
Chapter 7 The Central Belt — continued. Black Shale Bands North of Moffatdale

Proceeding now to the region lying between the Moffat Water and the northern margin of the Tarannon area beyond the vale of Tweed, we shall describe the successive anticlines of the Moffat Shales within these limits, and indicate the lateral variation of the sediments as we approach the Abington and Leadhills districts.

Polmoody. — [NT 17667 14342] In the basin of the Moffat Water there are several local anticlines of the Moffat Shales. A glance at Sheet 16 will show that one of these folds has been traced from the Tail Burn issuing from Loch Skene to a small stream about a mile north-east of Polmoody. The Birkhill Shales are exposed in this outcrop, and in the Seary Sike, joining the Polmoody Burn from the slopes of the Turnberry Hills, the Barren Mudstones form the crest of the arch, with the crushed and contorted Birkhill zones on either side.

Carrifran Burn (Lower Section). — [NT 15943 11883] A small anticline occurs near the foot of this stream revealing only the Birkhill zones. Owing to the decomposition of the strata, the stream follows the crest of the fold for a short distance.

Bodesbeck. — [NT 15432 09402] In like manner, this minor fold shows only Birkhill Shales charged with *Monograptus Sedgwicki* (Portl.), *Monograptus lobiferus* (M'Coy), *Climacograptus normalis* (Lapw.), *Diplograptus tamariscus* (Nich.).

Roundstonefoot and Shortwoodend. — [NT 13673 07964] Here two small isoclinal folds of the Birkhill shales occur in the midst of the Tarannon grits; the exposure near the foot of Shortwoodend Burn has yielded *Monograptus Hisingeri* (Carr.), *Monograptus lobiferus* (M'Coy), *M. leptotheca* (Lapw.), *M. gregarius* (Lapw.), *Diplograptus tamariscus* (Nich.), *Climacograptus normalis* (Lapw.).

Frenchland Burn. — [NT 10557 06039] Two separate exposures of the Moffat series occur in this stream; the intervening area, about a quarter of a mile in extent, being occupied by the Tarannon greywackes and shales. In the lower section the black shales are overlapped by the Permian rocks, and may be traced up stream for a quarter of a mile. They are arranged in sharp isoclinal folds dipping to the north-west. The strata being much corrugated, fossils are not easily obtained from all the zones but those which can be found clearly belong to the Birkhill division, The lowest zone, as described by Professor Lapworth, yields *Diplograptus vesiculosus*, passing upwards into the higher beds, which in turn plunge underneath the greywackes and shales to the south. At the upper limit of this exposure the higher bands yield, in fine preservation, *Monograptus Sedgwicki*, *M. Becki*, *M. Hisingeri*.

In the upper exposure the strata are similarly arranged, being isoclinally folded towards the north-west. Here the zones range from the base of the Birkhill division to the members of the upper group. At the south-west limit the strata belonging to the Lower Birkhill division are truncated by a fault bringing in the overlying greywackes and shales. Further up the stream higher zones succeed, but the junction of the latter with the greywackes is not visible. The following fossils have been obtained from these beds:

Monograptus Sedgwicki (Portl.)

Monograptus leptotheca (Lapw.)

Monograptus lobiferus (M'Coy.)

Monograptus gregarius (Lapw.)

Petalograptus folium (His.)

Climacograptus scalaris (His.)

Climacograptus normalis (Lapw.)

Dimorphograptus elongatus (Lapw.)

Diplograptus vesiculosus (Nich.)

Diplograptus acuminatus (Nich.)

Diplograptus tamariscus (Nich.)

Garpol Water. — [NT 06706 03239] The relations of the Moffat Shales to the Tarannon greywackes are clearly displayed in this stream, which lies to the west of the river Annan, and is about a mile and a half distant from the town of Moffat. Here a gorge has been carved out of the softer shales between the overlying grits and greywackes. The strata are arranged in a compound anticline traversed in the centre by a small fault, as shown by Professor Lapworth. The lowest beds exposed in the centre of the arch belong to the *Diplograptus acuminatus* zone of the Lower Birkhill Shales, which have yielded the following fossils:

Diplograptus vesiculosus (Nich.)

Diplograptus acuminatus (Nich.)

Dimorphograptus Swanstoni (Lapw.)

Climacograptus normalis (Lapw.)

Climacograptus innotatus (Nich.)

Monograptus attenuatus (Hopk.)

Monograptus tenuis (Portl.)

Dawsonia campanulata (Nich.)

Below the waterfall near the bend in the stream higher bands are well seen, in particular the *Monograptus gregarius* zone, containing nodules of limestone as in the Dobb's Linn section. Some of these nodules are several feet in diameter. This exposure occurs on the north limb of the anticline as the observer ascends the stream. Though the bands are there much disturbed they are highly fossiliferous, and have yielded the following fossils, some of which are preserved in the solid:

Monograptus gregarius (Lapw.)

Monograptus cyphus (Lapw.)

Monograptus leptotheca (Lapw.)

Monograptus lobiferus (M'Coy.)

Monograptus triangulatus (Hark.)

Monograptus tenuis (Portl.)

Diplograptus with ovarian capsules.

Diplograptus tamariscus (Nich.)

Diplograptus physophora (Nich.)

Petalograptus folium (His.)

Climacograptus innotatus (Nich.)

Rastrites peregrinus (Barr.)

