Chapter 16 The Northern Belt — continued. Arenig, Llandeilo, and Caradoc formations between Nithsdale and Loch Doon.

i. Black Shale Bands between Burnmouth, Nithsdale, and Dalshangan, North of Dalry.

Along the axial line that extends from Burnmouth [NS 83872 05099] on the river Nith (four miles S.E. of Sanquhar) to Dalshangan [NX 59633 89001] near the junction of the Deugh with the river Ken (five miles north from St. John's Town of Dalry) — a distance of 17 miles — the Moffat series is well developed. In certain sections it yields characteristic Glenkiln graptolites and forms belonging to the two lower zones of the Hartfell black shales. In some of the anticlines, again, the Arenig cherts are well represented, while in the Nith section at Burnmouth and in the Linn Burn, southwest of Fardingmullach (Sheet 15 of the Survey Map), small exposures of volcanic rocks make their appearance. Though prominent outcrops of the Moffat series can be traced along this line, it must be borne in mind that they are not prolongations of one and the same band. The outcrop at Dalshangan, for example, lies to the south of that of Shinnelhead.

River Nith at Burnmouth. — [NS 83864 05292] In the Nith, opposite Ardoch Farmhouse, four miles south-east of Sanquhar, the following arrangement of the strata is visible in the river. On the right bank above the bend, nearly south-west from Ardoch Farmhouse, shattered and crushed black shales are followed on the north side by dark blue shales, and on the south by grey and red cherts. A few yards further down, a fault brings the Glenkiln black shales against the cherts and a small mass of igneous rock like one of the types of Arenig lava. To all appearance the cherts here form the core of an arch with a small exposure of Arenig lava, truncated on the south side by a fault. From the black shales near this fault the fossils given in the subjoined list were collected, which are characteristic of the Glenkiln group. None of the Lower Hartfell forms found in the Cairn Burn, to be referred to presently, was obtained from this locality, but the black shales are too much crushed to permit of examination close to the overlying shales and conglomerates:

Didymograptus superstes (Lapw.)

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Dicranograptus zic-zac (Lapw.)

Dicranograptus ramosus (Hall.)

Diplograptus foliaceus (Murch.)

Diplograptus mucronatus (Hall.)

Lasiograptus bimucronatus (Nich.)

Cryptograptus tricornis (Carr.)

Climacograptus bicornis (Hall.)

Glossograptus Hincksi (Hopk.)

Dicellograptus moffatensis (Carr.)

A brachiopod.

Southwards this outcrop of black shales is followed by another arch of the radiolarian cherts, with the black shales on the south side. Here a blank interrupts the section for a short distance, when grey and blue shales with scattered pebbles,

merging into a bed of conglomerate, appear. This conglomerate has a shaly and gritty matrix, in which pebbles of white quartz and pieces of black shale occur, with occasional rounded pebbles of greywacke. It is followed by crushed and dislocated black shales, forming a small exposure. Lower down the river, greywackes and blue shales with conglomeratic bands appear. At this point dark blue shales alongside of the conglomeratic bands have furnished a *Climacograptus,* probably *C. caudatus.* Still further down, beyond some greywackes and shales, another conglomeratic band is seen, with pebbles, either of quartzite or altered greywacke and quartz-felsite. The greywackes here have a baked appearance, possibly altered by an intrusive felsite dyke.

Burnsands Burn. — To the south of the axial fold referred to above, grey and blue shales are well seen in a cutting by the road-side about half a mile south of Burnmouth, and also in the Burnsands Burn above Crairieknowe. In this series of shales a remarkable conglomerate is typically displayed in the last-named stream, about half a mile above Crairieknowe [NS 83444 04142]. The rock is variable in character. In places it is a pebbly grit with small white quartz pebbles; sometimes it contains sub-angular pieces of black shale with graptolites, lying either along or across the bedding planes. Rounded nodules of grey limestone and pebbles of greywacke, grit, quartzite, and one or two pebbles of a banded rock like a quartzose gneiss, also occur. Some of the larger pebbles vary from six inches to a foot across. From the black shale fragments the following fossils were obtained: *Caenograptus, Dicellograptus sextans, Diplograptus foliaceus,* and *Corynoides.* No fossils were observed in the limestone nodules. This conglomerate furnishes additional evidence of the local elevation and erosion of the Glenkiln black shales and other Silurian sediments.

Fardingmullach. — In a streamlet that drains into the Burnsands Burn from the south, about 400 yards east of Fardingmullach shepherd's house [NS 81898 04489], an excellent section shows the relation of the radiolarian cherts to the Glenkiln black shales, on a rocky scar at the head of the burn (Figure 78) and (Figure 79). The cherts and black shales occur on the east side of the burn. The black shales form the lower portion of the scar on the northern limb of the anticline, while the radiolarian cherts are prominently developed near the top of the scar, in the core of the arch (C. (Figure 78)). The black shales are disposed in sharp synclinal folds of the cherts, and appear likewise on the south-east limb of the fold (2I, 3II, (Figure 79)). The grey and red mudstones are exposed in the centre of the fold, the grey and green cherts predominating. The best fossiliferous localities for graptolites are to be found on the northern limb of the fold, where the outcrop of black shales facing the burn is about 40 feet broad. The lower portion of the band is composed of thin black siliceous bands with thin seams of sooty shales containing graptolites.

The following species, among others, were obtained from the Glenkiln horizon: *Didymograptus superstes, Caenograptus, Lasiograptus bimucronatus, Diplograptus foliaceus,* and *Dicellograptus.*

These strata are succeeded by black shales yielding *Dicranograptus ramosus, Climacograptus bicornis, C. caudatus, Diplograptus foliaceus,* and *Acrotreta Nicholsoni.* Some of the thin seams are crowded with this brachiopod, and also with *Climacograptus.* In addition to these fossils, the same shales contain *Corynoides calycularis,* and *Dicellograptus elegans,* while in some seams *Climacograptus caudatus* is abundant, in others *C. bicornis.* Blue and grey shales emerge on the grassy slope on the other side of the hollow, but the sequence upwards to these shales is not visible. The general dip in this section being to the northwest, the strata are thus disposed in a series of isoclinal folds (Figure 79).

About half a mile to the north-east of the section just described, the Lawyers Cleuch [NS 82516 04717] — a tributary of the Burnsands Burn from the north — displays crushed and shattered black shales, bounded on both sides by shales with scattered pebbles, like the beds at Burnmouth on the Nith.

About a mile to the south-west of Fardingmullach, in the Druidhill Burn [NS 80560 03646], in the line of strike of the folds already described, an axial fold of cherts brings up black shales on both sides. The black shales reappear in the Linn Burn — a tributary of the Druidhill Burn — but in both streams the strata are much shattered and crushed, and fossils were not obtained from them. At a point about a third of a mile above the junction of the streams [NS 80540 03024], decomposing green diabase-lava occurs in the Linn, in contact with black shales. Though much crushed and veined with carbonate of lime, the rock exhibits the pillowy structure at one point.

Cairn Burn. — This stream which drains the northern slope of the Cairnkinna Hill (1813 feet), affords a section of black shales near the fork [NS 79195 02398]?, and for some distance below that point. At the foot of, the north branch, platy

black shales have yielded *Dicellograptus Forchhammeri* (seen in countless profusion on the slabs); and *Diplograptus foliaceus,* &c., beautifully preserved. *Glossograptus Hincksi* and *Climacograptus* have also been found. A few yards up this branch, at the foot of the waterfall, a fault crosses the burn, and brings grey shales and greywackes against the black shales.

The most important fossiliferous locality, however, lies about 60 yards below the fork, on the north bank of the stream, where platy shales dip about 70° to S.S.E. In a thickness of about twelve inches of these strata the following fossils were collected:

Dicellograptus Forchhammeri (Gein.)

Dicellograptus caduceus (Lapw.)

Dicellograptus elegans (Carr.)

Dicranograptus ramosus (Hall.)

Leptograptus flaccidus (Hall.)

Climacograptus bicornis (Hall.)

Climacograptus caudatus (Lapw.)

Amphigraptus radiatus (Lapw.)

Glossograptus Hincksi (Hopk.)

Diplograptus foliaceus (Murch.)

Lasiograptus margaritatus (Lapw.)

Corynoides calycularis (Nich.)

Acrotreta Nicholsoni (Dav.)

Siphonotreta micula (M'Coy.)

The presence of *Climacograptus caudatus* and *C. caduceus* defines the horizon of this band which underlies the *Pleurograptus linearis* zone, and belongs to the middle zone of the Lower Hartfell black shales. Certain interesting features connected with the mode of occurrence of some of these graptolites deserve notice. For example, some of the slabs are crowded with *Dicellograptus Forchhammeri,* others with *Leptograptus flaccidus,* others again with *Diplograptus foliaceus.* Apart from the presence of the special zonal forms, the occurrence of these species in such profusion is a feature peculiar to the lower Hartfell zones.

In the Carlinstane Burn [NS 77696 01093] which joins the Scar Water about a mile below Glenmanno, black shales occur, very much crushed. They reappear in the Hallscar Cleuch [NS 77404 01561], probably in the same line of strike.

Scar Water. — Further north, in the Scar Water, at the bridge across the stream leading to Glenmanno [NS 76858 02031], platy black shales dip to the south-east at high angles. A few feet south of the bridge they have supplied *Diplograptus foliaceus* in profusion on a single slab to the exclusion of other forms. Specimens of *Lasiograptus margaritatus* and siculae of *Diplograpti* have also been obtained. Under the bridge greywackes and shales crop out.

Hall Burn. — [NS 77159 02264] The band of black shale in the Scar Water, at the Glenmanno Bridge, is represented in several arches in the Hall Burn.

Tributary of the Dalzean Burn (South-West of Glenmanno). — [NS 75393 01013] South-westwards from the Scar Water a tributary of the Dalzean Burn, which rises on the slope of Craigbuie Hill displays a section of the radiolarian cherts and black shales fault runs up the bed of the stream, bringing greywackes and shales in contact with the charts and black shales. In addition to the Glenkiln black shales with thin dark flinty ribs; some layers are crowded with *Diplograptus foliaceus* and *Corynoides calycularis.* It is probable, therefore, that the lower zones of the Hartfell black shales are also represented in this section.

Chanlock Water. — A section of the radiolarian cherts with black shales has been laid open at the top of the Peathouse Cleuch [NS 75369 00574], a small tributary of the Chanlock Water above Chanlockhead. About half a mile west from Chanlockhead shepherd's house, the most westerly exposure of black shales occurs, and from this downwards for a distance of 500 yards the stream flows over black shales with radiolarian cherts and greywackes. In the foregoing section (Figure 80) the most westerly fold is represented by a. At locality b another fold shows the black shales. On the west side of this arch a small fault brings the graptolite shales in contact with the greywackes. A few feet from this fault these platy shales contain well-preserved graptolites belonging to the Lower Hartfell zones, as given in the following list:

Dicellograptus moffatensis (Carr.)

Dicellograptus sp.

Diplograptus foliaceus (Murch.)

Dicranograptus ramosus (Hall.)

Dicranograptus Nicholsoni (Hopk.)

Climacograptus caudatus (Lapw.)

Climacograptus bicornis (Hall.)

Corynoides calycularis (Nich.)

Acrotreta Nicholsoni (Dav.)

At this locality some of the slabs are crowded with *Dicellograptus,* as is the case with the same zone in the Cairn Burn and at intermediate localities.

Lower down the stream the radiolarian cherts occur in compound folds with the black shales (C, 2I, (Figure 80)). After a blank in the section the black shales reappear in the stream near a footbridge about 500 yards west from Chanlockhead shepherd's house. In this case also they are associated with radiolarian cherts which form the core of the arch. A few yards above the footbridge they afforded the following typical Glenkiln forms:

Didymograptus superstes (Lapw.)

Caenograptus pertenuis (Lapw.)

Dicranograptus formosus (Hopk.)

Dicranograptus ramosus (Hall.)

Dicellograptus sextans (Hall.)

Dicellograptus patulosus (Lapw.)

Cryptograptus tricornis (Carr.)

Climacograptus bicornis (Hall.)

Black shales appear in the Chanlock still further down, opposite the shepherd's house of Chanlockhead.

Shinnelhead (Sheet 9 of Survey Map). — In the basin of the Shinnel Water, an interesting section of the Arenig cherts and black shales is to be seen in Patie Cleuch [NX 72565 99081], about 300 yards west of Shinnelhead shepherd's house. In this stream the grey Arenig cherts with radiolaria are brought to the surface along several axial folds, followed by the Glenkiln–Hartfell black shales. The following fossils were obtained from the exposures of the Glenkiln shales in this section:

Lasiograptus bimucronatus (Nich.)

Diplograptus euglyphus (Lapw.)

Diplograptus foliaceus (Murch.)

Cryptograptus tricornis (Carr.)

Climacograptus bicornis (Hall.)

Climacograptus tridentatus (Lapw.)

Climacograptus Schärenbergi (Lapw.)

Dicranograptus ramosus (Hall.)

From the Hartfell black shales the following assemblage was collected:

Climacograptus caudatus (Lapw.)

Climacograptus bicornis

Dicellograptus caduceus (Lapw.)

Diplograptus foliaceus (Murch.)

Lasiograptus margaritatus (Lapw.)

Glossograptus Hincksi (Hopk.)

Corynoides calycularis (Nich.)

Retiolites in large numbers, but indistinct.

Acrotreta Nicholsoni (Dav.)

