

both sides for a breadth of 80 yards, in some places under the present soil. At a particular line a change takes place, and instead of shells and sand, we find washed ashes, the debris of the fires of the salt pans, indicating the period from the commencement of coal-working in connection with salt-making in the twelfth century. The present beach, within the last twenty-five years, at some places, consists of shales and slags from iron works and mines, with ashes from steam engines and from two salt pans, the only representatives in this district of what was formerly a great trade, while scarcely any shells are now to be seen.

II. *On the Lower Silurian Rocks in the neighbourhood of Galashiels.* By CHARLES LAPWORTH, Galashiels. (With a Map.)

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I. INTRODUCTORY.

The Lower Silurian rocks of Scotland, largely developed as they are in the south, and in spite of the great labour that has been bestowed upon them, are by far the least known of all the fossiliferous formations of this country. While the maps of the Government Geological Survey are coloured in all the sub-divisions of the strata of the other formations included in the area, the Lower Silurians are merely indicated by a common purple tint, and not the slightest attempt at a subdivision is made. Even the single bed of limestone they contain below the horizon of that of the west coast is doubtfully referred to the Llandeilo, and the sign of interrogation is carefully placed before its title. Nicol, Harkness, J. C. Moore, and many other eminent

geologists, have worked different portions of these ancient deposits since the publication of "The Silurian System," but as yet very little progress has really been made in correlating its different parts with those of the type formation of the sister country.

Now this want of accurate information is due to two causes: 1st, The strata are so rapidly folded and contorted, and are consequently so intricate and confused, while at the same time they present so few differences lithologically, that anything like a physical separation of its masses is well-nigh impossible; and, 2d, The whole formation, if we except of a few isolated bands of limestone towards the west, and some bands of anthracitic shale that make their appearance about the geographical centre of the system, seems to be nearly destitute of organic remains.

The following has been considered to be the ascending order in the Lower Silurian of the south of Scotland:—

1. The bottom rocks of Hawick and Borthwick water.
2. The particoloured shales and greywackes of Dryfe Water.
3. The Moffat series or anthracitic schists.
4. A thick group of greywackes and shales, supposed to include the Grieston and Barlae flags.
5. The Wrae limestone and its superimposed shales.
6. The Caradoc of Girvan.
7. The Llandovery of Girvan.

Such is the order generally received among geologists, but there is necessarily much difference of opinion, and all below the limestones of Carrick may be said to be in an exceedingly confused and uncertain condition. The Wrae limestone has been paralleled by some with that of the Stinchar, and considered to be the equivalent of the Bala limestone of Wales; while the Geological Survey doubtfully places it among the Llandeilo beds. At the same time the anthracitic schists of Moffat are proved by their fossil contents to belong to the Upper Llandeilo, and thus no place is left in the system for the 24,000 feet of strata supposed to lie (Geol. Journal, vol. xi. p. 393) between these well-marked horizons.

Professor Harkness endeavours to rid himself of this awkward difficulty, by placing the Moffat beds in the Lower Llandeilo, and considering them of the age of the Skiddaw slates (Geol. Journal, vol. xi. p. 393), and when this idea has to be abandoned, by supposing the Grieston and Barlae flags to represent the fucoidal sandstones of Sweden, and thus to be inferior to the Moffat series, but repeated to the north by faults or flexures (Geol. Journal, vol. xii. p. 238); while Mr Geikie is of opinion that "One cannot cross the section of these strata in the railway cuttings, or traverse the valleys between the line of the Wrae limestone and the Dobb's Linn anthracitic bands, with-

out surmising, that on the whole there is an ascending section to the north-west, and hence that there must be a group of thick beds of greywackes and shales between the anthracitic series and the limestone." (Trans. Geol. Soc. Glas. vol. iii. p. 81.)

There are three places known to be fossiliferous in this unplaced and puzzling portion of the Lower Silurian, viz., Grieston, near Innerleithen; Thornilee, near Galashiels; and Barlae, near New Galloway.

From the Grieston Professor Nicol obtained *Graptolites priodon*, Bronn, *G. convolutus*, His., *G. distans*, and *G. tenuis*, Portlk., and a new species he named *Griestoniensis*. (Geol. Jour., vol. vi. p. 53.) Of these *G. distans* and *G. tenuis* are considered as bad species, while *G. Griestoniensis* is most likely merely a form of *G. sagittarius* (Geinitz. Ueber die Graptolithen, p. 35), a common Moffat fossil.

