# Chapter 6 The Central Belt — continued. Black Shale Bands South of Moffatdale

Having indicated the order of succession in the Moffat black shales, we shall now proceed to describe the various outcrops of the series in the region lying to the south-east of St. Mary's Loch and Moffatdale. A glance at the map (Sheet 16) will show that in the narrow belt of high ground between the Moffat Water and the Lower Ettrick there is a series of persistent bands of the black shales running more or less parallel to each other and coming to the surface along sharp anticlinal folds. The belt of territory along which these bands can be traced extends from the Permian basin of Moffat at Bellcraig to the vale of Yarrow, a distance of 18 miles.

## i. The Band of Bodesbeck Summit, Range Cleuch, Muckra, and Crosscleuch, St. Mary's Loch

At the south-west termination of this band, which is traceable for a distance of 10 miles, there is a well-marked isoclinal fold in the black shales about 100 yards north-east of the road on Bodesbeck summit. Only the highest bands of the Birkhill Shales are visible in the heart of the greywackes and shales, the strata dipping to the north-west.

**Range Cleuch**. — [NT 19293 10668] Towards the north-east along the outcrop, the members of this series are again visible in the Range Cleuch, a tributary of the Upper Ettrick. Here, in a beautiful isoclinal fold, the various subdivisions are clearly defined where two streams unite to form the Range Cleuch. In the centre of the anticline the black shales belonging to the Lower Harden horizon appear, and these are succeeded in regular order by the Barren Mudstones yielding near the top the characteristic form *Dicellograptus anceps.* To these succeed the flaggy shales containing the Lower Birkhill graptolites, followed by the clays, grey and black shales forming the upper portion of this group.. The highest bands in contact with the greywackes on both limbs of the arch yield *Rastrites maximus* and *M. Sedgwicki.* The strata are considerably crumpled, but the sequence is none the less apparent.

**Rowantree Gutter**. — [NT 19709 12528] Further to the north-east in a small cleugh flowing into the Kirkhope Burn there is a similar isocline showing the Hartfell black shales in the core of the arch, which have yielded the following forms:

*Pleurograptus* linearis (Carr.)

*Leptograptus flaccidus* (Hall.)

*Diplograptus foliaceus* (Murch.

*Diplograptus truncatus* (Lapw.)

*Climacograptus bicornis* (Hall.)

*Dicellograptus pumilus* (Lapw.)

*Dicellograptus Forchhammeri* (Geinitz.)

*Dicellograptus moffatensis* (Carr.)

These are succeeded by the Barren Mudstones and the Birkhill Shales. On the south limb of the fold the greywackes and shales follow in regular order, but on the north limb the natural sequence is disturbed by a fault.

**Brockhope Burn**. — [NT 21191 13389] An instructive section is met with near the head of this stream showing how the Moffat black shales gradually "nose out" or disappear under the overlying greywackes as we ascend the slope to higher ground. In the Brockhope Burn the isoclinal fold reveals the Upper Birkhill zones, with the white clays, grey shales and black shales, the highest bands on either side yielding *Rastrites maximus* and *Monograptus Sedgwicki.* But as we ascend the streamlet on the east bank (the Overscar) the zones gradually coalesce till at the 1750ft. contour line they

pass underneath the Tarannon greywackes.

**Trow Grain**. — [NT 21026 14484] Still further to the north-east two streams unite to form the Back Burn, which joins the Ettrick at Brockhoperig. At the junction of the streams, the isoclinal fold again appears, with the Lower Birkhill bands in the centre and the higher zones on either side. From these exposures the following forms have been obtained: *Monograptus leptotheca* (Lapw.), *M. triangulatus* (Hark.), *M. lobiferus* (M'Coy), *M. spiralis* (Geinitz), *Rastrites maximus* (Carr.).

Not far to the east, in the Fala Grain, this isoclinal fold is further demonstrated by the appearance of the Barren Mudstones in the core of the arch, bounded on either side by the flaggy black shales containing *Diplograptus vesiculosus* and *Monograptus gregarius,* succeeded by the grey shales, clays, and dark seams of the Upper Birkhill group.

Far up the south slope of Herman Law, in a streamlet flowing into the Black Grain and also in the latter stream, there is an exposure of the Upper Birkhill beds in the midst of the greywackes. In the main stream these zones are repeated by several sharp folds, but in the small tributary only one is seen. At one locality the fossils are in a fine state of preservation. Those obtained are given in the following list:

*Monograptus Sedgwicki* (Portl.)

*Monograptus attenuatus* (Hopk.)

*Monograptus spiralis* (Lapw.)

*Monograptus leptotheca* (Lapw.)

*Rastrites peregrinus* (Barr.)

*Rastrites distans* (Geinitz.)

*Rastrites capillaris* (Carr.)

In the Muckra Burn the north-east prolongation of this band is visible, but in part of this section the black shales are very much shattered and crushed, so that it is difficult to interpret the sequence with certainty. The lowest beds exposed seem to represent the Barren Mudstones overlain by the Lower Birkhill Shales. Towards the north, the upper beds of this division are repeated by folds, and yield *Monograptus spinigerus, M. Hisingeri, M. Sedgwicki,* and *Rastrites maximus.* On both sides of the anticline they plunge underneath the Llandovery greywackes.

Again at Crosscleuch, near St. Mary's Loch, only the Birkhill beds are represented, there being two small anticlines with an intervening syncline of greywackes.

## ii. Band of Thirlstane Score

Not far to the south of the band just described, and about a mile to the east of St. Mary's Cottage at the south end of St. Mary's Loch, a small anticline in the black shale series is traceable for no great distance. The section is visible in a small stream flowing into the Thirlstane Burn [NT 25105 19882]. The lowest beds exposed belong to the lower portions of the Birkhill group, and form the core of the arch. They yield *Diplograptus acuminatus, D. vesiculosus,* and *Monograptus gregarius.* These are succeeded by the black and grey shales and mudstones, partly of a purple colour, charged with *M. spinigerus,* followed in order by the highest bands containing *Rastrites maximus* and *Monograptus Sedgwicki* in excellent preservation. An intrusive felsite dyke is traceable along the north-west limb of the fold. The anticline is inverted, and the various zones succeed each other regularly on both sides of the arch. But in the intervening area the sequence is disturbed by a normal fault. On the east limb of the fold, the anticline of the Lower Birkhill zones is truncated by a normal fault bringing down higher members of this division into conjunction with the lower.

## iii. Band extending from Pot Law by Peniestone Knowe to Moory Sike: probable continuation towards the south-west from Capel Fell to Craig Fell

For a distance of eight miles this band is traceable between Pot Law and Moory Sike; but towards the south-west, after a gap of about a mile and a half, a band of black shales appears much on the same line of strike, extending for three miles from Capel Fell to Craig Fell.

**Cossarshill Burn**. — [NT 22616 15113] About a mile and a half to the east of Birkhill, an interesting transverse section of this hand is to be seen in a small stream at the head of Cossarshill Burn, a tributary of the Ettrick. At the northern end the grey shales with dark seams containing *Rastrites maximus* dip below the Tarannon greywackes and shales at high angles. Descendingthe section, these higher zones with black seams and white clays are repeated by sharp inverted folds. Soon the hard black flaggy shales, charged with *Diplograptus vesiculosus,* rise from underneath them. These Lower Birkhill beds are cut off on the south side by a fault that brings them into contact with the Tarannon flags and shales. Further down the section we meet with three successive anticlines of the Birkhill beds belonging to the higher zones, the intervening synclines being occupied by flags and shales.

Further to the north-east this hand is exposed in the Riskinhope Burn, which flows for some distance along the strike of the beds. At the head of the stream the grey and black shales appear, charged with *Restrites maxima,* but further down the sections lower horizons come to the surface. The flaggy shales with *Diplograptus vesiculosus* and *Monograptus gregarius* are met with, and at one point there is a small exposure of the Lower Hartfell black dudes in the midst of the Barren Mudstones.

**Moory Sike**. — [NT 24893 19345] Further to the north-east, a fine transverse section of this band is found in the Moory Sike, a tributary of the Whitehope Burn flowing into the Loch of the Lowes.

