing to the covering of vegetation the Glenkiln black shales do not appear at the surface. At the 1500-foot level, however, on the south-east limb of the arch, a dry gully within a few yards of the radiolarian cherts displays a fine section of the lower zones of the Hartfell black shales. Some of the slabs are crowded with *Dicellograpti* to the exclusion of any other form, and some with *Diplograptus foliaceus*. The following additional forms were noted, viz.: *Amphigraptus radiatus*, *Dicellograptus Morrisi*, *Climacograptus caudatus*, and *Dicellograptus Forchhammeri*.

The evidence now adduced regarding the exposures of the Moffat series in the neighbourhood of Cairnsгарroch and Garryhorn Burn indicates an ascending sequence from the Arenig cherts and Glenkiln–Hartfell black shales to the shales, grits, and conglomerates of the Carsphairn region.

### **Sediments mainly of Caradoc age overlying the Glenkiln–Hartfell Black Shales between the Nith and the Loch Doon Granite Mass**

Reference must now be made to certain sediments which overlie the various folds of the Arenig cherts and Glenkiln–Hartfell black shales to the north of the Llandoverly base-line, within the tract that extends from the Nith to the Loch Doon granite mass. The evidence adduced in the foregoing pages shows that in the arches of the Moffat series, extending from Burnmouth on the Nith to Dalshangan on the river Deugh, the Lower Hartfell black shales of the *Dicellograptus Clingani* zone still present the same general lithological characters as those in the Moffat region, where they consist of platy black shales. But when they are followed northwards to the Polmorlach and Polhote Burns, within two miles of the northern margin of the tableland at New Cumnock, this lithological type has disappeared, and the lower zones of the Hartfell black shale group are represented by thin black seams interleaved in blue and grey shales. Still further north, along the Silurian border, the Hartfell shales are no longer traceable, and in the region near Loch Muck, to the north-west of Carsphairn, the Glenkiln graptolites occur in dark shales embedded in grey shales and greywackes.

When these facts are taken into consideration, it is reasonable to infer that the coarse sediments between the Nith and the Loch Doon granite mass are mainly of Caradoc age, as they overlie some members of the Hartfell black shales throughout the greater part of the area. At the same time it is highly probable that some of the greywackes and shales which are intercalated in the graptolite shales that yield Glenkiln forms may be of Upper Llandeilo age.

The sediments now under consideration, the age of which cannot be definitely ascertained by means of fossils derived from the beds themselves, consist of (1) massive conglomerates, (2) black grits and greywackes with pebbly bands, (3) zones of flagstones and shales with occasional limestone nodules and bands of grit or conglomerate. These subdivisions are well seen in the tract between the Nith and the Kells Hills.

The group of flagstones and shales with limestone nodules are repeated by folds throughout the area, but are specially well seen in the river Nith between Enterkinfoot and Burnmouth, in the lower portion of the Burnsands Burn, in various slate quarries in the Dalwhat Valley, and also at the junction of the Deugh with the Ken. It is not improbable that as the flagstones and shales pass northwards from the Llandovery base-line across the successive anticlines of the Moffat series, they may occupy a slightly lower geological horizon than that of the Barren Mudstones of Moffat.