Discinocaris Browniana (Woodw.)

Theca (?)

Crustacean.

Above the bend in the stream where its course is nearly north and south, the beds, chiefly of the Upper Birkhill division, are exposed in transverse section, plunging on both sides under the Tarannon greywackes. Here the grey and black shales of the *Monograptus spinigerus* zone are met with, yielding that form in profusion, together with specimens of *Monograptus runcinatus* (Lapw.), *M. leptotheca* (Lapw.), *M. Hisingeri* (Carr.), *Rastrites hybridus* (Lapw.), *Petalograptus folium* (His.), *Diplograptus tamariscus* (Nich.), *Climacograptus*, &c. On the north limb of the fold the purple shales of the *Rastrites maximus* zone, which have here failed to yield their characteristic fossils, dip below the overlying greywackes. The same zone on the south limb of the fold has yielded a few characteristic forms.

Carrifran Gans and Blackhope Burn. — [NT 15882 13714], [NT 13797 11476] From the slope of White Coomb a band can be traced for about three miles across the Carrifran Burn to Blackhope Burn, along a line about a mile and a half to the north of the course of the Moffat Water. In the Broomy Gutter, draining the north slope of Carrifran Gans and flowing into the Carrifran. Burn, the following section occurs not far above the junction of the stream:

In the centre of the inverted anticline the Hartfell black shales are exposed, to which succeed the Barren Mudstones. To the south these are overlain by the Lower Birkhill black shales, while on the north limb the Barren Mudstones are truncated by a fault bringing in the greywackes and shales.

At the junction of the two streams the fold widens and reveals the underlying Glenkiln black shales, yielding the following characteristic forms:

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Caenograptus nitidulus (?) (Lapw.)

Diplograptus euglyphus (Lapw.)

Diplograptus foliaceus (Murch.)

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

Climacograptus bicornis (Hall.)

Dicellograptus sextans (Hall.)

Dicranograptus ramosus (Hall.)

Cryptograptus tricornis (Carr.)

Acrotreta Nicholsoni (Dav.)

Further up the small "score" the Barren Mudstones appear in the centre of the fold overlain by the Birkhill Shales, the southern limb being truncated by a fault.

Again, where this fold occurs in a "score" on the east side of the Blackhope Burn, only the Birkhill Shales are met with, but overlying these beds are green and grey shales which may represent part of the Vpper Birkhill strata.

Birnock Water. — [NT 09407 07540] The probable continuation of the foregoing band occurs in the Birnock Water about a mile and a half to the north-east of Moffat. There the beds are much shattered, and it is difficult to procure determinable fossils. The Birkhill Shales, Barren Mudstones, and a portion of the Hartfell black shales are met with. This outcrop is of interest as being the site of one of the mineral wells which have made the town of Moffat a favourite resort.

Blackhope Burn (Foot of Whirly Gill). — [NT 12961 12821] Immediately below the junction of these two streams an exposure of black shales yields Lower Birkhill forms in the heart of a mass of grey shales like those associated with dark bands yielding *Rastrites maximus* at Dobb's Linn. Here there are indications of the disappearance of the upper portion of the Birkhill group. Indeed, between the foregoing outcrop and that at the head of the Cold Grain — one of the sources of Blackhope Burn — there are several folds of these grey shales in the midst of the Tarannon grits.

Hartfell Section. — Reference has already been made to the fact that Professor Lapworth has proved the disappearance of the upper portion of the Birkhill division on the great anticline of Hartfell. Indeed, in most of the arches of the Moffat Shales on the strike of the Hartfell band, this modification of the Upper Birkhill division is more or less apparent. On referring to Sheet 16 of the one-inch geological map of Scotland, it will be seen that black shale bands in the line of the Hartfell arch can be followed at intervals from the south-west border of the map, north-east by Ruttonside, Hartfell, and Loch Skene, to Boar Cleuch in the basin of the Meggat Water. North of this line the Upper Birkhill beds, as developed in Dobb's Linn, are never met with on any of the anticlines of black shales. It is clear, therefore, that the Hartfell arch forms an important structural line in relation to the lateral variation of the lithological and palaeontological zones of the Moffat series.

The Hartfell section, extending for a distance of three miles from the edge of the Permian basin to the summit of that mountain [NT 11349 13538], has been described in detail, and the horizons of the various palaeontological zones have been indicated by Professor Lapworth. The strata generally are arranged in the form of a compound anticline, traversed by faults more or less parallel to the strike of the strata, the lowest zones being exposed in the fine section in the Hartfell "Score".

Not far from the margin of the Permian basin, in the Frizzle Burn, the black shales and mudstones of the *Monograptus gregarius* zone pass conformably upwards into the massive grits of Tarannon age without any representative of the Upper Birkhill Shales. The same strata reappear at the old copper mine, further up stream, where they have yielded the following forms

Monograptus gregarius (Law.)

Monograptus tenuis (Portl.)

Monograptus leptotheca (La w.)

Monograptus triangulatus (Hark.)

Monograptus lobiferus (M'Coy.)

Diplograptus tamariscus (Nich.)

Petalograptus folium (Hist.)

Rastrites peregrinus (Barr.)

Dawsonia campanulata (Nich.)

About 300 yards above the old mine another exposure of the *M. gregarius* zone occurs, from which the following fossils have been obtained:

Monograptus gregarius (Lapw.)

Monograptus lobiferus (M'Coy.)