From Thornilee he obtained *G. priodon*, *G. convolutus*, and another form which Mr Salter ultimately pronounced to be a scalariform impression of *G. sagittarius*, His., also *Crossopodia Scotica*, McCoy, and *Nereites cambrensis*, Murch. (Geol. Jour. vol. xi. p. 53.)

From the Barlae flags Professor Harkness has obtained *Chronodites*, *Crossopodia*, *Trichoides*, *Algæ*, and a small *Olenus*. (Geol. Jour. vol. xi. p. 393.)

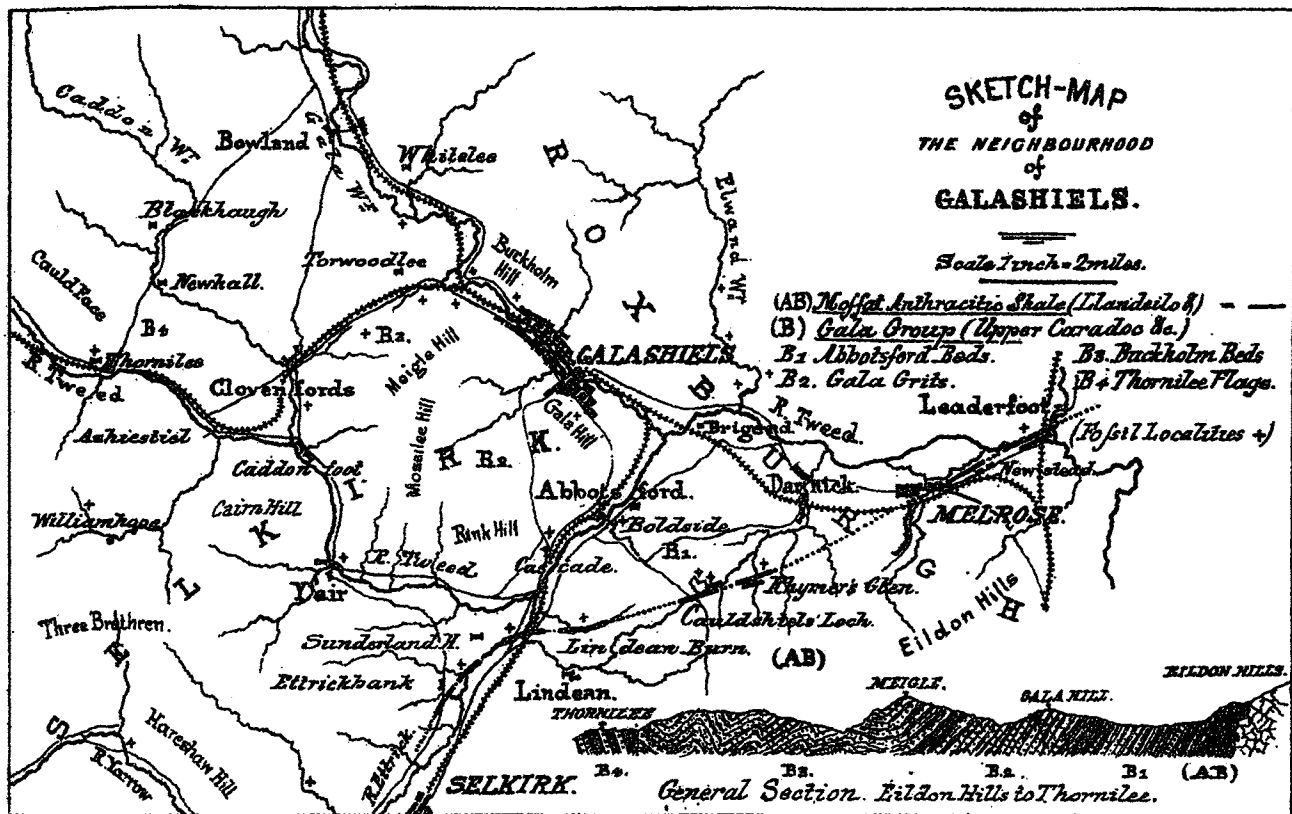
If we except *G. priodon*, and allow the Annelides a share in determining the age of the strata, the whole fauna seems to point to a very low place in the system, and Professor Harkness appears quite justified in referring the whole group to a position inferior to that of the Moffat series.