At the highest exposure of black shales in Patie Cleuch, which is about 400 yards up stream from the Shinnel Water, the black shales of the Hartfell group yielded *Dicellograptus Forchhammeri, D. moffatensis, Diplograptus foliaceus,* and *Leptograptus flaccidus.*

In a small streamlet that joins the Shinnel Water on the south side of the valley near Shinnelhead shepherd's house [NX 72913 99118], some axial folds reveal the grey radiolarian cherts and black shales. The latter are so crushed that fossils are difficult to obtain from: them, hut the following among other forms were here collected: *Lasiograptus bimucronatus, D. foliaceus. D. tricornis, Dicellograptus. Corynoides calycularis.*

South-westwards along the strike of the Shinnelhead band, the cherts and black shales reappear in the Appin Burn, about a mile from the head of the stream [NX 71515 98148]. About 150 yards north of a small tributary from the Conrick Hass, at the northern margin of an alluvial patch, Glenkiln shales with black cherty ribs and seams of black shales have

yielded an assemblage of characteristic fossils:

Didymograptus superstes (Lapw.)

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Thamnograptus scoticus (Lapw.)

Lasiograptus bimucronatus (Nich.)

Diplograptus foliaceus (Murch.)

Diplograptus euglyphus (Lapw.)

Cryptograptus tricornis (Carr.)

Lasiograptus margaritatus (Lapw.)

Glossograptus Hincksi (Hopk.)

Climacograptus bicornis (Hall.)

Climacograptus peltifer (Lapw.)

Climacograptus sp.

Dicranograptus zic-zac (Lapw.)

Dicranograptus ramosus (Hall.)

Dicranograptus Nicholsoni (Hopk.)

Dicranograptus formosus (Hopk.)

Dicellograptus sextans (Hall.)

Dicellograptus patulosus (Lapw.)

Corynoides calycularis (Nich.)

Further north in the Appin. Burn a small exposure of the grey cherts with radiolaria is succeeded on the north side by black shales. At the most northerly point, where the black shales in this section are seen in contact with greywackes, the black bands yielded *Dicranograptus Nicholsoni* (wide-angled variety), *Siphonotreta micula,* and a *Diplograptus* like *D. euglyphus.*

The small tributary of the Appin Burn which drains the southeast slope of Blackeraig Hill exposes black shales that dip southeast at an angle of 80°. They reappear on the col between the Appin and Dalwhat Waters [NX 70091 98539] ?, where in one exposure they yield *Dicranograptus ramosus* and *Diplograptus foliaceus.* They are visible at one point -in the Conrick Burn, about half a mile from the Dalwhat Water. Here they pass underneath a covering of boulder-clay and moraine-material to reappear in tht Dalwhat Water and Dibbin Lane.

Dibbin Lane and Dalwhat Water. — [NX 70089 96804] The sections now to be described are of special interest from the large exposures of the black shale series and the excellent preservation of the fossils at certain localities, and also from the assemblage of graptolites characteristic of part at least of the Hartfell black shales.

The Dalwhat Water, just below the mouth of Dibbin. Lane, flows over flaggy shales and grits; above that point black shales appear, associated with grey thefts that contain abundant radiolaria. On the north side of the axial fold, the thin partings of black shales between the black cherty ribs of the Glenkiln group contain the following fossils:

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Caenograptus surcularis (Hall.)

Dicellograptus sextans (Hall.)

Dicellograptus patulosus (Lapw.)

Dicellograptus moffatensis (Carr.)

Dicranograptus ramosus (Hall.)

Climacograptus bicornis (Hall.)

Climacograptus Schärenbergi (Lapw.)

Cryptograptus tricornis (Carr.)

The Dibbin Lane is a narrow pass that leads to the streams draining into the river Ken. Its lower slopes are covered with drift. At the lower end of the pass the Moffat Shales appear on the south bank and nm up the valley, forming a ridge at the outer edge of the alluvium. They are also visible at a bend in the Lane to the north of this ridge, as shown in the accompanying ground plan (Figure 81). On the south side of the stream at C [NX 70067 96799], two small arches of the red radiolarian charts are overlain by the Glenkiln black shales of the normal Moffat type, viz.: black cherty ribs with thin sooty partings of black shale, containing, among other forms characteristic of this group: *Climacograptus caelatus* var. *antiquus* (Lapw.) *Diplograptus perexcavatus,* and *D. foliaceus.* Representatives of the Hartfell black shales occur on the north limb of this fold at A, in the form of platy shales, yielding the following typical forms, which prove that these shales represent the lower portion of the Hartfell black shale group:

Climacograptus caudatus (Lapw.)

Diplograptus foliaceus (Murch.)

Corynoides calycularis (Nich.)

Dicellograptus Forchhammeri (Gein.)

Climacograptus bicornis (Hall.)

Climacograptus Schärenbergi (Lapw.)

Leptograptus flaccidus (Hall.)

At a point about 120 yards up the stream from the dyke that crosses the mouth of Dibbin Lane, the Glenkiln black shales, as displayed on the face of the bank on the south side of the stream, again present all the lithological characters so typical of this group in the Moffat region. They consist of black cherty ribs with thin partings of black sooty shales, from which a large assemblage of the typical Glenkiln fossils has been obtained:

Didymograptus superstes (Lapw.)

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Caenograptus surcularis (Hall.)

Lasiograptus bimucronatus (Nich.)

Lasiograptus Harknessi (Nich.)

Diplograptus foliaceus (Murch.)

Diplograptus Whitfieldi (Hall.)

Diplograptus perexcavatus (Lapw.)

Cryptograptus tricornis (Carr.)

Dicranograptus formosus (Hopk.)

Dicranograptus ramosus (Hall.)

Dicranograptus minimus (Lapw.)

Climacograptus bicornis (Hall.)

Climacograptus peltifer (Lapw.)

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

Dicellograptus patulosus (Lapw.)

Dicellograptus divaricatus (Lapw.)

Dicellograptus sextans (Hall.)

Dicellograptus moffatensis (Carr.)

Leptograptus flaccidus (Hall.)

Glossograptus Hincksi (Hopk.)

Higher up in the Dibbin Lane the charts appear in greater development. At a point about 600 yards up stream [NX 69678 96514], grey cleaved charts appear on the south bank associated with red and grey mudstones, which enclose brachiopods. The south limb of this fold of charts and red mudstones shows the Glenkiln black shales, which are abruptly succeeded by greywackes and shales.

The axial fold of radiolarian charts and mudstones which extends along the south bank of the Dibbin Lane crosses the stream at a point about half a mile up from the junction with the Dalwhat Water [NX 69514 96276]. Here the burn, taking a bend towards the south, crosses the strike of the fold. On the south bank, grits dip south-east near the black shales, and are succeeded by flaggy sandy shales with worm tracks. The latter occupy a synclinal fold, and are bounded by grits on the south side. These are in turn followed by another axial fold of the Arenig cherts, with the black shales (Glenkiln and Hartfell) on both sides. This arch, forming a prominent ridge of rock, can be traced southwestwards till it crosses the Dibbin Lane to the west of a sheepfold on the south side of the stream, where two arches of the cherts occur with the Glenkiln black shales in the centre of the syncline and flanking the outer folds of the chert ((Figure 81), Section).

On the north bank of the stream (at D [NX 68268 95416], (Figure 81)), the black shales with black cherty ribs in the central fold yielded the following forms:

Didymograptus superstes (Lapw.)

Lasiograptus bimucronatus (Nich.)

Diplograptus foliaceus (Murch.)

Cryptograptus tricornis (Carr.)

Dicellograptus sextans (Hall.)

Climacograptus bicornis (Hall.)

Dicranograptus ramosus (Hall.)

On the southern limb of the fold (at E, (Figure 81)), the Hartfell group occurs in the form of platy black shales, which resemble those of a similar horizon in the Cairn Burn *(supra* p. 336), and yield the forms characteristic of the *Climacograptus caudatus* zone. The slabs are crowded with large specimens of *Climacograptus caudatus,* also with *Corynoides calycalaris* and *Diplograptus foliaceus* in profusion. On the north side of this compound anticlinal fold (at F, (Figure 81)) the black shales yield *Climacograptus caudatus, Corynoides calycularis, Diplograptus foliaceus,* and *Glossograptus Hincksi.*

The section of this compound anticline shows that the Moffat black shales (Glenkiln–Hartfell), as here represented, still preserve the normal lithological characters of the Moffat region. The highest sub-zones of the Hartfell group, however, have not been detected in this section, and it is probable that they are represented by some of the succeeding sediments.

Still higher up the Dibbin Lane, further axial folds reveal the cherts and Glenkiln–Hartfell black shales, till at a point on the north bank of the stream, about two-thirds of a mile up from the Dalwhat Water, black shales of the Hartfell group merge into black sandy shales with large specimens of *Dicellograptus,* associated with *Diplograptus foliaceus, Glossograptus Hincksi,* and *Leptograptus flaccidus.*

About a third of a mile from the county boundary [NX 68995 95897], the hill slope on the south side of the Pass is scarred by several small streams, most of which expose some of the members of the Moffat series. In the second streamlet from the county boundary, draining the west slope of the Martour Hill, flinty black shales occur, and limestone nodules. On the other side of the county boundary, the representatives of the Moffat series can still be traced at intervals in a south-west direction [NX 68450 95602]. About a quarter of a mile from the boundary the stream forks [NX 68400 95547], one branch draining the southern slope of Benbrack Hill and the other rising on the mossy col between Dibbin Lane and Manwhill. On the south side of the latter branch, an arch of the radiolarian cherts throws off the black shales on either side; while in the former branch, the Hartfell black shales are well displayed in contact with the greywackes. Here the strata dip southwards at 56°, and the black shales have furnished the following characteristic assemblage of fossils:

Dicellograptus Forchhammeri (Gein.), in profusion.

Leptograptus, in profusion.

Corynoides, in profusion.

Diplograptus foliaceus (Murch.)

Dicranograptus ramosus (Hall.)

Dicranograptus Nicholsoni (Hopk.)

Climacograptus caudatus (Lapw.)

Climacograptus bicornis (Hall.)

Siphonotreta micula (M'Coy.)

Retiolites (Neurograptus) fibratus (Lapw.)

Manwhill. — [NX 66627 94274] On the north slope of the Straanfreggan Burn, the black shales appear in a small burn about 350 yards southwest of the shepherd's house, near the road leading to Manwhill. Cleaved black cherts are there seen with the black shales. The latter yielded the following fossils: *Didymograptus superstes, Cryptograptus tricornis, Climacograptus bicornis, Diplograptus foliaceus, Dicellograptus sextans, Dicranograptus ramosus, Glossograptus Hincksi.* The cherts and black shales are likewise met with in a tributary of the Stroanfreggan Burn on the north-west side of the valley, and about half a mile from Manwhill [NX 66062 93968 .

Stroanpatrick. — [NX 65206 92332] A good section of the Moffat series has been cut by the Long Burn, about a third of a mile north-east of the ruin of Stroanpatrick shepherd's house. Here two arches of the strata are exposed; of these the more southerly arch of grey cherts measures about two feet in breadth, while the distance from this point to the brown flaggy shales is about eight yards. The following fossils were found in the black shales on the south side of this arch of cherts, viz.: *Diplograptus foliaceus, Cryptograptus tricornis, Climacograptus bicornis, C. peltifer,* and *Acrotreta Nicholsoni,* &c. On the north side of the same arch of cherts the black shales yielded:

Didymograptus superstes (Lapw.)

Dicranograptus minimus (Lapw.)

Climacograptus bicornis (Hall.)

Diplograptus foliaceus (Murch.)

Leptograptus flaccidus (Hall.)

Clathrograptus cuneiformis (Lapw.)

Corynoides calycularis (Nick.)

Acrotreta Nicholsoni (Dav.)

Further up stream shattered Glenkiln Shales can be followed till they rest on the second arch of the cherts, which is from four to six yards across [NX 65109 92714]. The black shales on the south side of this fold clip at a low angle, while on the north side they are nearly vertical. At the northern limit of the section the Hartfell black shales contain *Dicellograptus caduceus, D. elegans, Diplograptus foliaceus, Leptograptus flaccidus;* in band next greywacke, *Dicellograptus sextans, Corynoides calycularis,* and *Siphonotreta micula.*

Near the ruin of Stroanpatrick shepherd's house a very small exposure of black shales may be seen.

Dalshangan, Water of Deuch. — [NX 59610 89608] Proceeding westwards for a distance of nearly four miles to the Water of Deugh, we find an important section of black shales of the Hartfell group to the north of the mansion house of Dalshangan. About a third of a mile north of Dalshangan the Pulwhanity Burn, about 200 yards above its junction with the Deugh, flows over black shales pierced by intrusive dykes, and associated with greywackes and shales. On the west bank of the Deugh, at a point about 300 yards from the foot of Pulwhanity Burn, fine specimens of *Climacograptus caudatus* have been obtained. The black shales occur on the grassy slope about fifty feet above the level of the Deugh, and are so completely isolated that their relations to the surrounding strata cannot be ascertained. They have supplied the following fossils:

Climacograptus caudatus (Lapw.)

Dicranograptus Nicholsoni (Hopk.)

Dicranograptus ramosus (Hall.)

Diplograptus foliaceus (Murch.)

Diplograptus mucronated

Leptograptus flaccidus (Hall.)

Dicellograptus Forchhammeri (Gein.)

Dicellograptus, numerous arms covering slabs.

Climacograptus bicornis (Hall.)

Retiolites (Neurograptus) fibratus (Lapw.)

Corynoides calycularis (Nich.)

Acrotreta Nicholsoni (Dav.)

Black shales are again exposed on the banks of the Deugh about 200 yards further to the north-east.

Small outcrops of the Moffat series come to the surface further to the south-west, in certain tributaries of the river Ken, that drain the lofty watershed of the Kells. These sections will now be described.

Pulmaddy Burn. — [NX 57799 88729] In this stream, about a mile above its junction with the Water of Deugh (Sheet 8 of the Survey Map), black shales, visible on the left bank near Largerie, and on the hill slope to the north-east, are corrugated and crushed and have supplied no graptolites.