Monograptus leptotheca (Lapw.)

Monograptus triangulatus (Hark.)

Monograptus Sandersoni (Lapw.)

Monograptus spiralis (Geinitz.)

Monograptus communis (Lapw.)

Rastrites peregrinus (Barr.)

Diplograptus tamariscus (Nich.)

Climacograptus rectangularis (M'Coy.)

Dawsonia campanulata (Nich.)

Discinocaris browniana (Woodw.)

The section in Hartfell "Score" at the head of the glen, as shown by Professor Lapworth (Quart. Jour. Geol. Soc., vol. xxxiv., p. 295), displays on a large scale the various sub-divisions of the Lower Hartfell black shales. From this locality the Hartfell division of the Moffat series takes its name (Figure 24).

The axis of the main anticline runs parallel to the stream draining the "Score" above the Spa Well, the crest of which coincides with a fault, probably reversed, that truncates the Birkhill Shales on the south side of the stream and brings them in contact with Glenkiln and Hartfell strata to the north.

Taking first the south limb of the main arch, which lies to the south of the fault just referred to, the observer finds a minor fold revealing the Hartfell black shales below the Spa Well, the lowest beds belonging to the *Dicranograptus Clingani* zone. The Barren Mudstones (3II' in section) follow in regular order to the north-west and south-east, folding round the underlying beds. They are likewise traceable for a short distance along the slope on the south side of the "Score", where they are associated with a band of highly decomposed volcanic breccia.

At the Spa Well the Lower Birkhill Shales (4III in section) appear to the north of the outcrop of Barren Mudstones, where they have yielded the following forms:

Monograptus gregarius (Lapw.)

Monograptus tenuis (Portl.)

Monograptus cyphus (Lapw.)

Monograptus attenuatus (Hopk.)

Diplograptus vesiculosus (Nich.)

Diplograptus tamariscus (Nich.)

Diplograptus acuminatus (Nich.)

Dimorphograptus elongatus (Lapw.)

The foregoing outcrop of Birkhill Shales, though in a somewhat shattered condition, can be traced along the south side of the gorge to the head of the "Score". Along the top of the south cliff the Tarannon grits and shales may be followed, where for some distance they pass down conformably into the *Monograptus gregarius* bands of the Lower Birkhill division.

Turning now to the great crag on the north side of Hartfell "Score" (Figure 24), the observer encounters a broad development of black shales, extending high up the mountain, which is due to the sharp reduplication of the Lower Hartfell black shales (3II in section) and the underlying mudstones, cherts, and black shales belonging to the Glenkiln group (2^c in section). Indeed, the alternation of bands of orange-coloured mudstones and cherts with black shales forms a striking feature of the lower portion of the scar.

Before describing the relations of these mudstones and cherts to the Hartfell black shales, we may refer to certain lavas and volcanic tuffs, which, from their associated fossils, are probably of Llandeilo age. They occur in the stream and on the adjoining slope to the north-east, at a point about 250 yards up the burn from the Spa Well. On the south side the volcanic rocks are truncated by the main fault in the Hartfell "Score", which brings them in contact with the Birkhill Shales on the south limb of the main arch; while on the north side they are cut off by a fault which places them in conjunction with Hartfell Shales. It will thus be seen that their horizon cannot be satisfactorily determined from their stratigraphical relations. The volcanic tuff, which is visible on the right bank of the burn below the forkings, is only a few feet broad, and on the north side of this exposure, where it is faulted against the Hartfell black shales, it contains a thin streak of fossiliferous black shale. On the slope to the north-east, and only a few yards from the burn, there is a small boss of lava and volcanic tuff, which is clearly the prolongation of the band in the stream. A specimen of the lava ([S7161](#)), examined by Mr. Teall, has been termed diabase-porphyrity, too much altered for precise determination. Here also, on the north side of the exposure, fossiliferous black shale appears, which is interleaved in the tuff. From the latter outcrop, as well as from the seam of dark shales in the ash in the stream, the following forms have been obtained, which have been kindly determined by Professor Lapworth:

Didymograptus superstes (Lapw.)

Leptograptus magnus (Lapw.)

Dicellograptus patulosus (Lapw.)

Climacograptus bicornis (Hall.)

Climacograptus caelatus var. *antiquus* (Lapw.)

Diplograptus foliaceus (Murch.)

Diplograptus euglyphus (Lapw.)

Lasiograptus Harknessi (Mich.)

A few yards to the north of the exposures of volcanic rocks and associated graptolite shales, the orange-coloured mudstones and cherts are visible at the forkings of the burn, where they occur along two isoclines overlain by the Hartfell black shales. Not far to the north-west of the forkings, on the north side of the northmost arch of these mudstones, their junction with the overlying black shales is well seen. Here, at the base of the Lower Hartfell division, occurs the *Climacograptus Wilsoni* zone, composed of grey flinty mudstone and dark shales, where specimens of that zonal form are associated with. *Buthograptus laxis*, *Climacograptus bicornis*, *Glossograptus Hincksi*, &c. This zone is underlain by two feet of black shales, with seams of volcanic ash half an inch thick; the latter resting directly on the orange-coloured mudstones, and yielding in profusion the following assemblage of forms: *Dicranograptus zic-zac*, *D. ramosus*, *Caenograptus pertenuis*, *Climacograptus Schärenbergi*, *Corynoides calycularis*. Of these species the first three occur on one slab from a seam about six inches above the top of the orange-coloured mudstones. It is probable, therefore, that this thin band of black shale between the *C. Wilsoni* zone and the top of the mudstones may represent the highest sub-zone of the Glenkiln shales, as in Dobb's Linn and Craigmichan Scaurs.

