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## Chapter 24 V. Upper Silurian rocks north of The Tableland

### Lanarkshire and Ayrshire

Within the territory occupied by the Old Red Sandstone in the midland valley of Scotland, several inliers of Upper Silurian Rocks make their appearance. They are found in Lanarkshire in the adjoining county of Ayr, and in the counties of Midlothian and Peebles. The Ayrshire and Lanarkshire tract, since the discovery of well-preserved Eurypterids in it by the late Dr. Slimon of Lesmahagow, has become widely known in geological literature. The more important of these inliers are situated several miles to the north of the Silurian Tableland, where they have been brought to the surface by the plication and subsequent denudation of younger Palaeozoic rocks.

One of the most interesting features connected with these Upper Silurian areas is the conformable sequence from the Upper Ludlow Rocks, into the Lower Old Red Sandstone. This conformability was clearly recognised by Murchison, Ramsay, A. Geikie and at a later date by Mr. B. N. Peach when he mapped the region between Lesmahagow and Douglas (see Geol. Survey, one-inch map of Scotland, Sheet 23, published in 1872). In the Explanation descriptive of the geology of the area included in Sheet 23, it is shown that, while the conformable portion of the Lower Old Red Sandstone contains red and yellow sandstones and conglomerates, it likewise includes certain green and red mudstones with bands of grey shale and greywacke, which, in the Lesmahagow district, yielded "*Beyrichia* and some obscure *Pterygotus*-looking crustacean remains." Explanation of Sheet 23, page 13. The occurrence in the passage-beds of certain organisms identical with those in the underlying Ludlow Rocks suggested the recurrence of marine or brackish water conditions during the deposition of the lower portions of the Old Red Sandstone.

In the course of the recent revision of the Upper Silurian inliers in Lanarkshire by the Geological Survey (Sheet 23, of the Map), special attention was paid to the fossiliferous bands in the red passage-beds overlying the Ludlow Rocks. Towards the close of 1896 they yielded to Mr. Macconochie fragments of crustaceans and certain obscure remains resembling ichthyolites. The search was resumed in 1897, and after a prolonged examination of the various exposures by Messrs. Macconochie and Tait, it resulted in the discovery of a fauna which in some respects is remarkable; for, in addition to representatives of all the genera of *Eurypteridae* found in the underlying Ludlow Rocks, there is likewise an assemblage of fishes, comprising five genera, four of which and seven species are new. Dr. Traquair, in whose hands the collection of fishes has been placed for determination, has kindly furnished the following notes embodying the results of his researches;

"The only fishes which have occurred in the 'Ludlow' beds of the Lesmahagow district are *Thelodus scoticus* (Traq.) and *Thelodus planus* (Traq.), besides a fragment of another form, which is too imperfect for description. The list from the 'Passage' or Downtonian beds is larger, and includes the following:

*Thelodus scoticus* (Traq.)

*Lanarkia horrida* (Traq.)

*Lanarkia spinosa* (Traq.)

*Lanarkia spinulosa* (Traq.)

*Ateleaspis tessellata* (Traq.)

*Birkenia elegans* (Traq.)

*Lasanius problematicus* (Traq.)

"All these are new to science.

"The geological interest of this discovery lies in the fact that a new fish-fauna has turned up in the Upper Silurian rocks of Scotland, two genera and several species of which belong to a family, the *Coelolepidae* of Pander, which, in strata of approximate age in England and other parts of the world, have hitherto been known only by scattered scales. A few isolated scales of *Thelodus* (*Th. tulensis*, Rohon.) have also occurred in the Upper Devonian of Russia, and the entire fish from the Lower Old Red Sandstone of Forfarshire, named by Powrie *Cephalopteras Pagei*, is now proved to belong to the same genus. Four other genera of striking novelty, *Lanarkia*, *Ateleaspis*, *Birkenia*, and *Lasanius*, also form part of the same fish-fauna, but it is remarkable that as yet no trace has been found in these Lesmahagow rocks of the *Onchus*-spines, of the Pteraspicians, or of the Cephalaspicians which have been long known from the Upper Silurian strata of the west of England and elsewhere.

"Zoologically the interest of these fishes is extreme. The *Coelolepidae* have, from their shagreen-like scales, been considered by many palaeontologists to be sharks, and to them have also been referred the undoubted selachian spines known as *Onchys*, and even certain selachian-like teeth such as *Monopleurodus* of Pander. But the recent 'find' of the Geological Survey puts a different face on the matter.

"We have here two genera of *Coelolepidae* — *Thelodus*, whose minute shagreen-scales are of the type seen in the species which occur in the Ludlow Bone-bed and in the Upper Silurian rocks of Oesel, and *Lanarkia*, a new genus in which the dermal covering consists of small, hollow, pointed spines, without a basal plate. In both genera the form of the creature is the same — the head plus the anterior part of the body being broad and flattened, with right and left posterior angles in the form of fin-like expansions, the contour of which is continuous with that of the head in front but sharply marked off from that of the tail behind, which latter part terminates behind in a deeply cleft heterocercal caudal fin. There is no trace of jaws, of teeth, or of fin spines in any of the numerous specimens which have been collected, nor has the position of the eye been discovered.

"Now, although through their dermal armature the *Coelolepidae* appear related to the sharks, their general form, along with the absence of teeth and the apparent absence of jaws, appears rather to claim a place for them in the Ostracodermi and in the order Heterostraci, of which the only family hitherto recognised is that of the Pteraspidae.

"*Ateleaspis tessellata* is the type of a new family, and presents us with a form in which the body has the same general shape as in the *Coelolepidae*, but the dermal covering consists in front of small minutely tuberculated polygonal plates, while the tail is provided with rhombic scales, ornamented with delicate tubercles and ridges. It reminds us strangely both of *Cephalaspis* and of *Psammosteus*, but more especially of the latter, as the presence of orbits on the upper aspect of the head is doubtful. It is unfortunate that *Ateleaspis* is so exceedingly rare that only one example showing the head and body has as yet been found, nevertheless what we do see of its structure leads us to the conclusion that the *Psammosteidae* of the Devonian epoch are, as Reis has already indicated, also Heterostraci, and allied to the Pteraspidae. And wherever *Psammosteus* goes there also must *Drepanaspis* of the German Lower Devonian find its place. And it may also be said that although the head and body of *Drepanaspis* are covered with plates instead of with minute scales or spines, the general coincidence of the shape of the fish with that of *Thelodus* or *Lanarkia* is exceedingly striking and suggestive.

"The recent 'find' therefore very greatly enlarges our conception of the Heterostraci, and indicates that, though we cannot consider them as actual Selachii, they probably had a common origin with the primitive Elasmobranchs. And it may here be noted that Rohon, though he calls the *Coelolepidae* 'extinct selachians,' and their scales genuine 'placoid-scales,' remarks that, as these scales in many respects show a simple condition of histological structure, they must be regarded as placoid scales in a lower stage of development.

"*Birkenia elegans* is a very peculiar as well as beautiful form, of elegant fusiform shape, with the head and body covered by narrow tuberculated scutes. There is a completely heterocercal bilobate caudal and a rudimentary dorsal fin, but no trace of paired fins, shoulder girdle, cranial bones, jaws, or even of distinct orbits. It is also the type of a new family, but it is doubtful if it can be included in the Heterostraci; more probably it represents a separate division of Ostracodermi.

"*Lasanius problematicus* is the name which I have applied to a fish whose remains show some very remarkable features. Apparently of an elongated form, the only hard parts which it possessed were a median row of small scutes with

backwardly directed thorns, and on the opposite side in front a peculiar gridiron-like arrangement of about eight parallel bony rods on each side, whose extremities are, at the margin of the body, bent at an angle inwards to meet their fellows of the opposite side. If the row of scutes is dorsal, then the rods may have had to do with the support of the branchial apparatus. Traces of the body are often seen in the form of a carbonaceous film, and in one or two instances this film seems to terminate behind in an acutely bilobate caudal fin. The affinities of this form are, as the specific name implies, very problematical, though I feel no doubt that it is an Ostracoderm, and almost as little that, in spite of its deficiency in dermal covering, it is allied to *Birkenia*.

