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## Chapter 15. The Northern Belt — continued. Arenig, Llandeilo, and Caradoc formations of the Leadhills district — continued

We may now trace the black shale bands which lie within a belt extending from Bail Hill, three miles north-west from Sanquhar, by Kiln Burn, Spotfore Burn, and Corsebank, in the basin of the Crawick Water, to Snar Castle and the Shiel Burn south of Crawfordjohn. This belt of ground furnishes evidence of the lateral modification of the Lower Hartfell group in the direction of the northern margin of the tableland. While the Glenkiln Shales in the neighbourhood of Bail Hill still present the normal lithological type of the Moffat region with their zonal fossils, the highest zone of the Hartfell black shales has disappeared, and its persistent form *Climacograptus caudatus* occurs in a thin dark seam in brown sandy shales near Carco, east of Bail Hill. No less interesting is the important development of Silurian volcanic rocks on Bail Hill, and the bands of andesite-lava and tuff interstratified with the Lower Caradoc Rocks of Craignorth Hill and other localities. While describing the various outcrops of the Moffat series along this belt of ground, we ought to point out that they occur on various compound folds separated by coarser sediments, some of which are composed of conglomerates indicating local unconformabilities. It ought further to be borne in mind that the black shale bands can be traced for no great distance, as they are buried to the north-east and south-west under younger deposits.

**Bail Hill volcanic area.** — By far the most important volcanic area in the Silurian Tableland, after that of Ballantrae, is to be found round Bail Hill [NS 76025 14239], about three miles north-west of Sanquhar. Truncated on the west side by the fault which bounds the Carboniferous basin of Upper Nithsdale, the volcanic materials occupy an area of about three-quarters of a square mile, and rise to a height of 1474 feet on Bail Hill. Small though it be, this limited tract is remarkable for the peculiar types of lava and agglomerate which it contains. Several stream sections traverse the western slope, but the volcanic rocks may be studied to advantage on the numerous rocky knolls near Cat Cleuch [NS 75664 12958] and to the south-west of Bail Hill (Figure 73), (Figure 74), (Figure 75).

The physical relations of the strata point to the conclusion that these volcanic materials were erupted mainly during Arenig time, for the Arenig cherts are found in contact with them at the south-east margin, and small outliers of chert likewise occur within the volcanic area. But while this is true, there are certain sections in the southern part of the tract where lavas are so interstratified with black shales yielding Glenkiln graptolites as to suggest that some local eruptions may have taken place in. Upper Llandeilo time.

At the south-east boundary of the tract, near the margin of the Sanquhar coal-field, a small burn, named the Cat Cleuch [NS 75664 12958], a tributary of the Tower Burn, traverses a part of the volcanic area. Near the spot where this stream crosses the old road between Sanquhar and Muirkirk, an excellent section may be seen of highly puckered green cherts with abundant radiolaria (C. (Figure 73), E.S.E. limit of section), associated with a thin band of ashy material. Descending the slope to a point about 100 yards south-west of the hill-road we find the radiolarian cherts close to volcanic agglomerate (1Ts, (Figure 73), E.S.E. limit of section). The junction is not visible, as it is covered with turf, but the distance between the two rocks is not more than a few feet. A microscopic section No. [\(S6817\)](#) of a specimen taken from the agglomerate at this locality shows that the "rock is composed of detached crystals of augite, hornblende, and felspar, and fragments of andestic rocks. The rock fragments are not all of the same type; some contain large phenocrysts of plagioclase and hornblende, similar to those which occur isolated in the rock, in a microlitic matrix; others are without phenocrysts. One fragment is mainly composed of microlitic felspar & which show a tendency to assume a feathery mode of aggregation". The foregoing type of hornblende-andesite-tuff is met with on the slope towards the sheep-ree and the stone fence that crosses the Cat Cleuch Burn. A specimen No. [\(S6818\)](#) [NS 75825 13384] taken from the rocky knolls just above this fence shows under the microscope "crystals and crystal fragments of pale brown hornblende very abundant, fragments of felspar and augite much less abundant, and somewhat vague rock fragments".

On the other side of the stone fence near the sheep-ree in the Cat Cleuch, fine-grained tuff appears with augite crystals. On the east bank brecciated black shales occur, in contact with the fine-grained tuff. Further down, on the same bank, black shales yield Glenkiln graptolites, followed by radiolarian cherts. On the opposite bank, about 100 yards below the stone fence, from a small exposure of black shales, the following Glenkiln graptolites in fairly good preservation were collected:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus moffatensis* (Carr.)

*Climacograptus Schärenbergi* (Lapw.)

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

*Glossograptus Hincksi*; (Hopk.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

A few yards down stream from this section of black shales, an intrusive igneous rock, resembling a mica-trap, occurs in the course of the burn where it traverses the radiolarian cherts. Near the spot where the fault that bounds the Carboniferous basin crosses the Cat Cleuch [NS 75735 13033], the latter receives a small tributary on the north side, which furnishes the following section. In the lower part of its course the intrusive rock just referred to appears where it clearly pierces the radiolarian cherts. The microscopic examination of a specimen No. [\(S6816\)](#) [NS 75768 13050] from this locality shows that the rock contains "phenocrysts of biotite, felspar (altered, but apparently for the most part plagioclase), and apatite, in a reddish-brown turbid matrix with carbonates. The apatite occurs in considerable abundance as limpid crystals, which are often as large as the porphyritic felspars. ' In general appearance the rock resembles a mica-trap.

About 200 yards above the point where this tributary joins the Cat Cleuch, evidence bearing on the relation of the lavas to the Glenkiln Shales and Arenig cherts is visible. The radiolarian cherts appear at a bend in the burn, followed by black shales and volcanic rocks; and these are in turn succeeded by 27 feet of black shales, which contain graptolites in fairly good preservation, proving the Glenkiln horizon of the shales, as shown in the following list:

*Didymograptus superstes* (Lapw.)

*Caenograptus* sp.

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Cryptograptus tricornis* (Carr.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus moffatensis* (Carr.)

*Dicranograptus ramosus* (Hall.)

*Climacograptus bicornis* (Hall.)

*Glossograptus Hincksi* (Hopk.)

At a spot about three feet from the northern margin of the band the following forms were obtained: *Dicranograptus ramosus*, *Diplograptus foliaceus*, *Climacograptus Schärenbergi*, *Cryptograptus tricornis*. These black shales are followed by a bed of diabase-lava three feet thick, and a band of black shales two and a half feet thick, yielding *Dicellograptus sextans*, *Diplograptus foliaceus*, *Climacograptus*, succeeded in turn by slaggy diabase-lava. As the junction between the lava and the black shales was here exposed, and no fault seemed to intervene, it is not improbable that these thin lava-sheets may point to contemporaneous volcanic action in Upper Llandeilo time.

Above this point the stream lays bare a fine section of the tuff. Though in places the rock at first sight resembles a lava, its fragmental character is apparent on a weathered face. A conspicuous feature in it is the abundance of large crystals of augite which project on the weathered surfaces, and which, where the matrix is highly decomposed, can easily be removed. The largest crystal observed in the field measured about an inch across, but this is quite exceptional. Under the microscope, a specimen of the rock taken from this locality No. (S6819) [NS 75768 13112] is found to be a tuff composed "of large fragments of a coarsely porphyritic augite-andesite. The augite crystals show the common forms, and are yellowish in thin sections. The felspar crystals polarise as aggregates, and are indeterminable in consequence of alteration. It is interesting to note that both hornblende- and augite-andesites have been broken up to form these tuffs". (1 Ts, (Figure 73), (Figure 74), E.S.E. limit of sections.)

Westwards this peculiar tuff and agglomerate can be traced for a distance of 300 yards south of the stone fence already mentioned, where it contains well-rounded blocks of various igneous rocks, including gabbro, diorite, granite, andesite, and lava of a more acid type than any found in the neighbourhood. A similar coarse agglomerate, charged with blocks of gabbro and pink and grey granite, is visible at a point about 550 yards up the west tributary of the Cat Cleuch. Close to this exposure a band of fine-grained andesite or diabase-lava comes to the surface.

In the streams and on the hill slopes, north-westwards across the area in a direction parallel to the fault bounding the Sanquhar coal-field, the volcanic rocks are exposed. The coarse agglomerate just referred to is succeeded by green fine-grained diabase, followed by a mass of agglomerate containing fragments of lava and blocks of a pink granitoid rock, which is visible on the slope about the level of the 1000-foot contour line. Further to the north-west, a small scar cut by a streamlet on the S.S.W. slope of Peat Rig (Figure 73), (Figure 74) gives an excellent exposure of porphyritic lava closely resembling the beautiful diabase-porphyrity at the mouth of the Currarie Burn, Ayrshire. Northwards a distance of 500 yards the volcanic rocks are met with in occasional knobs on the slope. Beyond a patch of covered ground the Grains Burn traverses the north-west part of the volcanic area [NS 74989 13870]. In this stream above the point where it is crossed by the fault bounding the Sanquhar coal-field, slaggy lava with elongated vesicles is visible, followed by rather fine-grained agglomerate with sub-angular fragments of igneous rocks in a rocky gorge a remarkable rock is to be seen, having a fine-grained matrix with porphyritic felspar and biotite. Under the microscope No. (S6820) it shows phenocrysts of altered felspar and biotite in a microlitic ground-mass", and has been termed by Mr. Teall a biotite-andesite (1 Po, (Figure 73)).

About half a mile above the Sanquhar basin, the Grains Burn divides [NS 75363 14134], one branch running south from the slope of Guffock Hill. The lower part of this rivulet crosses the biotite-andesite, which is succeeded northwards by a well-marked agglomerate which dips towards the north and contains small, well-rounded blocks of biotite-andesite (1 Ts, N.N.W. of Grains Burn, (Figure 74)).

About 130 yards above the fork, this agglomerate is abruptly truncated by a fault (f, N.N.W. of Grains Burn, (Figure 74)), which brings slightly conglomeratic greywackes and shales in contact with the volcanic series. At the fault, pebbles of the Arenig igneous rocks are found in the conglomerate, probably indicating that these volcanic rocks may have been exposed to denudation before the overlying conglomerate was formed.

Returning now to the hill slope north of the Grains Burn, the observer finds biotite-andesite lava at intervals for a distance of 200 yards north-west of that stream. Near this spot, within the volcanic area, black shales and cherts form a small patch about 70 yards north-east from the edge of the Carboniferous rocks (C, 2I, (Figure 73), (Figure 75), N. of Grains Burn). A second patch of red mudstones and radiolarian cherts appears about 100 yards further to the north, followed by

the lava for a distance of about 100 yards. This is the most northerly exposure of the volcanic rocks near the Carboniferous basin (Figure 73). A third patch of radiolarian cherts and mudstones with black shales appears within the volcanic area to the east of those just described, and almost due south of Guffock Hill.