Pulharrow Burn. — [NX 54459 86695] In a small tributary of the Pulharrow Burn, about 550 yards W.N.W. of Nether Forrest, near an old fence, a small outcrop of black shales has yielded *Caenograptus gracilis, Diplograptus foliaceus, Cryptograptus tricornis,* and *Dicellograptus.* In the Pulharrow Burn, about half a mile to the west of Nether Forrest and north of the Bush Cottage, another outcrop of the Moffat series, though not continuous, is interesting on account of the presence of a thin zone of volcanic rocks which seems to occupy a higher horizon than that of the Arenig series. The following ground-plan shows the disposition of the rocks at this place. At the western limit of this section, on the north bank of the stream, well-bedded platy shales yield *Dicellograpti* in profusion in certain layers, together with the large variety of *Diplograptus foliaceus.* The mode of occurrence of these forms suggests that the strata belong to the Lower Hartfell horizon. Two or three yards below this point, on the north bank, thin grey greywackes and shales occur with black shales, which yield poorly preserved graptolites. Eastwards a band of diabase-lava (Bb2, (Figure 82)), about 50 feet broad, weathers spheroidally, but is too much decomposed for microscopic determination., though in the field it bears a close resemblance to some of the fine-grained diabase-lavas of Arenig age. On the south-east side of the exposure, black shales occur, yielding the zonal Glenkiln form *Dicranograptus minimus.* Again, on the bank of the burn below the footbridge, black shales appear, from which certain typical Glenkiln fossils have been obtained. Further down, the stream lays bare alternations of blue-black shales and thin greywackes and shales. From one of the black shale bands on the north bank *Climacograptus caudatus* was obtained. From the arrangement of the strata in this section it would seem that the Glenkiln back shales are the lowest beds exposed, and that these are followed on both limbs by black shales and other sediments, from which Lower Hartfell fossils have been collected.

Near Burnhead [NX 55308 86257], south of Nether Forrest, various outcrops of black shares appear, but in places too much altered by the adjacent mass of igneous rock to yield graptolites.

ii. Black Shale Bands between Upper Appin, Shinnel Water, and Arndarroch, River Ken

Upper Appin (Shinnel Water, Sheet 9 of the Survey Map). — About a mile to the south of the black shale bands already described between Shinnelhead and Dalshangan, many of the outcrops of similar shales do not yield graptolites in such profusion, partly owing to their shattered character and partly to the cleavage of the shales.

In the Appin Burn, about half a mile to the west of Upper Appin shepherd's house [NX 72286 97891], the black shales, including about two feet of dark greywacke, have yielded the following fossils:

Lasiograptus bimucronatus (Nich.)

Diplograptus euglyphus (Lapw.)

Diplograptus foliaceus (Murch.)

Diplograptus tricornis (Carr.)

Climacograptus peltifer (Lapw.)

Climacograptus bicornis (Hall.)

Climacograptus Schärenbergi (Lapw.)

Glossograptus Hincksi (Hopk.)

Dicranograptus zic-zac (Lapw.)

Dicranograptus ramosus (Hall.)

Dicranograptus sp.

Corynoides calycularis (Nich.)

Corynoides sp.

Siphonotreta micula (M'Coy.)

Acrotreta Nicholsoni (Dav.)

Another fold of the black shales is seen in the Appin Burn less than a quarter of a mile west of Upper Appin shepherd's house. They are also exposed in a tributary of the Appin Burn from the south, opposite Upper Appin [NX 73086 97661], where they have yielded *Climacograptus caudatus, Dicranograptus ramosus, Diplograptus foliaceus, Acrotreta Nicholsoni,* &c.

Glenjaan Burn, Culmark, Arndarroch. — [NX 69554 94813] Further to the south-west, near the head of the Glenjaan Burn, and not far from the county boundary, the radiolarian cherts appear with the Glenkiln–Hartfell black shales. The following fossils, comprising forms characteristic of both groups, were collected from this band:

Lasiograptus bimucronatus (Nich.)

Diplograptus foliaceus (Murch.)

Cryptograptus tricornis (Carr.)

Climacograptus bicornis (Hall.)

Climacograptus Schärenbergi (Lapw.)

Climacograptus caudatus (Lapw.)

Glossograptus Hincksi (Hopk.)

Dicellograptus Morrisi (Hopk.)

Leptograptus flaccidus (Hall.)

Siphonotreta micula (M'Coy.)

Retiolites sp.

On the western side of the county boundary, the prolongation of this band is found in the Carlae Burn [NX 68831 94658], about a mile and a half to the east of Manwhill shepherd's house, where the black shales have yielded the following assemblage of organisms:

Lasiograptus bimucronatus (Nich.)

Diplograptus foliaceus (Murch.)

Diplograptus mucronatus (Hall.)

Climacograptus bicornis (Hall.)

Climacograptus peltifer (Lapw.)

Dicellograptus sextans (Hall.)

Dicellograptus patulosus (Lapw.)

Corynoides calycularis (Nich.)

Dicranograptus Nicholsoni (Hopk.)

Dicranograptus Nicholsoni wide-angled variety.

Dicranograptus ramosus (Hall.)

Glossograptus Hincksi (Hopk.)

Leptograptus fiaccidus

Acrotreta Nicholsoni (Dav.)

The black shales reappear in the Carroch Lane, north of Culmark [NX 64452 91036], where they are much corrugated, are associated with greywackes and shales, and have yielded *Dicranograptus Nicholsoni* (wide-angled variety), *D. ramosus, Climacograptus caudatus, Dicellograptus Morrisi, D. Forchhammeri,* &c. Still further to the southwest, similar strata are exposed by the roadside near Arndarroch, and in the river Ken near Dundeugh [NX 61079 88513]. Near Arndarroch [NX 61829 88972] they are associated with grey cherts, and contain *Diplograptus foliaceus, Cryptograptus tricornis,* and *Climacograptus bicornis* (wide forks).

iii. Black Shale Band 4 extending from Corfardine, Scar Water, by Clodderoch and Margree to Gordonston, near Dalry.

Corfardine, Clodderoch, Ballinie, Margree, and Gordonston (Sheet 9 of Survey Map) Proceeding southwards across the strike of the strata, we have now to describe an important band of flagstones, shales, and mudstones, including certain seams charged with a characteristic assemblage of graptolites which furnish definite palaeontological evidence of

the age of the series. This band, which is much broader at certain localities than at others owing to the reduplication of the strata, is traceable across Sheet 9 of the Survey Map from Corfardine and Laight on the Sear Water, south-west by the Clodderoch Burn, Craigdarroch, Ballinie, Margree, and Gordonston, north-east of Dalry (river Ken). Although graptolites have been found at various localities along the line of strike of the beds, no species which is exclusively confined to the Glenkiln group has yet been found in this series, nor any form characteristic of the Birkhill group. The assemblage collected comprises graptolites common to the Glenkiln and Hartfell groups and a few zonal Hartfell forms. There is always, however, a remarkable similarity in the palaeontological types.

The band is further interesting from the fact that certain seams in it have yielded fragments of trilobites, at Corfardine on the Scar Water and in Clodderoch Burn, a tributary of the Dalwhat Water. These fragments are obscure or indefinite, and by themselves they have not been of much service in fixing the age of the beds containing them. In the Explanation of Sheet 9 (Appendix, p. 59) reference is made to the specimen obtained by Professor Harkness from a slate quarry at Corfardine — a cast in black shale of one-half of the pygidium. Mr. Etheridge, senior, was inclined to refer it to either of two genera, *Cybele* or Encrinurus, probably the latter; though its indefinite character scarcely justifies the giving of a name to the specimen. The fossil might be referred to the Llandeilo or Caradoc Rocks but hardly to any higher group. A trilobite found by Mr. Macconochie in the Clodderoch Burn exhibited imperfectly the thorax, pygidium, and a small portion of the carapace, and was referred to the genus *Phacops*. Though the evidence furnished by these imperfectly preserved trilobites is indefinite, the assemblage of graptolites suggests that the age of the beds is Caradoc.

Beginning with the north-eastern prolongation of the band in. Sheet 9, we find admirable sections in the Scar Water immediately to the north of Corfardine Farmhouse [NX 80922 96151], northwards to the mouth of the tributary Auchenhessnane Burn [NX 80605 96640]. Though the general dip is to the north-west at high angles, the beds are evidently repeated by sharp folds. They consist of flagstones and shales with thin hard ribs of a golden yellow colour, from a quarter to half an inch thick, alternating with blue shales, and they are occasionally associated with greywackes. They occupy the bed of the stream southwards to a point nearly opposite Corfardine Farmhouse, where they are associated with dark blue shales having layers of black shales in thin seams or bands. These black seams have afforded the following assemblage of fossils characteristic of the *Pleurograptus linearis* zone:

Dicellograptus Morrisi (Hopk.)

Dicellograptus caduceus (Lapw.)

Climacograptus like *tridentatus* (Lapw.)

Climacograptus bicornis (Hall.)

Climacograptus bicornis (Hall), with very long radicles.

Leptograptus flaccidus (Hall.)

Diplograptus foliaceus (Murch.)

Cryptograptus tricornis (Carr.)

Retiolites (Neurograptus) fibratus (Lapw.)

Siphonotreta micula (M'Coy.)

The Corfardine slate quarry [NX 80481 96134], from which Professor Harkness obtained his trilobite fragment, has been opened on the hill slope about 500 yards west of the farmhouse, in grey and blue shales, slightly cleaved, and enclosing worm tracks. A pygidium of *Phacops* and an *Orthoceras* were found in the debris during 1895.

South-westwards, beyond the watershed between the Scar and Shinnel Waters, the same series reappears in a tributary of the Shinnel that drains: the south slope of the Bennan Hill [NX 79533 94370]. At a point about half a mile up this tributary the dark seams in the blue and grey shales yielded *Climacograptus bicornis* and. *Diplograptus foliaceus.* Similar

beds on the same line of strike yielded *Climacograptus bicornis* in a small burn south-west of Corfardine on the Laight Hill above the Scar Water [NX 80544 95576].

Clodderoch Burn. — [NX 77528 93165] On the western side of the Shinnel Water a good section is to be seen in the Clodderoch Burn, which joins the Shinnel about 300 yards above the village of Tynron. Near the head of the burn at a point about 400 yards above the hill-road or footpath leading to Moniaive, grey shales are well exposed with black seams or films from an eighth to a quarter of an inch thick. The mode of occurrence of these black seams or films recalls the Ethological type of the Lower Hartfell Shales in Polmorlach Burn (Sheet 15). They have furnished the following graptolites, which are likewise characteristic of the *P. linearis* zone:

Cryptograptus tricornis (Carr.)

Diplograptus foliaceus (Murch.)

Climacograptus bicornis (Hall.)

Climacograptus tridentatus (Lapw.)

Retiolites (Neurograptus) fibratus (Lapw.)

Retiolites (Neurograptus) fibratus slab covered with small form.

Dicellograptus Forchhammeri (Gein.)

Dicellograptus elegans (Carr.)

DicellograptusMorrisi (Hopk.)

Dicellograptus like *anceps* (Nich.)

Leptograptus sp.

On the left bank of the stream, at the same place, green sandy mudstones or shales weather in long pencil-shaped fragments, and contain derivative mica. They somewhat resemble the type of Barren Mudstones in the Moffat region. They are contorted and thrown into sharp folds. Near the hill-path leading to Moniaive, the gradual passage of these mudstones and shales into greywackes, grits and shales is visible on the left bank.

Lower in the burn, at a point about 100 yards below this footpath, on the right or south bank, clayey shales or mudstones are associated with blue and black seams containing graptolites. In the clayey shales the specimen of *Phacops* was found, together with fragments of *Orthoceras,* while the dark or black seams referred to in a preceding paragraph furnished *Leptograptus flaccidus, L. capillaris,* and *Diplograptus.*

Further down the stream a ravine [NX 78690 93547] affords a good section of strata that present similar lithological characters, and have yielded at one point *Diplograptus foliaceus, Leptograptus flaccidus, Climacograptus bicornis,* and *Corynoides.*

Dalwhat Water. — [NX 76479 91979] Southwards along the same strike, these beds are again exposed in the Dalwhat Water, near Caitloch. Near the cave on the banks of the stream massive greywackes and grits appear; at the north limit of the Caitloch Wood shales are seen. For some distance up stream these shales are met with, containing the hard yellow-weathering ribs from a quarter to an inch thick. The blue wid grey sandy shales include occasional dark or black seams yielding graptolites. The hard ribs are sometimes from three to four inches thick at the upper limit of this section, and are occasionally associated with greywackes.

The intercalation of the dark or black seams in the grey or blue shales is well seen at a point about 500 yards up stream from Caitloch [NX 76080 92162]. The following forms were there obtained from the black seams:

Pleurograptus or *Amphigraptus*

Diplograptus foliaceus (Murch.)

Climacograptus bicornis (Hall.)

Dicranograptus sp.

Dicellograptus pumilus (Lapw.)

These beds can be followed along the strike across the Craigdarroch Hill to the Ballinie Burn [NX 72186 90147], where at a point about three-quarters of a mile west of Ballinie Farmhouse they have been found to contain *Diplograptus foliaceus, Climacograptus bicornis, Dicellograptus, Corynoides, &c.* Some of these forms were obtained also from an exposure in a burn on the hillside a short distance south of Ballinie.

To the south-west the same group of flagstones and shales reappears with a general dip to the north-west in the Pointfoot Burn which joins the Castlefern Burn about half a mile south of Minnygryle shepherd's house [NX 74775 87281]. Thence they can be followed at intervals towards the streamlet draining into Regland Loch [NX 69374 85946]. In the Whitecairn Burn, about a quarter of a mile below its outlet from that loch [NX 68766 85395], a section of mudstones like the Barren Mudstones of Moffat includes a thin seam of dark or black shales which may possibly be found to contain *Dicellograptus anceps.*

In the burn at Regland shepherd's house [NX 67450 85701], about three-quarters of a mile south of Margree, and again in the Margree Burn, representatives of this group, consisting of dark blue and grey shales with black seams, have yielded the following fossils:

Leptograptus flaccidus (Hall.)