"It may, in conclusion, be truly said that this recent discovery of Silurian fishes by the Geological Survey of Scotland has opened out to us a new vista in the field of palaeozoic ichthyology".

The interest attaching to this group of rocks in Lanarkshire has been augmented by the recent discovery of ichthyolites in the admittedly Tipper Ludlow Rocks of the neighbourhood of Lesmahagow. In 1896 a species of *Thelodus* was collected from one of the upper zones by Mr. James Young, Lesmahagow, and in 1897–8 two new species of the same genus were obtained by Messrs. Makconochie and Tait from the same horizon. It was from this band also, that a fine example of a true scorpion (*Palaeophonus*) was collected, which was exhibited to the Geological Society of Edinburgh by Dr. Hunter, Carluke, and described by Mr. B. N. Peach.

The recent palaeontological discoveries in these passage-beds of Lesmahagow, prove the presence of so many normal Upper Silurian organisms in shales intercalated in the overlying red and yellow sandstones as to suggest the desirability of grouping these conformable red strata with the Upper Silurian system. Certain data connected with the lithological characters and stratigraphical relations of some of the zones overlying the true Ludlow Rocks seem to favour this view. For example, throughout the Douglas and Lesmahagow districts, two prominent beds of conglomerate have been of great service in working out the geological structure of that region. The lower one, which almost immediately overlies the fish-band above referred to, is composed mainly of pebbles of quartzite derived from the Highlands, while the higher one, which is separated from the lower by red and yellow sandstones and shales, is readily distinguished by the abundance of greywacke pebbles obtained from the Silurian Tableland of the Southern Uplands. Not, indeed, till we reach the horizon of this greywacke-conglomerate do we find conclusive evidence of the predominance of materials in the passage-beds that have been derived from the Silurian Tableland.

The greywacke-conglomerate preserves its distinctive features, as a well-marked horizon along the northern border of the Silurian Tableland from the Pentland Hills to Ayrshire. It forms the base of the sediments which herald the great volcanic series of the Lower Old Red Sandstone, and is to all appearance intimately associated with the terrestrial movements which preceded or accompanied those manifestations of volcanic activity. For both in the Pentland Hills and in Ayrshire this greywacke-conglomerate denotes a marked unconformability; in the former region, as we shall point out in the sequel, it rests on the upturned edges alike of the Wenlock, Ludlow, and passage-beds, while in the latter area it lies unconformably on Lower Silurian strata. It is remarkable, however, that in Lanarkshire and the adjoining part of the county of Ayr, where this horizon has been traced over many miles of country, no unconformability has been detected between it and the underlying sandstones. Some of the sections seem to indicate a gradual passage from the one series into the other, but even if this feature be deceptive it is at least clear that if a discordance does exist in that part of the country, it must be comparatively gentle.

In view of the palaeontological and to some extent also of the physical evidence regarding the passage-beds that overlie the Ludlow Rocks there seems ground for maintaining that they have greater affinities with the Silurian system than with the Old Red Sandstone. They may be looked upon as stratigraphical equivalents of the Tilestones, Downton Sandstones, and Ledbury Shales, which, in Herefordshire, overlie the Upper Ludlow Rocks and have been classified as forming the highest sub-division of the Upper Silurian rocks. See for example Sir A. Geikie's "Text-Book of Geology", 3rd ed., 1893, p. 753. In the following pages a similar grouping has been adopted, and, for the sake of convenience of description, the passage-beds, ranging from the fine local conglomerate underlying the red sandstones to the base of the greywacke-conglomerate, will be referred to as the Dovvntonian series. This modification in the classification hitherto adopted by the Geological Survey is represented in the annexed table, which gives the various sub-divisions of the Upper Silurian rocks in Lanarkshire in descending order:

## LOWER OLD RED SANDSTONE

### Volcanic Series

3. Andesites and tuffs (volcanic zone).
2. Chocolate-coloured sandstones with *Cephalaspis Lyelli*
1. Conglomerate with greywacke pebbles.

### Unconformability in the Pentland Hills and in Ayrshire; apparent conformability in Lanarkshire.

### Downtonian

11. Chocolate-coloured sandstones-1200 feet in Lesmahagow inlier.
10. Conglomerate with large pebbles of quartzite — 100 feet in Lesmahagow inlier.
9. Green and red mudstones with bands of grey shale and greywacke, containing a band with fishes and crustaceans-100 feet in Lesmahagow inlier.
8. Red and yellow false-bedded sandstones and red mudstones-1300 feet in Lesmahagow inlier.
7. Conglomerate of local occurrence, with small pebbles of Arenig volcanic rocks, radiolarian chert, quartz, &c., resting conformably on Ludlow shales —88 to 150 feet in the Hagshaw Hills anticline.

### Ludlow

6. Green flaggy and sandy greywackes, with partings of grey and red mudstone — about 130 feet,
5. Blue, grey, and green shales with sandy mudstones and greywackes, occasionally weathering with a rusty colour-200 feet (*Trochus* beds).
4. Hard blue and grey flaggy shales and mudstones, with occasional bands of calcareous nodules-350 feet (*Pterygotus* beds).
3. Hard grey flagstones and bands of hard greywacke, with bands and zones of dark fissile calcareous flaggy shales, weathering rusty brown-500 feet (*Ceratiocaris* beds and Ludlow fish band).
2. Grey, blue, and olive shales, with occasional greywacke bands-300 feet.

### Wenlock (?)

1. Hard bands of greywacke with shale partings-1300 feet.

<ref>The thicknesses of the sub-divisions of the Wenlock and Ludlow Rocks given in the above Table apply only to the Lesmahagow inlier.</ref>

The various areas of Upper Silurian strata in Lanarkshire and the adjacent part of the county of Ayr (Sheets 15 and 23 of the Survey Map) may be grouped as follows according to their size and relative importance:

1. The Lesmahagow inlier.
2. The anticline of the Hagshaw Hills.
3. The Carmichael Burn inlier.
4. The small exposure south of Tinto.

Of the foregoing inliers it is highly probable that the axial fold near Carmichael Manse (No. 3) is merely the north-easterly prolongation of that in the Hagshaw Hills (No. 2) reappearing from underneath the Carboniferous rocks of the basin of the Douglas Water. The most important, however, are the first two of the series, the anticline of the Hagshaw Hills (No. 2) being five miles and that of the Logan Water (No. 1) from seven to eight Miles distant from the northern limit of the Silurian Tableland. A careful study of the stratigraphical relations of these two inliers shows that there is a great similarity in the structure of both areas, for in each case the Wenlock and Ludlow Rocks form anticlines, now exposed at the surface by the removal of the Downtonian and Lower Old Red Sandstone strata which covered them to a great depth; each is bounded on the south-east side by a large fault, while along their north-west margins the sequence from the Ludlow to the Downtonian Rocks can be traced. A further interesting feature which illustrates the extreme plication of the Silurian and Lower Old Red Sandstone rocks in pre-Carboniferous time is the prominent inversion of the strata in the case of the Hagshaw anticline. Both limbs of the fold dip towards the north-west, and the south-east limb is truncated by a reversed fault, by means of which older are made to overlie younger rocks. In other words, we have here a repetition of over-folds culminating in reversed faults which is such a conspicuous feature of the mountain-building of the North-West Highlands. That this plication took place in pre-Carboniferous time is evident from the fact that the Upper Old Red Sandstone and Lower Carboniferous rocks rest unconformably on the folded Downtonian and Lower Old Red Sandstone strata.

## i The Lesmahagow Inlier

This area lies on the confines of the counties of Lanark and Ayr between Muirkirk and Lesmahagow. The boundary between the two counties forms there a sinuous line running along the watershed that separates the tributaries of the Clyde (Nethan, Kype, and Glengavel Waters) from the Greenock Water and its affluents, which flow into the river Ayr. Though the region lies within the midland valley of Scotland, it nevertheless forms a pastoral district, where some of the hills exceed 1500 feet in height. Excellent sections of the strata are exposed in the various streams, notably in the Logan and Greenock Waters and their tributaries, and as the beds over much of the area dip at gentle angles favourable opportunities are afforded of studying the various palaeontological zones (Figure 117).