On Bail Hill, which forms the north-eastern part of the volcanic area, there are few exposures of solid rock; but to the south-east of the cairn, and not far from the top, diabase-lava is visible at a point where a quarry has been opened for dyke-building. The lava is also seen on the northern spur of the same hill.

The volcanic materials within this limited area comprise lavas of andesite, diabase, diabase-porphyrity, and biotite-andesite; while the pyroclastic materials include augite- and hornblende-andesite tuff, biotite-andesite tuff, and agglomerate. The character of the agglomerates and their prominent development within such a small area probably point out the site of an old volcano in Arenig time.

We must now consider the relations of these Arenig volcanic rocks to the overlying sediments along the north and east sides of the tract. Along the north side a fine development of Arenig cherts may be seen, but not in immediate contact with the lavas. From a point near the margin of the coal-field they can be traced eastwards over the crest of the Guffock Hill in the direction of the Kiln Burn. Black shales, with imperfectly preserved graptolites, are associated with these cherts near the margin of the coal-field and on both sides of the outcrop of Guffock Hill, but at one or two spots these black shales yield a characteristic assemblage of Glenkiln forms (21, (Figure 75), Guffock Hill). The sediments in visible contact with the Arenig lavas and tuffs on the north side of the area are younger than the Arenig cherts, and probably form part of an unconformable series, because they contain rounded blocks of the volcanic rocks moreover, they are brought into their present position by the fault already referred to (Figure 75), which is seen in the small branch of the Grains Burn that drains the south slope of Guffock Hill.

Returning to the section laid bare in the tributary of the Grains Burn just referred to, and ascending that tributary from the margin of the volcanic rocks, we find conglomerate, greywackes, shales, and grits for a short distance. These are succeeded by black shales exposed on three separate anticlines, with greywackes and shales intervening. About 250 yards above the fault the following Glenkiln assemblage of fossils was obtained:

*Didymograptus superstes* (Lapw.)

*Caenograptus* sp.

*Dicranograptus ramosus* (Hall.)

*Dicranograptus minimus* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Diplograptus euglyphus* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Climacograptus bicornis* (Hall.)

*Glossograptus Hincksi* (Hopk.)

*Dicellograptus moffatensis* (Carr.)

Further up stream, on another fold of the Moffat series, a limestone nodule, from two to three feet long, was observed in the black shales, which afforded the following forms: *Dicranograptus ramosus*, *Diplograptus foliaceus*, *Diplograptus euglyphus*, *Climacograptus*, and *Acrothele granulata*. These strata are succeeded by blue shales with thin bands of greywacke, and, after a blank in the section, by a fine development of radiolarian cherts which continues for some distance up stream. Northwards they are followed by dark blue shales up to the old hill-road ((Figure 74), Guffock Hill, Road).

About 500 yards to the west of the same tributary, a dry gully descends the south slope of Guffock Hill, which, running nearly north and south, exposes a section along part of its course. In the higher portion, the black shales come to the surface on the north limb of a fold of Arenig cherts (21, (Figure 75)), but south of this zone there is a blank in the section for a short distance; soon, however, grey shales appear with black strains, followed by a conglomerate in immediate contact with the volcanic rocks.

Along the east side of the Bail Hill area, the relations of the volcanic zone to the overlying sediments are buried under a covering of turf and drift, but the radiolarian cherts are seen at two or three localities, as, for example, on the moor about 700 yard S.S.E. of the top of Bail Hill, and at the head of the Stoodfold Burn, a tributary of the Kiln Burn.

**Kiln Burn.** — Immediately to the north of Bail Hill, two small streams unite to form the head-waters of the Kiln Burn [NS 76203 14511], which flows southwards to join the Orawick Water north of Carco Mains. Various folds of the Arenig cherts and Glenkiln black shales occur in the course of this stream, together with younger sediments, some of which indicate local unconformabilities. Contemporaneous volcanic rocks likewise appear, the horizon of which is defined by the graptolite zones in association with them.

In the westmost branch of the Kiln Burn to the north of Bail Hill, an arch of Arenig cherts and Glenkiln black shales may be seen near the head of the streamlet [NS 75729 14753]; indeed, it appears to be the easterly prolongation of the fold of cherts already described as extending from the margin of the coal-field, over the crest of Guffrock Hill in the direction of the Kiln Burn. The centre of this arch is occupied by the red cherts, followed by the green cherts, in which radiolaria are abundant. On the north limb of the fold, in normal sequence after the green cherts, come black cherts with clayey shales, succeeded by alternations of black shales with green and white shales like fireclays. The lowest band of black shales yielded the following characteristic assemblage of graptolites belonging to the Glenkiln group:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis*

*Caenograptus pertenuis* (Lapw.)

*Caenograptus surcularis* (Hall.)

*Dicranograptus minimus* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus perexcavatus* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus bicornis* (Hall.)

*Climacograptus Schärenbergi* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus patulosus* (Lapw.)

*Dicellograptus moffatensis* (Carr.)

*Corynoides calycularis* (Nich.)

*Acrothele granulata* (Linnr.)

Northwards these black shales are succeeded by alternations of grey clays and black shales, and at a point about ten yards above the last named fossiliferous locality the black shales furnished:

*Climacograptus caelatus* (Lapw.)

*Didymograptus superstes* (Lapw.)

*Caenograptus* sp.

*Climacograptus bicornis* (Hall.)

*Cryptograptus tricornis* (Carr.)

*Dicellograptus sextans* (Hall.)

Grey shales and greywackes appear in the stream to the north of this development of the Glenkiln black shales.

On the south side of the arch, the cherts are succeeded by a thin band of crushed black shales, followed by an alternation of greywackes and shales. Within a short distance a band of black shales is met with in the stream, yielding graptolites in a fragmentary form. Further down the stream, grey shales and greywackes are met with as far as a point about 70 yards above a stone fence on the south side of the valley. Here a remarkable conglomerate, evidently indicating a local unconformability, is well seen on both banks of the stream. Its matrix consists of grey and brown clayey or shaly substance, in which are embedded blocks of various materials. The largest of these consist of grey greywacke, which are well rounded, and frequently attain a great size, some measuring about three feet across. In places the conglomerate consists of an assemblage of angular and sub-angular fragments of black shales, yielding the following typical Glenkiln graptolites: *Didymograptus superstes*, *Dicellograptus*, *Dicranograptus*, *Diplograptus*. The conglomerate rests on black shales, and at this point it is composed chiefly of black shale fragments. Still further down, near the fork of the burn, it contains well-rounded blocks of greywacke, with small fragments of radiolarian chert.

Near the foot of the Sow Burn [NS 76221 14508] — a small stream which drains the south slope of the Cocker Hill — a conglomerate occurs with fragments of red cherts, and a little further up black shales appear on the strike of the band in the Kiln Burn that seems to be overlain by the conglomerate. After a blank in the stream, the conglomerate is again seen, followed by grey cherts and black shales, while further up stream the conglomerate is once more exposed in another fold. In this tributary stream there are three outcrops of conglomerate separated by the underlying cherts and black shales. Beyond the final exposures of the conglomerate, black shales are seen, followed by greywackes and shales, the latter occupying a space of 200 yards. These are followed by black shales, grey and green cherts, and by the red cherts, exposed in descending order. The strike of this fold of radiolarian chert and black shales lies further to the north than any of those exposed on the north side of the Bail Hill or in the Kiln Burn. The general dip of the strata in this tributary stream is to the north-west; hence the folds are isoclinal.

Eastwards from its fork the Kiln Burn, north of the top of Bail Hill, for nearly a third of a mile flows obliquely across the strike of an alternating series of conglomerates, greywackes, and shales [NS 76426 14473]. The conglomerate along this part of the stream course varies in character — sometimes it is composed chiefly of well-rounded fragments of greywacke, sometimes it is a brecciated mass of radiolarian chert, while again it is made up chiefly of sub-angular fragments of black shales. At the bend where the Kiln Burn flows towards the south, and at the junction of a small streamlet from the north, an excellent example of the last type is seen, where, from one of the included fragments of black shale, the following graptolites were collected: *Didymograptus superstes*, *Caenograptus gracilis*, *C. pertenuis*, *Diplograptus euglyphus*, *D. foliaceus*, *Climacograptus Schärenbergi*. The conglomerate appears at intervals for a distance of about 100 yards below the marked bend towards the south, and is succeeded by greywackes and grits with black shale galls, and eventually by dark blue micaceous and felspathic shales, with fragments of graptolites, including

*Dicranograptus ramosus* and *Climacograptus Schärenbergi*, the average dip of the strata being towards the N.N.W. at 60°.

At the foot of the Stoodfold Burn [NS 76939 13814], that joins the Kiln Burn about three-quarters of a mile north of Carcoside, a small development of volcanic rocks may be seen which evidently occupy a higher horizon than those of Arenig age. They extend westwards along the south bank of the Stoodfold Burn for a distance of 300 yards, where a volcanic breccia is visible, containing rounded bombs of diabase-lava, and on the top of the same bank, slaggy diabase-lava, like the blocks in the tuff, appears. Excellent sections, too, are to be found on the west bank of the Kiln Burn, where the tuff contains minute fragments of black shales. Under the microscope the rock No. (S6825) [NS 76267 14485] is found to be "largely composed of fragmentary felspars (mostly plagioclase) and bits of altered igneous rock. Biotite is also present". In the bed of the Kiln Burn below the junction of the streams, the tuff, where it forms a series of cascades, merges into an ashy grit, with recognisable fragments of black shales, and is there interleaved in grey and blue shales. A few yards below these waterfalls the agglomerate and lava are visible on the west bank. A microscopic examination of the lava No. (S6824) shows it to be composed of "phenocrysts of idiomorphic hornblende and felspar (the former now only represented by pseudomorphs largely composed of carbonate's) in a microlitic matrix", the rock being named by Mr. Teall a hornblende-andesite.

We have now to consider the sediments in contact with this narrow volcanic zone, which does not exceed thirty yards in breadth. On the north side, at the junction of the Stoodfold and Kiln Burns, blue and grey shales dip towards the N.N.W. at angles varying from 50° to 60°; along the strike of these beds, a few yards to the north-east, near the foot of the Shiel Burn — a tributary from the east — certain dark shales afford *Dicranograptus ramosus*, *Climacograptus Schärenbergi*, *Dicellograptus Forchhammeri*, and *Corynoides calycularis*. At a point 350 yards up Stoodfold Burn from its junction with the Kiln Burn dark blue shales succeed, with black seams charged with iron pyrites and containing numerous white specks. The dark seams are fossiliferous, and have yielded the following fossils:

*Climacograptus peltifer* (Lapw.)