At the south end of the section, at the waterfall, the greywackes and shales are brought into contact with some of the Birkhill zones by a fault. Close to the fault, dark shales appear, alternating with white clays, and dipping to the south. These are followed by the black flaggy shales of the *Diplograptus vesiculosus*zone. For a short distance there is an exposure in a highly contorted form of grey shales, blue clays with black shales, and white clays representing the higher members of the Birkhill group. Further north the black flaggy shales again Appear belonging to the *Diplograptus vesiculosus*zone. These are faulted against the Lower Hartfell black shales and a small portion of the Barren Mudstones. The Hartfell black shales are highly contorted, but they seem to be arranged in an anticlinal fold, for the Barren Mudstones reappear on the north side of the fold. Several of the characteristic zones can be proved by means of the fossils. The lowest bands yield *Climacograptus Wilsoni* and *Dicranograptus Clingani, D. ramosus,* and *Corynoides calycularis.* The highest zone, *Pleurograptus linearis,* is met with, and towards the north it plunges below the Barren Mudstones with black seams yielding *Dicellograptus anceps.*

By means of a fault the Barren Mudstones are brought into conjunction with the Upper Birkhill beds. These consist of grey shales with black bands yielding *Monograptus spinigerus* and *M. Hisingeri.* Further north these pass upwards into the grey shales with white clay bands of the *Rastrites maximus* zone, which are repeated by means of small folds.

Though this section is disturbed by faults, yet it is sufficiently clear that the lowest beds exposed in the core of the arch belong to the Hartfell black shales, succeeded by the Barren Mudstones. The Birkhill beds are also found on both limbs of the anticline, and on the north side they pass gradually upwards into the Tarannon flags and shales.

## iv. Band extending from Brockhope Burn by Whitehope and Berryknowe to Eldinhope in the Vale of Yarrow

This band is traceable for a distance of nine miles from the basin of the Upper Ettrick to the Vale of Yarrow.

**Black Grain**. — [NT 22335 14258] One of the chief sections across this band is exposed in the Black Grain, a small tributary of the Back Burn joining the Ettrick at Brockhoperig. At the northern limit of the section, grey and purple shales

with dark seams are associated with flaggy shales and greywackes which evidently represent the higher zones of the Birkhill division. These dip to the north-west at high angles. Rising from underneath these beds come the black flaggy shales of the *Diplograptus vesiculosus* zone, forming a flat arch truncated on the south side by a fault bringing in the grey flags and shales overlying the highest Birkhill zones. Descending the stream, the grey and purple shales with dark seams appear passing downwards into the gnarled and flaggy black shales of the *Diplograptus vesiculosus* zone.

These are underlain by a small exposure of the Barren Mudstones, which, yielding *Dicellograptus anceps* and *Diplograptus truncatus,* form the centre of the arch. On the south side of the fold they are followed in natural sequence by the black flags of the *D. vesiculosus* zone. Overlying the Lower BirkhillShales, grey and black shales yield *Monograptus spinigerus.* These beds pass upwards into grey and purple shales with dark seams and white clays, representing the upper portion of this division, from which have been obtained *Rastrites maximus* and *Monograptus Sedgwicki.* At the south end of the section there is a great cliff of grey flags and shales with greywacke bands, including repetitions of some of the *Monograptus Sedgwicki* bands.

**Whitehope Burn**. — [NT 33821 27975] In this section the Birkhill Shales, ranging from the *Monograptus gregarius* zone to the top of the series, are visible, and though the strata are much disturbed and contorted there is sufficient evidence to show that they are arranged generally in an anticlinal fold.

**Eldinhope Burn**. — [NT 30240 23873] At the north-east termination of this band there is a small exposure in this burn, in which only the highest zones of the Birkhill division appear. On the north, the *Rastrites maximus* bands plunge underneath the greywackes and shales underlain by the *M. spinigerus* zone; while towards the south the highest hands dip below the greywackes.

## v. Mountbenger

An interesting section is met with in this stream close by the road in the Vale of Yarrow [NT 31237 25057], where the strata are arranged in an anticlinal form. Towards the north the highest zones of the Birkhill division, consisting of grey and purple shales with black seams and white clays, pass underneath the greywackes and shales. They contain in admirable preservation the characteristic forms, *Rastrites maximus, Monograptus Sedgwicki, &c.* The beds are underlain by black shales representing the Lower Birkhill beds. The section is not continuous, but in the centre there seems to be a double fold of the Lower Hartfell black shales with the Barren Mudstones. The horizon of these black shales is evident from the accompanying list of fossils obtained at that locality:

*Pleurograptus linearis* (Carr.)

*Dicellograptus Forchhammeri* (Geinitz.)

*Dicellograptus moffatensis* (Carr.)

*Dicellograptus caduceus* (Lapw.)

*Dicellograptus Morrisi* (Hopk.)

*Dicellograptus elegans* (Carr.)

*Leptograptus flaccidus* (Hall.)

*Climacograptus bicornis* (Hall.)

*Climacograptus tubuliferus* (Lapw.)

*Diplograptus truncatus* (Lapw.)

*Diplograptus foliaceus* (Murch.)

*Siphonotreta micula* (M'Coy.)

*Acrotreta Nicholsoni* (Dav.)

Further south, after a blank in the section, the Birkhill Shales again appear, the lowest consisting of the hard flaggy shales of the *D. vesiculosus* zone, followed by the grey and black shales and clays of the upper portion of the group. From the various exposures of the Birkhill beds at Mountbenger the following forms have been obtained:

*Monograptus Sedgwicki* (Portl.)

*Monograptus triangulatus* (Hark.)

*Monograptus lobiferus* (M'Coy.)

*Monograptus cyphus* (Lapw.)

*Monograptus Hisingeri* (Carr.)

*Monograptus leptotheca* (Lapw.)

*Monograptus Sandersoni* (Lapw.)

*Rastrites peregrinus* (Barr.)

To the south-west of the band of black shales, extending from Altrieve to Brockhope Burn, another has been traced, much in the same line of strike, from that stream to the eastern slope of Capel Fell — a distance of about four miles. After a gap of about half a mile, a band reappears on the crest of Capel Fell, and can be followed at intervals to Brackenside Burn.

## vi. Band extending from Bellcraig by Craigmichan Seaurs, Entertrona, the Upper Ettrick, to Berrybush

On referring to Sheet 16, it will be seen that between Bell-Craig at the edge of the basin of Permian rocks at Moffat and Berrybush, two miles east of the Loch of the Lowes, a band of black shales can be traced more or less continuously. At intervals, owing to the intense plication of the strata, thin portions of the Tarannon greywackes and shales occupy narrow synclinal folds in the Moffat series. Hence it frequently happens that minor anticlines of the black shales branch off from the dominant fold, forming wedge-shaped masses in the Tarannon greywackes. Where, owing to denudation, the latter beds have been removed, the folds are represented in the black shale series. For convenience of description, therefore, the various outcrops of the Moffat Shales along the foregoing line will be regarded as belonging to one general baud.

**Bellcraig**. — [NT 11311 01181] The physical relations of the strata in this important section have been worked out by Professor Lapworth. The section occurs partly in the Bellcraig Burn and partly in one of its small branches, the Hodge Burn.

Beginning with the transverse section exposed in the Hodge Burn [NT 12301 01492], the observer finds that the beds have a uniform inclination to the north-west, and hence that the fold is isoclinal and the southern limb is inverted. The relations of the highest zones of the Birkhill group to the Tarannon greywackes are clearly seen at the southern limit of the section. There the latter dip to the north-west at angles from 45° to 50°, and are succeeded by flaggy beds and shales with black shales and thin white clays associated with blue shales and black grits. From the black bands the following forms have been obtained, indicating that they belong to the highest zone:

*Rastrites maximus* (Carr.)

*Rastrites capillaris* (Carr.)

*Rastrites distans* (Lapw.)

*Monograptus Sedgwickii* (Portl).

*Monograptus Barrandei* (Tullb.)

From the bands representing the *M. lobiferus* sub-zone the fossils given in the accompanying list were got:

*Monograptus lobiferus* (M'Coy.)

*Monograptus triangutatus* (Hark.)

*Monograptus spiralis* (Geinitz.)

*Monograptus proteus* (Barr.)

*Monograptus leptotheca* (Lapw.)

*Diplograptus tamariscus* (Nich.)

*Petalograptus folium* (His.)

*Dimorphograptus Swanstoni* (Lapw.)

*Rastrites hybridus* (Lapw.)

Next we find the bands yielding *M. gregarius* and the black flaggy shales of the *D. vesiculosus* zone containing the following fossils:

*Diplograptus vesiculorus* (Nich.)

*Climacograptus scalaris* (His.) var.

*Climacograptus normalis* (Lapw.)

*Dimorphograptus Swanstoni* (Lapw.)