### Wenlock and Ludlow Series

The Wenlock and Ludlow Rocks of the Lesmahagow inlier extend in a north-east direction from the Greenock Water [NS 66975 28407] by the Priesthill Height (1615 feet) [NS 73276 32557] and Nutberry Hill [NS 74369 33787] (1712 feet) to the Logan Water [NS 75194 37066], a distance of six miles. In this instance only the northern limb of the anticline has been preserved, as along a portion of the south-east margin the Wenlock and Ludlow Rocks are truncated by a normal fault bringing them in contact with the Downtonian beds. The sequence is still further interrupted by a sheet of intrusive felsite, which runs along the strike of the lowest beds in the core of the fold.

(1) The lowest beds (No. 1 of the Table given above and 5a of (Figure 117)), consist of blue greywackes with partings of shale. They extend along the southern margin of the area, being visible in the head-waters of the river Nethan, in the Ponesk Burn [NS 71635 30473], and in other streams in the direction of Hall on the Greenock Water. Indications of the anticlinal arrangements of these beds are to be found on Nutberry Hill [NS 74369 33787], where, at various points, they dip to the north-west, north-east and south-east. One noteworthy feature connected with this group is the presence of mineral veins (galena and barytes), which have been expressed on the one-inch map, Sheet 23, published in 1872. Few fossils have been obtained from this sub-division; indeed, the only determinable forms, comprising *Orthis* (?) and *Murchisonia*, have been collected from one locality on the north-east slope of Nutberry Hill [NS 75145 33950], where the sandy greywackes and shales dip to the north-west at angles varying from 40°–60°. In the absence of definite palaeontological evidence it is impossible to fix with precision the age of the beds forming the lowest group. We are inclined to believe that they may belong in part at least to the Wenlock formation, but this question is one which must be verified by future research.

(2) The members of the next group (Nos. 2 and 5b) consist of grey, blue, and olive shales, with occasional greywacke bands, which form a very narrow strip immediately to the north of the presumably Wenlock strata. They range from the neighbourhood of Hall, in the Greenock Water, to the north-west slope of Nutberry Hill, where, crossing the Long Burn

they sweep round the east limit of the anticline towards the river Nethan, west of Eaglinside, their general dip in the latter region being easterly. At one locality, near the head of the Long Burn [NS 74762 33887] — a tributary of the Logan Water — at a point about a mile to the south-east of Logan House, the following fossils were collected by the Geological Survey from certain nodular sandy greywackes occurring in this subdivision.

*Ceratiocaris papilio* (Salt.)

*Ceratiocaris stygius* (Salt.)

*Anodontopsis bulla* (M'Coy.)

*Anodontopsis lucina* (Salt.)

*Ctenodonta obesa* (Salt.)

*Mytilus mytilimeris* ((Jour.)

*Orthonota amygdalina* (Sow.)

*Orthonota* var.

*Orthonota bulla* (Salt.)

*Orthonota impressa* (Sow.)

*Orthonota solenoides* (Sow.)

*Pterinea retroflexa* (Wahl.)

*Pterinea retroflexa* var. *naviformis*. (Conr.)

*Pterinea pleuroptera* ((Jour.)

*Holopella obsoleta* (Sow.)

*Murchisonia* sp.

*Platyschisma helicites* (Sow.)

(3) The *Ceratiocaris*-beds (No. 3 and 5c) are of special interest, as they contain the layer which has recently yielded the Ludlow fishes. Lithologically the sediments of this group are coarser than those of the underlying and overlying groups. They consist of hard grey flagstones and bands of hard greywacke, in which occur zones of dark fissile calcareous flaggy shales. The latter contain in remarkable abundance at certain localities remains of *Ceratiocaris*, which is indeed the distinctive palaeontological feature of the sub-division.

The Geological Map (Sheet 23) shows that the members of this group extend along the northern limb of the anticline from Linburn [NS 69589 29871] on the Greenock Water north-eastwards to the Logan Water [NS 75060 36912], where the finest exposures of the *Ceratiocaris* beds are to be seen. Thence they curve round the eastern termination of the arch towards the Nethan Water at Eaglinside.

At various points in the Logan Water the fossiliferous bands of this subdivision (No. 3 and 5c) are admirably displayed; indeed, owing to the gentle inclination of the beds, large surfaces of the more important seams are laid bare for investigation. Though fragments of the characteristic crustaceans are found on different horizons throughout the group, one band is of special importance from the abundance of species of *Ceratiocaris* in it, and from the occurrence of Ludlow fishes, and a well-preserved scorpion. The group is exposed in a small gorge in the midst of a plantation about three-quarters of a mile to the north-east of Logan House. Here the stream-course makes a marked loop at a place

known locally as Shank's Castle [NS 74537 36209]. The hard greywackes and flagstones at the southern curve of the loop dip to the north-west at 15°, being succeeded up-stream by rusty-brown calcareous flaggy shales, from which the following organisms have been obtained:

Worm tracks.

*Ceratiocaris laxa* (Woodw. & Jones.)

*Ceratiocaris longa* (Woodw. & Jones.,

*Ceratiocaris papilio* (Salt.)

*Ceratiocaris stygius* (Salt.)

*Ceratiocaris telson*, like *Murchisoni* (M'Coy.)

*Slimonia acuminata* (Salt.)

Above the wood a large alluvial flat extends up stream for half a mile to Logan House, where operations are now in progress for the formation of a large reservoir. Not far to the west of Shank's Castle, where excavations are now being made for an embankment [NS 74479 36166], the fossils given in the annexed list were collected from the debris of this band:

Worm tracks

Myriapods ? (impressions of).

*Ceratiocaris* sp.

*Dictyocaris Ramsayi* (Salt.)

*Pterygotus bilobus* (Salt.)

*Slimonia acuminata* (Salt.)

*Thelodus scoticus* (Traquair.)

Though the remains of Eurypterids are numerous, only two fragments of the Ludlow fish, *Thelodus scoticus*, were here obtained, which, however, are sufficiently distinct for determination.

As the Ludlow fish-band is followed westwards its outcrop is affected by two normal faults. The first, trending in a northwest and south-east direction not far to the west of Shank's Castle, shifts the outcrop to the north side of the valley; the second, trending E.N.E. and W.S.W., produces a still further displacement towards the north-west. Near Logan House, certain members of the *Ceratiocaris*-group — though on a slightly lower horizon than the fish-band — appear at the foot of the Long Burn [NS 73991 35623], a tributary of the Logan Water. Here the blue greywackes and shales dip towards the north-west at angles varying from 20° to 35°, and contain the following forms:

*Spirorbis* sp.

*Beyrichia Kloedeni* (M'Coy.)

*Beyrichia Kloedeni* var. *torosa* (Jones.)

*Ceratiocaris*.

*Dictyocaris Ramsayi* (Salt.)

*Pterygotus bilobus* (Salt.)

*Lingula minima* (Sow.)

*Modiolopsis Nilssoni* (His.)

*Orthonota* sp.

*Platyschisma (Trochus) helicites* (Sow.)

About Logan House [NS 73958 35256] the stream has laid open various exposures of greywackes and shales having a similar inclination to the north-west, till at a point about half a mile south of the farmhouse the best development of the Ludlow fish-band in the Lesmahagow inlier is displayed. From this locality, also, the finely-preserved scorpion, *Palaeophonus caledonicus*, was obtained. Here the stream for a short distance flows in an E.N.E. direction, and obliquely crosses the strike of the beds, which dip to the W.N.W. at angles varying from 12°–15°. On the left bank the strata form a cliff about thirty feet high, the upper portion of which consists of hard greywacke bands about a foot thick, and the lower of brown flaggy shales which contain the remains of *Ceratiocaris* in abundance, with a few fragments of *Pterygotus*. The fishes are partly embedded in ironstone nodules in the brown flaggy shales. These nodules are sometimes arranged in lines close to each other, and the organic structures are found to be much better preserved in them than in the ordinary flaggy shales. The following fossils have been collected from this outcrop by the Geological Survey:

*Archidesmus loganensis* (Peach.)