*Climacograptus Schärenbergi* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Diplograptus foliaceus* (Murch.)

*Dicranograptus ramosus* (Hall.)

*Dicellograptus Forchhammeri* (Gein.)

*Dicellograptus sextans* (Hall.)

*Acrotreta Nicholsoni* (Dav.)

Again on the south side of the volcanic zone in the Kiln Burn, similar dark blue shales with white specks dip southwards, off the lava, at 60°, yielding *Dicranograptus ramosus* and *Climacograptus Schärenbergi*. From the evidence now adduced it is not improbable that this volcanic zone may be on the horizon of the passage beds between the Glenkiln (Upper Llandeilo) and Hartfell black shales (Lower Caradoc).

In the Kiln Burn below the outcrop of volcanic rocks, flaggy blue shales with yellow calcareous ribs and nodules are followed by massive grits and greywackes, in the midst of which there is a fold of black shales yielding the following undoubted Glenkiln forms:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Didymograptus pertenuis* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Dicranograptus formosus* (Hopk.)

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

*Climacograptus Schärenbergi*, (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus euglyptus* (Lapw.)

*Diplograptus foliaceus* (March.)

*Diplograptus perexcavatus* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus patulosus* (Lapw.)

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

*Corynoides* sp.

About 200 yards N.N.W. of Carcoside Farmhouse [NS 77473 13034], in a rivulet joining the Kiln Burn from the south-west, a band of vesicular diabase-lava occurs in the midst of the greywackes, which may probably be of Caradoc age, but no fossiliferous bands were found near it.

**Polcraig Burn, Meikle Carco.** — [NS 78096 14259], [NS 78263 13673] Evidence from this section affords further proof that the lithological characters of the Hartfell black shales have undergone modification, for the zonal form, *Climacograptus caudatus*, here occurs in brown sandy shales. The Polcraig Burn rises on the south slope of the Black Hill, and joins the Crawick Water above Meikle Carco. Near the head of this stream [NS 77725 14427] grey- and buff-coloured shales with sandy layers, much decomposed, after a careful search furnished gasteropods from certain seams. Among the graptolites the following were recorded: *Glossograptus Hincksi*, *Climacograptus caudatus*, *Dicellograptus elegans*, *D. caduceus*, *Dicranograptus ramosus*, *Cryptograptus tricornis*, which indicate the position of the *Climacograptus caudatus* zone. In the decomposed sandy seams specimens of *Maclurea (Ophileta) macromphala* (M'Coy) were obtained; indeed, on one slab no fewer than six specimens of *Maclurea* were noted.

Further down the stream [NS 78367 13924], these grey sandy shales with grits and greywackes are met with, together with two outcrops of black shales. The lower and better outcrop, distant about a quarter of a mile from the foot of the stream, yielded graptolites, sometimes in excellent preservation, which are given in the following list:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Dicellograptus patulosus* (Lapw.)



*Dicellograptus sextans* (Hall.)

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

*Climacograptus Schärenbergi* (Lapw.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Dicranograptus ramosus* (Hall.)

On the north side the greywackes and shales appear to be faulted against the black shales, while on the south side they are regularly interbedded with the graptolite bands.

**Spotfore Burn (Tributary of the Crawick Water).** — [NS 79240 14149] In this stream, above its point of junction with Crawick Water, blue greywackes and shales appear near the mouth of the glen and at intervals for about half a mile. Opposite the first sheepfold, barely half a mile up stream, in a little scar on the west side of the valley, a band of black shales, associated with a grey shaly rock like fireclay, contains the following fossils:

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Dicranograptus ramosus* (Hall.)

*Glossograptus Hincksi* (Hopk.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus patulosus* (Lapw.)

*Leptograptus flaccidus* (Hall.)

*Diplograptus euglyphus* (Lapw.)

Higher up the stream [NS 78609 15082] we find blue well-bedded sandy and micaceous shales, resembling the fossiliferous blue shales near the volcanic zone in the Kiln Burn, already described. These are followed by grey grits containing black shale galls, till at a bend in the stream below a picturesque water-fall the radiolarian cherts and Glenkiln black shales appear, associated with a band of volcanic agglomerate.

The accompanying ground plan (Figure 76) shows the relations of the strata. At the south end of the section, a calcareous breccia, composed of angular fragments of chert with radiolaria, is seen close to the grits, and higher up merges into a calcareous tuff visible on the west bank. Here the grey radiolarian cherts form a cliff at the bend on the east bank. After a blank in the section for a short distance, an exposure of black shales is seen with cherts on both sides (C, 21, E.S.E. of waterfall, (Figure 77)). The black shales, at this first exposure on the east bank, are well bedded and platy, yielding in abundance a characteristic assemblage of Glenkiln graptolites — one form in particular, *Didymograptus superstes*, being very plentiful. The following forms were here obtained:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

*Climacograptus Schärenbergi* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus patulosus* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Dicranograptus minimus* (Lapw.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

Immediately to the north of this the cherts are well seen in the bed of the stream and on both banks. They are followed by Glenkiln black shales on the south side of the agglomerate that forms the waterfall (21, (Figure 77)). Here the black shales appear to dip beneath the agglomerate as if truncated by a reversed fault. Some of the typical Glenkiln graptolites were found on the bank on the west side of the waterfall in contact with the agglomerate, including *Didymograptus superstes*, *Dicranograptus ramosus*, *Dicellograptus sextans*, and *Climacograptus Schärenbergi*.

The waterfall is formed by a band of volcanic ash or agglomerate (1 Ts, (Figure 77)), the matrix of which is of a greenish colour and contains minute lapilli of volcanic materials. Throughout this matrix, conspicuous bombs of a slaggy diabase-lava are scattered, some measuring 18 inches across. They are well seen in the bed of the burn at the top of the waterfall. Another variety of lava is represented among these blocks, viz.: the augite-andesite with well-defined crystals of augite.

Further up the stream, the Glenkiln black shales on the north side of the agglomerate have a thin strip or fold of the radiolarian cherts in the heart of them. It is not improbable that the volcanic tuff may overlie the Glenkiln Shales in this section, a suggestion which is strengthened by the evidence at the head of the Penfraw Burn, to be described presently. At the bend above the waterfall [NS 78626 15076], on the north-east bank, the Glenkiln black shales occur on the grassy slope a few yards from the stream, where they have furnished the following characteristic Glenkiln forms:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Dicranograptus zic-zac* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Dicellograptus patulosus* (Lapw.)

*Dicellograptus moffatensis* (Carr.)

*Dicellograptus sextans* (Hall.)

*Glossograptus Hincksi* (Hopk.)

*Diplograptus euglyphus* (Bron.)

*Diplograptus foliaceus* (Murch.)

From this point the stream flows for a few yards over a rapid alternation of Arenig cherts and Glenkiln black shales, repeated by sharp folds, the cores of which are occupied by the cherts. Some of the folds are normal, others isoclinal.

At the foot of the Penfraw streamlet that joins the Spotfore Burn [NS 78585 15087], seventy yards west of the waterfall, volcanic ash like that just described is visible in the bed of the stream, and is traceable a short distance up the Penfraw section, bounded on the north side by a well-marked fault (1 Ts, (Figure 77), W.N.W. of waterfall). Blue shales and greywackes are laid bare in the lower part of the Penfraw Burn, but at the very head of the stream there is an excellent exposure of volcanic ash, evidently on another fold, as the strike of the beds is to the north of that at the waterfall in the Spotfore Burn. Here the grey and decomposing rock is well seen on the face of a scar, where it weathers spheroidally and exfoliates in such a way that a fresh fracture is not easily obtained. But on the weathered surfaces its pyroclastic character is well defined, the angular and sub-angular volcanic fragments being visible to the naked eye. On the south side of the tuff, and almost in contact with it, black shales clip to the north-west, and yield *Didymograptus superstes* and *Climacograptus bicornis*, suggesting the probability that this band may be later in time than the Arenig volcanic series.

Returning now to the Spotfore Burn section, where it is joined by the Penfraw streamlet, the observer finds that the volcanic ash is bounded on the north side by the fault already indicated. The rock, brecciated at the junction, includes angular fragments of chert with radiolaria. For 300 yards up stream to the foot of the Poltarn Burn [NS 78387 15234], that drains the west slope of Largbrae Head, there is a succession of blue shales and greywacke bands like those of the Kiln Burn. Ten yards beyond the junction of the streams, conglomerate appears, charged with well-rounded fragments of greywacke, set in a matrix of shaly greywacke. From 20 to 30 yards above the foot of the Poltarn Burn, the radiolarian cherts are seen in the stream with the conglomerate resting on them unconformably. Thence to a spot not far above the foot of the Polholm Burn, that joins the Spotfore Burn half a mile west of Largbrae Head — a distance of about 300 yards — the cherts are visible either in the bed or banks of the stream, with the conglomerate resting directly on them. This appears to be a local unconformability, resembling that between the Benan conglomerate and the Arenig volcanic rocks north of the Stinchar. The denudation which marks it had not proceeded far enough to reveal the volcanic zone, and hence the comparative absence of volcanic blocks in the conglomerate. The cherts and overlying conglomerates are so rapidly folded together that the cherts do not extend far up the slopes of the valley. An interesting feature of these cherts is the occurrence of very thin layers of fine ashy material interleaved in them.

In the rocky gorge a few yards above the junction of the Polholm Burn [NS 78131 15313], a fragment of black shale in the conglomerate was found to contain Glenkiln graptolites (*Didymograptus superstes*, &c.). From this point the conglomerate extends up the stream for two-thirds of a mile. In the scars on the south side of the Spotfore Burn the cherts are visible. The conglomerate is also seen in the Polholm Burn near the foot, and again in the Shiel Burn half a mile to the west, near its point of junction with the Spotfore Burn. A continuous section of the conglomerate has been cut by the Shiel Burn between the sheep-ree and the foot of the burn. Here the conglomerate has a shaly matrix with well-rounded pebbles of greywacke and grit.

**Back Burn (Tributary of the Crawick Water).** — This stream rises on the slopes of the Shiel Hill [NS 78389 16720], and flows south-east to join the Crawick Water below Nether Cog [NS 80334 14875]. Ascending this stream from its point of junction with the Crawick Water, we find grey greywackes and blue shales, the former merging into massive grits, till about 600 yards from the foot [NS 79806 15131] we reach an exposure of black shales, which yielded the following among other fossils:

*Didymograptus superstes* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus bicornis* (Hall.)