*Monograptus tenuis* (Portl.)

*Monograptus attenuatus* (Hopk.)

*Monograptus gregarius* (Lapw.)

*Monograptus leptotheca* (Lapw.)

To these beds succeed the shattery dark shales of the *D. acuminatus* zone, which are repeated by small folds at the bend of the burn above the old hill-road. This horizon has yielded the following forms:

*Dimorphograptus elongatus* (Lapw.)

*Dimorphograptus Swanstoni* (Lapw.)

*Diplograptus acuminatus* (Nich.)

*Climacograptus normalis* (Lapw.)

*Climacograptus,* sp.

*Diplograptus* sp.

*Monograptus tenuis* (Portl.)

*Monograptus attenuatus* (Hopk.)

*Monograptus Hisingeri* (Carr.)

*Dawsonia campanutata* (Nich.)

Here a small fault intervenes, bringing the basal zones of the Lower Birkhill division into contact with the Hartfell shales; for in the stream near where it is crossed by the old roadway the black shales yielded these characteristic forms:

*Pleurograptus linearis* (Carr.)

*Leptograptus flaccidus* (Hall.)

*Dicellograptus moffatensis* (Carr.)

*Dicellograptus elegans* (Carr.)

*Cryptograptus tricornis* (Carr.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus quadrimucronatus* (Hall.)

*Climacograptus tubuliferus* (Lapw.)

Immediately to the north of the old roadway in the Hodge Burn the Glenkiln black shales appear in the core of the arch charged with certain typical forms (2I, (Figure 16)):

*Caenograptus gracilis* (Hall.)

*Caenograptus surcularis* (Hall.)

*Didymograptus superstes* (Lapw.)

*Dicranograptus formosus* (Hopk.)

*Dicranograptus ramorus* (Hall.)

*Dicellograptus patulosus* (Lapw.)

*Dicellograptus divaricatas* (Hall.)

*Dicellograptus sextans* (Hall.)

*Cryptograptus tricornis* (Carr.)

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus mucronatus* (Hall.)

*Climacograptus bicornis* (Hall.)

On their northern margin the Glenkiln black shales are bounded by a fault bringing down the Barren Mudstones, which occupy the lower portion of the section, to a point near the junction of the two streams. There is a fine exposure also of this Upper Hartfell group in the main stream above the junction with the Hodge Burn; the Barren Mudstones are succeeded by black shales yielding *Leptograptus flaccidus* and *Pleurograptus.* These are faulted against the Birkhill Shales seen at the junction of the streams and in Bellcraig Burn, where they have yielded the following forms:

*Diplograptus tamariscus* (Nich.)

*Petalograptus folium* (His.)

*Cephalograptus cometa* (Geinitz.)

*Rastrites peregrinus* (Barr.)

*Rastrites distans* (Lapw.)

*Rastrites hybridus* (Lapw.)

*Monograptus spiralis* (Geinitz.)

*Monograptus Sedgwicki* (Portl.)

*Monograptus triangulatus* (Hark.)

*Monograptus lobiferus* (M'Coy.)

*Monograptus attenuatus* (Hopk.)

*Monograptus leptotheca* (Lapw.)

Below the place where the Bellcraig Burn is crossed by a basalt, dyke the Glenkiln black shales are exposed in the centre of the fold, separated on the north-west side from the Barren Mudstones by a fault — evidently a continuation of that seen in the tributary burn. The strata have yielded:

*Didymograptus superstes* (Lapw.)

*Caenograptus gracilis* (Hall.)

*Caenograptus surcularis* (Hall.)

*Thamnograptus typus* (Hall.)

*Dicranograptus formosus* (Hopk.)

*Dicellograptus patulosus* (Lapw.)

*Dicellograptus sextans* (Hall.)

*Leptograptus flaccidus* (Hall.)

*Cryptograptus tricornis* (Carr.)

*Lasiograptus bimucronatus* (Nich.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus* sp

The Bellcraig anticline of the Moffat Shales can be followed at intervals towards the north-east in the direction of the sources of the Brackenside Burn, and thence to the pass at the head of the Wamphray Water. At the latter locality the strata form a compound anticline. Near the head of the stream the greywackes, shales, and black grits on the south side of the arch dip towards the north-west, succeeded by the Birkhill Shales, Barren Mudstones, and Hartfell black shales with their characteristic fossils, the latter forming the lowest beds exposed. On the north limb of the fold, the Barren Mudstones again appear, followed by the Birkhill Shales, which are thrown into an inverted synclinal fold with Tarannon greywackes and shales in the centre.

From this latter point the outcrop descends to Selcoth Burn and Craigmichan Scaurs, which sections have been described in detail in the previous chapter. Here the Belleraig and Entertrona band, and the Upper Ettrick and Berrybush band approach each other very closely. From the Selcoth Burn the black shale series can be traced north-east to the Entertrona Burn, one of the tributaries of the Upper Ettrick (Figure 17), (Figure 18).

The section in the Entertrona Burn reveals the presence of black grits in part of the Birkhill division. In the higher part of the stream the greywackes and flags, with zones of shale, dip steadily towards the north-west at angles from 40° to 60°. Descending the section, black grits, grey grits, and black shales with reddened bands, yielding *M. Sedgwicki,* appear along isoclinal folds. These occur to the south of the main outcrop. Further down the stream, about a third of a mile from its junction with the Ettrick, the Birkhill zones are exposed, consisting of grey shales and clays, dark seams, with grey and black grits and greywackes. The dark seams yield *Rastrites maximus.* In the centre of the arch the Glenkiln–Hartfell black shales appear, containing *Didymograptus superstes, Caenograptus Dicellograptus,* and *Leptograptus.* On the north side the black grits and shales with *M. Sedgwicki*bands succeed, being visible as we approach Over Phawhope.

**Potburn**. — [NT 18251 08860] Joining the Ettrick at the latter point, we come upon several interesting exposures in the river, downwards to Potburn. Crossing the alluvial flat at Over Phawhope, the Barren Mudstones are found on the right bank of the stream, soon followed by the Hartfell–Glenkiln black shales. In the centre of the fold there is a fine exposure of white cherts with a ribbed mode of weathering representing the radiolarian zone. On the north-west side the black shales reappear, followed by alternations of blue and black shales with white clays and black grits representing the Birkhill zones. The anticline just described between Over Phawhope and Potburn can be followed at intervals south-west to Craigmichan Scaurs and along the Upper Ettrick towards Shorthope and Berrybush.

The accompanying section (Figure 18) shows the relation of the two anticlines at Entertrona and Potburn, and it further illustrates the dominant isoclinal folding over the region south to Ettrick Pen. The representatives of the Moffat series, occurring on some of these inverted folds south of Entertrona, will be described in the following chapter.

**Range Cleuch**. — [NT 19628 10117] As the anticline is traced down the Ettrick, various exposures of the black shale series are found. At the foot of the Range Cleuch, the Hartfell–Glenkiln black shales appear in the centre of the arch, pierced by a felsite dyke, yielding *Dicranograptus* and *Dicellograptus.* Towards the north they are succeeded by a mass of grey mudstones (Barren Mudstones), followed by black shales representing the Lower Birkhill zones. These are overlain by light greenish shales, black shales, clays, and flags, representing the Upper Birkhill beds.

Again, in the river, opposite Broadgairhill [NT 20104 10052] and above Nether Phawhope, the Moffat Shales are visible.

At Shorthope only the Birkhill beds are represented, being repeated by several folds. The lowest beds consist of the black flaggy shales at the base of the group, yielding *Diplograptus acuminatus, Diplograptus resiculosus,* and *Climacograptus normalis.* These are succeeded by blue shales, white clays, and dark seams with black shales representing the upper division, from which the following forms have been obtained:

*Monograptus Sedgwicki* (Portl.)

*Monograptus attenuatus* (Hopk.)

*Monograptus tenuis* (Portl.)

*Monograptus lobiferus* (M'Coy.)

*Petalograptus folium* (His.)

*Rastrites hybridus* (Lapw.)

*Peltocaris aptychoides* (Salt.)

From the bend of the Ettrick at Shorthope, the band can be traced north-eastwards to the Cossarshill Burn.