This view of the correlation of these mudstones and overlying black shales is strengthened by evidence obtained from another exposure on the same crag to the north of the Spa Well. Owing to the scree material it is difficult to fix the spot from which the fossils in the following list were collected; but the band underlies the *Climacograptus Wilsoni* zone with *Buthograptus laxus*, and overlies the orange-coloured mudstones and cherts with radiolaria:

Dicranograptus zic-zac (Law.)

Dicranograptus ramosus (Hall.)

Dicranograptus Nicholsoni (Hopk.)

Dicranograptus formosus (Hopk.)

Thamnograptus scoticus (Lapw.)

Cryptograptus tricornis (Carr.)

Climacograptus peltifer (Lapw.)

Diplograptus foliaceus (Murch.)

Diplograptus angustifolius (Hall.)

Lasiograptus bimucronatus (Nich.)

Glossograptus Hincksi (Hopk.)

Clathrograptus cuneiformis (Lapw.)

Proceeding now to the sub-zones of the Hartfell black shales overlying these orange-coloured mudstones, the observer can trace them along the face of the north crag, where they are much contorted and thrown into parallel folds. The bands of the *Climacograptus Wilsoni* zone have yielded at various points along their line of outcrop the following fossils:

Climacograptus Wilsoni (Lapw.)

Climacograptus tricornis (Hall.)

Climacograptus Schärenbergi (Lapw.)

Diplograptus foliaceus (Murch.)

Cryptograptus tricornis (Carr.)

Glossograptus Hincksi (Hopk.)

Dicranograptus ramosus (Hall.)

Dicranograptus Nicholsoni (Hopk.)

Corynoides calycularis (Nich.)

Acrotreta Nicholsoni (Dav.)

Next in order occurs the zone of *Dicranograptus Clingani*, consisting of flaggy black shales, which may be studied to advantage in the fine exposures on the north side of the "Score", where the forms given in the annexed list were collected:

Dicranograptus Clingani (Carr.)

Dicranograptus ramosus (Hall.)

Dicranograptus Nicholsoni (Hopk.)

Dicellograptus Forchhammeri (Geinitz.)

Dicellograptus caduceus (Lapw.)

Dicellograptus elegans (Carr.)

Leptograptus flaccidus (Hall.)

Climacograptus caudatus (Lapw.)

Diplograptus foliaceus (Murch.)

Diplograptus truncatus (Lapw.)

Cryptograptus tricornis (Carr.)

Discina, sp.

Acrotreta, sp.

To these succeed the slaty black shales of the *Pleurograptus linearis* zone, from which the following forms have been collected:

Pleurograptus linearis (Carr.)

Leptograptus flaccidus (Hall.)

Leptograptus capillaris (Carr.)

Diplograptus quadrimucronatus (Hall.)

Diplograptus foliaceus (Murch.)

Retiolites (Neurograptus) fibratus (Lapw.)

Dicellograptus elegans (Carr.)

Dicellograptus Morrisi (Hopk.)

Amphigraptus divergens (Hall.)

Climacograptus bicornis (Hall.)

Climacograptus tubuliferus (Lapw.)

Corynoides calycularis (Nich.)

Acrotreta Nicholsoni (Dav.)

So highly convoluted are the strata on the north cliff that it is almost impossible to determine definitely the extent of the reduplication of the zones; but at the extreme north-eastern corner of the "Score" the *Climacograptus Wilsoni* zone

reappears where it yields specimens of *Buthograptus laxis*, and is followed towards the north by the orange-coloured mudstones of the Glenkiln division.

The crest of the ridge north-west of Hartfell "Score" is occupied by grits and shales (Tarannon), but the Moffat Shales come to the surface on another anticline in Bill's Cleugh (Figure 24) parallel to that of Hartfell. There the lowest visible strata consist of Barren Mudstones, which are followed by black shales yielding Lower Birkhill graptolites.

About half a mile to the north-east — in Pot Burn — the prolongation of the Hartfell band is met with, where Lower Birkhill strata are exposed, and again at the head of Cold Grain, below the summit of Hartfell. At the latter locality the black shale bands present an interesting palaeontological feature, for there the *Monograptus spinigerus* zone occurs with the *M. gregarius* zone, thus showing that at the north-east termination of this anticline a portion of the Upper Birkhill division is still to be found. The following forms have been collected from this exposure: *Monograptus spinigerus* (Nich.), *M. Hisingeri* (Carr.), *M. lobiferus* (M'Coy), *M. gregarius* (Lapw.), *M. attenuatus* (Hopk.), *M. spiralis* (Geinitz), *M. tenuis* (Portl.), *Climacograptus normalis* (Lapw.).

Ruttonside. — [NT 04322 07528] Taking now the bands more or less in the strike of Hartfell to the west of the Permian basin, the observer finds a similar absence of the fossiliferous zones of the Upper Birkhill division. At Ruttonside, in the railway cutting, there are two anticlines of black shales embedded in grits and greywackes. They yield *Diplograptus vesiculosus* (Nich.), *Monograptus gregarius* (Lapw.), *Climacograptus normalis* (Lapw.), &c. These beds are followed rapidly by greywackes, with only thin flags and shales intervening. The same features are observable in the Cloffin Burn about a mile to the south-west of Ruttonside.