*Ceratiocaris longa* (Jones & Woodw.)

*Ceratiocaris Murchisoni?* (M'Coy.)

*Ceratiocaris papilio* (Salt.)

*Ceratiocaris stygius* (Salt.)

*Slimonia acuminata* (Salt.)

*Physocaris* sp.

*Pterinea retroflexa* (Wahl.)

*Platyschisma (Trochus) helicites* (Sow.)

*Thelodus scoticus* (Traq.)

*Thelodus planus* (Traq.)

Fish fragment undt.

In the valley of the Greenock Water, another exposure of these beds is to be seen at Linburn [NS 69590 29892], where they yielded specimens of *Ceratiocaris papilio*, *C. robusta*, *C. stygius*, and *Thelodus scoticus*.

(4) The *Pterygotus*-beds, the strata so successfully explored by Dr. Slimon of Lesmahagow, though traceable from end to end of the anticline as a narrow belt lying to the north of group No. 3, are best exposed in the Logan Water and its tributaries. At Dunside [NS 75105 37091], on the south bank of the Water, the strata dip to the W.N.W. at an average angle of 20°. The stream flows generally along the strike of the beds for a distance of about a quarter of a mile, and large masses of stone can there be easily dislodged from the dip slope and searched for Eurypterid remains. The strata consist of hard blue and grey flaggy shales and mudstones with calcareous nodules. Like the concretions in the fish-band, these calcareous nodules are sometimes arranged in lines, which partly envelope the organic remains. The following fossils were collected from an exposure on the right bank of the stream, about 400 yards west from Dunside:



*Ceratiocaris papilio* (Salt.)

*Neolimulus falcatus* (Woodw.)

*Eurypterus lanceolatus* (Salt.)

*Eurypterus obesus* (Woodw.)

*Eurypterus scorpioides* (Woodw.)

*Pterygotus bilobus* (Salt.)

*Pterygotus bilobus* var. *accidens* (Woodw.)

*Pterygotus bilobus* var. *inornatus* (Woodw.)

*Pterygotus raniceps* (Woodw.)

*Slimonta acuminata* (Salt.)

*Stylonurus Logani* (Woodw.)

*Lingula minima* (Sow.)

In a small tributary of the Logan Water from the north, at a spot about 250 yards west from Dunside [NS 74835 36966], these flaggy shales have yielded specimens of *Spirorbis Lewisi*, *Beyrichia Kloedeni*, *Dictyocaris Slimoni*, *Pterygotus bilobus*, *Slimonia acuminata*, and *Platyschisma helicites*.

In like manner, in the Blackberry Burn, at a point about 100 yards up stream from the alluvial cone where it joins the Logan Water [NS 73897 35632], the following forms have been obtained from these beds, viz.: *Dictyocaris Ramsayi*, *D. Slimoni*, *Pterygotus bilobus*, *Lingula cornea*, and *L. minima*. South-westwards along the strike, the members of this group are found in the Kip Burn [NS 73220 34799], another tributary of the Logan Water from the north, where they have yielded examples of *Ceratiocaris stygius*, and *Pterygotus bilobus*.

On the south-west side of the county boundary, and close to the watershed, the representatives of this sub-division reappear near the head of the Lease Burn, where they consist of blue-grey flaggy shades, dipping to the W.N.W. at angles varying from 20° to 30°, and are traversed by thin basalt dykes. Some of the seams freely yield fragments of Eurypterids, the following fossils having here been collected: *Beyrichia Kloedeni*, *Ceratiocaris papilio*, *C. stygius*, *Pterygotus bilobus*, and *Slimonia acuminata*.

(5 and 6) Along the northern limit of the Upper Ludlow Rocks numerous excellent sections show the two highest subdivisions (5e and 5f of (Figure 117)) of the Ludlow strata that immediately underlie the Downtonian or passage beds. One of the best sections is in the Blackberry Burn [NS 73281 35703], which joins the Logan Water about a mile and a quarter to the south-west of Dunside. Prominent among these upper beds, as developed in this stream, are certain blue, grey, and green shales, with sandy mudstones and greywackes occasionally weathering into a rusty colour, which constitute group 5. The distinctive palaeontological feature of this sub-division is the abundance in it of *Platyschisma (Trochus) helicites*, which is here associated with *Spirorbis Lewisi*, *Beyrichia Kloedeni*, *Modiolopsis Nilssoni*, and *Orthonota solenoides*.

Some of the same characteristic fossils are likewise found in tributaries of the Logan Water from the north, viz., in the Kip Burn [NS 72170 34311] and in a stream near Dunside. To the south-west of the county boundary the members of this group reappear in the Lease Burn [NS 72631 32879], where they have furnished specimens of *Platyschisma helicites* and *Beyrichia Kloedeni*; and still further to the south-west, in a dry gully about half a mile W.N.W. of Priest hills shepherd's house [NS 71142 31359], the following organisms have been obtained: *Spirorbis Lewisi*, *Beyrichia Kloedeni*, *Modiolopsis*, *Orthonota solenoides*, and *Platyschisma helicites*.

The most highly fossiliferous locality in the basin of the Greenock Water is to be found in a small streamlet about half a mile E.N.E. of Waterhead [NS 70619 31104], in the Greenock Water, where the grey sandy greywackes and greenish shales dip towards the north-west at 20°, and yield the fossils given in the annexed list:

*Spirorbis Lewisi* (Sow.)

*Beyrichia Kloedeni* (M'Coy.)

*Dictyocaris* sp.

*Slimonia acuminata* (Salt.)

*Goniophora cymbaeformis* (Sow.)

*Modiolopsis complanata* (Sow.)

*Modiolopsis Nilssoni* (His.)

*Orthonota impressa* (Sow.)

*Orthonota rotundata* (Sow.)

*Orthonota solenoides* (Sow.)

*Platyschisma helicitis* (Sow.)

In the prolongations of this group towards the south-west of the Greenock Water, some of the characteristic fossils have been found in the Lann Burn [NS 69095 29635], about three-quarters of a mile to the south-west of Waterhead and in an adjoining streamlet.

The members of the highest sub-division of the Ludlow rocks, consist of green flaggy and sandy greywackes with partings of grey and red mudstones, that have hitherto proved unfossiliferous. Indeed, they merge gradually into the red and fellow sandstones which form the base of the overlying Downtonian series.

### **Downtonian Series**

On the north-west side of the arch of Wenlock and Ludlow rocks, in the Lesmahagow inlier, there is a broad area occupied by the overlying strata forming the Downtonian group. Indeed, over much of that region the beds lie at low angles; and sometimes form gentle undulations. In this respect the geological structure of the Downtonian area on the north-west side of the Lesmahagow inlier differs widely from that met with in the case of the Flagshaw anticline.

Though there are various sections showing the gradual sequence from the Upper Ludlow rocks into the conformable series of red and yellow sandstones, yet the local conglomerate (Sub-division 7) has nowhere been detected on the north-west limb of the Lesmahagow inlier. In the sequel we shall point out that it is typically developed in the Hagshaw anticline and near Carmichael Manse.

**(8) Red and Yellow Sandstones (6b in (Figure 117)).** — Perhaps the finest section of the passage from the green flaggy and sandy greywackes (Upper Ludlow) into the overlying red and yellow false-bedded sandstone is to be seen in the Blackberry Burn — a tributary of the Logan Water. At a point about half a mile up from the foot of the stream [NS 73060 35722], the passage-beds consist of red mudstones and sandstones which dip towards W.N.W. at angles varying from 15° to 18°. They graduate downwards into the uppermost Ludlow group. Similar strata are observable near the junction of the Kip Burn [NS 73827 35231], but the sequence is there disturbed by a normal fault trending E.N.E., by means of which the, Downtonian beds are brought into conjunction with the underlying Ludlow rocks.