Dicellograptus caduceus (Lapw.)

Dicellograptus caduceus or *Morrisi* (Hopk.)

Dicellograptus like *anceps* (Nich.)

Diplograptus foliaceus (Murch.)

Climacograptus bicornis

Retiolites sp.

The same strata can be followed in small exposures at intervals to Ardoch and Gordonston, a mile and a half north-east of Dalry. In the Ardoch Glen, 200 yards south from the farmhouse of Ardoch [NX 63465 83105], cleaved dark-blue shales have afforded *Climacograptus bicornis, Diplograptus foliaceus, Dicellograptus Morrisi, Dicellograptus caduceus (?),* and *Leptograptus flaccidus.* Again, in the Gordonston Burn [NX 63760 83024], that unites with the Ardoch stream to form the Torlane Burn [NX 63657 82506], the following fossils were obtained from these beds:

Diplograptus foliaceus (Murch.)

Cryptograptus tricornis (Carr.)

Climacograptus bicornis (Hall.)

Dicellograptus Morrisi (Hopk.)

Retiolites (Neurograptus) fibratus (Lapw.)

River Ken North of St. John's Town of Dalry. — The section in the river Ken northwards from Dalry displays very massive greywackes and grits. At the Miltonpark Burn, where a strip of alluvium flanks the river on the east bank [NX 61792 82336], the banded series of Corfardine on the Scar Water reappears, composed of blue-grey shales with thin hard ribs, weathering yellowish brown. Further up stream it is well seen in knobs in the river, dipping N.N.W. at 40°; the cleavage angle being 60°. At this locality four thin hard ribs, weathering yellow, were observed to be interleaved in blue-grey shales within a thickness of six inches of strata. Still higher on the west bank, and in the bed of the stream when the water is low, these dark blue shales with black seams extend for a distance of about 200 yards, dipping persistently to the N.N.W. at high angles, and yielding specimens of *Dicellograptus, Climacograptus,* and *Diplograptus.* Fragments of graptolites are very abundant, but few determinable forms are obtainable. The beds are evidently repeated by sharp isoclinal folds.

Beyond some blanks in the section, massive greywackes and grits appear to the west of Milton. Dark blue shales, greywackes, and black grits, at a point on the east bank about 150 yards south of the mouth of Barskeoch Burn, yield specimens of *Dicellograptus* and *Climacograptus* These strata occupy the river section northwards to the mouth of the Barskeoch Burn [NX 61053 83513], which joins the Ken from the west about a quarter of a mile north of Barskeoch Mains. This stream, at various points in its course, displays a section of black shales, so crushed and shattered, that few determinable graptolites can be got from them. About 250 yards west from the road leading to Dalry they have yielded *Diplograptus foliaceus* and *Climacograptus Schärenbergi;* a few yards west from the same road *Climacograptus*was found.

The section in the Ken, where this burn joins it, does not very satisfactorily show the relations of the cherts and black shales, which there crop out to the coarse sediments. The cherts, as seen on the west bank at the north edge of the alluvial patch, are grey in colour and contain abundant radiolaria. But they are here succeeded by greywackes and grits, and it is evident that the black shales are faulted out. The east bank of the Ken, however, affords two exposures of the black shales associated with greywackes, &c., but too shattery to yield graptolites for determination. The occurrence of the cherts and black shales at this point in the Ken section indicates that the adjoining sediments must be younger than Upper Llandeilo time, and younger than part of the Lower Harden black shale series.

North from the mouth of the Barskeoch Burn, the Ken flows over a succession of grits, greywackes, and shales similar to those above described. Below the junction of the Pulharrow Burn, the river has cut a deep gorge through these strata [NX 60732 84119]; indeed, at this part of the section the grits are very massive, and in some features differ but slightly from the grits of Tarannon age. Here and there throughout the grits, lenticular seams, patches, and bands of grey and blue shales appear, which give them an irregular character. The regular system of jointing, which, in unaltered areas, is such a conspicuous feature of the Queensberry or Llandovery grits, is not here present. At one point in the gorge the grits become pebbly like the "Haggis Rock", and contain well-rounded pieces of quartz, with fragments of felspar, black shale, and igneous rocks, &c. At the south end of the alluvial land at the mouth of the Pulharrow Burn, flaggy shales appear with a north-west dip, which may be on the horizon of the flaggy shales of Barlae.

iv. Black Shale Bands between Whiny Burn, Buchan Water, and Beninner Hill, near Cairnsmore of Carsphairn

Whing Burn (Euchan Water, a mile and a half southwest of Sanquhar; Sheet 15 of Survey Map). —Along a line of axial folds which stretches from the Whing Burn [NS 76137 06891], near Sanquhar, south-westwards by the Scar Water to the Lorg (river Ken) [NS 66787 00596] and Beninner Hill [NX 60604 97131], near Cairnsmore of Carsphairn (Sheet 9), excellent sections expose the relations of the Arenig volcanic rocks to the radiolarian cherts and Glenkiln black shales. In some of the arches the type of diabase or andesite-lava, so common at Ballantrae and throughout the Southern Uplands, is well represented, and the radiolarian cherts, which immediately overlie it, together with the Glenkiln black shales.

In a small burn which joins the Whing Burn from the east, near the Ulzieside Plantation [NS 76187 07088], the pillowy lava is faulted against greywackes on the north side, while on the south side, red mudstones and charts appear, which are followed by an outcrop of black shales.

In the Tongue Burn, another tributary of the Whing Burn west of Cairn Hill, about 300 yards above its mouth [NS 76482 06930], the following fossils were found in black shales associated there with grey shales:

Dicranograptus ramosus (Hall.)

Climacograptus bicornis (Hall.)

Dicellograptus Forchhammeri (Gein.)

Dicellograptus sp.

Diplograptus foliaceus (Murch.)

Leptograptus flaccidus

Retiolites sp.

Acrotreta Nicholsoni (Dav.)

Hyalostelia fasciculus (M'Coy.)

From this assemblage of organisms, as well as from the mode of occurrence of some of the forms, this band may be regarded as representing the basal portion of the Lower Hartfell black shales. The shells occur in profusion in a single layer, and likewise the arms of *Dicellograptus.*

In the Whing, northwards from the foot of the Tongue Burn [NS 76411 07234], there are frequent exposures of black shales, and radiolarian cherts with greywackes and shales. The strata are traversed by numerous reversed faults which disturb the relations of the rocks (Figure 83), (Figure 84). About eighty yards below the junction with the Tongue Burn, folded and contorted black shales occur, with a few feet of chert in the heart of the black shales. The black shales yield the following fossils:

Didymograptus superstes (Lapw.)

Cryptograptus tricornis (Carr.)

Climacograptus bicornis (Hall.)

Dicellograptus sextans (Hall.)

Dicellograptus patulosus (Lapw.)

Further down stream, at a bend about a quarter of a mile north from the foot of Tongue Burn [NS 76493 07503] and 70 yards north from southern limit of ground-plan (Figure 83), the black shales have supplied a fine suite of Glenkiln graptolites. In this part of the section admirable examples of the repetition of the beds by reversed faults are to be found. Here, on the right bank of the stream, the cherts occur in the heart of the black shales. The latter have yielded the following Glenkiln fossils:

Didymograptus superstes (Lapw.)

Caenograptus pertenuis (Lapw.)

Cryptograptus tricornis (Carr.)

Dicranograptus ramosus (Hall.)

Dicellograptus sextans (Hall.)

Dicellograptus patulosus (Lapw.)

Climacograptus Schärenbergi (Lapw.)

Climacograptus bicornis (Hall.)

Diplograptus euglyphus (Lapw.)

Lasiograptus bimucronatus (Nich.)

A few yards further down, on the right bank of the stream, well-banded black shales occur with cherts, and are overlain by greywackes (3 in (Figure 83)). This exposure affords well preserved graptolites belonging to the Glenkiln horizon, in particular, fine specimens of *Didymograptus superstes.* The following list was obtained from this locality:

Didymograptus superstes (Lapw.)

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Dicellograptus sextans (Hall.)

Dicellograptus moffatensis (Carr.)

Dicellograptus patulosus (Lapw.)

Climacograptus bicornis (Hall.)

Climacograptus Schärenbergi (Lapw.)

Lasiograptus trimucronatus (Nich.)

Diplograptus euglyphus (Lapw.)

Cryptograptus tricornis (Carr.)

Diplograptus foliaceus (Murch.)

Though in the Whing Burn the strata are much disturbed, and fossils are not easily obtained, the black shales associated with the cherts yield characteristic Glenkiln forms where the fossils can be determined. Above the point of junction with the Tongue Burn, black shales occur on several folds with rusty greywackes and shales. On the top of a waterfall formed of shales and greywackes, a band of black shales may be noticed, with alternations of grey and black seams, three to four feet broad. This band contains *Corynoides calycularis* in profusion, *Climacograptus bicornis, Cryptograptus tricornis ,* and *Diplograptus foliaceus.*

Cramley Burn (Tributary of the Glenmaddie Burn immediately to the west of the Whing Burn). — About a quarter of a mile above the junction of this stream with Glenmaddie Burn [NS 75278 06735], the Arenig lava is exposed on a green grassy knoll on the left bank of the stream, and on the south side of the lava the cherts are seen. A few yards further down stream the grey and dark cherts appear with black shales in separate folds. In the second outcrop of black shales in this burn, the following fossils have been obtained:

Didymograptus superstes (Lapw.)

Dicranograptus formosus (Hopk.)

Dicellograptus sextans (Hall.)

Dicellograptus patulosus (Lapw.)

Climacograptus Schärenbergi (Lapw.)

Dicranograptus ramosus (Hall.)

On the moor between the Cramley and Glenmaddie Burns, a small exposure of the lava may be noticed, and in the Glen-maddie Burn, at various places, the black shales and cherts are seen.

To the south-west of Glenmaddie Burn, on the moor between that stream and the Glen Burn, two prominent grassy knolls, which rise above the general level of the ground, consist' of the typical diabase-lava, slightly decomposed and showing pillowy structure. The more easterly mass, named "The Earl's Seat" [NS 74625 06477], is about 70 yards long. A few yards to the east of it the radiolarian cherts are visible, as the only exposure of sediments round this igneous projection. The western mass, over 200 yards in length, slopes gently off into the surrounding ground. At one place on the north-west side of this arch, the radiolarian cherts dip at a gentle angle to the north-west, and a few yards further north the black shales are visible. On the south side of the fold the red mudstones are seen, with the black shales close at hand to the south.

Along the line of strike of these arches, no section of the solid rocks has been cut by the Glen Burn [NS 74164 06343], the watercourse lying in boulder clay; but on the hill to the south-west of that stream, the volcanic rocks, cherts, and black shales reappear. On the hill slope facing the Glen Burn, and about 200 yards from the stream, the radiolarian cherts and black shales are repeated several times over a distance of 300 yards across the strike. Above the level of the 1250-feet contour line, and within 200 yards of the cairn on the hill-top, measured in a north-west direction, the diabase-lava is exposed. The cherts are seen at the north-west corner of the mass, and highly puckered black shales and cherts occur in the neighbourhood of the cairn.

The Glenlarie Burn, another tributary of the Euchan Water, a little further to the west, supplies sections at its sources where the relations of the volcanic rocks to the overlying sediments are displayed. Immediately to the west of the Mid Rig, this burn divides into two branches, both of which give sections of the Arenig Rocks [NS 73298 05676]. The west branch, about 300 yards above the fork, displays pillowy lava and tuff, resembling the Ballantrae volcanic series. The accompanying diagrams (Figure 85), (Figure 86) show the arrangement of the strata there. Grey and dark radiolarian cherts are pierced by a felstone dyke, which shows fluxion structure along its edges. Red mudstones succeed on the north, followed by a bed of tuff resting on a mass of, diabase-lava showing pillow-structure, about eighty-five yards in breadth (1 B, (Figure 85), (Figure 86). To the north this lava is followed by three feet of red mudstones, six to eight feet of lava, and three feet of tuff. Beyond this point no rocks are exposed till near the fork. The main mass of the volcanic rocks in this fold, as elsewhere, is shown to underlie the radiolarian cherts; and at one point tuff is associated with the cherts.

This section is probably bounded by a fault along the northwest side, for near its northern limit greywackes appear at the base of the steep grassy slope on the north side of the stream (1, (Figure 86)). Eastwards, where the burn flows through alluvium and peat, the lava appears on a grassy knoll, on which a sheep-stell is built, above the fork. This rock can be followed eastwards across the east branch of the Glenlarie Burn to the moor beyond. Two small exposures of lava lie to the south of this main fold, one in the east branch of the burn and another on the moor to the east. Two felstone dykes are seen in the east branch a few yards to the south of the second exposure of lava. Black shales and black flints appear further up the some rivulet.

Along the strike of the main fold of Arenig lava in Glenlarie Burn, the radiolarian cherts can be followed westwards for nearly a mile to the crest of the watershed between the Euchan and Scar Waters. At a few places, the black shales can be found both on the north and south sides of this fold.

On the watershed between the Glenlarie Burn and a tributary of the Scar Water east of Polgown [NS 73431 04972], another fold of the radiolarian cherts with the black shales is traceable at intervals for a distance of 600 yards.

Upper Basin of the Scar Water. — Crossing the watershed between the Scar and Euchan Waters, we will now follow the development of the Arenig rocks and overlying sediments in the upper part of the basin of the Scar Water.