*Dicellograptus moffatensis* (Carr.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus euglyphus* (Lapw.)

The black shales again appear at the mouth of a tributary burn, where they are traversed by a small fault. For about 100 yards the black shales come to the surface several times, with intervening greywackes, grits, and blue shales. Further up, the stream flows over a fine succession of blue and grey shales like those in Kiln Burn, which are sparingly fossiliferous. A few yards above the point where a streamlet joins the Back Burn from the east, the following fossils were found in blue shales: *Climacograptus Schärenbergi*, *Dicranograptus ramosus*, *Diplograptus*, *Acrotreta Nicholsoni*. This fine development of blue shales which from the included fossils are probably of Caradoc age, is eventually succeeded by pebbly grits and conglomerates, with well-rounded pebbles of greywacke, visible in the stream as far as the bend below the fork of the burns. Here a fine outcrop of black shales, upwards of 100 yards in breadth, is laid open in the stream. Although repeated by folds, these strata yield graptolites in profusion and in excellent preservation: Certain layers on the east bank of the stream at the bend are crowded with characteristic Glenkiln forms. Lithologically the black shales differ from the black cherty bands with black shale partings belonging to this horizon in the Moffat area. They are flaggy and platy in character. The following fossils were here obtained:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus nitidulus* (Lapw.)

*Caenograptus surcularis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus rugosus* (Emm.)

*Diplograptus foliaceus* (Murch.)

*Cryptograptus tricornis* (Carr.)

*Glossograptus Hincksi* (Hopk.)

*Climacograptus* sp. nov.

*Climacograptus coelatus*, var. *antiquus* (Lapw.)

*Climacograptus Schärenbergi* (Lapw.)

*Climacograptus peltifer* (Lapw.)

*Dicellograptus moffatensis* (Carr.)

*Dicellograptus divaricatus* (Hall.)

*Dicellograptus sextans* (Hall.)

*Leptograptus flaccidus* (Hall.)

*Dicranograptus formosus* (Hopk.)

*Dicranograptus ramosus* (Hall.)

*Thammograptus typus* (Hall.)

*Corynoides calycularis* (Nich.)

*Acrotreta Nicholsoni* (Dav.)

To the north of this point, as far as the head of the burn, blue and grey grits and shales appear. At the head of the tributary which rises on the south-east flank of Shiel Hill the conglomerate is exposed [NS 78390 16721].

**Polthistly Burn (Tributary of the Crawick Water at Corsebank).** — [NS 80246 16530] This burn, about two-thirds of a mile in length, drains the northern slope of the Crucreach Hill. Near its head, between the 1000 and 1250 feet contour-lines [NS 79714 16322], black shales may be seen in a branch of the stream. From the following list of fossils obtained here there can be little doubt that these strata belong to the Glenkiln horizon:

*Didymograptus superstes* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Dicranograptus minimus* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus intortus* (Lapw.)

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

*Climacograptus Schärenbergi* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus euglyphus* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Cryptograptus tricornis* (Carr.)

*Glossograptus Hincksi* (Hopk.)

From the manner in which the black shales strike at the conglomerate in this scar, it is probable that the two are brought together by a fault. It would seem that the radiolarian cherts are not far from the surface here, for their debris is visible at intervals in the line of strike eastwards in the direction of Corsebank. At one point they appear about a quarter of a mile from the scar of black shales. We may reasonably infer that they form the core of the arch, and are followed on the south side by the Glenkiln black shales.

On the southern slope of Craignorth Hill, below Corsebank, a rocky gorge has been cut by a small stream, near the foot of which dark blue flaggy shales crop out, much jointed and traversed by faults. Just above the point where this burn

takes a bend to the south-east [NS 80963 16233] a band of volcanic ash occurs in the middle of the gully, but owing to a talus of debris the relations of this band to the surrounding rocks are not apparent. On the slope, however, on the north-east side of the stream, the ash is brought into contact with the blue flags by a fault. A microscopic section No. [\(S6829\)](#) from this latter outcrop shows the rock to consist of "felspar fragments and fragments of hornblende and mica-andesite. Felspars and bisilicates decomposed". The rock has been termed by Mr. Teall an andesitic tuff. A few yards to the right of this exposure, the volcanic ash is seen to be regularly interbedded with the sediments. On the cliff to the right three bands of ashy material are intercalated in the dark blue shales, two of them about one foot thick each, while the third is several feet across. Here in blue-black shales the following fossils were obtained:

*Dicellograptus sextans* (Hall.)

*Dicranograptus ramosus* (Hall.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus bicornis* (Hall.)

*Climacograptus Schärenbergi* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Glossograptus Hincksi* (Hopk.)

On the cliff further up the gorge, the volcanic ash again appears, and beyond it, blue-black flaggy shales, which are well seen in the bed, of the burn, extend for a few feet up stream. This locality is just a few yards below the point where the stream bends to the E.N.E. Fossils occur here in fine preservation, as given in the following list:

*Dicranograptus ramosus*

*Leptograptus flaccidus* (Hall.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus patulosus* (Lapw.)

*Dicellograptus moffatensis* (Carr.)

*Diplograptus foliaceus* (Murch.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus Schärenbergi* (Lapw.)

*Corynoides calycularis* (Nich.)

*Acrotreta Nicholsoni* (Dav.)

*Hyalostelia fasciculus* (M'Coy.)

As this band evidently represents the passage beds between the Glenkiln and Hartfell divisions, it is reasonable to infer that the bands of volcanic ash may belong to the same horizon.

**Eller Scaur.** — [NS 80581 15723] At the side of the road leading to Sanquhar, below Corsebank on Crawick Water, an excellent section of black shales may be seen, from which the following fossils have been obtained:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Dicranograptus minimus* (Lapw.)

*Dicranograptus zic-zac* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus intortus* (Lapw.)

*Dicellograptus moffatensis* (Carr.)

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

*Diplograptus foliaceus* (Murch.)

*Diplograptus euglyphus* (Lapw.)

*Leptograptus flaccidus* (Hall.)

**Wanlock Water (Lower Section).** — Towards the foot of this stream, opposite Clackleith shepherd's house [NS 83169 17140], grey and blue shales with grits and greywackes are traversed by a peculiar type of igneous rock, like that in the small stream on the south side of the Craignorth Hill, just described. At a point about 60 yards below the mouth of Clackleith Burn, an exposure of black shales alongside of greywackes has yielded the following fossils: *Dicranograptus ramosus*, *Climacograptus bicornis*, *Cryptograptus tricornis*, *Diplograptus foliaceus*, and *Didymograptus superstes*. In the scar on the other side of the Wanlock Water, nearly opposite the north end of the wall bounding the enclosed field at Clackleith, the prolongation of this shale band is exposed, where the following Glenkiln forms were obtained: *Didymograptus superstes*, *Diplograptus foliaceus*, *Dicranograptus ramosus*, *D. sextans*, *Climacograptus bicornis* (?), *Caenograptus surcularis*, and *Dicellograptus moffatensis*. About 30 yards down stream black shales again appear, from which *D. superstes*, *Climacograptus bicornis*, *Dicranograptus ramosus*, *D. Forchhammeri*, and *Cryptograptus tricornis* have been collected. About 200 yards still lower certain peculiar blue shales visible in the stream resemble those in Craignorth Burn.

**Glenrae Burn.** — [NS 83324 16995] In this stream, that joins the Crawick Water three-quarters of a mile above Spango Bridge, brown sandy shales are visible in the lower part of the section, associated in places with bands of pebbly grit like the Snar Water conglomerate and grit. At a point about a third of a mile above the foot of the burn [NS 82896 17550], dark sandy lumpy shales are exposed, which yield a few graptolites. Beyond this point, alternations of shattery brown shales or mudstones with brown-weathering grits, probably on the horizon of the Duntercleuch grits, are exposed at intervals. About half a mile up the stream, at a point not far from where it branches, black shales are well displayed in a compound anticline. On the north side of the northmost fold, where they are seen in contact with grey shales, they are well bedded or platy and abundantly charged with well-preserved graptolites. They occupy the left bank for a distance of about twelve feet, until succeeded southwards by brown-crustured greywackes and shales of the same type as those on the north side of the fold. The following list of fossils obtained from this locality indicates that the strata which contain them belong to the lower portion of the Hartfell black shale group.

*Dicranograptus ramosus* (Hall.)

*Dicranograptus Nicholsoni* (Hopk.)

*Dicranograptus Clingani* (Carr.)

*Diplograptus foliaceus* (Murch.)

*Glossograptus Hincksi* (Hopk.)

*Dicellograptus Forchhammeri* (Gein.)

*Dicellograptus elegans* (Carr.)

*Dicellograptus sextans* (Hall.)

*Cryptograptus tricornis* (Carr.)

*Climacograptus bicornis* (Hall.)

*Leptograptus flaccidus* (Hall.)

*Leptograptuscapillaris* (Carr.)

*Amphigraptus* sp.

*Corynoides calycularis* (Nich.)

*Siphonotreta micula* (M'Coy.)

*Hyalostelia fasciculus* (M'Coy.)

Further up stream, black shales too much crushed to yield recognisable graptolites cover a space of about thirty yards, and appear again still higher in a third anticline in a similarly crushed and disturbed condition.

**Nether Whitecleuch Burn (Crawick Water).** — [NS 84428 18829] The small branches at the head of this burn expose black shales, with clays so much shattered and disturbed that graptolites are difficult to obtain from them, but fragments of *Dicranograptus ramosus*, *Climacograptus*, *Diplograptus*, were here collected. A bed of breccia occurs near at hand, but its relations cannot be satisfactorily determined owing to the disturbance of the beds. Near the fork, pebbly grit and conglomerate with large boulders of greywacke are seen for about 100 yards. At a point about half a mile from the farmhouse, a mass of volcanic agglomerate rises in the bed of the stream and on both banks. Under the microscope, the rock No. [\(S7159\)](#) [NS 84269 18919] "appears to be mainly composed of fragments of a biotite-andesite, consisting of large phenocrysts of oligoclase and plates of altered biotite in a very finely crystalline matrix. One or two fairly large apatites occur having also the appearance of phenocrysts". Greywackes and shales like those at Duntercleuch, seen close to the agglomerate, continue down stream for about 330 yards. About 600 yards from Nether Whitecleuch Farmhouse [NS 84094 19015] the grey cherts are exposed, and are brecciated along their contact with the grits, so that the junction line may be a fault. Further down the stream black shales alternate with green mudstones, followed by fireclay-look-ing shales much shattered, and these by flaggy black shales, yielding the following graptolites in good preservation:

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Dicellograptus sextans* (Hall.)