Still further to the south-west, in the Lease Burn, one of the tributaries of the Dippal Burn, in the adjoining county of Ayr, the grey flaggy sandy greywackes (No. 6) pass upwards into red flaggy sandstones and shales which are inclined to the W.N.W. at angles varying from 10° to 20°. These are succeeded by false-bedded yellow sandstones, which are extremely friable, and likewise dip to the W.N.W. at an angle of about 10°, though in some instances gentle undulations are observable. In the Dippal Burn above and below the mouth of the Lease Burn [NS 70973 32849], these yellow beds are admirably seen. Beyond the valley of the Dippal in the tributary which drains the hollow between Regal and Goodbush Hills, red sandstones are associated with the yellow beds.

**(9) The Fish-beds.** — The group of strata which includes the Downtonian fish-band (6c in (Figure 117)) is well exposed in the lower reaches of the Dippal Burn, in the Slot Burn, and in various streamlets forming the sources of the Glengavel and Kype Waters. Its members, as there displayed, may be described as green and red mudstones, with bands of grey shale and greywacke in marked contrast to the underlying subdivision. Several small faults intervene which interrupt the natural sequence of the strata both in the Dippal Burn and some of its tributaries. The fish-band, the most interesting feature of this group, comprises from twelve to fifteen feet of alternations of brown flaggy carbonaceous shales and green mudstones. No organic remains have hitherto been found in the mudstones; the fishes and eurypterids occur at various levels throughout the carbonaceous shales.

The Dippal Burn, from the shepherd's house at Dippal [NS 69957 32393] down to near its point of junction with the Slot Burn [NS 69120 31407], displays an almost continuous section of these green mudstones and sandy greywackes, and has excavated a small gorge for a short distance through them. At a point about 350 yards up stream from the shepherd's house, on the south bank, an exposure of the fish band may be seen [NS 70218 32560]. Here the yellow sandstones are overlain by black carbonaceous sandstone, which is in turn succeeded by the green mudstones with brown flaggy carbonaceous shales containing ichthyolites. The thickness of the fish-band at this locality is not more than about four feet. Below the shepherd's house, green mudstones and greywackes, there exposed, lie not far from the horizon of the fish-band, for the latter reappears at a point about 200 yards up from the junction of the Dippal Burn with the Greenock Water [NS 69166 31578], where some of the characteristic fishes of the zone have been obtained, viz.: *Thelodus scoticus*, *Birkenia elegans*, *Lasanius problematicus*, *Ateleaspis tessellata*, together with a eurypterid.

Again, near the head of Dippal Burn, about half a mile to the south-east of the crest of Goodbush Hill [NS 71670 34314], the fish-band is again met with, evidently occupying a geological position similar to that near the foot of the stream. The normal passage downwards into the yellow sandstones is, however, here concealed by a fault, which is probably the continuation of that already described as occurring in the Kip Burn. Where it crosses the Dippal Burn it is probably of no great magnitude. On the north side of this fault the green mudstones and fish-bearing shales, which are here thrown against the yellow sandstones, are about twelve feet thick [NS 71273 33682]. The fossils obtained from this exposure are given in the subjoined list:

Furoid-like markings.

*Pachytheca* sp.

*Parka*, new sp.

*Ceratiocaris* sp.

*Eurypterus dolichoschelus* (Laurie.)

*Lanarkia spinulosa* (Traquair.)

*Lanarkia horrida* (Traquair.)

*Lanarkia spinosa* (Traquair.)

*Thelodus scoticus* (Traquair.)

*Birkenia elegans* (Traq.)

The various exposures of the fish-band just described occur along the south-east margin of the belt formed by the members of group 9. In the Slot Burn, one of the tributaries of the Greenock Water near Seggholm, an important outcrop of this fossiliferous zone lies considerably to the north. It may, nevertheless, be on the same horizon, for the beds are inclined at gentle angles, and in some cases are almost flat, while the outcrop of the fish-band is shifted by a normal fault. This view is strengthened by the fact that, on the crest at the watershed east of Seggholm, an outlier of the overlying quartzite conglomerate (group 10), appears about half a mile to the south of the normal outcrop of the band. The Slot Burn outcrop appears about 200 yards up stream from the house at Seggholm (now in ruins) [NS 68156 32175]. Here the fish-band, comprising fifteen feet of fossiliferous mudstones, is visible on the right bank, here it forms a steep slope strewn with rocky debris. This is one of the two best localities for ichthyolites in the Downtonian series, for all the species determined by Dr. Traquair from this horizon have been obtained here, together with eurypterids. The fossils from this place so far as they have been named are given in the annexed list:

Plant stems.

*Pachytheca* sp.

*Dictyocaris* sp.

Sponge?

*Ceratiocaris taxa* (Jones and Woodw.)

*Eurypterus dolichoschelus* (Laurie.)

*Stylonurus ornatus* (Laurie.)

Myriapod.

*Lanarkia spinulosa* (Traq.)

*Lanarkia horrida* (Traq.)

*Lanarkia spinosa* (Traq.)

*Thelodus scoticus* (Traq.)

*Birkenia elegans* (Traq.)

*Lasanius problematicus* (Traq.)

*Ateleaspis tessellata* (Traq.)

A short distance up the Slot Burn Mr. Tait recently detected a second fish-band on a slightly higher horizon, which yielded several species of fishes, together with a myriapod; and in a streamlet about half a mile to the south of this locality he also obtained specimens of *Glaucanome* in sandy shale not far below the outcrop of the quartzite-conglomerate.

It is highly probable that other exposures of the fish-band may yet be found along the northern limb of the Lesmahagow inlier, as that region has not yet been thoroughly explored since the recent discovery of fish-remains.

**(10) Quartzite-Conglomerate.** — The outcrop of this remarkable conglomerate (6d in (Figure 117)) follows a sinuous course through the moors from Middlefield Law [NS 68053 30714], north-west of the Greenock Water in the county of Ayr to Townend [NS 74754 41932] on the Kype Water, southwest of Strathavon, in the county of Lanark, a distance of about ten miles. In this region, however, it is not so typically developed as in the anticline of the Hagshaw Hills, further to the south. In the Slot Burn, for instance, near Middlefield Law, it is only a few feet thick, though it still bears its peculiar

features, viz., abundance of well-rounded blocks of quartzite. To the north, in the Powbrone Burn [NS 68769 34415], it is represented by a yellowish ferruginous sandstone, in which are set a few pebbles of quartzite. Its presence can be traced by the number of its peculiar pebbles strewn over the moorlands between that stream and the Kype Water at Juan Hill, where it again attains a considerable thickness and is split up into two beds.

**(11) Chocolate-coloured Sandstones.** — Next in order chocolate-coloured sandstones (6e in (Figure 117)), occupy a considerable area to the north of the outcrop of the quartzite-conglomerate, and require no special description beyond reference to the fact that they present the normal characters of the Lower Old Red Sandstone division. They underlie the greywacke-conglomerate, however, which, according to the classification adopted in these pages, may be taken as a convenient base to the Lower Old Red Sandstone. This conglomerate is well seen in the Cove Burn [NS 61170 32128], one of the sources of the Avon Water, in the south-west corner of Sheet 23 of the Survey Map. Though it has not been traced across the northern part of the red sandstone area, its presence is indicated by numerous scattered pebbles of greywacke. Still further to the north-west, in the neighbourhood of Lanfine, remains of *Cephalaspis Lyelli* were found many years ago in the overlying red sandstones, which clearly belong to the beds that underlie the great series of Lower Old Red Sandstone volcanic rocks.

Having described in the foregoing paragraphs the relations of the Downtonian rocks along the north-west margin of the Lesmahagow Tipper Silurian inlier, we may now refer to their development on the east and south-east sides of that tract, where, as already indicated, the Wenlock and Ludlow rocks are abruptly truncated by a normal fault that obscures the natural sequence from the Upper Ludlow to the Downtonian series. In this area the various zones from the red and yellow sandstones (Group 8) to the greywacke-conglomerate, at the base of the Old Red Sandstone, are to be seen.