**Scabcleuch**. — [NT 24652 14522] Much on the same line of strike, an anticline in the black shales can be traced from Scabcleuch Burn to Berrybush. In the former stream — a tributary of the Ettrick — a small gorge known as the Slunk has been carved out of the black shale series along the strike of the beds. The lowest bands belong to the *Pleurograptus* zone of the Lower Hartfell black shales, followed by the Barren Mudstones, which in turn are succeeded by the zones of the Birkhill black shales containing *Diplograptus acuminatus* and *D. vesiculosus.* These are followed by grey and yellow clays, shales, and mudatones yielding *Monograptus gregarius,* and towards the top *Rastrites peregrinus.*

**Berrybush Burn**. — [NT 26930 18956] To the north-east in Berrybush Burn the prolongation of this band is met with, the section being of special interest from the fine exposure of Glenkiln beds abundantly charged with their characteristic graptolites.

In the bed of the stream, about half a mile above Berrybush Cottage, the Glenkiln shales dip towards the south-east. Here there is a good development of the cherts and mudstones, representing the radiolarian zone underlying the black shales of this group. The horizon of the black shales associated with them is placed beyond doubt from the following suite of fossils collected at that locality:

*Caenograptus gracilis* (Hall.)

*Clathrograptus cuneiformis* (Lapw.)

*Lasiograptus bimucronatus* (Nich.)

*Lasiograptus* sp.

*Didymograptus superstes* (Lapw.)

*Cryptograptus tricornis* (Carr.)

*Diplograptus Whitfieldi* (Hall.)

*Dicranograptus formosus* (Hopk.)

*Climacograptus bicornis* (Hall.)

*Dicellograptus moffatensis* (Carr.)

*Dicellograptus patulosus* (Lapw.)

*Leptograptus flaccidus* (Hall.)

*Acrothele granulata* (Linn.)

Ascending the burn for about half a mile, no rock being visible on the way, the observer finds, high up on the slope of Fall Law, an exposure of the Hartfell group. The various zones of the Hartfell black shales, ranging from the *Climacograptus Wilsoni* zone to that of *Pleurograptus linearis,* are represented, yielding imperfectly preserved fossils. These are overlain by the Barren Mudstones dipping towards the north-west, the highest beds visible in the section.

Much in the same line of strike there is a local exposure of the Moffat Shales near the top of the Eldinhope Burn.

**Yarrow Feus**. — [NT 33906 25809] Again, on the left bank of the Yarrow, near Sunnybank, a small isoclinal fold of the Upper Birkhill Shales dips to the north-west, It is much on the same line of strike as that of the Berrybush band. The area is well defined, bounded on either side by the Abbotsford flags and shales.

## vii. Shorthope and Phawhope, Upper Ettrick

To the south of the persistent bands of black shales extending from Bellcraig by Craigmichan Scaurs to Berrybush, several local isoclines in the basin of the Upper Ettrick reveal thin seams of black shales associated with black grits and shales, which yield at certain localities specimens of *Rastrites maximus.* Generally these bands are sparingly fossiliferous, and their horizon is not quite certain; but though they are provisionally regarded as representing higher zones of the Birkhill division, they may, in some cases, belong to the Tarannon series.

In the sections already described in this chapter there are indications of a gradual variation from the normal type of the Birkhill group in Dobb's Linn. The grey shales with black seams and white clays forming the *Rastrites maximus* zone in the latter section are there separated only by a few feet of strata from the underlying graptolite-bearing beds. About a mile and a half to the south-east, in Prow Grain, barren flags and shales intervene between the *Rastrites maximus* bands and the black shales of the Upper Birkhill group. About three-quarters of a mile to the south-east, in the Black Grain — a tributary of the Back Burn — this modification is more pronounced. The thin dark seams, however, containing *Rastrites maximus* (Carr.), though reduced to a fraction of an inch in thickness, are wonderfully persistent, and together with the white clays form a valuable horizon.

**River Ettrick below Shorthope**. — [NT 22646 12720] Eastwards from Shorthope the river Ettrick flows over folded Tarannon greywackes and shales for about two hundred yards, followed by black shale bands which are likewise repeated by flexures. To these succeed black and grey grits with thin black shale partings, also forming sharp undulations.

**Shorthope Burn**. — [NT 23219 12740] In this stream, which is formed by the junction of two small burns (the East Grain and Master Grain) the *Rastrites maximus* bands are found about 50 yards from its junction with the Ettrick. They reappear about 300 yards up the stream associated with black and grey grits and grey greywackes with black shale seams. In the east branch, the *Rastrites maximus* bands occur on successive anticlines; the most southerly one exposing also the underlying black grits and shales. In the west branch (the Master Grain) various folds of thin black seams with *Rastrites maximus* are associated with black and grey grits, black sandy shales, and grey and green mudstones. In both these sections the strata are isoclinally folded, the beds dipping to the north-west at angles varying from 40° to 65°.

**Phawhope Burn**. — [NT 21822 10941] In this stream six sharp anticlines of thin black shale seams are accompanied by strata similar to those referred to in the previous sections. Here they yield one or two Birkhill graptolites (Figure 17).

**Glendearg Burn**. — [NT 21156 10462] In the deep trench carved by this stream, to the south-west of Phawhope Hill, there is striking evidence of the repetition of these black shale seams by rapid isoclinal folds, for there are upwards of twelve inverted arches exposing bands of this type. The only seams, the horizons of which have been proved by fossils, belong to the *Rastrites maximus* zone, but most of the folds display the associated black and grey grits (Figure 17) and (Figure 18).

**Coomb Burn**. — [NT 20581 09559] In the lower part of this stream, alternations of black grits and shales are visible on the anticlines of this series. The upper part of the stream is filled with boulder-clay and moraine-drift.

**Entertrona**. — [NT 18703 07977] Attention has already been directed (page 116) to the occurrence of black grits and shales in the main fold in this stream. A few hundred yards further up the burn an inverted fold occurs with thin bands of dark shales and white seams on each side of the arch, belonging to the *Rastrites maximus* zone. In the heart of this isocline we find alternations of grey and black grits with grey and black shale partings.

## viii. Ettrickbridge-end Section

The section exposed in the river Ettrick at Ettrickbridge-end [NT 39047 24332] is of great interest and importance, as it shows the extreme variations from the normal type of the Moffat series in Dobb's Linn, when traced towards the south-east. The evidence already adduced in this chapter shows that these variations are gradual. Although from the nature of the sharp isoclinal folds, the representatives of the Glenkiln Shales are never brought to the surface to the south-east of the band at Entertrona and the Upper Ettrick, in the Ettrickbridge-end section the Glenkiln black shales and radiolarian cherts are visible, so that we have here representatives of the three great divisions of the Moffat series.

The physical relations of the strata are, however, extremely complicated owing to the occurrence of isoclinal folds and reversed faults. Indeed at one locality the south limb of the fold has been removed by a reversed fault, so that at first it would appear as if we had an ascending sequence from the brown flags and shales on the south into the Glenkiln beds.

From the ground-plan (Figure 19) and horizontal sections (Figure 20), (Figure 21), (Figure 22), (Figure 23) the variations in the sequence of deposits may be readily grasped. The greater portion of the grey shale group of the Upper Birkhill division has disappeared, and has been replaced by greywackes, flags, and shales forming the Abbotsford flag series. A band of blue-black shale occurs at the foot of the cliff below the manse of Ettrickbridge-end which yields the fossils of the *Rastrites maximus* zone; but the relations of this band to the Lower Birkhill beds are not clearly displayed at this point. Its horizon must be from 10 to 20 feet higher than a black shale yielding the Lower Birkhill forms. It is also cut off from the Abbotsford flags by a fault with a downthrow to the north-west. But from other evidence it is probable that this band is interleaved in the Abbotsford flags. In the Lower Birkhill group a portion of the *Monograptus lobiferus* band is separated from the *Monograptus gregarius* zone by the intercalation of several feet of black grit and dark fossiliferous shale. The beds ranging from the *Monograptus gregarius* zone to the *Diplograptus acuminatus* zone appear less thick than in the typical Moffat sections, though reliable measurements are not easily obtained owing to the reduplication of the bands by folding. A portion of the *Dicellograptus anceps* zone is separated from the Birkhill Shales only by a very thin layer of sediment.

The greatest variation, however, is visible in the upper portion of the Hartfell group. About 180 feet of grits are intercalated with the Barren Mudstones. Thin bands of green shale with thin fossiliferous black shales are occasionally interleaved in the grits. In one of the thicker zones of shale, bands and nodules of limestone occur which may probably represent the Wrae Limestone of Peeblesshire. Some of the characteristic fossiliferous zones of the Lower Hartfell black shale have been recognised in these exposures.