Headshaw Linn. — [NT 04533 09548] About a mile north of Ruttonside, in the Headshaw Linn, Dead Burn, a small but clear section is found. The lower part of the burn is occupied by greywackes and shales dipping towards the north-west at an angle of about 30°. On crossing a line of fault trending north-west, with a downthrow to the west, members of the Moffat series are exposed in an isoclinal fold. Here they consist of beds belonging to the *Monograptus gregarius* zone and the *Diplograptus vesiculosus* zone. At one point the Barren Mudstones emerge from beneath thin black shale bands. All the strata are very much decomposed, the *Diplograptus vesiculosus* band being even bleached into a lilac-coloured clay. The following among other forms were obtained: *Monograptus gregarius* (Lapw.), *M. triangulatus* (Hark.), *M. cyphus* (Lapw.), *Rastrites peregrinus* (Barr.), *Petalograptus folium*, *Diplograptus tamariscus* (Nich.).

To the north and south of this fold a few feet of purple barren shales succeed, and these are followed by the greywackes and shales (Queensberry grits) of Llandovery–Tarannon age.

Gameshope Burn. — [NT 13393 18487] Further to the north-east of Hartfell there are three small local folds in the streams draining into this burn near the watershed. In the west branch, about two miles north-east of Hartfell, black shales that have bleached white occur, in which *Climacograptus normalis* (Lapw.) was found. Grey shales are associated with the foregoing bands, and in the north side of the fold they plunge underneath the greywackes and grits at angles varying from 40° to 50°.

In another branch of the Gameshope Burn, north of the watershed at Loch Skene, bands belonging to the *Monograptus gregarius* zone occur, yielding also *M. leptotheca* (Lapw.), *Diplograptus tamariscus* (Nich.). These are immediately overlain by shales, flags, and greywackes.

Mid Craig, Loch Skene. — [NT 16585 16362] In a notch on the Mid Craig overlooking Loch Skene, on the west side, a band appears of Moffat Shales, which can be traced for about two miles. The Barren Mudstones occupy the centre of the fold, followed on both sides by the Lower Birkhill black shales, with their characteristic fossils, especially those of the *Monograptus gregarius* zone. These are overlain by a limited thickness of grey shales, probably representing part, if not the whole, of the upper portion of this division. At the head of the "Score" the inverted anticline is abruptly narrowed by two branching faults with a downthrow to the west. Of these the northern one is the more powerful, as it brings the greywackes and grits into contact with the black shales, while the southern one throws the grey shales against the fossiliferous bands.

To the west of the faults the anticline does not show the Barren Mudstones, but only the overlying black shales.

A short distance to the south of the foregoing arch, in a notch on the Mid Craig opposite the middle of Loch Skene, a black sandy bed occurs among the Tarannon grits. It is about three feet wide, with a few inches of shaly clay containing indistinct traces of graptolites. Here occur nodular masses of crystalline limestone and spathic iron-ore, the latter decomposing into brown oxide of iron.

Immediately to the south of the anticline of the Moffat Shales on the Mid Craig there is a broad exposure of grey slaty shales, which are evidently repeated by numerous folds. They may probably represent the series immediately overlying the Birkhill beds.

The band at the head of Loch Skene reappears on the slopes of Lochcraig Head at a height of 2000ft., rising from underneath the Queensberry grits. Here, as on the Mid Craig just referred to, there is a greater breadth of the barren grey shales on the south than on the north side of the fold.

Garlie's Cleuch, Winterhope. — [NT 17670 18208] On the other side of the watershed the same band is met with again in the streamlets flowing into Garlie's Cleuch, a tributary of the Meggat Water, where there are several flat anticlines of the Lower Birkhill beds associated with barren grey shales. Here a band of pebbly grit, interleaved in the latter strata, may probably lie on the same horizon as the pebbly band that occurs in the shales to the northeast.

From the occurrence of these local folds of the Moffat Shales in Garlie's Cleuch and the ridge to the south, within no great distance of each other, and in the strike of the strata in Mid Craig, Loch Skene, it is, probable that the Moffat Shales lie near the surface in several of the folds of grey shale at the latter locality.

Towards the north-east, black shales again appear on the hill-slope east of the great bend in Winterhope Burn, yielding *Diplograptus vesiculosus* (Nich.) and *D. acuminatus* (Nich.).

Shielhope, Syart Law, and Craigierig. — [NT 19354 22022] In the basin of the Meggat Water a band is traceable from the burn at Shielhope by Syart Law to the stream at Craigierig [NT 20873 23015]. Of the sections there exposed, one in the scar opposite Cramalt [NT 20142 22196], on the slope of Syart Law, shows the greatest development of this series.

The Barren Mudstones are seen at the top of the scar, with the Lower Hartfell black shales rising from underneath, but here inverted. The latter are repeated by numerous isoclinal folds. They contain *Diplograptus foliaceus* (Murch.), *Dicranograptus ramosus* (Hall), *Dicellograptus Forchhammeri* (Geinitz).

The Barren Mudstones lie in some of the small synclines, but eventually they dip to the north-west and pass underneath the Lower Birkhill Shales and the overlying grey shales.