The best section occurs in the Birkenhead Burn [NS 76424 36035], a tributary of the Logan Water which traverses all the important zones in the Downtonian series, save the local conglomerate at the base (Figure 117). At the fault which brings the Downtonian rocks into contact with the *Ceratiocaris* beds (No. 3), red sandy mudstones extend for a short distance down stream, inclined to the E.N.E. at an angle of about 20°. These are followed by red sandstones and mudstones, and eventually by friable yellow sandstones, which are pierced by a mass of yellow felsite, and dip in a similar direction at angles varying from 40° to 50°. From their lithological characters there can be no doubt that these beds belong to group 8, a conclusion which is confirmed by the fact that further down the stream the red mudstones pass upwards into the group of strata containing the fish-band. This group is admirably seen in the burn, at a point about a mile west of Birkenhead Farmhouse, where, on the north bank, it forms a cliff, partly covered with herbage, but laid bare for exploration at the mouth of a tributary rivulet. Like the beds in the Dippal Burn, the members of this group consist of alternations of green mudstones and brown carbonaceous fish-bearing shales, which dip to the E.N.E. at an angle of about 30° and pass below a fine exposure of the quartzite-conglomerate (10).

By means of a small normal fault which crosses the Birkenhead Burn in an E.N.E. direction, the outcrops of the green mudstones, fish-bearing shales, and the overlying quartzite-conglomerate are shifted westwards on the south side of the stream. On that side the green mudstones and shales are more weathered than in the exposure on the north bank, and they more readily yield the characteristic fishes and eurypterids. They are inclined to the north-east at an angle of about 45°, and are there seen to rest on red sandy mudstones.

The total thickness of the fish-bearing band in Birkenhead Burn is about fifteen feet, which includes the associated layers of barren green mudstone. The lowest fossiliferous zone of carbonaceous shales is about a foot thick, while higher up the fish-bearing seams measure from one to six inches. The remarkable feature of this exposure is the constant association of the fish-fauna with eurypterids that are characteristic of the underlying Upper Ludlow rocks. The fossils obtained by the Geological Survey from this locality are given in the annexed list:

Plants.

Sponge.

*Ceratiocaris* sp.

*Eurypterus* sp.

*Pterygotus bilobus?* (Salt.)

*Slimonia acuminata* (Salt.)

*Stylonurus* sp.

*Theolodus scoticus* (Traq.)

*Lanarkia horrida* (Traq.)

*Lanarkia spinosa* (Traq.)

*Lanarkia spinulosa* (Traq.)

*Birkenia elegans* (Traq.)

*Lasanius problematicus* (Traq.)

*Ateleaspis tessellata* (Traq.)

Lower down the stream the quartzite-conglomerate and part of the underlying fish-band are together repeated by a strike fault with a downthrow to the east. Still further east red and grey friable sandstones (11), are followed by the greywacke conglomerate, which is visible near the foot of Birkenhead Burn [NS 78208 36982], and passes under the red sandstones of Lower Old Red Sandstone age, which at Lesmahagow yield *Cephalaspis Lyelli*.

The section of Downtonian rocks in the Logan Water, though by no means continuous, resembles in some respects that in the Birkenhead Burn, for the group containing the fish-band, together with the overlying quartz-conglomerate, is repeated by means of a strike fault. Immediately to the east of the north and south fault that truncates the Ludlow rocks at Dunside [NS 75288 37078], red sandstones and red sandy mudstones appear with a N.N.E. dip. About one-third of a mile to the east of the fault a small exposure of the quartzite-conglomerate protrudes through the drift to the north of the alluvium. A fault, though not visible, must intervene immediately to the east of this point, for the red mudstones reappear and are associated with red and grey flaggy shales. Further east, towards Achrobert [NS 76445 37941], the Logan Water displays a fine development of the quartzite-conglomerate interbedded with sandstone, the strata dipping to the north-east at an angle of 15°. The pebbles of quartzite vary in size from a few inches to a foot across. A search has been made for ichthyolites in the grey shales associated with the green mudstones beneath the conglomerate at this locality, but without success. At the base of the conglomerate zone a sill of acid intrusive rock has been injected along the bedding planes. Another mass of igneous rock occurs to the east of this conglomerate, which is followed by the chocolate and grey sandstones below the greywacke-conglomerate.

Along the south-east side of the Wenlock and Ludlow rocks of the Lesmahagow inlier, the boundary-fault gradually increases in magnitude. Hence the observer finds that southwards from the Birkenhead Burn to the Nethan Water and the Auchenstilloch Hills [NS 75400 31887], higher sub-divisions of the Downtonian series successively come in contact with the Wenlock and Ludlow rocks. For example, in the Birkenhead Burn, as we have shown, the red sandstones and mudstones (8) appear next the fault, while to the south-west, in the Nethan Water, the quartzite-conglomerate (10) occupies that position, and near the Auchenstilloch Hills the overlying red sandstones (11) are in contact with the Wenlock rocks. Further to the south-west the Wenlock, Ludlow, and Downtonian strata are buried underneath the various sub-divisions of the Carboniferous system.

## ii Hagshaw Hills Anticline

To the south of the Carboniferous areas of Muirkirk, Glenbuck, and Bankend, the Ludlow and Downtonian rocks reappear along the anticline of the Hagshaw Hills, where the strata are inclined at high angles and where, in consequence, the various zones follow each other in rapid succession. Though the beds on the southern limb of this fold are inverted, the anticlinal structure is well defined by means of the various bands of conglomerate which in that region are typically

developed.

From the neighbourhood of Little Cairn Table [NS 73159 25463] (Sheet 15) north-eastwards by the Glenbuck reservoir [NS 75383 28931] to a point near the margin of the Carboniferous rocks at Douglas (Sheet 23), a distance of about five miles, the Ludlow beds can be traced below the Downtonian strata, in a belt which varies from a quarter to a third of a mile in breadth. Excellent transverse sections are to be found in the various streams that drain the southern slopes of the Hagshaw Hills [NS 79190 29731] and also in the Ree Burn [NS 76071 27388], that flows north to join the Douglas Water at Parishholm, south of the Glenbuck reservoir. Though some of the zones of the Lesmahagow inlier have been identified in the anticline of the Hagshaw Hills they have not been traced from end to end of the Silurian belt, which is largely due to the difficulty of obtaining the characteristic fossils. Only the northern limb of the arch of Wenlock and Ludlow rocks has here been preserved, as in the case of the Lesmahagow inlier; the southern limb having been abruptly truncated by a reversed fault, by means of which the strata have been made to over-ride successive zones of the inverted Downtonian beds (Figure 118).

### **Wenlock and Ludlow rocks**

For the purpose of this work it will be sufficient to refer to one or two typical sections showing the order of succession from the base of the Downtonian series in descending order.

Perhaps the best section occurs in the Ree Burn [NS 76037 27579], south of the Glenbuck reservoir, where an almost continuous sequence of the Ludlow rocks is exposed. At a point in the Douglas Water about 250 yards east of the foot of the Ree Burn [NS 76132 28021], the highest visible beds beneath the basal conglomerate of the Downtonian series consist of hard grey greywackes and grey-blue flaggy shales, dipping towards the north-west at an angle of 55°. Westwards, beyond a basalt dyke [NS 76105 27970], blue and grey shales appear, inclined at a similar high angle, and yielding specimens of *Orthoceras*. A few yards up the Ree Burn [NS 75996 27877], blue finely-bedded shales and flaggy greywackes have supplied specimens of *Ceratiocaris*, *Slimonia*, and *Beyrichia Kloedeni*. Further south these beds are succeeded by flaggy shales, which contain in considerable abundance fine examples of *Orthoceras*, and are in turn underlain by greywackes and blue shales, which, near the fault, are shattered and folded, the dip in one or two instances being towards the south-east.

In the Podowrin Burn [NS 78535 29483], which drains the south-west slope of Hagshaw Hill and joins the Douglas Water near Monksfoot, a good transverse section is obtained of the Ludlow rocks. Lithologically they resemble those just described as occurring in the Ree Burn, and they likewise have a general dip to the northwest at angles of from 50° to 60°, though in a few instances they are inclined to the south-east. About midway between the south-east boundary fault and the upper limit of the Ludlow rocks certain beds have proved highly fossiliferous, which tends to encourage the hope that further investigation may trace some of the sub-divisions from end to end of the Hagshaw Hills anticline. The following species have been obtained from this locality:

*Favosites asper* (D'Orb.)