The section extends for about three-quarters of a mile from the foot of the Baillie Burn, joining the Ettrick from the south, along the course of the river to the bend in that stream named Gait Crook. If, for the moment, we eliminate the reversed and normal faults, the strata are arranged in an isoclinal fold trending north-east and south-west, the axis of which is inclined to the north-west, the strata dipping at angles varying from 25°–70°.

**Lower Section from the Baillie Burn to the Cliff below the Manse in the River Ettrick**. — Descending the Baillie Burn [NT 38643 24074] (Figure 20), the brown crusted flags and shales (Abbotsford flags) are exposed on the east bank and in the bed of the stream dipping to the N.N.W. About 150 yards above the foot of the burn the angle of inclination is 50°, but as we descend it decreases to 15°. A few yards above the junction the jointed grey greywackes are succeeded by black cherts much jointed and exposed in the bed of the stream. The latter are not seen in contact with the greywackes, there being a blank of a few feet in the section. Here, as we shall point out in the sequel, a reversed fault must intervene. Following the burn downwards the black cherts charged with radiolaria are well seen on the east bank, dipping down stream. About seven yards from the junction a band of black shales occurs, containing the following characteristic Glenkiln forms: *Dicranograptus minimus* (Lapw.), *Caenograptus gracilis* (Hall), *Cryptograptus tricornis* (Carr.), and *Diplograptus.*

At the junction in the bed of the Ettrick, visible when the stream is low, the lowest zone of the Hartfell black shale is found, yielding specimens of *Climacograptus Wilsoni* and *Diplograptus foliaceus.* These bands are succeeded by a few feet of pale shales, followed by the main mass of the Hartfell black shales. At the foot of the Baillie Burn the cherts which extend down the Ettrick are truncated by a normal fault trending north-east, bringing in the Lower Hartfell black shale.

Westwards up the Ettrick, the Hartfell black shales are succeeded by 150 feet of shales, the lower portion resembling mudstones, and weathering with a cream colour, while the upper part is more micaceous and of a green tint. In the lower bands there are two thin seams of black shale yielding large *Diplograptus* in the upper portion are two thin layers of black shale, with *Dicellograptus anceps* (Nich.)

These mudstones, dip to the N.N.W. at angles varying from 40° to 50°. Here they are followed by a mass of grey and black grits about 180 feet thick, pebbly in places and containing galls of black shale with intercalations of grey and black shales. At this point they are exposed on a cliff where a small reversed fault is seen; they can be examined to better advantage further up the river.

This arenaceous series is overlain by black shales, soft and friable, associated with dark blue shales yielding the following fossils: *Monograptus gregarius* (Lapw.), *M. tenuis* (Portl.), M. *attenuatus* (Hopk.), *Diplograptus confertus* (Nich.), *Climacograptus normalis* (Lapw.), and *Dawsonia campanulata* (Nich.). The flaggy black shales of the *D. vesiculosus* zone are not here represented. They occur further up the stream, and hence it is evident that a portion of the Lower Birkhill Shales has been thrown out by a fault (Figure 20).

These black shales are overlain by a few feet of shales and greywackes, followed by blue shales with dark seams. In one of these thin seams the following assemblage of fossils was obtained under the Manse Cliff. From this list it is apparent that the band belongs to the horizon of *Rastrites maximus,* the specimens being remarkably well preserved:

*Rastrites maximus* (Carr.)

*Rastrites capillaris* (Carr.)

*Monograptus tenuis* (Portl.)

*Monograptus spiralis* (Geinitz.)

*Monograptus Sedgwicki* var. *spinigerus* (Nich.)

*Monograptus Hisingeri* (Carr.)

*Monograptus lobiferus* (M'Coy.)

*Monograptus priodon* (Bron.)

*Monograptus attenuatus* (Hopk.)

*Petalograptus folium* (His.)

*Diplograptus Hughesi* (Nich.)

A small fault, amounting to a few feet in its displacement, brings down the overlying flaggy greywackes and shales (Abbotsford flags), and probably conceals part of the *Rastrites maximus* zone.

In ascending the river from the cliff below the Manse [NT 25984 14503], where it takes a bend towards the south, we pass in descending order (1) the Lower Birkhill black shales, (2) the grits with thin bands of dark shales yielding graptolites, (3) the green and grey shales representing the Barren Mudstones. Here the strata are thrown into a sharp anticlinal fold well seen on both banks of the stream. In the centre of this arch on the north side of the river a small exposure of black shales has yielded *Dicellograpti* belonging to the Hartfell group.

On the south bank, at this locality, the Lower Birkhill black shales (4III) are seen forming an inverted anticline and apparently dipping below the Hartfell black shales (3II), as shown in the accompanying section (Figure 21).

The horizon of these black shales on the south bank is clearly Droved by the following list of fossils obtained from them:

*Diplograptus acuminatus* (Nich.)

*Diplograptus* showing radicles

*Climacograptus innotatus* (Nich.)

*Climacograptus normalis* (Lapw.)

*Monograptus gregarius* (Lapw.)

*Monograptus tenuis* (Portl.)

*Monograptus cyphus* (Lapw.)

*Retiolites,* sp.

*Dawsonia campanulata* (Nich.)

It is evident, therefore, that the Lower Hartfell black shales at this point have been made to overlie the Birkhill black shales by, means of a reversed fault, probably the continuation of the dislocation which in the Baillie Burn truncates the inverted anticline.

As we advance up the river, we pass from the exposures of the Lower Birkhill beds to the greywackes and shales of the Tarannon series dipping towards the N.N.W. at an angle of 25°. On the cliff bounding the stream on the north side the flags and greywackes plunge underneath the Birkhill beds, so that here there may be the southern limb of an isoclinal fold.

On referring to the ground-plan (Figure 19) it will be seen that about 300 yards up stream from the Manse Cliff a normal fault crosses the river with a downthrow to the west, by means of which the outcrop of the Birkhill beds has been shifted from the north to the south bank. At this point grey and blue shales are inclined to the north-west at 30°, yielding *Rastrites capillaris* (Carr.), *Monograptus tenuis* (Portl.), &c. Underneath lies an inverted arch of the lower zones of the Birkhill Shales, which extends up the south bank. The river cuts obliquely across this isocline, which continues up the stream for a distance of about 200 yards. The fold widens so as to expose the band yielding *Dicellograptus anceps* (Nich.) and *Diplograptus truncatus* (Lapw.). But soon the arch is truncated by a normal fault, which, crossing the river, brings the Hartfell black shales into contact with the Lower Birkhill beds.

For 250 yards up the stream the Lower Hartfell black shales are "stepped" downwards to the west by six small normal faults (Figure 19). Further, these beds have been driven over each other by reversed faults well seen on the right bank at the bend of the stream nearly opposite Kirkhope Farmhouse. The Barren Mudstones are seen in the bed of the river, occupying their normal position above the Lower Hartfell black shales.

But on the cliff that forms the north bank of the river along this part of its course, the Llandovery greywackes and shales succeed, dipping towards the N.N.W. at angles varying from 20° to 30°. Their horizon is clearly defined by the occurrence of thin dark seams near the foot of the cliff yielding *Rastrites maximus* (Carr.) and *Monograptus Serigwicki.* This zone is there interleaved in the grey shales and greywacke ribs (Abbotsford flags), the cleavage of the shales between the greywackes being at a higher angle than the dip of the beds. It is clear, therefore, that a fault must here intervene between the Barren Mudstones and the *Rastrites maximus* zone (Figure 22).

At the bend in the river above Kirkhope Farmhouse, the Glenkiln cherts are exposed in the bed of the stream, in the strike of the fold referred to, showing the Lower Hartfell black shales. On the north side of the cherts, and on the left bank, hardened black shales succeed, yielding *Diplograptus foliaceus* (Murch.), *Dicellograptus Morrisi* (Hopk.), *Climacograptus,* &c.. and thus indicating a Lower Hartfell horizon.

**Upper section from the bend above Kirkhope Farmhouse to Gait Crook**. — From the bend above Kirkhope Farmhouse [NT 38056 23750] to Gait Crook [NT 38125 23477], an interesting sequence is met with. There the course of

the river is nearly north and south, and a transverse section of the strata is displayed. Their stratigraphical relations are disturbed by several normal faults exposed in the bed of the stream, but the general order of succession can be pretty clearly established (Figure 23).

Beginning with the anticline of the Lower Hartfell black shales seen at the band near Kirkhope Farmhouse, we find their position to be clearly proved by the following list of fossils:

*Pleurograptus linearis* (Carr.)