Prominent among these overlying sediments are the conglomerates of the Shinnel and Afton Waters. The Shinnel group is traceable from the Shinnel valley north-eastwards into those of the Chanlock and the Scar. The coarse conglomerates shade into pebbly grits and greywackes with thin shaly partings; the included pebbles, which are embedded in a greyish gritty matrix, sometimes calcareous, vary from the size of a pea to a foot in diameter. The blocks are well rounded, and consist of acid and basic intrusive igneous rocks, slaggy diabase-lavas (Arenig), radiolarian chert, black and grey varieties, blue and grey greywacke, grey shale, black shale, quartz, &c. From the fragments of black shale in the conglomerate of the March Burn, two small graptolites were obtained, one probably a *Diplograptus*, and the other a *Climacograptus*. From the same place *Orthis calligramma* and remains of encrinite stems, probably *Glyptocrinus*, were procured — forms which occur in the Duntercleuch conglomerate of the Leadhills region. Further palaeontological evidence is supplied by the dark shales associated with the pebbly grits and fine conglomerates of this series, which yield imperfectly preserved graptolites. For example, in the Kirkconnell Burn — a tributary of the Shinnel from the west — a specimen of *Climacograptus* of Llandeilo type was found in black shales and dark grit, about 300 yards from Cormilligan shepherd's house [NX 74247 95678], and to the north of a band of conglomerate (Sheet 9 of the Survey Map). Again, in the Glenskelly Burn [NX 73597 94154] — a tributary of the Dalwhat Water, about three miles north-west of Moniaive — graptolites of Caradoc types were obtained. In the middle branch of this stream, about 900 yards above Dalwhat House, dark blue or grey shales, with black seams or leaves about an eighth of an inch thick, yielded *Leptograptus flaccidus*, *Dicellograptus elegans*, *Diplograptus foliaceus*, and *Climacograptus bicornis*. Similar palaeontological evidence was afforded by the Corrodow slates, at a point about four miles north-west from Moniaive in the Dalwhat valley. Again, at the sheep-stell, in the Kirkconnell Burn, about a quarter of a mile south of Cormilligan, blue shaly mudstones and shales contain limestone nodules and oval masses of grit, about two feet across. One of the limestone nodules yielded a coral. Where a stone fence crosses the stream, the shales are slightly stained, and some of the hands have a silky texture.

Though the palaeontological evidence regarding the age of the Shinnel Water conglomerate is not very definite, it nevertheless furnishes reasonable ground for assigning this rock to the Caradoc rather than to the Llandovery formation. The recurrence of zones of grey shales with black strains containing Caradoc graptolites between Clodderoch Burn (Shinnel Water) and Corrodow (Dalwhat Water) points to the conclusion that the associated strata are of the same age. But while this is doubtless a reasonable inference, it ought to be frankly admitted that some of the massive grits lying to the north of the line which has been provisionally drawn as the base of the Llandovery Rocks resemble the Llandovery grits, and may be of the same age. Examples of these grits occur in the Barlae Hill [NX 62551 85757], three miles north of Dalry; but even there, the fossil evidence supplied by the flaggy shales in the Barlae Quarry is opposed to the reference of them to the Llandovery formation, for in the flaggy shales of this quarry the worm tracks long ago recorded by Professor Harkness are associated with *Diplograptus foliaceus* and *Climacograptus*.

An outcrop of fossiliferous conglomerate appears in the Pulharrow Burn, about a mile below its junction with the Burnhead Burn [NX 56547 86395]?. It contains pebbles of fine-grained limestone, granulitic quartz-schist, grit, and fragments of black shales some portions of the rock are highly calcareous, and yield encrinites, shells, &c. (Sheet 8 of the Map).

Far to the north-west, at the head of the Afton Water (Sheet 15), this conglomeratic series is prominently developed on both sides of the valley between Craigdarroch and Montraw [NS 63847 03826], where its beds dip to the N.N.W. at high angles. The pebbles, which are well rounded, lie in a matrix of grey grit, and vary in character in different layers. The largest boulders consist of granite and greywacke. One of grey granite was found to measure three feet by one foot and a half, and another 18 inches by six inches, while some of the greywacke pebbles measure two feet in diameter. The following percentage of included blocks was taken on the moor about a mile south-west of Craigdarroch on the way to Montraw:

Gabbro, banded and other varieties, and dolerite

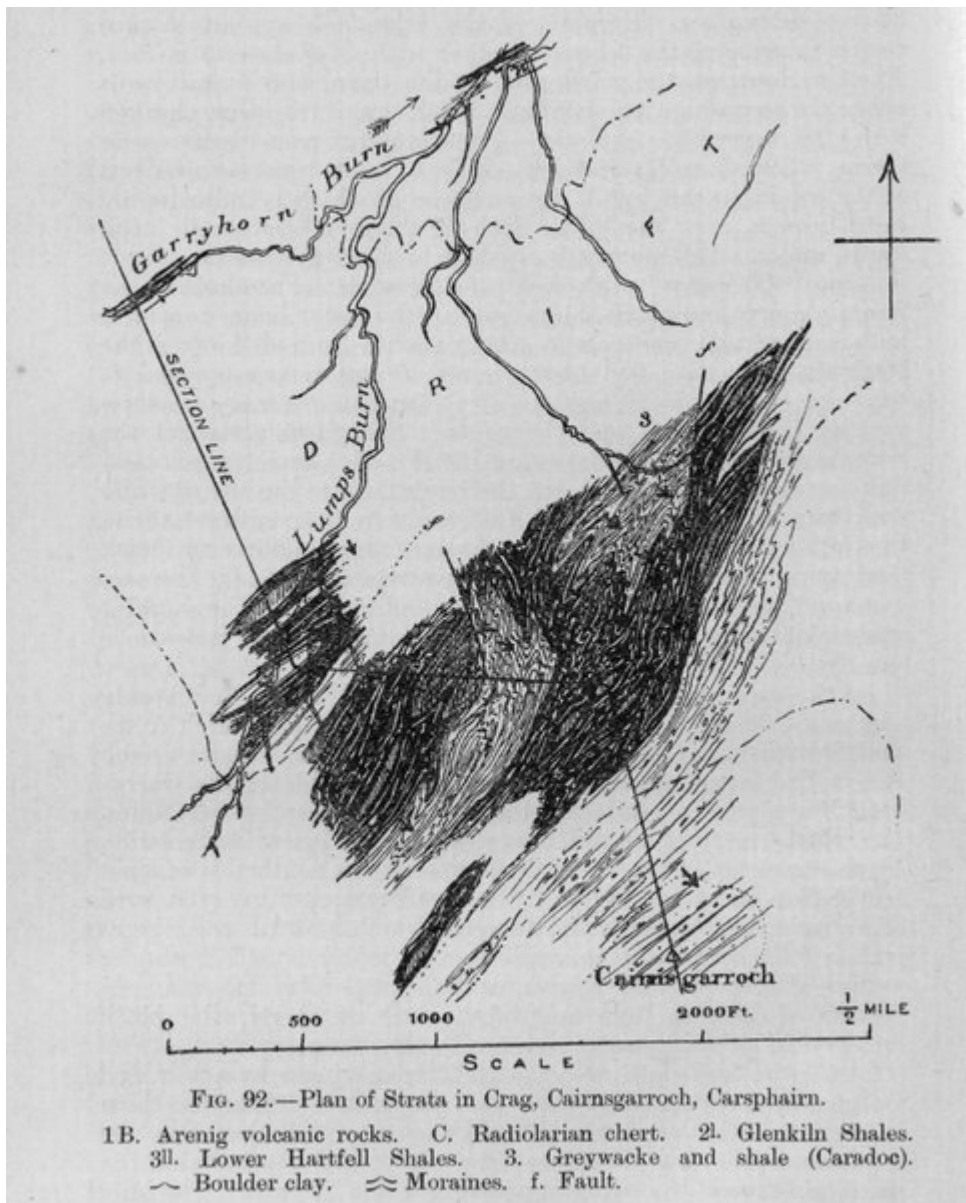
22 per cent.

Grey felsitic rock	27 per cent.
Granite	10 per cent.
Greywacke	10 per cent.
Diabase-lava	6 per cent.
Intrusive felsite	4 per cent.
Limestone	7 per cent.
Shale	4 per cent.
Chert	9 per cent.
Quartz	1 per cent.
	100 per cent.