*Lindstromia* sp.

*Glyptocrinus basalis* (M'Coy.)

Crinoid stems.

*Ceriopora* sp.

*Cornulites* sp.

*Beyrichia Kloedeni* (M'Coy.)

*Ceratiocaris papilio* (Salt.)

*Calymene Blumenbachi* (Brong.)

*Encrinurus* sp.

*Iliaenus* sp.

*Proetus Stokesi* (Murch.)

*Slimonia acuminata* (Salt.)

*Athyris (Glassia) compressa* (Sow.)

*Orthis Bouchardi* (Dav.)

*Orthis (Dalmanella) elegantula* (Dalm.)

*Orthis polygramma* (Sow.)

*Strophomena (Leptaena) rhomboidalis* (Wilck.)

*Ctenodonta* sp.

*Orthonota* sp.

*Orthoceras angulatum* (Wahl.)

*Orthoceras* small smooth sp.

It is not improbable that the beds containing this assemblage of fossils may belong to Group 2 of the succession in the Lesmahagow inlier, where a somewhat similar facies of organic remains has been obtained (p. 572).

### **Downtonian Series**

The groups of the Downtonian series are typically developed along the north side of the Hagshaw Hills anticline. Within a horizontal distance of three-quarters of a mile, the various subdivisions from the local conglomerate at the base to the chocolate sandstones (11), which underlie the greywacke-conglomerate, can be examined. The relations of the Downtonian groups to the Ludlow and Wenlock strata of that region are illustrated by the accompanying horizontal section which is drawn across the southwestern part of the arch from Parishholm Hill [NS 77046 27263] north-west by Glenbuck reservoir [NS 75348 28892] to Hareshaw Hill [NS 76389 29640].

In the northern limb of the fold the basal conglomerate (6a) follows the Upper Ludlow rocks in normal sequence on the south side of the road at the south-west termination of the Glenbuck reservoir, where it is inclined to the north-west at an angle of 30°. Lithologically, it differs in a marked degree from the quartzite-conglomerate and greywacke-conglomerate that occupy higher horizons, inasmuch as it consists generally of small pebbles of Arenig volcanic rocks, radiolarian chert, and quartz, with an occasional small pebble of Silurian grit or greywacke. The matrix is composed of a greenish-grey friable grit, which readily decomposes.

Next in order come red and yellow sandstones (6b), visible on the west bank of the reservoir, and dipping in a similar direction at angles varying from 30° to 40°. These correspond to Group 8 of the Lesmahagow inlier. The south-east side of the reservoir displays a fine development of the succeeding sub-division containing the fish-band (6c). Here red mudstones with green mudstones and brown carbonaceous shales, are inclined to the N.N.W. at angles varying from 45° to 50°. At a point where a small stream enters the reservoir, ichthyolites were exhumed from these shales, referrible to the genera *Lanarkia* and *Birkenia*. The fossiliferous zone is followed on the east bank of the reservoir by the quartzite-conglomerate (6d), which there attains a thickness of 100 feet, and presents its characteristic features, viz., the abundance and well rounded character of pebbles of quartzite derived from the Highlands. Next in order come the red



and grey sandstones (6e) followed by the greywacke-conglomerate (Cl) of Hareshaw Hill. On the southern limb of the fold represented in (Figure 118), only the members of the highest group (6e) appear on the south side of the reversed fault. They consist of red and grey sandstones and dip generally to the north-west at angles varying from 45° to 50°.

The various sub-divisions of the Downtonian series can be traced along the north side of the Ludlow anticline of the Hagshaw Hills. During 1898, Mr. Tait proved the occurrence of the fish-band at three new localities — (1) in the Douglas Water south-west of Parishholm [NS 76190 27998], (2) in the Monk's Water [NS 78079 28925], and (3) in the Smithy Burn [NS 78938 29948], north-east of Glenbuck reservoir. The fossils obtained from an exposure in a gully on the right bank of Monk's Water, about three-quarters of a mile south of Monkshead [NS 77802 29141], are given in the subjoined list:

Sponge?

*Ceratiocaris* ?

*Eurypterus*, small sp.

Scorpion.

*Thelodus scoticus* (Traq.)

*Lanarkia spinosa* (Traq.)

*Lanarkia spinulosa* (Traq.)

*Lanarkia horrida* (Traq.)

*Birkenia elegans* (Traq.)

*Lasanius problematicus* (Traq.)

At the top of the green mudstones (No. 9 of the Table, p. 569 and 6c of (Figure 118)) Mr. Tait detected a brown sandy shale abundantly charged with *Glauconome*, together with *Spirorbis*, eurypterids, fishes and other organic remains. This zone overlies the fish-bearing bands, both in the Lesmahagow and Hagshaw Hills anticlines. The fossils given in the following list have been collected from the *Glauconome* band, in the Smithy Burn — the west branch of Podowrin Burn, that drains the south slope of Hagshaw Hill.

*Pachythea* sp.

Sponge.

*Glauconome disticha* (Goldf.)

*Eurypterus dolichoschelus* (Laurie.)

*Spirorbis* sp.

*Lasanius problematicus* (Traq.)

*Ateleaspis tessellata* (Traq.)

On the southern side of the Ludlow arch only the members of the highest sub-division (6e) of the Downtonian series can be traced from end to end of the area, being followed in normal order by the greywacke-conglomerate. At one point, however, viz., in the Monk's Water, a small exposure of the quartzite-conglomerate can be seen in contact with the Wenlock and Ludlow rocks, the remainder of the outcrop being concealed by the reversed fault. It is worthy of note that the inversion of the Downtonian rocks is not persistent along the southern limb of the fold, for in the Monk's Water the

sub-divisions of that series generally have a normal dip to the south-east.

### iii Carmichael Burn Inlier

To the north-east of the Carboniferous basin of the Douglas Water the Ludlow and Downtonian rocks reappear along an axial fold in the neighbourhood of Carmichael Manse [NS 92456 38012], which, as already indicated, is probably a continuation of the arch of the Hagshaw Hills. The sections, however, are imperfect, much of the evidence being concealed by drift or alluvial deposits. In the Explanation descriptive of the area included in Sheet 23 of the one-inch Map of Scotland, reference is made to the occurrence of Upper Silurian fossils in certain beds, which, at that time, were believed to lie more than 5000 feet up from the base of the Lower Old Red Sandstone of this region. The discovery of these fossils was made by Sir A. Geikie in the course of the survey of that district. During the recent re-examination of the ground by the Geological Survey certain known stratigraphical horizons were detected which throw light on the geological structure.