At the head waters of the Polgown Burn interesting sections appear of the Arenig Rocks; one in particular is deserving of special mention, because intrusive dolerite is associated with the normal pillowy lava. It occurs about half a mile to the northwest of Polgown shepherd's house, in a streamlet draining a hill called the Rough Naze [NS 71561 04473]. In this rivulet, blue shales crop out (3, (Figure 87), south limit of diagram) about 300 yards above its point of junction with the Polgown Burn. These are faulted against massive reddened cherts which occupy about ten paces of the section, and are followed by highly puckered black shales (2I) pierced by a felsite dyke (F). To the north of these shales radiolarian cherts (C) appear, followed in descending order by a mass of pillowy lava (1 B), about twelve paces broad, which occupies the stream course at the prominent bend, and for some distance below it, and contains an inlier of red mudstones (C). Just above the bend, the pillowy lava is succeeded by coarse dolerite (B■), which is there faulted against the radiolarian cherts. On the grassy slope in the angle formed by the bend of the burn there is a boss of dolerite, probably the continuation of the mass in the burn a few yards to the north-east.

The radiolarian cherts (C) can be followed for a distance of ten paces north of the dolerite, when they are succeeded by greywackes and shales (3) for a space of 29 paces. The cherts reappear to the north with an infold of black shales (2I), from which the following fossils were obtained: *Didymograptus superstes, Dicellograptus sextans, D. Forchhammeri, Climacograptus bicornis,* and *Cryptograptus tricornis .*

About 200 yards to the east, two exposures of volcanic rocks may be seen on the grassy slope, evidently on separate folds, not far from each other, and parallel. The northern one shows diabase-lava, with an infold of chert and bounded by chert. The southern exposure contains both intrusive dolerite and the diabase-lava, with Arenig cherts and black shales, and is prolonged to the north-east. By means of chert debris it can be followed for a distance of half a mile in that direction.

Along the same strike the radiolarian cherts and black shales are exposed in another tributary of the Polgown Burn [NS 70950 04223], associated with intrusive dykes. They reappear on the south-east slope of the Rough Shoulder, in the Dalgonner Burn [NS 69171 03512], on the moor south of Corse Hill, and in the Polskeoch Burn at the very head of the Scar Water.

Water of Ken (Tributaries in Sheet 15 of the Survey Map). — Proceeding westwards along the general line of strike of the axial folds described in the foregoing pages, to the Polvaddoch Burn [NS 67930 02199]— a tributary of the Ken to the west of Polskeoch — we find a considerable development of black shales repeated by sharp folds, the radiolarian cherts being also exposed. About 200 yards south from the junction of the Pot Burn with the Polvaddoch Burn the black shales have yielded *Didymograptus superstes, Caenograptus pertenuis,* and *Dicellograptus moffatensis.* At an exposure of black shales to the north-east of this locality, and about the 1600-feet level, the following forms were collected: *Caenograptus gracilis, Dicranograptus zic-zac, Diplograptus tricornis,* and *Dicellograptus sextans.*

Westwards beyond the Lorg Hill, which separates the Polvaddoch and Lorg Burns, a section of great interest is displayed on the Rough Craig, overlooking the Lorg shepherd's house on the north-east side of the valley [NS 66857 01522](see ground plan, (Figure 89)). The hill-top is covered with peat and turf, and the Rough Craig appears as the observer begins to descend the steep slope towards the Lorg Burn, about the 1600-feet level. This section shows the sequence from the Arenig lavas and overlying cherts to the Glenkiln band of black shales. No coarse sediments are here associated with the volcanic rocks, cherts, or black shales, till we reach the greywackes and shales overlying the Glenkiln–Hartfell band of black shales.

At the northern limit of the section, where the black shales occur as rapid folds in the midst of greywackes and shales, the following fossils were obtained: *Caenograptus gracilis, Lasiograptus bimucronatus, Cryptograptus tricornis, Climacograptus,* and *Corynoides calycularis.* Passing south-eastwards along the face of the crag, where a felsite dyke traverses the black shales and greywackes, the observer finds about the 1600-feet level highly puckered black shales, terminating in sharp V-shaped folds in the upper portion of the crag, and there plunging underneath the overlying greywackes and shales. Still further south, the grey cherts appear in a sharp fold of the black shales nosing out northwards, and along the strike of this same fold the black shales are seen, followed by the overlying greywackes and shales higher up the crag. Crossing this sharp fold, we can trace cherts round the syncline of black shales, and they are succeeded by a fine exposure of the fine-grained diabase-lava occupying the core of an arch, the breadth of the

exposure of lava being about 30 yards. Here the rocky craig terminates, and the rock-exposures peer through a covering of grass. Still there is evidence of the occurrence of the lava on a second fold parallel with the foregoing, surrounded by the radiolarian cherts and black shales.

This section enables the observer to study the sharp folding and rapid reduplication of the strata. On the face of the crag, he may see along one and the same fold radiolarian chert, followed by black shales and greywackes and shales in the higher part of the crag. Hence, while along the face of the crag the rocks consist mainly of lava, cherts, or black shales, on the hilltop they are composed mainly or wholly of greywackes and shales.

Lorg Burn. — [NS 66693 00727] From the alluvial flats near the shepherd's house up to the fork, about half a mile above, this stream reveals a constant repetition of greywackes, black shales, and cherts, which, as a rule, are much shattered and cleaved (Figure 91). Fossils are difficult to find in the black shales. The cherts sometimes show fine flaser-structure, and the beds are traversed by various dykes. Two or three very small exposures of the lava appear among the folds of chert, so much crushed and deformed as to be almost unrecognisable.

On the west side of the valley, facing the Lorg shepherd's house, a gloomy crag nearly a quarter of a mile in length, displays a fine section [NS 66280 00702]. of Arenig cherts, black shales, and other sediments pierced by a great network of dykes. Here again the black shales are so cleaved and indurated, that it is difficult to prove the horizon of the bands by means of graptolites. It is instructive, however, to note the manner in which the radiolarian cherts appear in small lenticles, plunging rapidly under the black shales. The greywackes and shales frequently come next to the cherts on one limb of the fold without the intervention of the black shales — a structure probably due to normal or reversed faults. This feature is specially noticeable on that part of the crag to the south of the main burn, on the declivity immediately to the south of the network of dykes.

At the head of the main burn (south of Rough Cleuch) [NS 66037 00794] black shales have yielded the following fossils, which indicate that the zone may represent perhaps the passage beds between the Glenkiln and Harden groups:

Dicranograptus ramosus (Hall.)

Dicranograptus Nicholsoni (Hopk.)

Cryptograptus tricornis (Carr.)

Climacograptus bicornis (Hall.)

Dicellograptus sextans (Hall.)

Diplograptus foliaceus (Murch.)

To the north of the dykes, a constant repetition of radiolarian cherts and black shales extends as far as the Rough Cleuch [NS 66194 01013], at the head of which a deep ravine has been carved out of the black shales and charts. North of the Rough Cleuch, the presence of the cherts is indicated by debris of that material, seen at intervals. The black shales also appear on the slope facing the Alwhat Burn [NS 66213 01280], one of the tributaries of the Lorg Burn.

The top of the Ewe Hill [NS 65685 00818] is more or less covered with thin peat and turf, and hence it is not possible to trace continuously the folds of chert and black shales so well displayed on the crags in the Lorg valley. The western slope of that hill [NS 65282 00726], overlooking the Spout Burn, has a grassy covering, but occasional exposures of the radiolarian cherts and black shales may be noticed above the limit of the glacial deposits. For a distance of nearly a third of a mile along the slope, the cherts and black shales are brought to the surface again and again. Many, if not most, of the folds appear to be nosing out as we descend the slope, and hence the overlying sediments are exposed in the same line of strike in the bed of the stream in the centre of the valley. On the other hand, towards the top of Ewe Hill, the cherts appear, and seem to cover a considerable breadth of ground. It is highly probable, therefore, that the arches of Arenig cherts and black shales may extend across the Ewe Hill to the crag on the west side of the Lorg valley.

In the Spout Burn, about half a mile above its junction with the Holm Burn [NS 65320 00126], and again about half a mile above that junction, the cherts and black shales are visible. About two miles to the south-west, the Arenig cherts and overlying black shales reappear on Beninner [NX 60733 97166] and Moorbrock [NX 62124 9836] Hills.

Beninner Gairy, Cairnsmore of Carsphairn. — The ridge of Beninner (2328 feet) [NX 60730 97161], forming the south-east spur of Cairnsmore of Carsphairn, has a rocky escarpment along its eastern face, composed of Silurian rocks, which have undergone more or less alteration in contact with the granite mass; portions of this gairy are precipitous, but the exposures of the Moffat series are readily accessible.

About 300 yards to the south of the cairn on the top of Beninner, four folds of the radiolarian cherts, associated with black shales, can be followed down part of the rocky escarpment [NX 60592 96770]. A few yards further north in the gairy, another small fold of the cherts is bounded by the black shales, and followed immediately by brown-weathering greywackes and shales, with abundant minute biotite of secondary origin. The cherts are slightly granulitised, and the black shales are changed into graphitic schist, with traces of graptolites.

Advancing northwards along the crag, the observer crosses fine-grained greywackes and shales with mica of contact origin, till at the bend due east of the cairn on the top of the mountain he comes upon an arch which brings in the Arenig volcanic rocks. On referring to the one-inch map (Sheet 9), it will be seen that the granite boundary, which crosses the Poldores Burn in an east and west direction, skirts the base of the Beninner Gairy, [NX 60869 97292] and thence curves towards the north-west [NX 60443 97690] along the base of the escarpment formed by the altered Silurian rocks. At the bend due east of the cairn on Beninner top, a fine development of the grey cherts in contact with the granite can be followed up the cliff for some distance. The alteration displayed by the cherts at this locality is not nearly so pronounced as at the granite margin south of Loch Doon, but they are granulitised.

The heart of this fold of cherts encloses a small exposure of volcanic rocks, partly bedded and partly intrusive, which measures about five yards broad by about fifteen yards long. The lava is vesicular, with garnets developed in the vesicles by contact alteration. It is granulitised, and contains abundant brown mica of secondary origin. In the centre of the altered lava there is a small mass of coarse-grained altered dolerite or gabbro. The cherts are succeeded by altered black shales on the south side of the fold, and these in turn towards the south-west by altered greywackes and shales.

Moorbrock Gairy. — [NX 62063 98554] The development of Arenig cherts on Moorbrock Gairy, one mile N.N.W. of Moorbrock shepherd's house, and on the crest of the ridge to the west, readies a much grander scale than on Beninner Gairy. They are not much altered; indeed, radiolaria can be detected in many of the exposures though the rocks are slightly granulitised. Both the dark and grey varieties occur. The volcanic rocks have not been here detected in the cores of any of the folds of Arenig cherts.

A broad development of cherts on the gairy due east of the cairn on Moorbrock Hill, contains in its centre a trough of black shales, yielding characteristic Glenkiln forms. This synclinal fold occurs at the base of the crag and above the 1600-feet contour line. Inclusive of this fold of black shales in the centre of the mass, the distance from the southern boundary of this outcrop of chert to its northern limit is about 150 yards. The cherts are highly corrugated. Along the southern margin of the cherts, the black shales are visible not far to the north of an oval mass of intrusive granite in the gairy. The intrusive rock, being of less durable material, has been decomposed, and is surrounded by indurated Silurian rocks. On the crag above the small granite mass, the cherts may be seen to form tongue-shaped projections in the overlying black shales and dark gritty greywackes, due to the rapid folding of the strata. The black shales are sometimes thrown out by faulting, and the greywackes come in contact with the cherts. But at the top of the crag the black shales occur next to the chert on the south side of the fold. These black shales yield graptolites. The best locality for fossils, however, is the trough of black shales in the heart of the cherts at the base of the crag, east of the cairn, where the following species were obtained:

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Dicranograptus zic-zac (Lapw.)

Dicranograptus ramosus (Hall.)

Dicellograptus sextans (Hall.)

Dicellograptus moffatensis (Carr.)

Dicellograptus patulosus (Lapw.)

Leptograptus flaccidus (Hall.)

Lasiograptus bimucronatus (Nich.)

Diplograptus foliaceus (Murch.)

Climacograptus bicornis (Hall.)

Cryptograptus tricornis (Carr.)

The black shales are not seen on the gaily along the north margin of this fold of chert; they are evidently faulted out. A dyke of acid intrusive rock runs up the cliff about the line of junction between the cherts and greywackes. The strata found in the gairy to the north of this point consist of greywackes, which show a considerable development of brown mica of secondary origin.

To the south of the small granite boss above referred to as occurring in the gairy [NX 62182 98392], there are minor folds of the cherts and black shales. In the coomb-shaped hollow that forms the south half of the Moorbrock Gairy, drained by the White Burn, west of Glenhead, another exposure of cherts, grey and dark, of the nodular varieties, is nearly 150 yards broad. Along its north and south margins, the black shales appear, and they likewise form a synclinal fold in the centre of the mass. This broad fold of the cherts can be traced westwards from the gairy of Moorbrock across the hill-top to the edge of the granite mass. The alteration of the chert is irregular; in places the rock is granulitised, while at other localities it merges into the fine granular quartz variety which is a phase of the extreme metamorphism that occurs near Loch Doon.

Band of volcanic rocks between the Kello and Euchan Waters, probably of Caradoc age

About two miles to the north of the belt of Arenig Rocks and Glenkiln–Hartfell black shales which stretches from the headwaters of the Ken to the Sanquhar basin of Carboniferous Rocks, a narrow zone of volcanic rocks runs more or less parallel, and traceable at intervals for three miles, from near the edge of the Sanquhar coal-field to the Poltallan Burn, one of the higher tributaries of the Euchan Water. Nowhere along their line of outcrop are these volcanic rocks associated with Arenig cherts or with black shales yielding characteristic Glenkiln graptolites. The fossils which do occur are common to both horizons. In the sequel we shall point out that several miles to the north of this line of outcrop, the radiolarian cherts and Arenig volcanic rocks are to be found in the area bordering the New Cumnock coalfield, where the characteristic Glenkiln graptolites are still met with in black shales. It is probable, therefore, that the narrow zone between the Kello and. Euchan Waters may occupy a higher horizon than that of the Arenig volcanic series. Indeed, in the Poltallan Burn, tuff is interbedded in shales which contain graptolites that indicate a Lower Hartfell horizon.