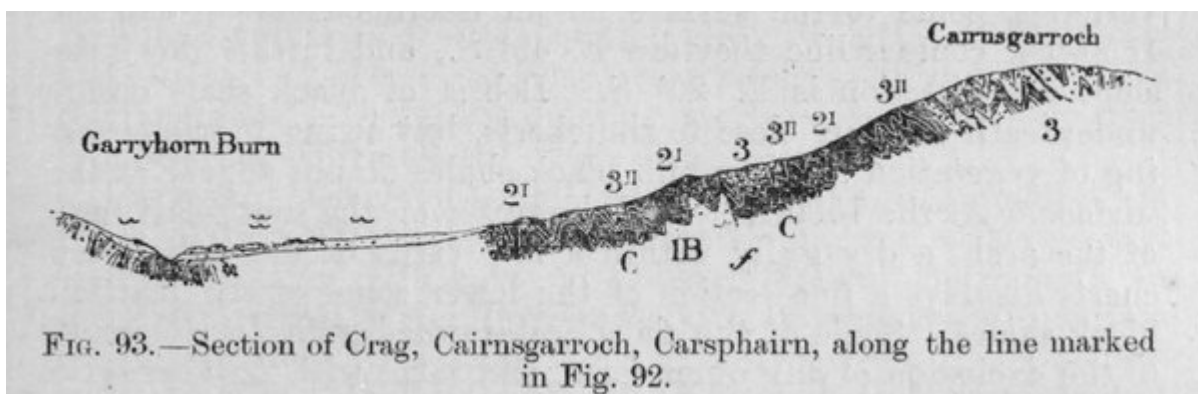
Another outcrop of conglomerate on the south slope of Auchincally Hill [NS 60147 06657], two miles west of the Afton Water, is traceable southwestwards to the head-waters of the Deugh. One of the best exposures (south-east corner of Sheet 14) is to be seen on the east slope of Hillend Hill, about a mile north of Hillend, where the lithological characters of the rock are similar to those of the Afton Water conglomerate just described. A fine section of highly inclined or vertical beds of massive grits, greywackes, and shales is also met with on the west slope of the neighbouring Craignane Hill [NS 57980 04137]. The slope is bare of drift, and the observer can see to advantage the massive character of the sediments. No fossils have been found in the conglomerates or grits of the Afton or Dough Waters, but these rocks lie to the south of the strike of the thin seams of black shale in the Polmorlach and Polhote Burns, which yield graptolites belonging to the lower zones of the Lower Hartfell black shales.

Again, in the Carsphairn district, well-marked conglomerates and pebbly grits occupy synclinal folds of the Moffat series, as, for example, on the Craig of Knockgray, N.N.E. of Carsphairn [NX 57034 94381], on the Cairnsgarroch Hill [NX 51545 91337], on the Meaul [NX 50031 90980] and Carlins Cairn [NX 49580 88902] in the Kells range, south-west of the Woodhead Lead Mines (Sheet 8). Here there is a similar assemblage of pebbles, though perhaps in slightly different relative proportions. On the eastern spur of Cairnsgarroch Hill, south of Woodhead Lead Mines, a pebble of quartzite several inches long, like that of the Perthshire Highlands, was found in the conglomerate. The conglomerates and pebbly grits appears to lie there in a trough of Arenig cherts and Glenkiln–Hartfell black shales, the highest zone represented being that of *Climacograptus caudatus* of the Lower Hartfell division

A glance at the map that accompanies this volume will show that from the number of outcrops of the Moffat series in the broad track extending from the Llandovery base-line in the northern margin of the tableland, the coarse sediments now under consideration must be repeated by innumerable folds. It is true that over a belt of ground, about four miles in width, between the Polhote Burn west of Kirkconnell and the black shale bands south of the Euchar Water, no exposures have been detected which can without doubt be referred to the Arenig cherts or Glenkiln black shales. But even within this tract the Caradoc sediments may be highly folded, because along the strike of the strata south-westwards in the Carsphairn district, the Arenig cherts and overlying black shales repeatedly come to the surface.



(Figure 92) Plan of Strata in Crag, Cairnsgarroch, Carsphairn. 1B. Arenig volcanic rocks. C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc). [Boulder-clay symbol] Boulder clay. [Moraines symbol] Moraines. f. Fault.



(Figure 93) Section of Crag, Cairnsgarroch, Carsphairn, along the line marked in (Figure 92).