*Climacograptus Schärenbergi* (Lapw.)

These strata are succeeded by the usual greywackes and shales, which dip S.S.E. in isoclinal folds.

**Snar Water (Lower Section).** — This stream above Gott [NS 86539 20750], about two miles S.S.W. of Crawfordjohn, has exposed three anticlines of the cherts, with black shales and fireclays occupying the synclines. In the second syncline, on the left bank, in well-bedded black shales, with greenish mudstones, the following graptolites were obtained:

*Caenograptus gracilis* (Hall.)

*Didymograptus* sp.

*Cryptograptus tricornis* (Carr.)

*Dicellograptus patulosus* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Diplograptus foliaceus* (Murch.)

*Climacograptus Schärenbergi* (Lapw.)

*Dendrograptus* sp.

*Acrothele* sp.

On the north side the Permian breccia rests on the cherts; on the south side, the black shales on the left bank form the southern limb of the third arch, while the greywackes occur on the right bank. In the wood of the Old Castle of Snar [NS 86232 20021], brown decomposing pebbly grits like the Duntercleuch grit are found. At a point about 400 yards above the Castle [NS 86045 19718] an arch of grey cherts is succeeded by black shales on the north side only, while on the south side there is a breccia made up of very small fragments of chert. A short distance up stream, along the strike, at a bend in, the burn, brown-weathering grit appears which closely resembles the Duntercleuch grit.

The Snar Water upwards for about a mile flows over a constant repetition of grits like the Duntercleuch beds. The same rocks are seen also in a tributary which joins the Snar from the west, at the bend in its course. This brown grit with clayey shales is also exposed in a tributary [NS 85514 18804] that drains the north slope of the Windy Dod to the Snar.

**Glentewing Burn (Duneaton Water, south of Crawfordjohn).** — The black shales and cherts reappear in this stream on three separate anticlines between the farmhouse of Glentewing [NS 87743 22265] and Cleuch [NS 88289 21883]. The most northerly exposure, which is about 300 yards up stream, shows radiolarian cherts in the centre, followed on the north side by black shales and an ashy grit with black shale galls. The southern limb is not exposed owing to a covering of drift. About 100 yards higher up fragments of volcanic rock are met with, but the material was not here observed *in situ*; but a few yards further south, where a stone fence reaches the burn, black shales occur, yielding *Didymograptus superstes*, &c. Still higher in the valley, large masses of coarse volcanic agglomerate are found, in such abundance as to suggest that it may be in place underneath. Southwards, in a little side rivulet, near Cleuch Farmhouse, the black shales rise on another fold, and near the head of this streamlet they are associated with volcanic agglomerate like that described as occurring in the Nether Whitecleuch Burn. By means of small exposures on the intervening ridge the agglomerate can be traced E.N.E. across the Mill Scar (1399 feet) [NS 88527 22437] to the Glenliscleuch Burn [NS 89141 22828]. On the slope of the ridge east of Cleuch Farmhouse, the cherts and black shales occur on three separate folds.

**Glenliscleuch Burn (a Tributary of the Shield Burn).** — [NS 89141 22828] A continuous rock section is exposed in this stream that drains the north-east slope of Mill Scar, from its source to the point of junction with the Shield Burn one mile south-east of Crawfordjohn. In the scars at the head of the Cleuch an, outcrop of radiolarian alerts and black shales attains a breadth of upwards of 100 yards; the cherts occurring on three separate anticlines. All the strata are much shattered and crushed, and are further altered by much bleaching and decomposition. These folds are succeeded to the

north and south by grits; on the north limb, in the midst of the greywackes and grits, masses of agglomerate occur on the top of the bank, which are evidently portions of a similar rock underneath. A specimen from this exposure, when viewed under the microscope, shows "numerous phenocrysts of felspar in a dark, almost black, compact ground mass", and the rock seems to be highly altered hornblende-biotite-andesite, resembling the type of rock in. Kiln Burn, Nether Whitecleuch, and in the Shield Burn to be described presently. The Glenliscleuch Burn obliquely traverses the strike of the strata for the next 350 yards down to a point where it is crossed by a Tertiary dolerite dyke [NS 89121 22828]. In this distance it exposes three imperfect folds of cherts, black shales, and overlying greywackes and shales. East of the dyke, the course of the stream almost coincides with the strike of the beds, and for some distance the channel is carved out of black shale, bounded on the south side by an outcrop of radiolarian chert. In the black shales immediately overlying the cherts, the following fossils were obtained: *Didymograptus superstes*, *Caenograptus gracilis*, *C. pertenuis*, *Dicranograptus sic-sac*, *D. minimus*, *Dicellograptus sextans*, *D. moffatensis*, *Climacograptus bicornis*. The following assemblage was found in the bands in the north bank: *Climacograptus caudatus*, *C. bicornis*, *Dicellograptus caduceus*, *D. elegans*, *Diplograptus foliaceus*, *Corynoides calycularis*.

The black shales here obviously lie in a synclinal fold, as the radiolarian cherts reappear on the north limb of the trough at the foot of the Glenliscleuch Burn.

In the Shield Burn [NS 89522 22968], above its junction with the last-named stream, the first visible strata consist of radiolarian cherts, and within a short distance volcanic rocks appear. The latter are again succeeded by cherts, in the heart of which a small arch of fine-grained diabase-lava appears, with the usual pillowy structure. Southwards these cherts are followed by black shales and pebbly grits. In the midst of the coarser sediments a bed of altered andesite occurs, which, when examined with the microscope, is found to be crowded with phenocrysts of altered felspar, and contains some altered rock fragments. It is highly probable that this volcanic zone, like those in Nether Whitecleuch Burn and at the head of Glenliscleuch Burn, occurring as they do in grits that overlie the black shale series, may be of Lower Caradoc age. Southwards, grey micaceous shales are met with, followed at intervals by folds of radiolarian cherts and black shales.

## **Fossiliferous (Caradoc) conglomerate of Duntercleuch and Glendowran, Lead Hills**

Having described the various black shale bands in the Leadhills district between Abington and Sanquhar, we have now to consider certain pebbly grits and conglomerates, which, at several localities in the same region, are abundantly charged with fossils. Their fossiliferous character was first observed in the course of his original survey of the district by Mr. R. L. Jack, who, from their assemblage of organisms, regarded them as of Caradoc age (Explanation of Sheet 15, p. 14.). In his descriptive account he states that the strata "consists of greywacke passing, on the one hand, into crumbling sandstone, and, on the other hand, into pebbly grits with partings of shale resembling that of the Lowther (shales) series, and with beds of conglomerate which are chiefly found at the base of the group". Among the pebbles, white vein quartz is by far the most prominent constituent, but fragments of greywacke, black and grey shale, alert, and fragments of volcanic rocks also occur. The two chief localities from which fossils have been obtained are (1) the Back Burn west of Duntercleuch Rig [NS 83374 15793] — one of the minor tributaries of the Wanlock Water; (2) the Snar Water south of Snarhead [NS 86101 16736]. A third locality lies still further to the north-east on Glendowran Hill [NS 88630 19983]. Though organic remains are scattered through the matrix, they occur chiefly in brown decomposing calcareous nodules, which are evidently not derivative. As has been shown in the foregoing pages, these fossiliferous bands lie in rapid synclinal folds of the Arenig volcanic rocks, radiolarian cherts, and overlying black shales. In the Back Burn (page 292) and in the Duntercleuch Burn (page 292) nearly all the graptolites characteristic of the Glenkiln group are found in these shales close to the Caradoc strata. In this region the Moffat type of the Hartfell black shales has largely disappeared, and some Hartfell graptolites; as, for example, *Climacograptus caudatus*, *Dicellograptus elegans*, *D. caduceus*, &c., occur in brown sandy shales (p. 313) overlying the radiolarian cherts and Glenkiln black shales (see Glenrae Burn, p. 320).

After the publication of the list of organic remains from the Duntercleuch conglomerate in the Explanation of Sheet 15, the brachiopoda from this horizon, in the Geological Survey Collection, were examined by the late Mr. Davidson, who regarded them as of Caradoc age. The subjoined list gives the assemblage of organisms which have been obtained from the various exposures of this conglomerate in the Leadhills district:

*Nidulites favus* (Salt.)

*Alveolites* sp.

*Favosites asper* (D'Orb.)

*Favosites* sp.

*Monticulipora lens* (M'Coy.)

*Petraia bina* (Lonsd.)

*Petraia elongata* (Phil.)

*Petraia uniserialis* (M'Coy.)

*Stenopora (Favosites) fibrosa* (Goldf.)

*Glyptocrinus basalis* (M'Coy.)

Crinoid stems.

*Serpulites* sp.

*Calymene* sp.

*Cheirurus* sp.

*Homanolotus* sp.

*Ogygia* sp.

*Phacops caudatus* (Briinn.)

*Trinucleus fimbriatus* (Murch.)

*Fenestella* sp.

*Ptilodictya dichotoma* (Portl.)

*Leptaena sericea* (Sow.) var. *rhombica* (M'Coy.)

*Leptaena (Christiania) tenuicincta* (M'Coy.)

*Orthis (Platystrophia) biforata* (Schl.)

*Orthis calligramma* (Dalm.)

*Orthis crispa* (M'Coy.)

*Orthis polygramma*, var. *pentlandica* (Dav.)

*Orthis (Dalmanella) testudinaria* (Dalm.)

*Rhynchonella Jacki* (Dav.)

*Strophomena arenacea* (Salt.)

*Strophomena corrugatella* (Dav.)

*Ctenodonta* sp.

*Modiolopsis* sp.

*Bellerophon acutus* (Sow.)

*Bellerophon trilobatus* (Sow.)

*Cyclonema* sp.

*Euomphalus* sp.

*Holopella* sp.

*Murchisonia* sp.

*Pleurotomaria (Raphistoma) elliptica* (His.)

*Pleurotomaria lenticularis* (Sow.)

*Turbo* sp.

*Hyolithes* sp.

*Orthoceras* sp.

## **Representatives of Glenkiln Shales and associated sediments, from the Sanquhar Coal-field to the Clyde near Wandel Mill**

Approaching still further north to the margin of the Silurian Tableland between the north-east corner of the Sanquhar coal-field and the river Clyde at Wandel Mill, we discover that the Lower Hartfell black shales have disappeared, and that the characteristic fossils of the Glenkiln group occur in black seams or films in sandy shales and greywackes. The radiolarian cherts, however, are traceable along the margin of the tableland in a great development, closely associated with a prominent band of "Haggis Rock" or conglomerate, which, in certain sections, rests unconformably on the radiolarian cherts.