Barr Moor (three miles S.W. from Sanquhar). — [NS 74435 08076] At the eastern limit of the volcanic zone a small exposure of black shales is met with in the Birk Burn, in the wood at the very edge of the Carboniferous basin [NS 74006 09157]. Black shales, containing nodules of greywacke and grit, or nodular masses of these materials, have there been laid bare by the denudation of the overlying thin cake of Carboniferous sandstone. In the west fork of this stream, about a quarter of a mile from the edge of the basin, a section on the right bank exposes upwards of 20 feet of lava [NS 73948 10061], the vesicular character of which is well seen in weathered specimens. On the north side of the lava, in the bed of the stream, crushed dark blue shales occur, while on the south side blue shales are seen on the right bank.

The next exposure of the volcanic zone is to be seen in a small tributary of the Kello Water, about half a mile to the west of the outcrop just described [NS 73165 10065], and nearly a mile from the foot of the stream. The burn flows over tuff, which has a grey matrix of volcanic debris and contains bombs of diabase-lava. On the south side of this tuff, and in contact with it, black shales yield the following fossils:

Dicranograptus ramosus (Hall.)

Cryptograptus tricornis (Carr.)

Diplograptus foliaceus (Murch.)

Leptograptus flaccidus (Hall.)

Climacograptus sp.

Dicellograptus sextans (Hall.)

Dicellograptus Forchhammeri (Geiz.)

Westwards, the tuff is traceable by means of debris in drains to the March Burn [NS 72055 08392], while occasional debris of vesicular lava also appears, as on the hill slope not far to the west of the March Burn. Still further west, in the Polsalloch Burn [NS 71353 08266], a tributary of the Kello Water between the March Burn and Glengap, and two-thirds of a mile from its junction with the Kello, tuff appears in the bed of the stream. On the north side, grey greywackes and shales dip to the south-east. Though the actual contact of the tuff with the greywackes is not seen in the stream, they occur close to each other. The greywackes form the slope on the north bank, where they dip to the S.S.E. The tuff has here also a grey matrix, and contains blocks of vesicular lava.

South-westwards on the slope, about 100 yards distant from the Polsalloch Burn, the slaggy lava is exposed in a small scar, and reappears on the hill slope facing the Glengap Burn. A microscopic examination of a specimen of the lava from the latter locality shows that "only the felspars are preserved, which occur in the form of short laths, and are associated with carbonates and turbid decomposition products. The spherical amygdules are formed of calcite". On this slope, both slaggylava and tuff are visible in a well-marked grassy feature through which they protrude. Black shales occur at one point on the south side of the volcanic rocks, followed immediately by coarse grits. Indeed, on the slope near the col between the Glengap and Poltallan Burns the grits become conglomeratic.

Poltallan Burn (Euchan Water). — [NS 69652 06927] In this burn, about 300 yards up from its junction with the Euchan Water, a band of tuff passes into an ashy grit, about eight feet broad. On the north side it is followed by dark blue sandy shales yielding *Diplograptus foliaceus, Corynoides calycularis,* and *Climacograptus.* The shales are much cleaved, but in certain seams *Corynoides calycularis* and *Climacograptus* occur in profusion. The tuff is also visible in the bed of the Euchan at the Euchanhead shepherd's house.

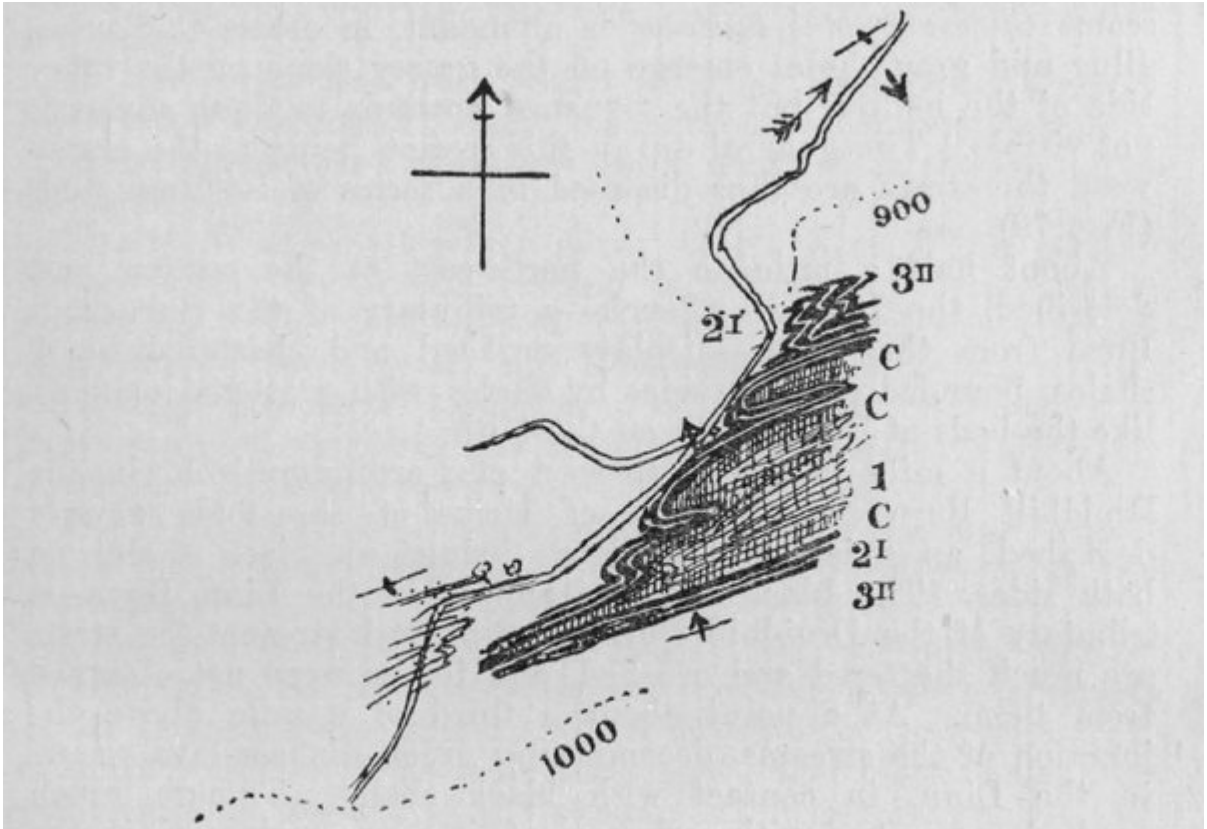

Fig. 78.—Plan of Strata in a tributary of Burnsands Burn, 400 yards east of Fardingmullach, Nithsdale.

1. Red mudstone (Arenig). C. Radiolarian chert. 2l. Glenkiln Shales. 3ll. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc).

(Figure 78) Plan of Strata in a tributary of Burnsands Burn, 400 yards east of Fardingmullach, Nithsdale. 1. Red mudstone (Arenig). C. Radiolarian chert. 2l. Glenkiln Shales. 3ll. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc).

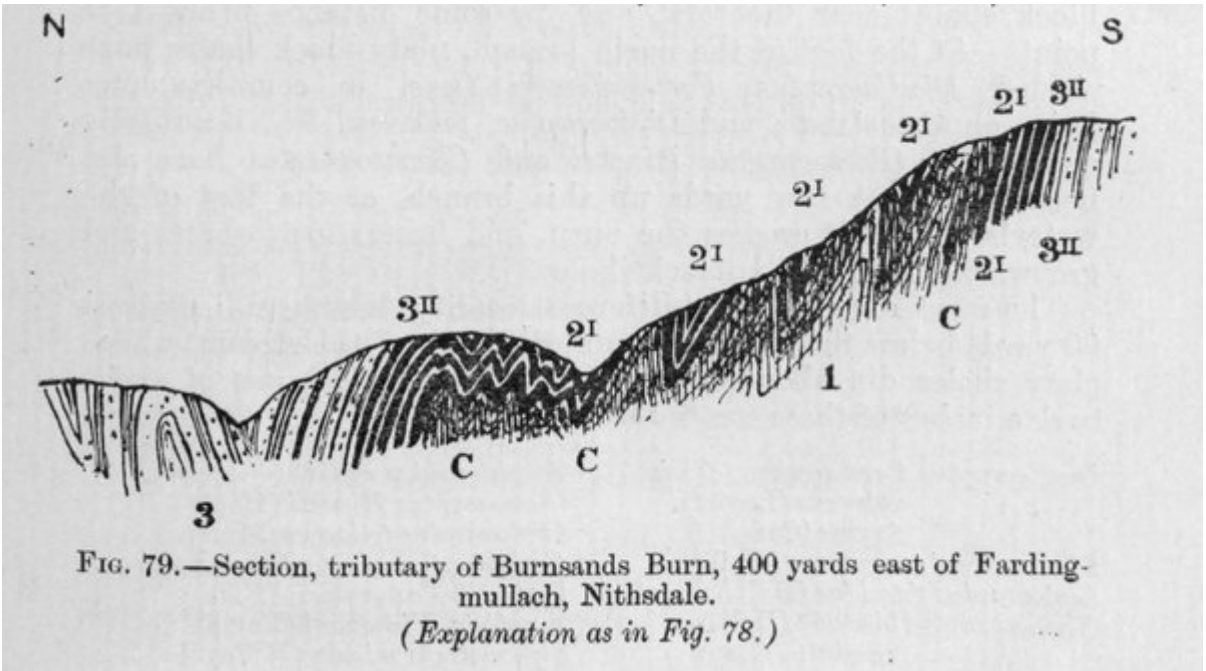

Fig. 79.—Section, tributary of Burnsands Burn, 400 yards east of Fardingmullach, Nithsdale.

(Explanation as in Fig. 78.)

(Figure 79) Section, tributary of Burnsands Burn, 400 yards east of Fardingmullach, Nithsdale. (Explanation as in (Figure 78).)

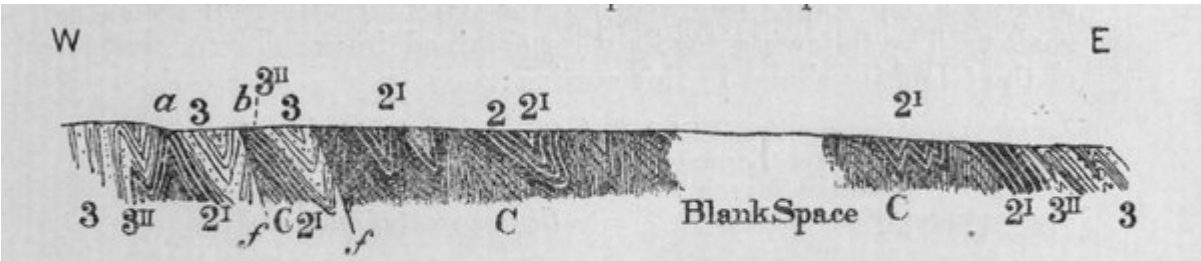

FIG. 80.—Section in Chanlock Water, Chanlockhead.
C. Radiolarian chert. 2l. Glenkiln Shales. 3ll. Lower Hartfell Shales.
3. Greywacke and shale (Caradoc).

(Figure 80) Section in Chanlock Water, Chanlockhead. C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc).

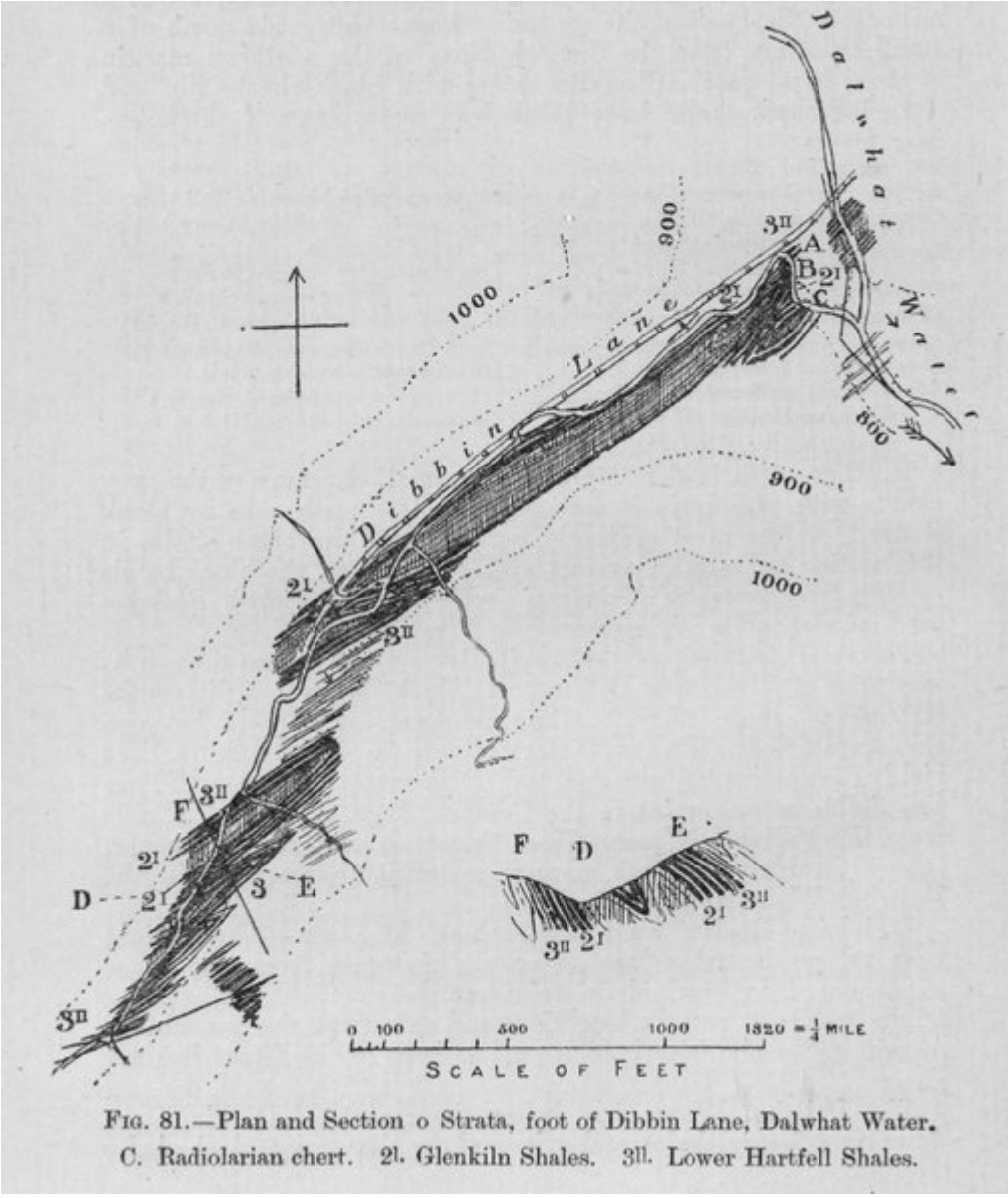

FIG. 81.—Plan and Section o Strata, foot of Dibbin Lane, Dalwhat Water.
C. Radiolarian chert. 2l. Glenkiln Shales. 3ll. Lower Hartfell Shales.