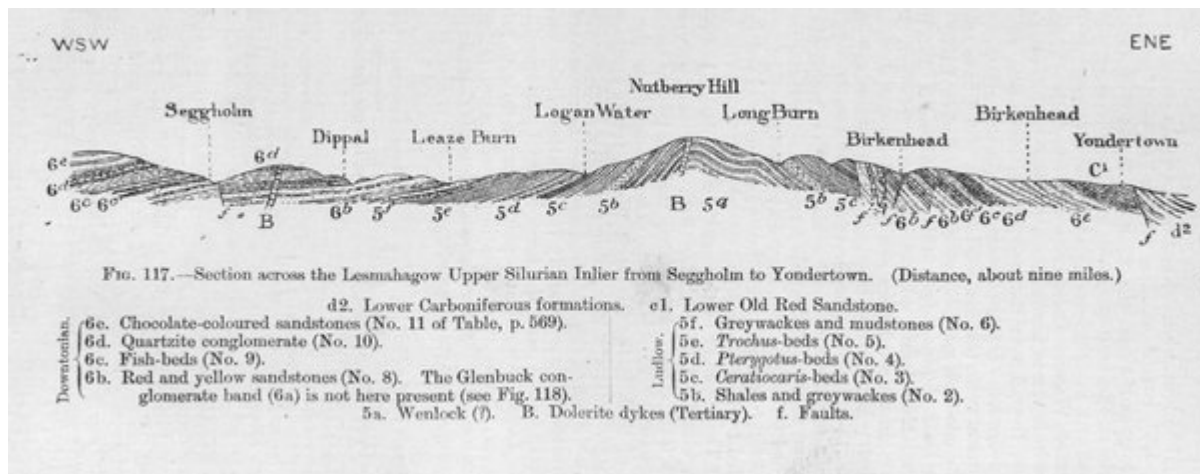
The fossils occur in the Carmichael Burn, at a point about 250 yards south of the manse and about 60 yards north from a bridge across the stream manse [NS 92530 37744], on the right bank, green mudstones appear with a dip to the north-west at angles varying from 45° to 50°, and have furnished specimens of *Monograptus*, *Beyrichia Kloedeni*, *Dithyrocaris striata*, and *Orthoceras dimidiatum*. These mudstones are immediately succeeded by a fine conglomerate, containing fragments of radiolarian chert and Arenig volcanic and plutonic rocks, which closely resembles in lithological characters the fine conglomerate that forms the base of the Downtonian series in the Hagshaw Hills and immediately overlies the Upper Ludlow beds. Indeed there can be little doubt that we have here the representatives of the Upper Ludlow rocks and the basal conglomerate of the Downtonian series, for further down the stream at a distance of 500 yards the quartzite-conglomerate (6d) is met with on the left bank. Owing to the depth of boulder clay no solid rock is visible between the two conglomerates, but, notwithstanding this fact, the petrological characters of the upper band are quite distinct. It contains well-rounded pebbles of quartzite, which are embedded in a sandy matrix, and dips to the north-west at an angle of 20°. When traced to the south-west this horizon reappears on the slope of Chapel Hill, where the rock merges into a conglomeratic sandstone and passes underneath chocolate sandstones.

To the south of the exposure of Upper Ludlow mudstones in the Carmichael Burn, no solid rock is visible for a distance of upwards of half a mile, so that we have no evidence bearing on their relations to the strata in that direction. The latter consist of sandstones with conglomeratic bands, which are associated with the volcanic and plutonic rocks of Lower Old Red Sandstone age. It is highly probable, however, that in the Carmichael Burn area the geological relations of the Upper Ludlow and Downtonian rocks are identical with those which prevail in the Hagshaw Hills; or, in other words, that an arch of Ludlow and Downtonian rocks is there truncated by a reversed fault which may be the prolongation of that in the Hagshaw Hills.

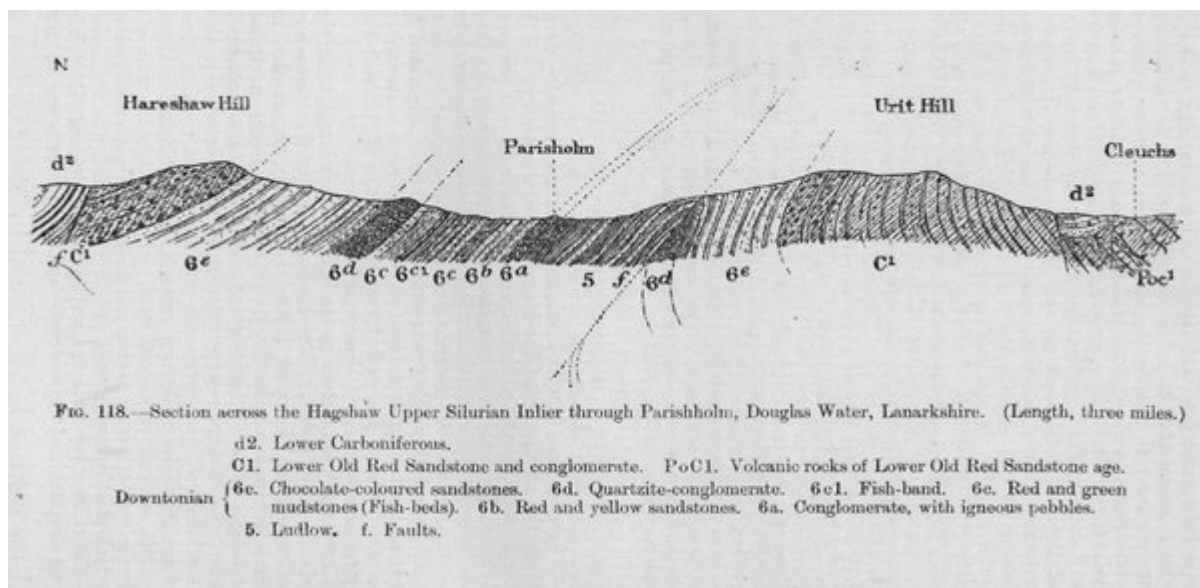
### iv Area south of Tinto

The south-east slope of Tinto displays a prominent exposure of the quartzite-conglomerate of the Downtonian series, at a point about a mile due north of the village of Wiston [NS 95788 33387]. In the fields to the north-west of Eastfield Farmhouse [NS 96780 33356], the green mudstones and shales (Group 9) which elsewhere contain the Downtonian fish-band, are visible, while in the bed of the reservoir at the farm-steading hard greenish-grey greywackes and shales resembling the Ludlow rocks of Lanarkshire are met with [NS 96760 33377]. No organic remains have been obtained from these beds, but the zones of the Downtonian series are nevertheless quite recognisable. Their relations to the greywacke-conglomerate and the volcanic series of the Lower Old Red Sandstone have not been worked out in detail, but it seems clear that the greywackes and shales at Eastfield Farmhouse are faulted against the adjacent lavas of Lower Old Red Sandstone age which lie to the south. During 1899 Mr. Tait obtained further organic remains from the Ludlow and Downtonian rocks of the Lesmahagow "inlier", regarding which Dr. Traquair has kindly supplied the following note: "Two additional specimens of *Lasanius*, collected by Mr. Tait at Seggholm since my notes at p. 587 were in type, indicate a new species distinguished from *L. problematicus* by the considerably greater proportional size and length of the spurs or thorns borne by the median scutes, and which I propose to designate *Lasanius armatus*. In one of these two examples, the rays of the acutely bilobate heterocercal tail are preserved, the arrangement of which furnishes the

long-desired clue to the position of the median row of scutes, proving that they were placed along the ventral margin of the body. Consequently, it is now very improbable that the gridiron-like arrangement of ossicles in the anterior part of the body had anything to do with the support of the bronchial. "*Birkenia elegans* has now been found by Mr. Tait in the *Ceratiocaris* band (Ludlow) at a new locality, a few yards west of Shanks Castle, Logan Water".</ref>



(Figure 117) Section across the Lesmahagow Upper Silurian Inlier from Seggholm to Yondertown. (Distance, about nine miles.) d2. Lower Carboniferous formations. c1. Lower Old Red Sandstone. Downtonian 6e. Chocolate-coloured sandstones (No. 11 of Table, p. 569). 6d. Quartzite conglomerate (No. 10). 6c. Fish-beds (No. 9). 6b. Red and yellow sandstones (No. 8). The Glenbuck conglomerate band (6a) is not here present (see (Figure 118)). Ludlow 5f. Greywackes and mudstones (No. 6). 5e. *Trochus*-beds (No. 5). 5d. *Pterygotus*-beds (No. 4). 5c. *Ceratiocaris*-beds (No. 3). 5b. Shales and greywackes (No. 2). 5a. Wenlock (?). B. Dolerite dykes (Tertiary). f. Faults.



(Figure 118) Section across the Hagshaw Upper Silurian Inlier through Parishhohn, Douglas Water, Lanarkshire. (Length, three miles.) d2. Lower Carboniferous. C1. Lower Old Red Sandstone and conglomerate. PoC1. Volcanic rocks of Lower Old Red Sandstone age. Downtonian: 6e. Chocolate -coloured sandstone. 6d. Quartzite conglomerate. 6c1 Fish-band. 6c. Red and green mudstones (Fish-beds). 6b. Red and yellow sandstones. 6a. Conglomerate with igneous pebbles. 5 Ludlow. f. faults.