*Leptograptus flaccidus* (Hall.)

*Leptograptus capillaris* (Carr.)

*Cryptograptus tricornis* (Carr.)

*Diplograptus foliaceus* (Murch.)

*Dicellograptus Forchhammeri* (Geinitz.)

*Dicellograptus moffatensis* (Carr.)

*Climacograptus,* sp.

*Siphonotreta micula* (M'Coy.)

Southwards along the east bank there is a clear exposure of grey and purple shales representing the Barren Mudstones, with occasional bands of grey greywacke and grit. These beds are inverted and dip to the N.N.W. Next in order come dark grits and shales, with black shale bands, probably on the same horizon as the grits already described in the Hartfell group below the Manse.

Further southwards grey shales appear together with a black shale band yielding *Diplograptus truncatus* (Lapw.).

Further south this horizon is followed by grey shales with nodules and ribs of limestone, till another exposure of Lower Hartfell shales is met with, yielding *Pleurograptus linearis* (Carr.), *Leptograptus capillaris* (Carr.), *Diplograptus foliaceas* (Murch.), *Cryptograptus tricornis* (Carr.), *Retiolites (Neurograptus) fibratus,* &c. By means of a fault this band is brought into conjunction with the zone of *Dicellograptus anceps* (Nich.) on the south side of the outcrop. The latter horizon has also yielded *Diplograptus truncatus* (Lapw.)

Owing to faulting, the Lower Birkhill black shales are not satisfactorily exposed on the east bank, but on the opposite side of the stream they are seen to advantage on a cliff rising from the river channel. From the latter locality the following forms have been obtained:

*Monograptus gregarius* (Lapw.)

*Monograptus tenuis* (Portl.)

*Monograptus Hisingeri* (Carr.)

*Climacograptus normalis* (Lapw.)

*Diplograptus vesiculosus* (Nich.)

*Diplograptus acuminatus* (Nich.)

*Diplograptus confertus* (Nich.)

Towards the south they are succeeded on the west bank by grey greywacke bands with grey silky shale partings, which dip towards the north at high angles.

Returning to the east bank of the stream and crossing the bands of black shales that represent the Lower Birkhill zones, we find on the south side black grits and barren shales which are abruptly truncated by a fault. Next in order a few feet of black grit are followed by grey shales with dark streaks and about six feet of dark shale, the lower portion of which yields fossils belonging to the upper part of the *Monograptus gregarius* zone. To these beds succeed the Abbotsford flags, occupying the stream section to Gait Crook.

On the south side of the loop at Gait Crook the foregoing flags and shales form an inverted arch. From this point to the bank on the south side of the bend of the river there is a blank in the section. But at the latter locality, near a cottage, black shales, much corrugated and shattered, have yielded the following characteristic Hartfell forms (Figure 19), (Figure 23):

*Dicellograptus Morrisi* (Hopk.)

*Dicellograptus* like *anceps* (Nish.)

*Dicellograptus elegans* (Carr.)

*Leptograptus flaccidus* (Hall.)

*Climacograptus bicornis* (Hall.)

*Diplograptus foliaceus* (Murch.)

*Diplograptus truncatus* (Lapw.)

*Siphonotreta micula* (M'Coy.)

The relations of this outcrop to the surrounding strata are completely obscured; but it is highly probable that the Hartfell black shales come to the surface along another anticline to the south of the main fold at Ettrickbridge-end. If this be so, then in the alluvial flat at Gait Crook it is probable that the Abbotsford flags may be thrown into a synclinal fold underlain by the Lower Birkhill Shales (Figure 23).

Returning now to the section in the river below the junction of the Baillie Burn, we may observe that the Abbotsford flags and shales occupy the stream down to a point below where it is joined by Jean's Burn from the west. From the latter locality, for a distance of 300 yards, no rocks are visible; but at the bend below Woodend, the Barren Mudstones, with a band of black shales and the black grits, are found. Near the foot of the Brockhill Burn the black shales of the Birkhill division are associated with black grits. The section is much disturbed and broken by faults.

If we review the evidence now adduced regarding the physical relations of the strata in the Ettrickbridge-end section, it is clear that originally the representatives of the Moffat series must have been arranged in one great isoclinal fold inclined to the northwest at a very gentle angle, extending from the foot of the Baillie Burn to the bend above Birkhope Farmhouse. The isolated outcrop of Hartfell shales south of Gait Crook probably indicates a minor fold to the south of the main anticline.

At the foot of the Baillie Burn, however, the southern inverted limb of the main anticline has been removed by a reversed fault, and hence the radiolarian cherts in the Glenkiln group appear to overlie the Abbotsford flags. The horizon of the latter is clearly defined in other parts of the section by the intercalation of the *Rastrites maximus* bands.

The outcrop of this reversed fault or thrust-plane seems to cross the river Ettrick at the bend above the Manse Cliff, where the Lower Hartfell black shales appear to overlie the Lower Birkhill Shales. The natural order of the strata is further disturbed by a series of normal faults with a general downthrow to the west.

**Singlee Burn**. — [NT 36882 22185] On the north side of the valley of the Ettrick, and about a mile up stream from the arch of the Moffat series at Ettrickbridge-end, black shales again appear in the Singlee Burn, which yield forms characteristic of the Hartfell and Birkhill divisions.

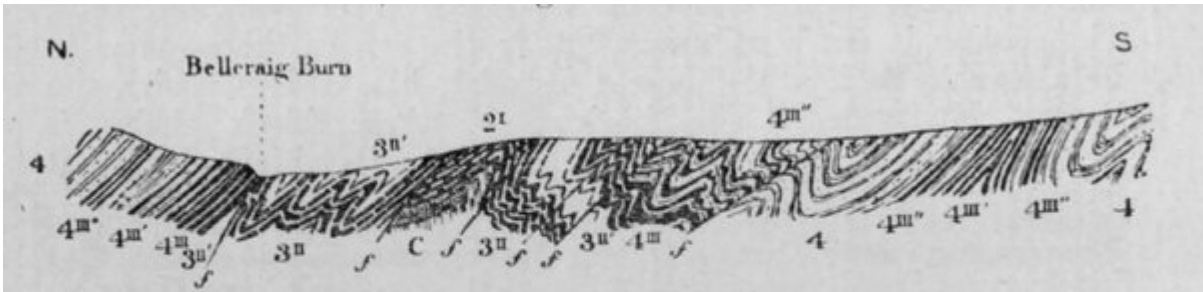


FIG. 16.—Section in Hodge Burn, Bellcraig, Moffat.

C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3II′. Barren Mudstones. 4III. Lower Birkhill Shales. 4III′. Upper Birkhill Shales. 4III″ *R. maximus*-zone. 4. Tarannon series. f. Fault.

*(Figure 16) Section in Hodge Burn, Bellcraig, Moffat. C. Radiolarian chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3II′. Barren Mudstones. 4III. Lower Birkhill Shales. 4III′. Upper Birkhill Shales. 4III″ R. maximus-zone. 4. Tarannon series. f. Fault.*

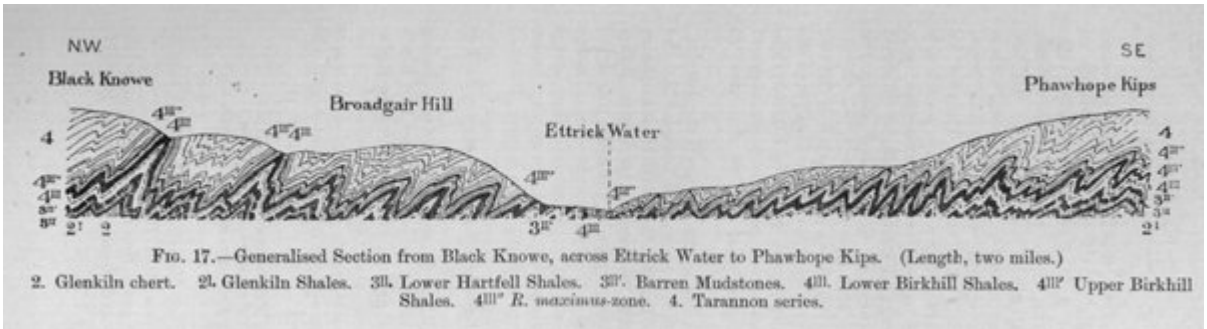


FIG. 17.—Generalised Section from Black Knowe, across Ettrick Water to Phawhope Kips. (Length, two miles.)