(Figure 81) Plan and Section o Strata, foot of Dibbin Lane, Dalwhat Water. C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales.

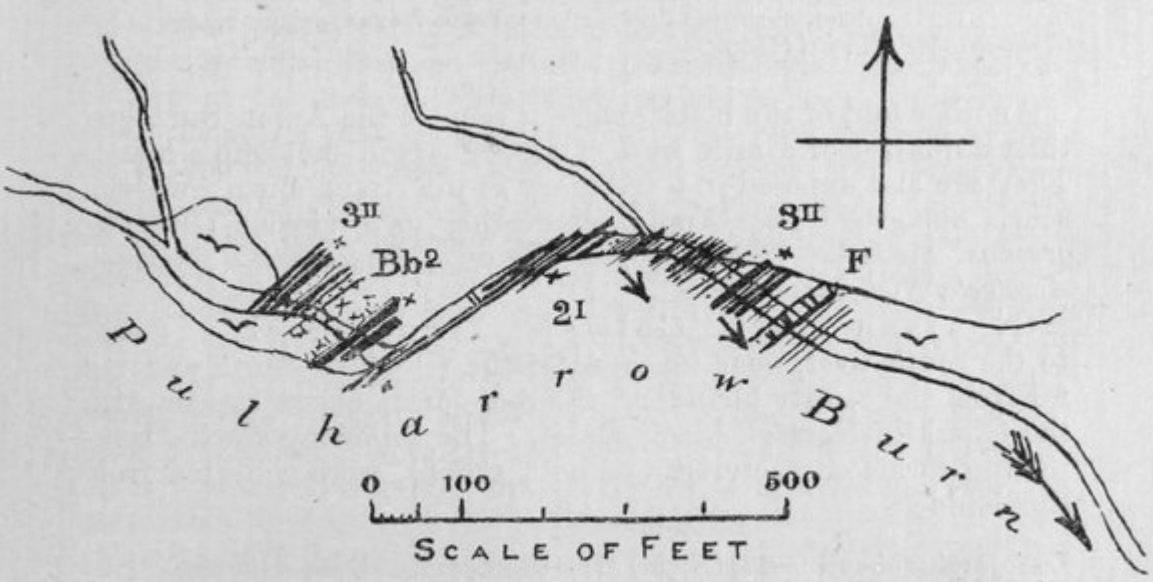

FIG. 82.—Plan of Strata in Pulharrow Burn, near Nether Forrest.

2l. Glenkiln Shales. 3ll. Lower Hartfell Shales. Bb2. Diabase-lava.
F. Felsite dyke. ~ Alluvium.

(Figure 82) Plan of Strata in Pulharrow Burn, near Nether Forrest. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. Bb2. Diabase-lava. F. Felsite dyke. [Alluvium symbol] Alluvium.

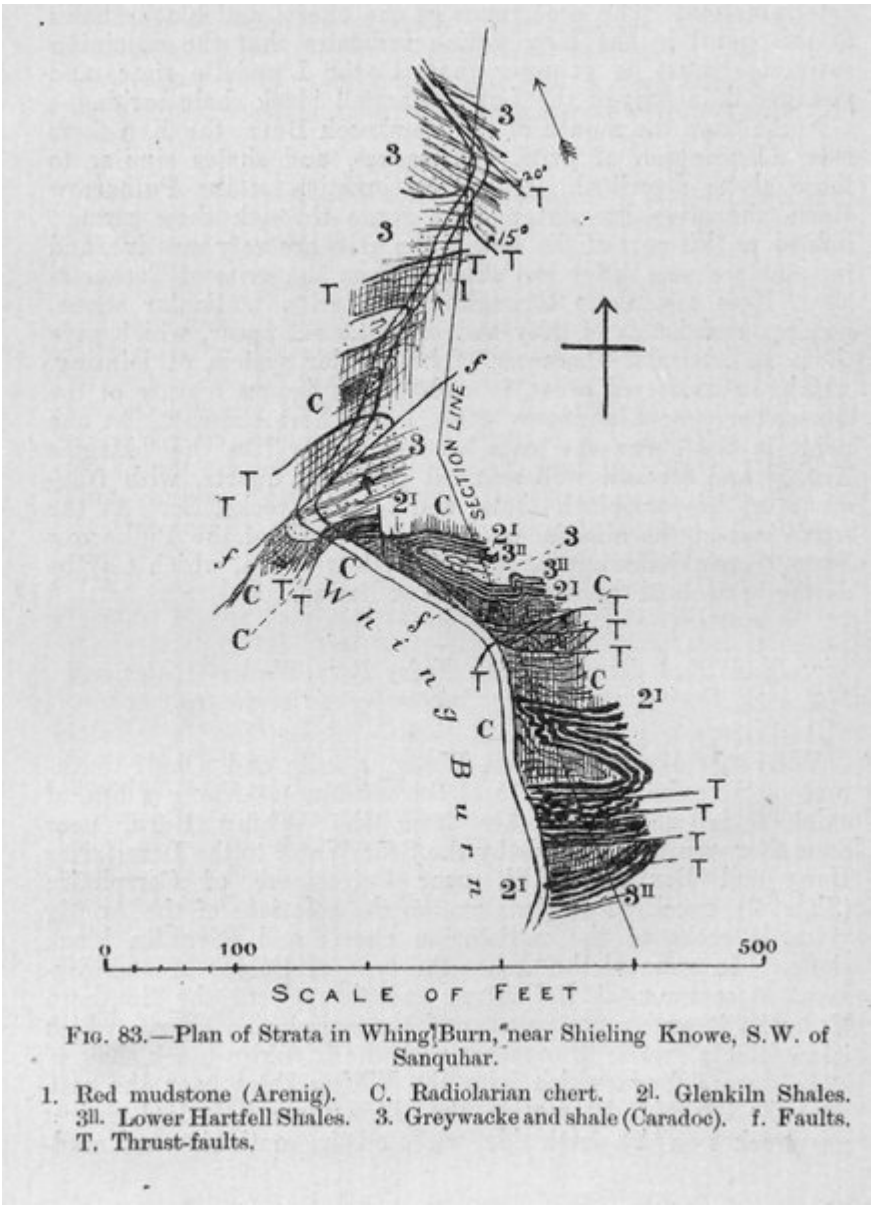

FIG. 83.—Plan of Strata in Whing Burn, near Shieling Knowe, S.W. of Sanquhar.

1. Red mudstone (Arenig). C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc). f. Faults, T. Thrust-faults.

(Figure 83) Plan of Strata in Whing Burn, near Shieling Knowe, S.W. of Sanquhar. 1. Red mudstone (Arenig). C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc). f. Faults, T. Thrust-faults.

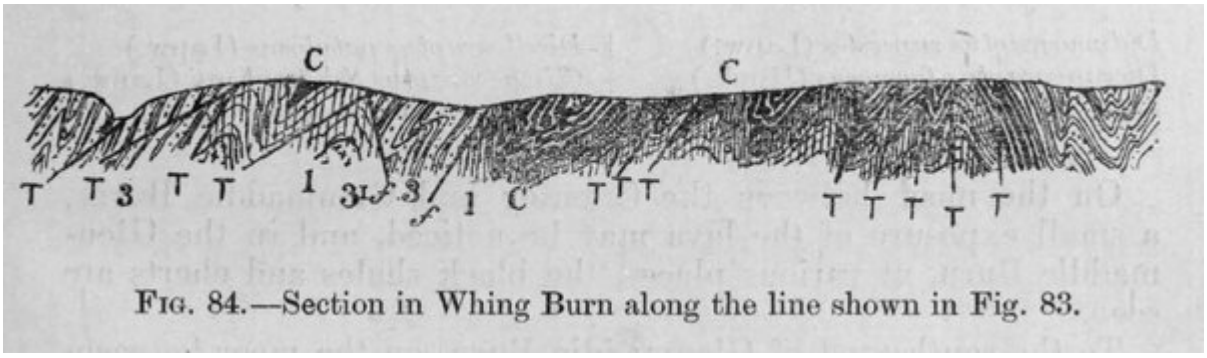

FIG. 84.—Section in Whing Burn along the line shown in Fig. 83.

(Figure 84) Section in Whing Burn along the line shown in (Figure 83).

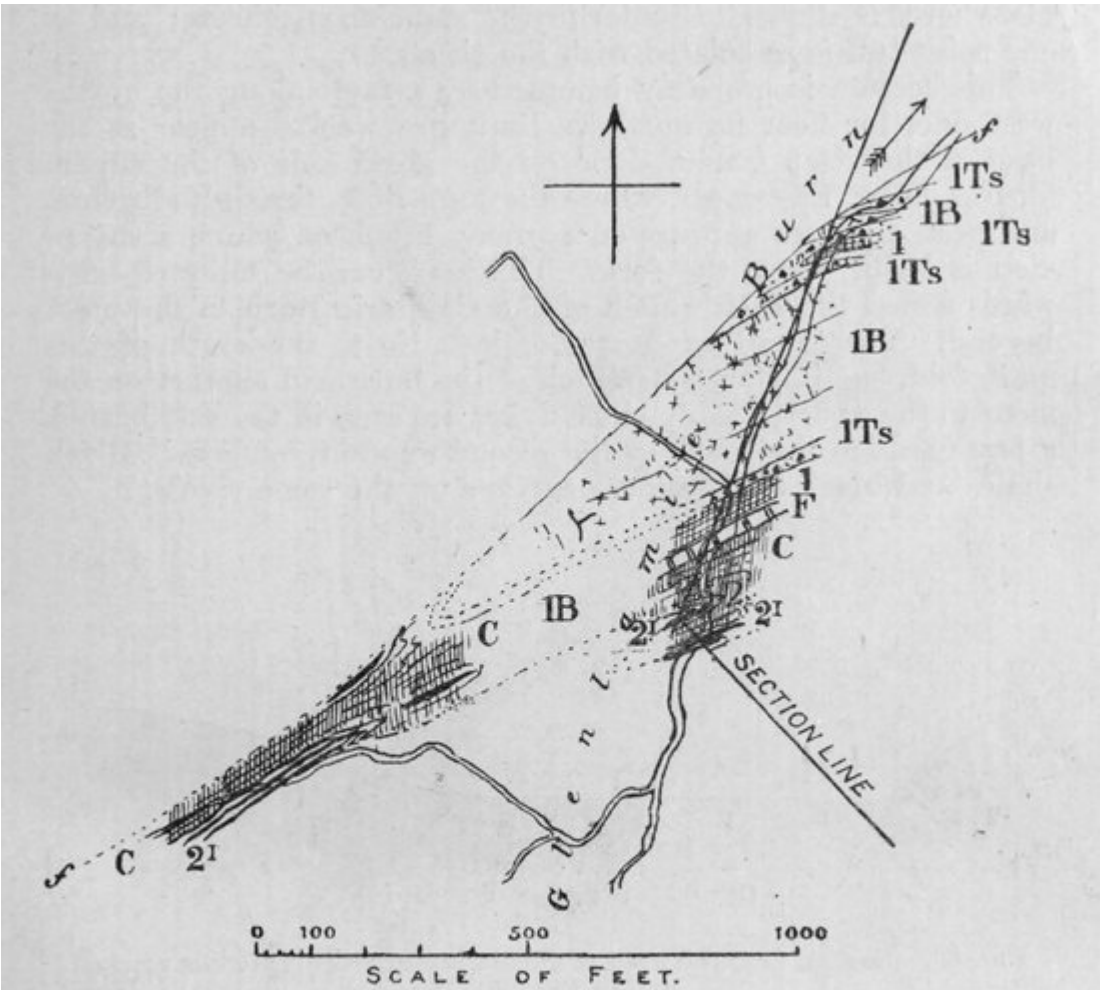

FIG. 85.—Plan of the Strata near the Head of Glenlarie Burn, 4½ miles S.W. from Sanquhar.