**Glenaylmer Burn (four miles and a half north-west from Sanquhar).** — [NS 72962 15045] In this burn, above the fault that bounds the Carboniferous basin, grits and greywackes with minute fragments of black shales and cherts are associated with much-jointed dark blue sandy shales. At a point about a quarter of a mile up stream an important section occurs on the north bank and on the slope overlooking the stream, where the green cherts with radiolaria are exposed. In contact with them, and apparently resting unconformably on them, lies a well-marked breccia, the grey matrix of which contains fragments of the grey radiolarian chert, sometimes measuring four by two inches; also fragments of black shale, though most of the pebbles are of greywacke. About 100 yards up the stream, on the same side of the valley, a beautiful light green variety of chert with radiolaria appears at the edge of the alluvium. On the bank the brecciated conglomerate, seen in contact with the chert, is composed chiefly of greywacke pebbles, some measuring nine inches long, with fragments of chert and black shale. The rock merges into a pebbly grit. About 200 feet above the bed of the stream, due north from this last-mentioned exposure, a very coarse conglomerate is visible, its pebbles being well-rounded and consisting chiefly of greywacke and chert lying in a gritty matrix. Some of the included blocks of Arenig igneous rocks measure two feet across. Near the head of this valley, about the Craggs, and just below the point where the Glenaylmer Burn is joined by a tributary from the north [NS 73958 15885], graptolites, referred to *Climacograptus* and *Diplograptus*, are found in thin black seams interleaved in blue shales. In the stream, on the south side of the valley near the watershed, blue shales and greywackes are visible; some of the small branching burns have their courses determined by

faults.

Beyond the watershed of the Glengap Burn [NS 74256 16202], occasional exposures of conglomerate, gritty greywacke, and yellow clayey shales are met with, in which no fossils have been found. In the lower portion of that stream, where it flows between the High Knypes and Glenguffock Hill [NS 74990 17063], the solid rocks are for the most part buried under alluvium. A short distance below Blackgannoch [NS 75479 17688] the Spango Water is joined on the south side by a tributary — the Reeve Burn [NS 75881 17760] — which drains the eastern slope of Glenguffock Hill, and shows along its course the radiolarian cherts coming to the surface along several folds. In places the cherts are immediately succeeded by blue grits, greywackes, and conglomerate. On the hill slope to the east of this stream, there is an excellent display of the red and grey cherts, which when traced towards the north-east, down the slope towards the old drove road, gradually become granulitised as the margin of the granite is approached. Exposures are rare, but the evidence here of contact metamorphism is similar to that found at some distance from the Loch Doon granite. (See Chapter 27).

The cherts are also seen on the Meikle Knypes [NS 76415 17182] — the hill east of Reeve Burn.

**Blackgannoch Cleuch and Glenwhinny Burn.** — [NS 76946 16441] In the small burns uniting to form the Blackgannoch Cleuch, that joins the Spango Water, one mile below Blackgannoch, sections are laid open of grey clayey shales, which decompose readily and contain worm tracks. In like manner, at the head of Glenwhinny Burn [NS 78022 16746] — a tributary of the Blackgannoch Cleuch — similar grey clayey shales weather externally like the Lowther Shales, though in these tributaries of the Spango Water it is probable, if not certain, that they belong to a lower horizon than the Barren Mudstones of Moffat. In these tributaries the shales are indurated, and show evidence of contact alteration by the Spango granite. The metamorphism of the Silurian rocks in the stream and on the hill slopes to the south of that igneous mass, and as far east as Glenwhinny Burn, is noteworthy, though the rocks at the junction are mostly buried under drift. In the Gairland Burn, on the north side of the granite mass, the alteration of the "Haggis Rock" is very pronounced. The included fragments of chert are quite granulitised and the matrix is rendered schistose, brown mica being abundantly developed.

**Fingland Burn (Head of Spango Water).** — [NS 74024 17320] This stream above the point where it is joined by the Glengap Burn, affords an excellent exposure of the radiolarian cherts, which continues at intervals up to a point about 250 yards from the foot of the burn. Greywackes are occasionally enfolded with these cherts. The massive red and green cherts are again displayed at the foot of the Calf Grain [NS 90469 11010], about 700 yards up stream from the foot of the Fingland Burn. On the south side of this fold, dark sandy shales with black shale strains lie, only a few yards from the edge of the charts (the black shale seams varying in thickness from an inch to a tenth of an inch). These black seams yielded the following characteristic Glenkiln fossils:

*Caenograptus gracilis* (Hall.)

*Caenograptus surcularis* (Hall.)

*Dicranograptus minimus* (Lapw.)

*Dicranograptus ramosus* (Hall.)

*Thamnograptus typus* (Hall.)

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus foliaceus* (Murch.)

*Climacograptus Schärenbergi* (Lapw.)

Brachiopod.

The arch of cherts just referred to can be traced north-east to the slope on the north side of the valley. Towards the southwest the red cherts can be followed by means of small outcrops along the crest of the High Knypes and Kirkland

Hills. On the south-west slope of the latter they rapidly "nose out" and are succeeded by greywackes and shales. In a little dry gully on the west slope of the Kirkland Hill [NS 72625 16356], about half a mile to the south of the fault between the Silurian and Old Red Sandstone formations and about 300 yards east from that which bounds the Carboniferous basin of Sanquhar, a peculiar igneous rock is exposed for a distance of 150 yards. The rock resembles a lamprophyre. On the south side of the gully, greywackes and shales are visible, and at the head of the gully the red cherts are seen.

**Duneaton Water.** — On the west slope of the ridge, at Stonehill [NS 83827 21307], three miles S.W. of Crawfordjohn, grey and red cherts are exposed, which contain abundant radiolaria, and are repeated by sharp folds. Some of the bands are hardened, probably by underlying granite. Black shale bands have not been observed anywhere on this hill, but they are visible in an isolated exposure at the bend of the Duneaton Water at Craighouse, and are there interleaved with grey shales, like those in the Fingland Burn just described, and at Craiglure, near Loch Doon. On the south side of the outcrop of the radiolarian cherts on the Stonehill ridge, a band of fine conglomerate, which can be traced along the ridge, contains pieces of grey radiolarian chert, sometimes an inch across, likewise fragments of black shale and some igneous rocks. On the north side, however, this conglomerate assumes the characteristic type of the well-known "Haggis Rock". It includes abundant minute fragments of various igneous rocks of the volcanic series, with red and grey chert and black shales. The strata on this hill are isoclinally folded, and dip to the south-east at angles varying from 60° to 70°.

In a little burn west of Stonehill [NS 83569 21287], the grey, green, and red cherts, together with the "Haggis Rock", are repeated by folds. Along the line of strike, quarries have been opened in the radiolarian cherts at the Stonehill Farmhouse; red mudstones, which occasionally contain bands of tuff, are there associated with red cherts. On the southern slope of Mountherrick Hill [NS 86368 22669], the fine conglomerate has yielded fragments of *Glyptocrinus* and *Petraia*. At the village of Crawfordjohn, the red mudstones and cherts may be seen by the roadside.

**River Clyde near Wandel Mill.** — [NS 94489 27902] In the Clyde, at the bridge about half a mile above Wandel Mill, a continuous rock section is laid open on the right bank of the stream, where blue grits, weathering with a rusty brown tint, occur in association with blue platy shales which alternate with leaf-like blue-black fossiliferous seams (about an eighth of an inch thick). One layer, about nine yards north of the bridge, yielded the following typical assemblage of Glenkiln fossils:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus pertenuis* (Lapw.)

*Caenograptus explanatus* (Lapw.)

*Caenograptus surcularis* (Hall.)

*Diplograptus euglyphus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Lasiograptus bimucronatus* (Nich.)

*Cryptograptus tricornis* (Carr.)

*Glossograptus Hincksi* (Hopk.)

*Climacograptus Schärenbergi* (Lapw.)

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

*Climacograptus bicornis* (Hall.)

*Climacograptus tridentatus* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Dicellograptus Forchhammeri* (Gein.)

*Dicellograptus moffatensis* (Carr.)

*Leptograptus flaccidus* (Hall.)

*Dicranograptus ramosus* (Hall.)

Again, in Duneaton Water, about three-quarters of a mile above the junction of that stream with the Clyde [NS 92297 25911], south-west of the Middencots Farmhouse, shattered and corrugated shales and greywackes, form a gentle anticline. Fossils are more difficult to obtain at this locality in the dark seams, but the following were collected: *Caenograptus pertenuis*, *Dicellograptus sextans*, *Diplograptus foliaceus*, *Climacograptus*. Though the strata are repeated by folds, their prevalent dip is towards the south-east. Here the greywackes, shales, and dark seams yielding Glenkiln (Upper Llandeilo) graptolites rest on the radiolarian cherts.

### **Black shale bands in the basins of the Elvan and Menock waters and in the tributaries of the Nith near Kirkbride**

In this belt of ground between the Clyde and the various folds of the Moffat series reveal in some instances the Arenig lava, the radiolarian cherts, and the Glenkiln–Hartfell bands of black shales in the midst of sandy shales and other sediments. Some of these outcrops of the Moffat series come to the surface in the midst of the Lowther Shales, which are regarded as the equivalents of the Barren Mudstones of Moffat.

**Elvan Water.** — About a mile to the south-east of Leadhills, in the Windygate Burn [NS 90585 13821]?, a tributary of the Shortcleuch Water, twisted black shales appear in the midst of greywackes and shales, from which the following graptolites were collected: *Climacograptus caudatus*, *C. bicornis*, *Cryptograptus tricornis*, *Diplograptus foliaceus*, *Dicranograptus ramosus*, *Corynoides calycularis*. This band is prolonged north-eastwards into the Lead Burn, where a core of radiolarian chert appears in the midst of the black shales, the latter being cleaved and yielding fossils sparingly. Several Lower Hartfell fossils were, however, obtained from this locality. In the strike of these exposures near the head of Lead Burn in a north-east direction, a small outcrop of cherts and black shales appears on the north-west slope of Lousie Wood Law [NS 93224 15234], not far from the band of conglomerate on that hill, to which we shall presently refer. Other folds displaying the cherts and black shales are met with in a tributary of the Shortcleuch Burn [NS 91645 16217] immediately to the west of Leadburn Rig.