In the Shielhope Burn two small folds of the Lower Birkhill group may be seen. Again, in the burn at Craigierig, on the north bank of the Meggat Water, a very small exposure of the highest bands of the lower division of this group has yielded *Monograptus lobiferus* (M'Coy), *Diplograptus tamariscus* (Nich.), *Rastrites peregrinus* (Parr.). These strata are overlain by shales and pebbly grits, with fine silky shales like those with *Monograptus Sedgwicki* in Dobb's Linn. Some of the pebbly grits contain fragments of black shales.

Boar Cleuch, Glengaber Burn. — [NT 20982 24314] A beautiful normal anticline, as described by Professor Lapworth, occurs in this stream, and shows the infraposition of the Moffat series to the Queensberry grits. The Yair Burn is here deflected into the Boar Cleuch along the crest of the arch in the black shales. The flaggy black shales of the *Diplograptus vesiculosus* zone are exposed in the bed of the stream, being the lowest visible strata, followed by the bands representing the *Monograptus gregarius* zone. These are in turn overlain by a considerable thickness of grey flaggy shales underlying the grits. They are not fossiliferous, but it is highly probable that they represent the upper portion of the Birkhill division in Dobb's Linn.

Proceeding northwards, either along the course of the Glengaber Burn, or by the road from Craigierig towards the head of the Manor Water, we encounter several folds in the overlying Queensberry grit series, which bring up the dark grey shales associated with the Lower Birkhill beds in that region.

Dryhope Hope, Kirkstead Burn. — [NT 26086 24683] About a mile and a half to the north-east of the folds in Glengaber Burn and Boar Cleuch, similar evidence is obtained of change in the lithological characters of the members of the Birkhill division. For in the Kirkstead Burn, west of Dryhope Hope, there is a constant repetition of blue-grey shales with thin grits, containing at one or two localities thin black seams, which enclose graptolites of the Upper Birkhill division. About one-third of a mile west of the shepherd's house of Dryhope Hope a thin dark seam in highly inclined grey shales furnishes specimens of *Monograptus spinigerus*.

Douglas Burn. — [NT 25419 28595] Crossing the watershed to the basin of the Douglas Burn, which joins the Yarrow about a mile and a half to the east of St. Mary's Loch, we find in several tributaries of this stream, near Muttonhole, exposures of representatives of the Moffat series. On the south slope of Jeffrey Rig, about half a mile to the west of Muttonhole, black shales and cherts, and black shales with white clays, are visible in small scars.

Slate Cleuch, Douglas Burn. — [NT 25106 29141] Further to the northeast, in the Slate Cleuch, that unites with the Douglas Burn at Muttonhole, members of the Glenkiln and Birkhill divisions appear in a highly disturbed condition on the south-west bank about 700 yards up the stream.

Beginning at the north-west limit of the section, the observer finds grey sandy shales dipping towards the north-west at 30°, which are faulted against a mass of black shales with black cherts, representing the Glenkiln group. The beds are much shattered, but the following forms were here obtained:

Didymograptus superstes (Lapw.)

Caenograptus gracilis (Hall.)

Caenograptus pertenuis (Lapw.)

Dicranograptus formosus (Hopk.)

Diplograptus foliaceus (Murch.)

Cryptograptus tricornis (Carr.)

Climacograptus, sp.

These Glenkiln Shales are followed to the south-east by cherts and mudstones which may represent part of the radiolarian cherts of Arenig age, succeeded by a second band of black shales yielding *Cryptograptus tricornis*, *Climacograptus bicornis*, &c. The latter are followed by mudstones and black sandy shales, containing fossils, belonging to the Birkhill group, viz.: *Rastrites maximus*, *Diplograptus tamariscus*, *Monograptus tenuis*, &c. It is evident that a fault separates these Birkhill strata from the representatives of the Glenkiln division.

On both sides of this exposure of the Moffat series there is a development of grey slaty shales with occasional flaggy grit bands: these are associated, on the north-west side of the fold, with a peculiar series of white or cream-coloured flinty shales, resembling the flinty bands in Earnscleuch, Lauderdale (see p. 197).

Black Cleuch, Douglas Burn. — [NT 25368 31151] High up on the western slope of the watershed that separates the Douglas Burn from Traquair Water, another section reveals representatives of the Glenkiln, Harden, and Birkhill divisions. It is exposed in a scar at the head of a rivulet draining into Black Cleuch, about a mile and a half up from its junction with the Douglas Burn, and about half a mile south of the crest of Dun Rig (2433ft.). Ascending this streamlet, the observer finds greywackes and shales, nearly vertical or dipping to the north-west, followed by black shales. Along their south side the Moffat Shales are truncated by a fault that brings them in contact with the greywackes. Black flinty bands are associated with the black shales near the fault. From the following list of fossils obtained from these shales, it is evident that they represent the Glenkiln–Hartfell group, viz.: *Climacograptus peltifer*, *C. caelatus* var. *antiquus*, *C. Schärenbergi*, *C. caudatus*, *Dicranograptus ramosus*, *Dicellograptus*, *Cryptograptus tricornis*, *Diplograptus foliaceus*, *Corynoides calycularis*.