2. Glenkiln chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3II′. Barren Mudstones. 4III. Lower Birkhill Shales. 4III′ Upper Birkhill Shales. 4III″ *R. maximus*-zone. 4. Tarannon series.

*(Figure 17) Generalised Section from Black Knowe, across Ettrick Water to Phawhope Kips. (Length, two miles.) 2. Glenkiln chert. 2I. Glenkiln Shales. 3II. Lower Hartfell Shales. 3II′. Barren Mudstones. 4III. Lower Birkhill Shales. 4III′ Upper Birkhill Shales. 4III″ R. maximus-zone. 4. Tarannon series.*

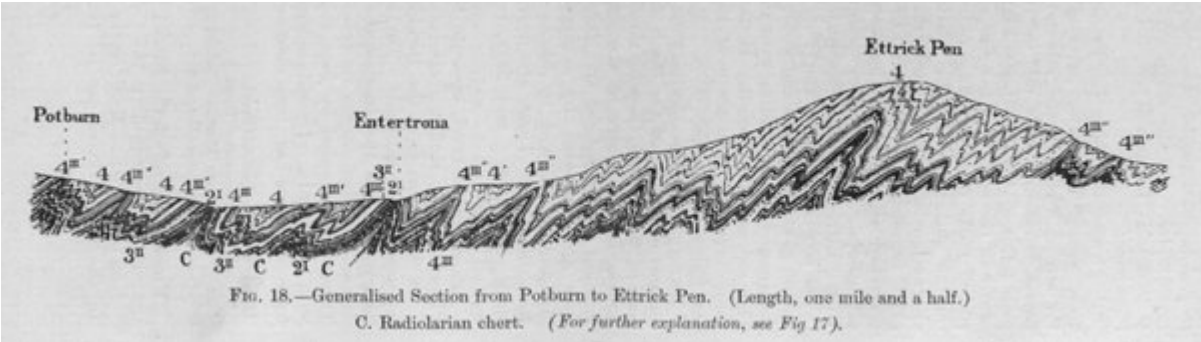


FIG. 18.—Generalised Section from Potburn to Ettrick Pen. (Length, one mile and a half.)

C. Radiolarian chert. *(For further explanation, see Fig 17).*

*(Figure 18) Generalised Section from Potburn to Ettrick Pen. (Length, one mile and a half.) C. Radiolarian chert. (For further explanation, see (Figure 17)).*

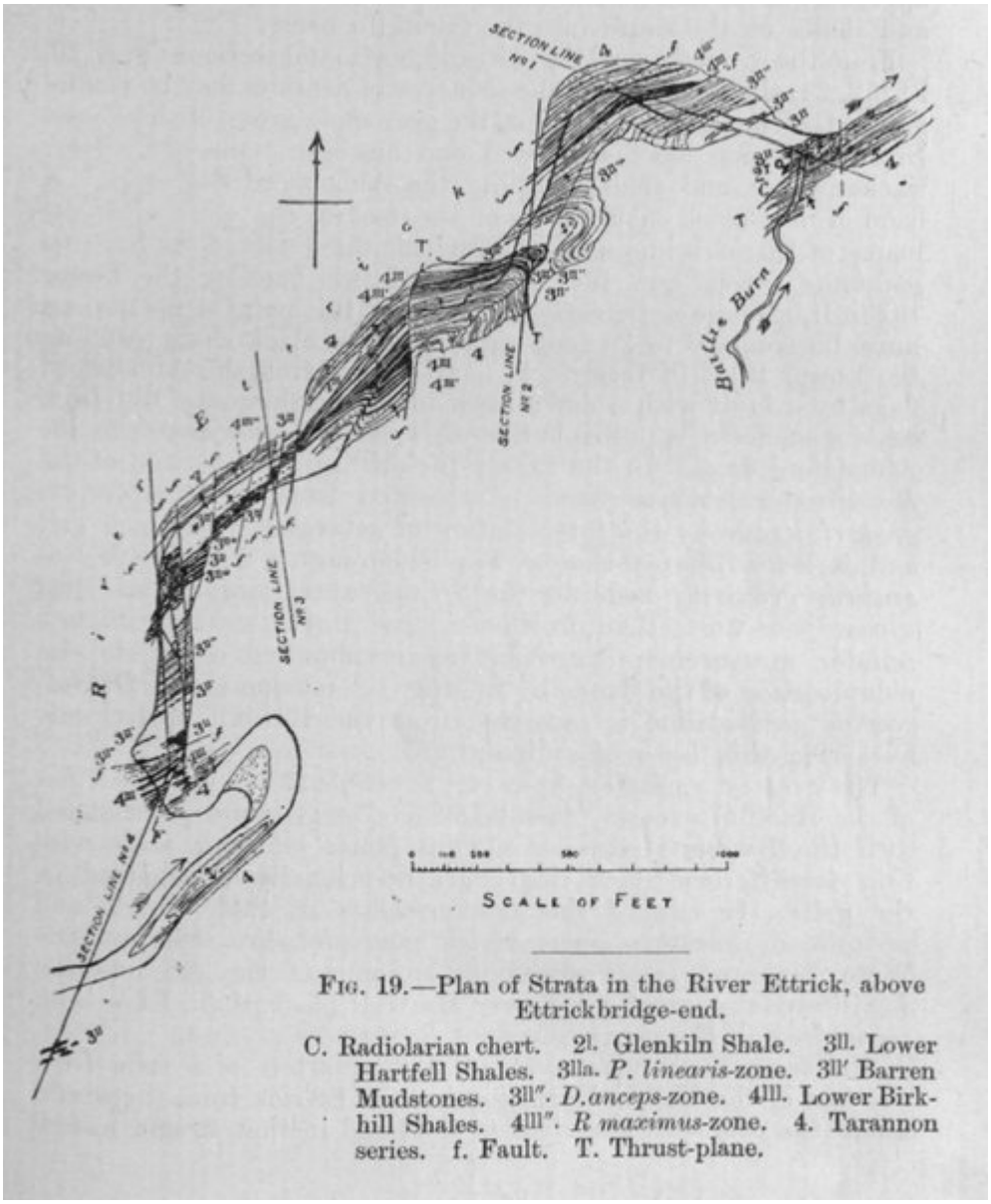


FIG. 19.—Plan of Strata in the River Ettrick, above Ettrickbridge-end.

C. Radiolarian chert. $2^{I}$. Glenkiln Shale. $3^{II}$. Lower Hartfell Shales. $3^{IIa}$. *P. linearis*-zone. $3^{II'}$ Barren Mudstones. $3^{II''}$. *D. anceps*-zone. $4^{III}$. Lower Birkhill Shales. $4^{III''}$. *R maximus*-zone. 4. Tarannon series. f. Fault. T. Thrust-plane.

*(Figure 19) Plan of Strata in the River Ettrick, above Ettrickbridge-end. C. Radiolarian chert. 2I. Glenkiln Shale. 3II. Lower Hartfell Shales. 3IIa. P. linearis-zone. 3II′ Barren Mudstones. 3II″. D. anceps-zone. 4III. Lower Birkhill Shales. 4III″. R. maximus-zone. 4. Tarannon series. f. Fault. T. Thrust-plane.*

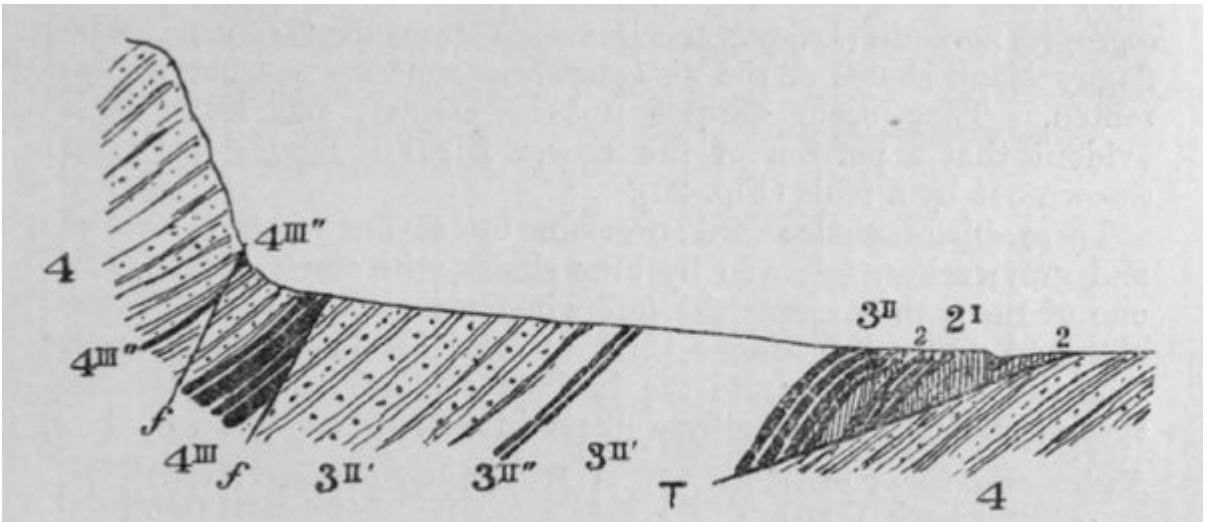


FIG. 20.—Section in River Ettrick from Manse Cliff to foot of Baillie Burn (No. 1 in Fig. 19).