**Menock Water (Two miles south of Wanlockhead).** — In the basin of the Menock Water, about two miles south of Wanlockhead, several arches of the Arenig Rocks and overlying black shales make their appearance. In one of these the volcanic rocks occur in the core of the fold, followed in regular order by the cherts and black shales. The rocks as a whole have undergone deformation, the cherts in particular showing fine flaser-structure, like the cherts and jasper bands in the neighbourhood of the North Esk, Forfarshire. The arch referred to occurs on the north side of the valley, where the high road crosses a small tributary of the Menock that drains the hill called Middle Moor [NS 86353 10028]?. At the point where a bridge spans the stream, black shales, much cleaved, dip to the north-west at angles from 45° to 65°. A felstone dyke crosses the burn above the bridge. The black shales have a peculiar sheen or glistening surface, and yield indeterminable traces of graptolites. Further up, cherts with fine flaser-structure succeed, followed by black shales, grey shales, and greywackes. About 200 yards to the east-north-east of this point, along the line of strike, coarse ophitic dolerite or gabbro appears, an intrusive rock of Arenig age; while a few yards further east, the pillowy lava reaches the surface. Both types of rock are cleaved and markedly schistose; thus resembling some of the schistose chloritic igneous rocks in the North Esk region above alluded to. At one point the band of igneous rocks in the core of the fold is 100 feet broad.

The cherts occur on both sides of the fold, and are so well cleaved or schistose, that it is difficult to obtain specimens of radiolaria from them. The black shales occur on the north side of the arch, but on the south side are concealed by vegetation. This fold is traceable for a third of a mile along the north side of the valley, and rapidly noses out towards the north-east; but towards the south-west black shales occur in the Menock Water much in the same line of strike. Again, on the south of the arch of volcanic rocks, black shales are found in the Menock Water below the junction with the Green Carli [NS 86519 09966]. From this point upwards, black shales and cherts appear on several folds.

Below the spot where the Whitestone Cleuch joins the Menock half a mile east of Middle Moor [NS 87237 10919], several repetitions of the black shales may be observed, and at one point, about 200 yards below the junction, the lava is seen, truncated by a fault on the east side which brings it in contact with greywackes. In the Whitestone Cleuch, beyond some greywackes and shales in which black shales occur, a fine exposure of cleaved cherts and black shales has been laid open in the stream which runs E.N.E. across the Meikle Arthur Grain [NS 87985 11253] towards the county boundary. Southwestwards this fold can be followed for half a mile along the slope on the south side of the valley to a small scar draining into the Menock, at the head of which, volcanic rock is associated with the cherts.

More or less parallel with this arch, and to the south of it, three separate bands of the radiolarian cherts and black shales may be traced, the highest reaching the 1750-foot contour-line. The strata, especially the cherts, are much deformed, so as to show fine flaser-structure; indeed, at some points the cherts have been sheared into paper-schists.

In the Horseman's Burn [NS 85681 09520], which joins the Menock from the south one mile north of Glenim, several repetitions of the black shales are to be seen, sometimes associated with the cherts. They occur also by the side of the Dempter Road leading to Glenim.

In the Glenimshaw Burn below Glenim, and at the junction with the Long Cleuch, black shales and cherts appear. They have been reddened by infiltration of iron oxide from the Permian rocks that formerly extended over the area. The limit of the stained rocks is well defined; the staining is not observable north of the foot of the Long Cleuch nor to the north of Glenim.

**Kirkbride (East of Nith).** — [NS 85556 05551] To the east of the Nith near Kirkbride, about five miles S.E. from Sanquhar, black shales are frequently exposed, sometimes in the line of strike of the Burnmouth, Cairn Burn, and Chanlock bands, to be described in the sequel. The most prominent outcrops — though, owing to the crushed and dislocated character of the shales, fossils are very difficult to find — are to be met with in the Stroquhairn Burn [NS 85616 05943]— a tributary of the Ha' Cleuch — and in one of its branches, the March Cleuch [NS 85522 06523]. In both of these sections the cherts appear with the black shales, the former being much crushed, though radiolaria can still be found in them. In these sections the beds are too shattered to yield graptolites. Several felsite dykes occur, and one dyke in particular deserves special mention. It occurs in the Stroquhairn Burn, about 200 yards above the junction with the March Syke, and consists of a purple diabase or melaphyre, closely resembling the lavas of the Permian basin of Thornhill. Here it appears as a dyke which runs east and west, piercing the greywackes on the north side of it and a yellow felsite dyke on the south side.

Crossing the grassy ridge between the head of the Stroquhairn Burn [NS 85887 06348] and the head of the Ha' Cleuch [NS 86300 06707], we find the black shales in the latter stream. From one of the less crushed layers the following fossils were obtained: *Leptograptus flaccidus*, *Dicellograptus Forchhammeri*, *Diplograptus foliaceus*, and *Corynoides calycularis*. There can be little doubt that this layer represents one of the bands of the Lower Hartfell black shales. The cherts do not appear at the head of the Ha' Cleuch, but they are exposed on the surface on the moor to the north-east of the burn, and can be traced to the head of the Old March Cleuch [NS 86431 06965], a tributary of the Enterkin Burn, where they are well displayed though much stained with the former cover of Permian or Carboniferous strata. They occur here in association with bleached black shales. In places the cherts are hardly recognisable as such, and the black shales might easily escape notice owing to the staining. The cherts appear again in streamlets at the foot of the Auchenlone Burn [NS 87259 07412], near the northern limit of the Permian basin.

Though fossils were not obtained from the black shales in the tributary of the Ha' Cleuch north of Kirkbride, yet it is clear from the presence of the radiolarian cherts and the dark flinty ribs that the Glenkiln black shales are there represented.



The Lower Hartfell black shales probably occur, though this horizon has not been proved by fossils. To the south of the exposure of black shales in the Stroquhairn Burn, dark blue shales appear which might yield fossils.

**Lime Cleuch, Cairn Hill.** — [NS 84946 06720] About half a mile to the north-west of Kirkbride, at the very head of the Lime Cleuch, above the 1000-foot level, and not far from the top of the Cairn Hill, black shales are exposed in a rocky gully which runs northeast and south-west, or nearly parallel to the strike of the beds. In this section both the Glenkiln and Hartfell black shales are represented. The black shales yield *Diplograptus foliaceus*, *Dicellograptus*, *Cryptograptus tricornis*, and *Lasiograptus margaritatus*. About 150 yards above the fork, on the right bank, platy black shales appear with seams of grey clays, and yield the following fossils:

*Dicellograptus Forchhammeri* (Gein.)

*Lasiograptus margaritatus* (Lapw.)

*Retiolites (Neurograptus) fibratus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Leptograptus flaccidus* (Hall.)

*Corynoides calycularis* (Nich.)

*Glossograptus Hincksi* (Hopk.)

The distribution of the organisms here is noteworthy. One layer is crowded with *Corynoides calycularis*, another with *Dicellograptus*, another with *Diplograptus foliaceus* in fine preservation. This is the continuation of the Lower Hartfell band found at the fork. A few yards up the gully, on the left bank, at the base of the cliff, in black shales dipping towards the south-east, the following forms of characteristic Glenkiln type were obtained:

*Didymograptus superstes* (Lapw.)

*Caenograptus pertenuis* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus foliaceus* (Murch.)

*Climacograptus bicornis* (Hall.)

*Climacograptus peltifer* (Lapw.)

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

*Dicellograptus sextans* (Hall.)

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

*Dicellograptus moffatensis* (Carr.)

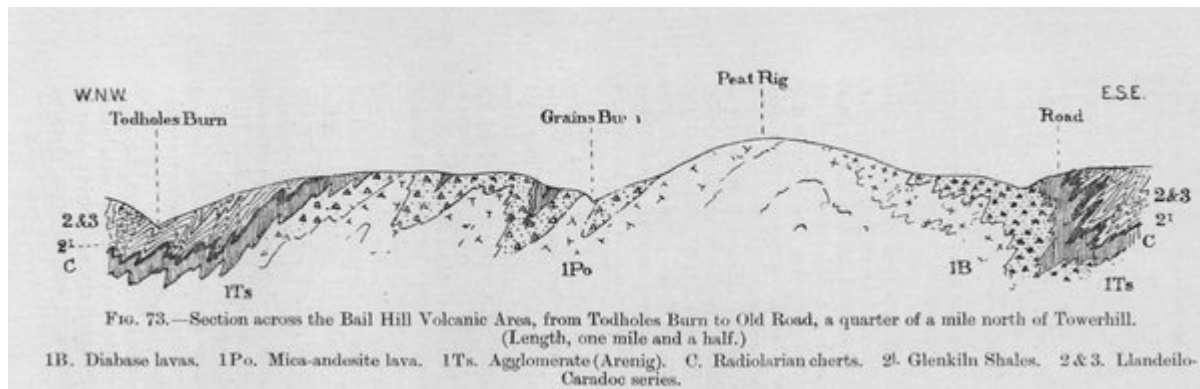
*Cryptograptus tricornis* (Carr.)

Grey fireclays are interleaved in these Glenkiln black shales, and thin black siliceous ribs are also associated with them. Another notable feature of this section is the presence of lenticles and patches of greywacke in the black shales.

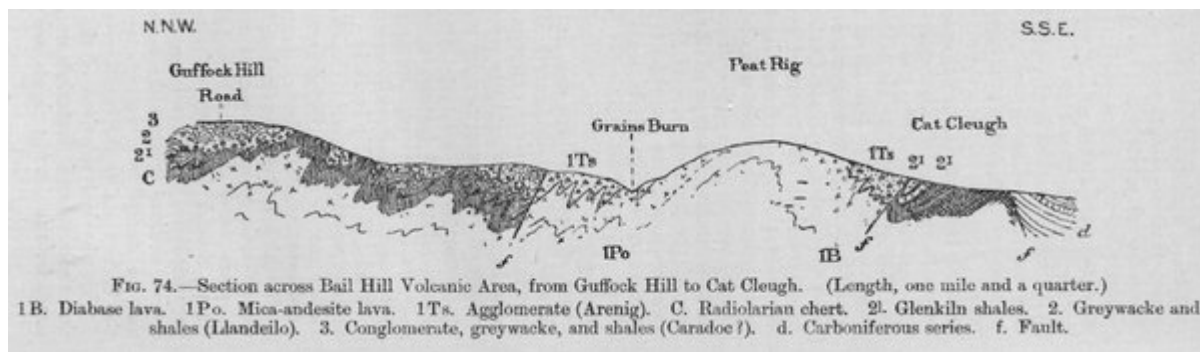
Still further north, black shales appear on isoclinal folds stretching from Glenim [NS 85471 08430] towards the Nith south of Dalpedder [NS 83268 06083]. In general they are too much crushed to yield recognisable species of fossils. A band

appears also in the Auchenlone Burn, about a mile above its junction with the Enterkin [NS 86718 08642]. To the south of a line drawn from the mouth of the Auchenlone Burn to Glenim, the beds (greywackes and shales, cherts, and black shales) are much stained.