These strata are truncated by a fault which brings them into conjunction with blue-black sandy shales and clays of the *Monograptus gregarius* zone of the Lower Birkhill division. They present the following assemblage of graptolites: *Monograptus gregarius*, *M. lobiferus*, *M. triangulatus*, *M. leptotheca*, *M. tenuis*, *M. attenuatus*, &c. On the north side there is a passage upwards into greywackes and shales, which may represent part of the Upper Birkhill Shale group.

Cow Linn, Fruid Water. — [NT 11447 15866] About a mile and a half from the source of the Fruid Water, north of Hartfell, below the foot of Black Cleuch, the stream flows through a rocky gorge in greywackes and grits. Near the bend of the stream, in an excellent exposure of the Lower Birkhill Shales, these strata are arranged in an isoclinal fold, the lowest beds being in the centre, and with the higher zones on either side. From the accompanying lists of fossils, which are abundant and well preserved, obtained from this locality, it is evident that all the main zones of the Lower Birkhill division are represented. The *Monograptus gregarius* zone has yielded the following forms:

Monograptus gregarius (Lapw.)

Monograptus leptotheca (Lapw.)

Monograptus cyphus (Lapw.)

Monograptus triangutatus (Hark.)

Monograptus lobiferus (M'Coy.)

Monograptus tenuis (Portl.)

Diplograptus tamariscus (Nich.)

Petalograptus folium (His.)

Rastrites peregrinus (Barr.)

From the two lower zones the following fossils were exhumed:

Diplograptus vesiculosus (Nich.)

Diplograptus acuminatus (Nich.)

Dimophograptus Swanstoni (Lapw.)

Monograptus tenuis (Portl.)

Climacograptus normalis (Lapw.)

Dawsonia campanulata (Nich.)

This band is of special importance, as it still yields the characteristic fossils of the *Monograptus gregarius* zone. To the north-west of this outcrop this particular horizon is no longer met with. On all the anticlines between the Cow Linn and the river Tweed above the Crook, only the two lower zones of the Lower Birkhill beds are represented.

To the south-west of the Cow Linn section, the prolongation of this band is met with in the White Cleuch, a branch of the Carterhope Burn, where grey and dark shales occur.

Powskein Burn. — [NT 07820 14341] In a small tributary of this burn — joining the Tweed about a mile to the north of the Permian outlier at Erickstane — a mass of grey and dark shales is exposed, from which no fossils have been obtained. They resemble those beds associated with the Lower Birkhill Shales at the head of Blackhope Burn on Hartfell.

Howecleuch, Eyan Water. — [NT 03038 12671] At Nether Howecleuch, near the junction of Harthope Burn with the river Eyan, an exposure of black sandy shale in an isoclinal fold may be seen in the midst of the Queensberry grits. The band is only a few feet broad, but it has yielded some Lower Birkhill fossils.

Fruid Water. — [NT 10160 18976] On the east side of the valley, about a mile below Fruid Farmhouse, in a small gully above the road, black sandy shales are met with in the grits, which are continued north-eastwards into the Menzion Water. Similar strata occur in the Hawkshaw Burn, a tributary of the Fruid Water, about a mile north of Carterhope.

Foot of Fruid Water, near junction with the Tweed. — [NT 08725 23053] Near the foot of Fruid Water interesting sections are found of the representatives of the Moffat series. For several miles this stream flows along an alluvial flat which conceals the rocks from view, but eventually it careers through a rocky gorge carved out of the pebbly bands of the Queensberry grits. Just above the gorge it traverses for about 100 yards a succession of dark blue, almost black, and grey shales, representing the two lower zones of the Lower Birkhill division. To the north of the grits the dark and grey shales once more appear. The strata have a constant dip down stream or towards the north at angles varying from 45° to 50°. It is highly probable that the dark shales are repeated by means of isoclinal folds. The most northerly outcrop is shifted by a fault trending north, which cuts obliquely across the stream.

It is a remarkable fact that in these exposures the two lower zones of the Lower Birkhill Shales have entirely changed their lithological characters. Instead of the persistent bands of black flaggy shales that run through the whole of the Moffat region, abundantly charged with fossils, the shales are now dark blue, hardly black, and seldom contain fossils. Indeed, after a most rigorous search by Mr. Macconochie, only the few following forms were obtained:

Diplograptus acuminatus (Nich.)

Diplograptus vesiculosus (Nich.)

Climacograptus normalis (Lapw.)

The more northerly band can be traced north-east to the Menzion Burn and to the Talla Water above Dykehead.

Tweed Valley. — On referring to the map (Sheet 16) it will be seen that a band which represents part of the Moffat series can be traced along the valley of the Tweed from the foot of the Talla Water [NT 09837 24305], south-west to the bend above Glenbreck [NT 06070 21366].

Where this band is exposed in the Tweed at Rigs it has yielded the following forms:

Diplograptus acuminatus (Nich.)

Diplograptus vesiculosus (Nich.)

Climacograptus normalis (Lspw.)

Dimorphograptus (?)

Here the fossiliferous zone is only a few inches thick, and fossils are extremely rare.

At other points along this line of outcrop between Glenbreck and the Talla Water the following additional fossils have been obtained: *Climacograptus innotatus* (Nich.), *Dimorphograptus elongatus*, and *Diplograptus*. One of these fossiliferous localities occurs at the bridge across the Tweed near the foot of the Talla Water.

On three successive anticlines in the Oliver Burn, north of the Tweed, three representatives of part of the Moffat series make their appearance. The folds are isoclinal, the strata having a uniform dip to the north-west at angles varying from 45° to 70°.