2. Glenkiln chert. *(For further explanation, see Fig. 19.)*

*(Figure 20) Section in the River Ettrick from manse Cliff to foot of Baillie Burn (No. 1 in (Figure 19)). 2. Glenkiln chert (For further explanation, see (Figure 19).)*

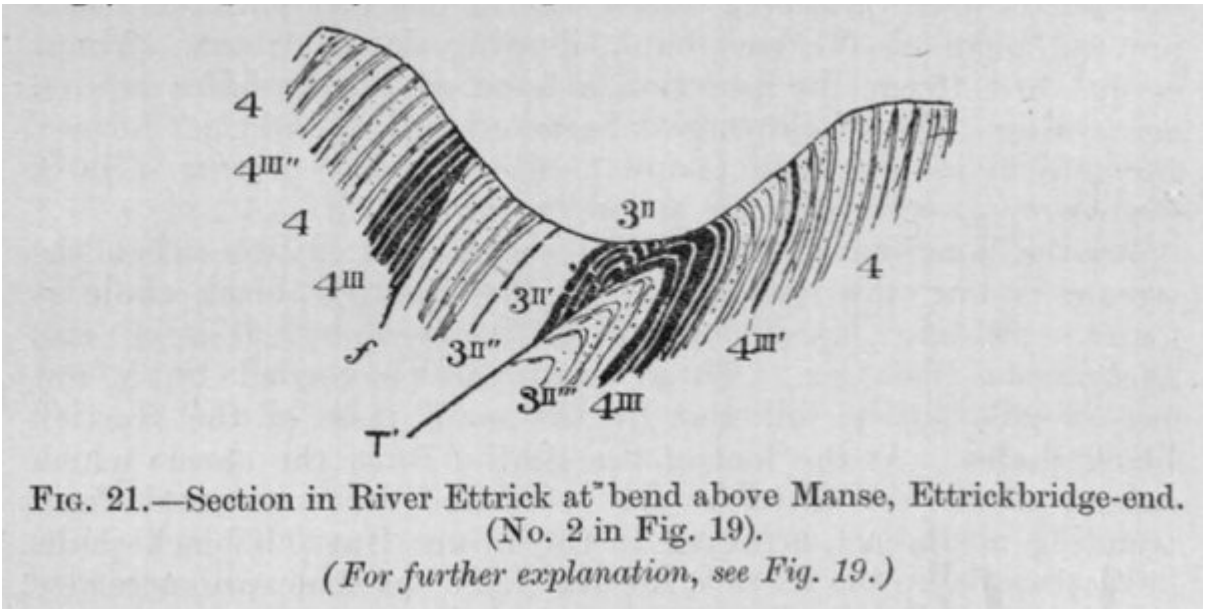


FIG. 21.—Section in River Ettrick at bend above Manse, Ettrickbridge-end. (No. 2 in Fig. 19).
*(For further explanation, see Fig. 19.)*

*(Figure 21) Section in River Ettrick at bend above Manse, Ettrickbridge-end. (No. 2 in (Figure 19)). (For further explanation, see (Figure 19).)*

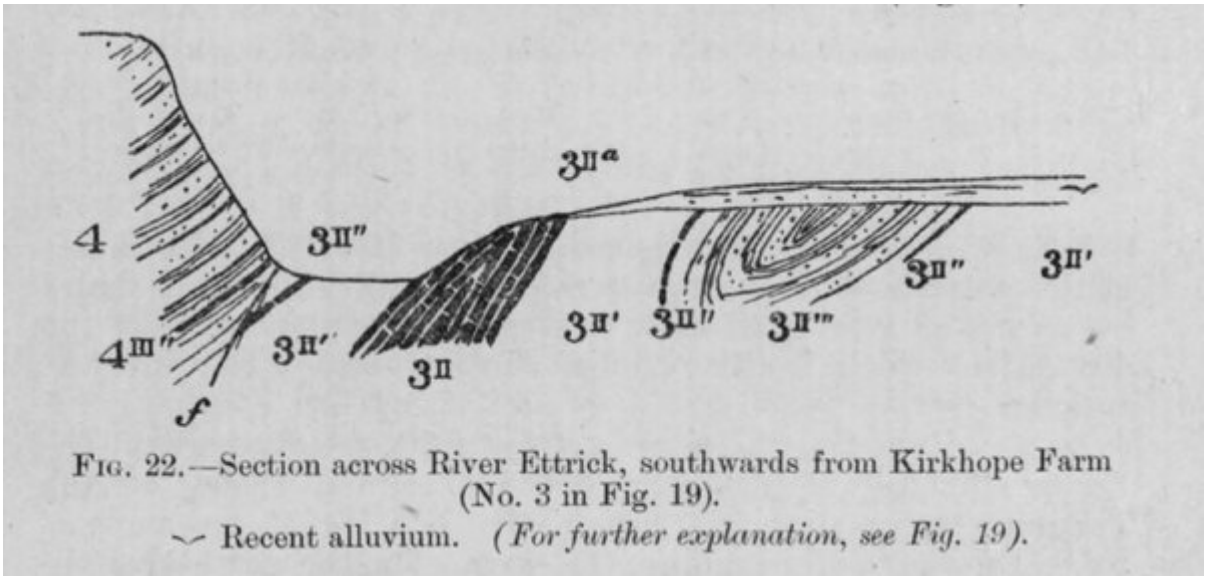


FIG. 22.—Section across River Ettrick, southwards from Kirkhope Farm (No. 3 in Fig. 19).
~ Recent alluvium. *(For further explanation, see Fig. 19).*

*(Figure 22) Section across River Ettrick, southwards from Kirkhope Farm (No. 3 in (Figure 19)). [symbol] Recent alluvium. (For further explanation, see (Figure 19)).*

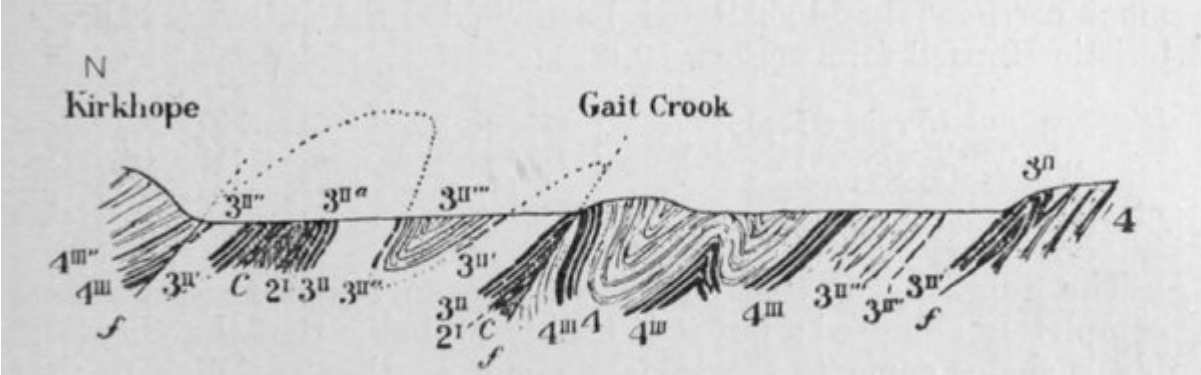


FIG. 23.—Section in River Ettrick from bend above Kirkhope, through the Gait Crook (No. 4 in Fig. 19).

*(For further explanation, see Fig. 19.)*

*(Figure 23) Section in River Ettrick from bend above Kirkhope, through the Gait Crook (No. 4 in (Figure 19)). (For further explanation, see (Figure 19).)*