1B. Diabase-lavas. 1Ts. Tuff. 1. Red mudstones. C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc). F. Felsite dyke.

(Figure 85) Plan of the Strata near the Head of Glenlarie Burn, 4½ miles S.W. from Sanquhar. 1B. Diabase-lavas. 1Ts. Tuff. 1. Red mudstones. C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc). F. Felsite dyke.

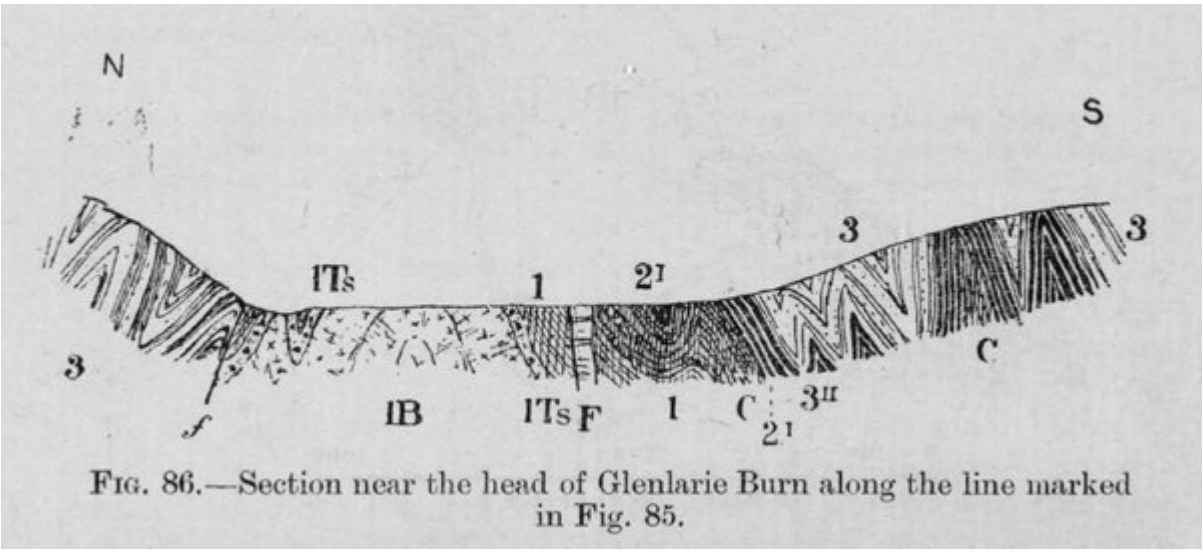

FIG. 86.—Section near the head of Glenlarie Burn along the line marked in Fig. 85.

(Figure 86) Section near the head of Glenlarie Burn along the line marked in (Figure 85).

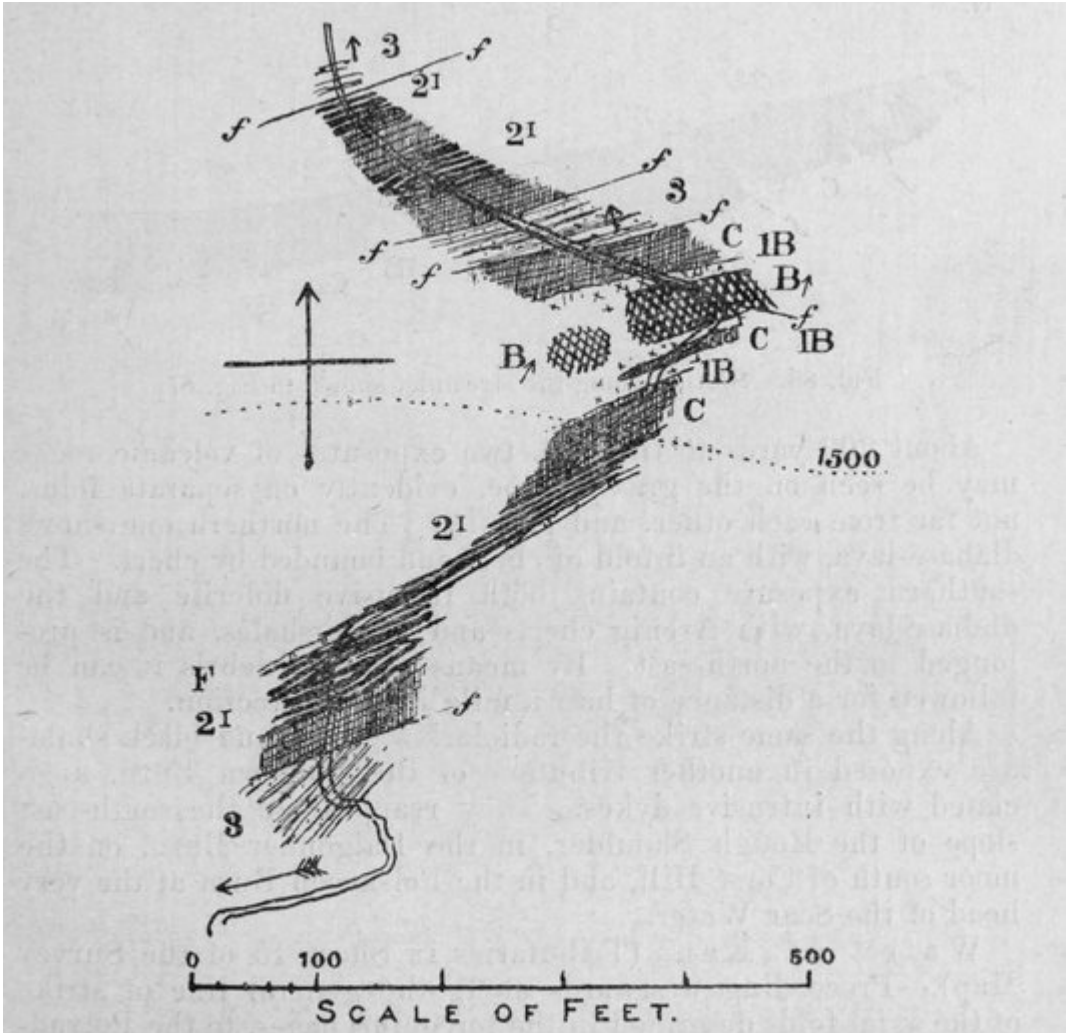

FIG. 87.—Plan of Strata in Streamlet near Polgown, Scar Water.

1B. Arenig lavas. 1B*T*. Intrusive dolerite (Arenig). C. Radiolarian chert. 2l. Glenkiln Shales. 3ll. Lower Hartfell Shales. 3. Greywake and shale (Caradoc). F. Felsite dyke. f. Fault.

(Figure 87) Plan of Strata in Streamlet near Polgown, Scar Water. 1B. Arenig lavas. 1B■ Intrusive dolerite (Arenig). C. Radiolarian chest. 2I. Glenkiln Shales. 3II. Lower Harden Shales. 3. Greywake and shale (Caradoc). F. Felsite dyke. f. Fault.

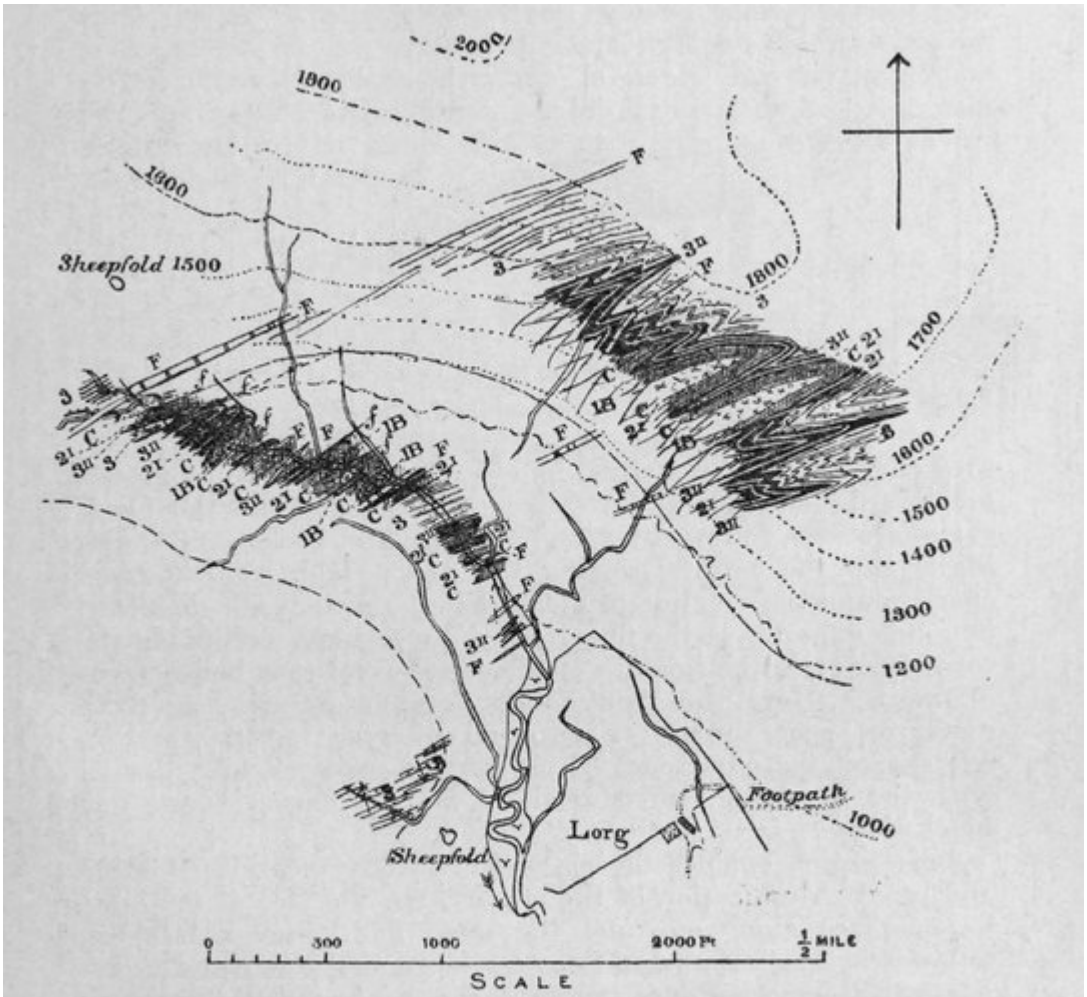

FIG. 89.—Ground Plan of Strata in Lorg Burn and Rough Craig, Water of Ken, Kirkcudbrightshire.

1B. Arenig lavas. C. Radiolarian chert. 2l. Glenkiln shales. 3ll. Lower Hartfell Shales. 3. Greywacke and shale (Caradoc). F. Felsite dyke. f. Fault. Dotted lines, contour lines. Interrupted lines, upper limit of glacial deposits.

(Figure 89) Ground Plan of Strata in Lorg Burn and Rough Craig, Water of Ken, Kirkcudbightshire. 1B. Arenig lavas. C. Radiolarian chert. 2I. Glenkiln shales. 3II. Lower Harden Shales. 3. Greywacke and shale (Caradoc). F. Felsite dyke. f. Fault. Dotted lines, contour lines. Interrupted lines, upper limit of glacial deposits.

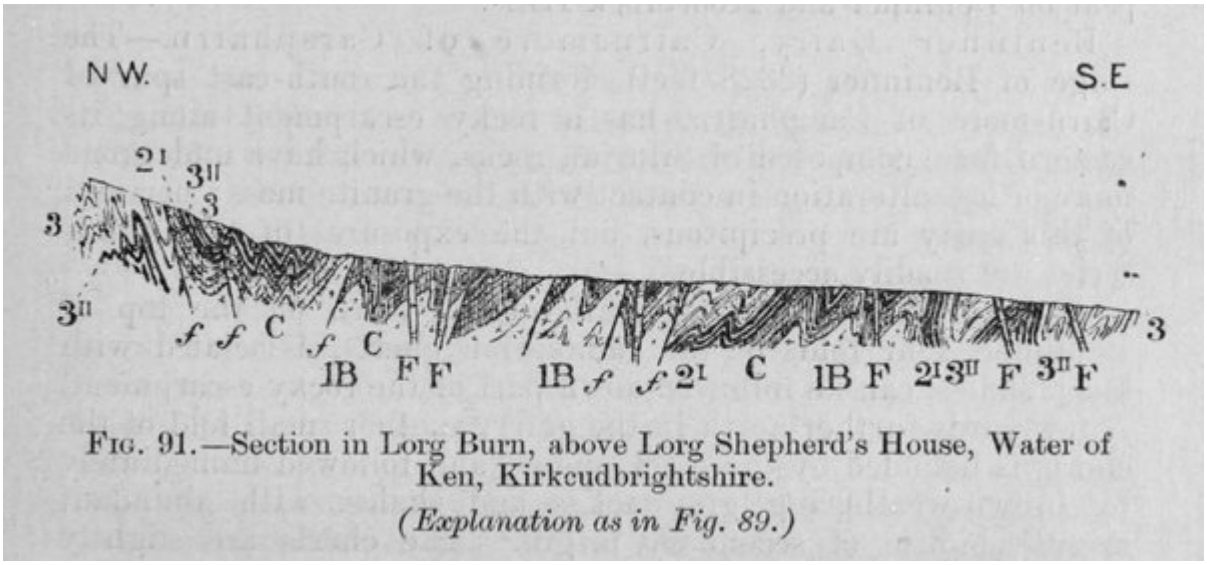

FIG. 91.—Section in Lorg Burn, above Lorg Shepherd's House, Water of Ken, Kirkcudbrightshire.

(Explanation as in Fig. 89.)

(Figure 91) Section in Lorg Burn, above Lorg Shepherd's House, Water of Ken, Kirkcudbrightshire. (Explanation as in (Figure 89).)