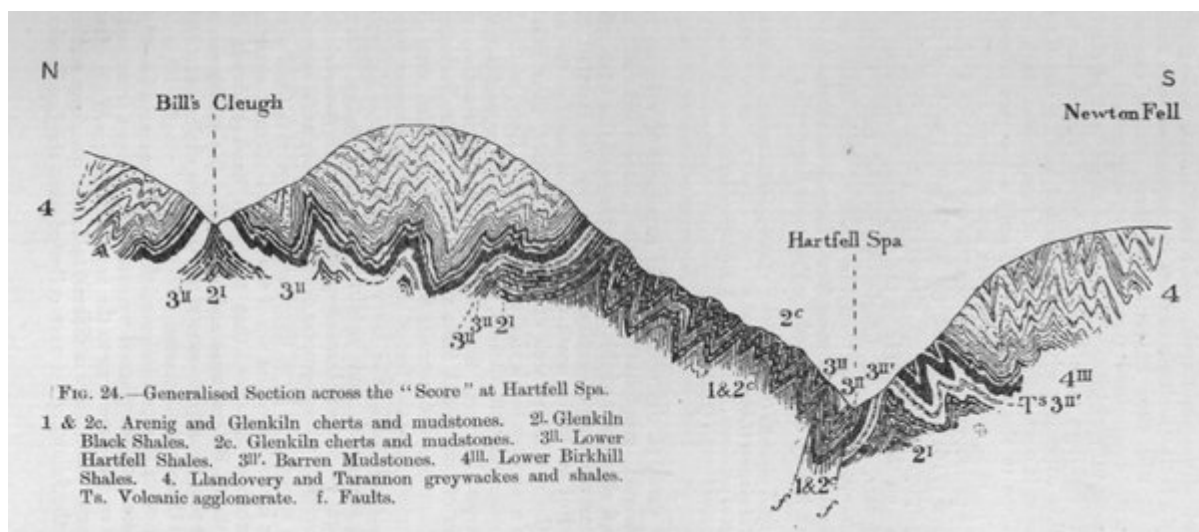
About two miles to the south-west of the Tweed at Glenbreck, several anticlines of these fossiliferous Moffat Shales occur in close association with the outcrops of the Pinstane Conglomerate. Here they yield fossils very sparingly, but in numbers sufficient to prove their horizon.

A glance at the map will show that along the northern margin of the Llandoverly and Tarannon area, between the valley of the Tweed and Kingledores Burn, and westwards towards the Midlock Water at Howe Cleuch, several local isoclinal folds expose similar dark blue shales which are probably the representatives of the very basal bands of the Birkhill division. In these bands, *Diplograptus vesiculosus* has not been detected, but fragments of certain graptolites which are the associates of that species and *D. acuminatus* at the foot of the Fruid Water and in the Tweed bands have been found. Amongst them there is a small and very attenuated form of *Climacograptus* which seems to be characteristic of the bands near the margin of the Tarannon area. Indeed, it is mainly by the aid of these bands that the boundary line has been drawn at the base of the Tarannon and Llandoverly rocks in the north-west part of Sheet 16. But it must be clearly borne in mind that fossils are extremely rare and poorly preserved. In the exposures along the boundary line neither *Diplograptus vesiculosus* nor *D. acuminatus* has been detected. It must be frankly admitted that there is no well-marked fossiliferous band which can be traced continuously at the base of the Llandoverly and Tarannon series in the northern area. These facts have an important bearing on the lateral variation of the Moffat series as we pass towards the Abington and Lead Hills districts.

Summarising the evidence given in this chapter regarding the modification of the Moffat zones between Dobb's Linn and the margin of the Tarannon area, it is observable that there is a gradual change in the lithological characters of the members of the Birkhill division and a gradual disappearance of the fossiliferous zones as we pass towards the north-west. Along the line of the Hartfell baud the fossiliferous zones of the Upper Birkhill division have either wholly or partially disappeared. The last appearance of the *Monograptus gregarius* zone, which is the highest band of the Lower Birkhill Shales, occurs on the anticline at Cow Linn near the head of the Fruid Water.

At the foot of the Fruid Water and in the bed of the Tweed between the foot of the Talla Water and Glenbreck, though specimens of *Diplograptus vesiculosus* and *D. acuminatus* have been obtained, the lithological characters of the zones marked by these species have been considerably changed. Fossils are extremely rare in the bands of dark blue shale.

North of the Tweed as far as the line selected to mark the base of the Llandoverly Rocks, *Diplograptus vesiculosus* and *D. acuminatus*, characteristic of the two lower zones of the Lower Birkhill Shales, seem to have disappeared, and there are only traces of graptolites which are the associates of these species in the bands of the Tweed. It is clear, therefore, that within a distance of nine miles from the typical Dobb's Linn section along the northern margin of the Llandoverly area, the characteristic zonal fossils of the Birkhill division have disappeared.



(Figure 24) Generalised Section across the "Score" at Hartfell Spa. 1 & 2c. Arenig and Glenkiln charts and mudstones. 2??? Glenkiln Black Shales. 2c. Glenkiln charts and mudstones. 3ll. Lower Hartfell Shales. 3ll'. Barren Mudstones. 4ll. Lower Birkhill Shales. 4. Llandoverly and Tarannon greywackes and shales. Ts. Volcanic agglomerate. f. Faults.