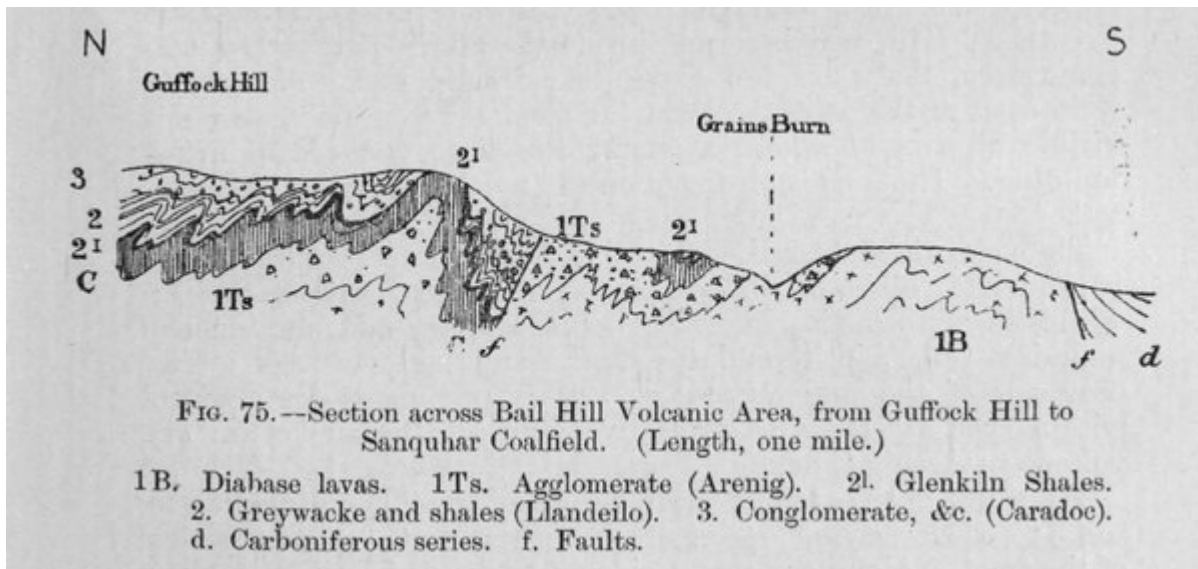
Immediately to the north of the line which has provisionally been drawn as the northern base-line of the Llandoverly Rocks of the Central Belt, a prominent group of shales typically developed in the Lowther Hills is traceable from the Clyde at Elvanfoot to the Nith above Enterkinfoot. It consists of finely laminated shales with flaggy greywackes and occasional grits or conglomerates. The shales weather with a brown or buff colour, with an occasional spotted appearance. The apparent synclinal arrangement of this shaly series in the Lowther Hills is quite misleading, because, as we have already shown, the Arenig cherts and Glenkiln–Hartfell black shales repeatedly come to the surface in the midst of the overlying Lowther group in the basin of the Elvan Water and between the Menock Water and Enterkinfoot. Various bands of pebbly grit and conglomerate appear in this series, of which the one on the northwestern slope of Lousie Wood Law, two miles south-west of Elvanfoot, is perhaps the most conspicuous. It contains well-rounded pebbles of grit, greywacke, pieces of hardened shale, Lydian-stone, and quartz embedded in a matrix of greenish grey quartzose grit.



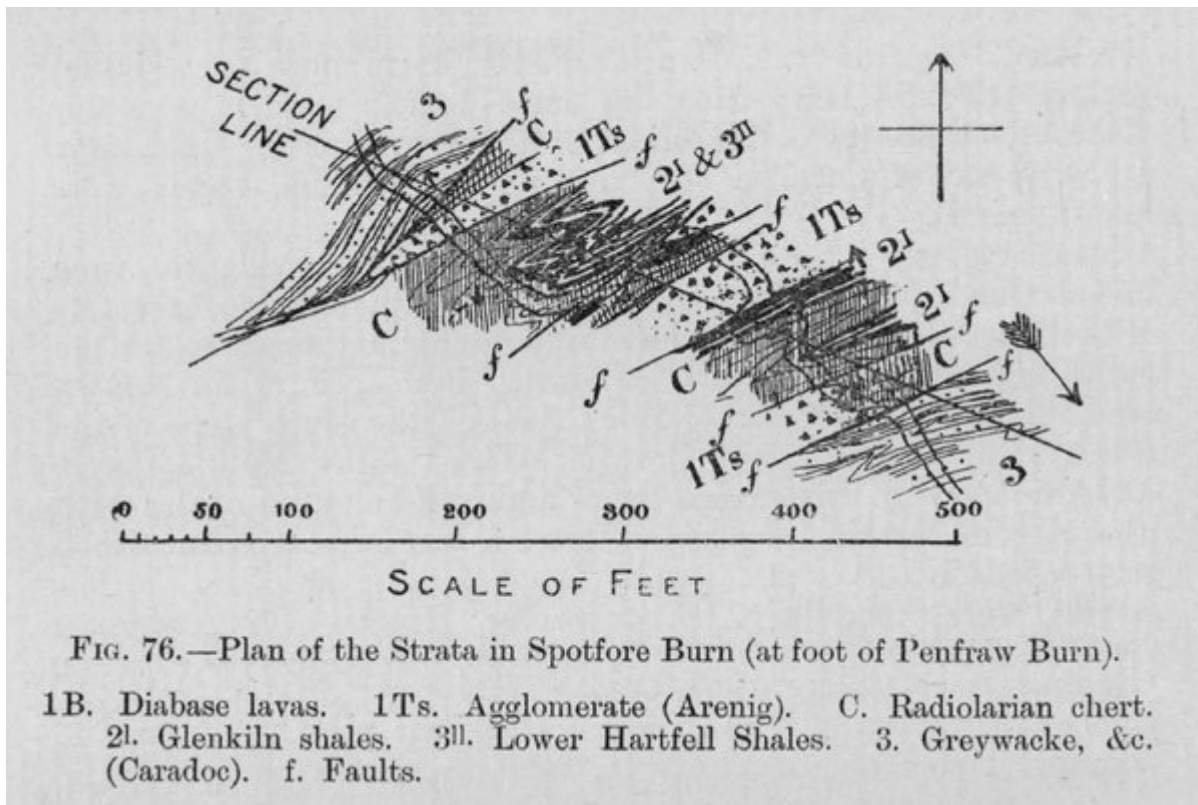
(Figure 73) Section across the Bail Hill Volcanic Area, from Todholes Burn to Old Road, a quarter of a mile north of Towerhill. (Length, one mile and a half.) 1B. Diabase lavas. 1Po. Mica-andesite lava. 1Ts. Agglomerate (Arenig). C. Radiolarian cherts. 2. Glenkiln Shales. 2 & 3. Llandeilo–Caradoc series.



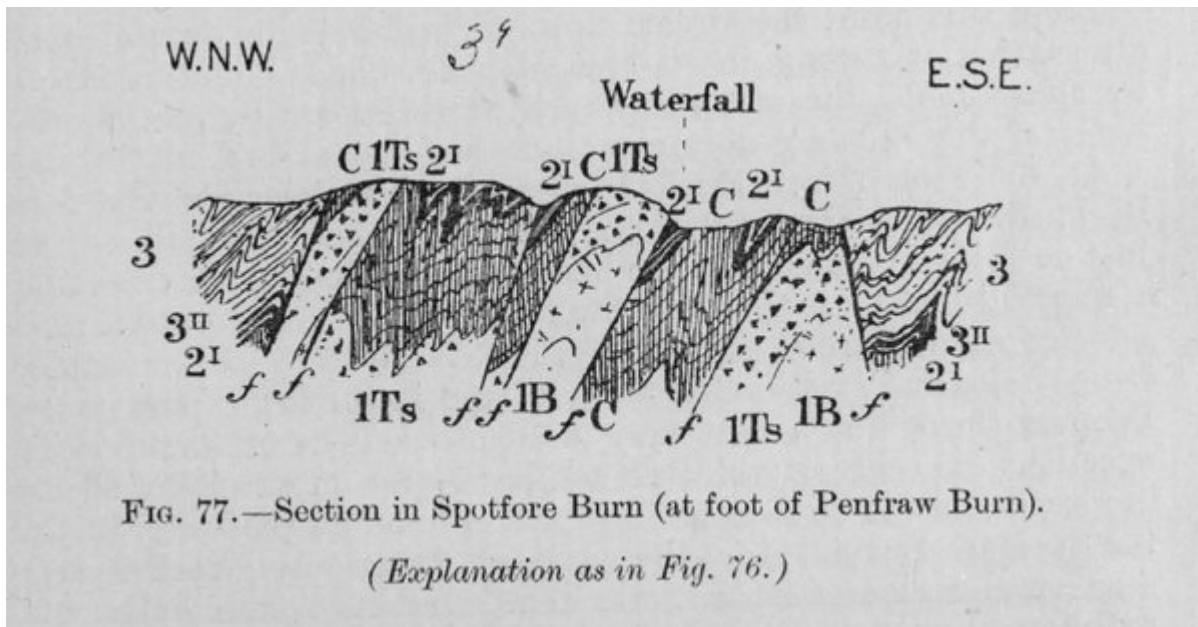
(Figure 74) Section across Bail Hill Volcanic Area, from Guffock Hill to Cat Cleugh. (Length, one mile and a quarter.) 1B. Diabase lava. 1Po. Mica-andesite lava. 1Ts. Agglomerate (Arenig). C. Radiolarian chert. 2. Glenkiln shales. 2. Greywacke and shales (Llandeilo). 3. Conglomerate, greywacke, and shales (Caradoc?). d. Carboniferous series. f. Fault.



(Figure 75). —Section across Bail Hill Volcanic Area, from Guffock Hill to Sanquhar Coalfield. (Length, one mile.) 1B, Diabase lavas. 1Ts. Agglomerate (Arenig). 2l. Glenkiln Shales. 2. Greywacke and shales (Llandeilo). 3. Conglomerate, &c. (Caradoc). d. Carboniferous series. f. Faults.



(Figure 76) Plan of the Strata in Spotfore Burn (at foot of Penfraw Burn). 1B. Diabase lavas. 1Ts. Agglomerate (Arenig). C. Radiolarian chert. 2l. Glenkiln shales. 3ll. Lower Harden. Shales. 3. Greywacke, &c. (Caradoc). f. Faults.



(Figure 77) Section in Spotfore Burn (at foot of Penfraw Burn). (Explanation as in (Figure 76).