Now it is of this especial portion of the Scottish Lower Silurian I have to speak, and I trust I shall be able to show, from its fossil contents, that it is not only superior to the Moffat beds, but that the evidence goes far to prove, that it is the representative, in time, of part of the Coniston group of England, or in other words, of a portion of the Caradoc formation of the typical Siluria.

II. THE LOWER SILURIANS OF GALASHIELS.

The town of Galashiels lies about 4 miles to the south-east of the Thornilee Quarry mentioned above, and as nearly as I can ascertain, about the centre of the puzzling group of strata I have more particularly noticed. Till within the last year, no fossils have been found in the neighbourhood, south of Thornilee; and it is with their discovery, and the light they throw on the position and age of the strata, I have more especially to deal.

Mr James Wilson of Galashiels, and myself, assisted by Mr Wardrop of Ladhope, have devoted much of our leisure to the careful examination of the rocks of the neighbourhood, during



C. Legaworth del. et lith.

the past summer, and have found them to be abundantly fossiliferous in places, and to contain what seems to be a distinct and characteristic fauna.

The rocks from which fossils have been obtained stretch in a north-westerly direction from the Eildon Hills, through the town of Galashiels to the Thornilee Quarry, and as the Grieston contains the same fauna, generally speaking, as that of our higher beds, I shall include that classic quarry in my description.

The whole series, which may be called "The Gala Group," is roughly separable into four sub-ordinate groups or divisions.*

1. The Abbotsford flags and greywackes ;
2. The Gala grits ;
3. The Buckholm sandstones ;
4. The slates of Thornilee and the Grieston ;

the whole underlaid by the representative of the higher portion of the Moffat series or anthracitic schists.

All these beds dip as a rule to the north-west till they reach Thornilee, where they turn over to the south-east, and continue thus to Innerleithen, where the north-west dip is resumed and is held to the Grieston.

The average dip is 60° , and the total distance across the strike about three miles, which gives us a gross thickness, in round numbers, of 13,000 feet. Allowing one-third of this for folds, we have a net thickness of about 9000 feet, to which, if we add 1000 feet for the slates of Thornilee and the Grieston, we get an approximate thickness of 10,000 feet for the whole of the known Gala group, or less than one-half that estimated by Professor Harkness (*Geol. Jour.*, vol. xi. p. 393). This is the greatest thickness possible ; the real thickness may be but a fraction of this estimate, but it cannot exceed it.

There are few exposures of the rocks themselves. Quarries for dry-stone dykes, and the rocky beds of rivers, which are submerged for ten months in the year, afford, roughly speaking, the only means of reaching the strata, so that nothing like a section is attempted, and a short description only of the different beds is subjoined, premising that the distinctive lithological characters are drawn principally from the varying appearance of the shalier strata, and that the order here adopted is almost entirely geographical.

(1.) *Rocks of the Moffat Series.*

First, then, for the underlying band of anthracite, which I have classed provisionally with the Moffat series.

The black shales make their first appearance in the neigh-

* These divisions are nothing more than the local distinctions used by us in working out the fossils ; they may be allowed to stand provisionally till the true succession is obtained.—(C. L., October 1870.)

bourhood, in a small stream falling into the Ettrick below Sunderland, about a mile and a half above the junction of the Ettrick and Tweed. They are associated with hard jointed grits, and indurated yellow, bluish, or white shales, and have, as yet, yielded no fossils.

They are next seen crossing the Ettrick at Lindean Bridge, are of the usual type, and exceedingly crushed and contorted. They have, however, here yielded *D. pristis*, His., and a *Cladograpsus*.

Prolonging the lines of strike (which is here from 20° to 25° N.E.), we meet with the black shales once more in a small burn that runs from near Cauldshields into the Ettrick, a quarter of a mile above Lindean. They are here developed to a greater extent than at any other place in the district, and have as usual been fruitlessly bored for coal. They are excessively disturbed, and are interlaced by fine veinings of quartz, but we have managed to obtain from them *Diplograpsus terefinusculus*, His., *D. vesiculosus*, Nich., *D. pristis*, His., *Cladograpsus linearis*, Carr., and *Graptolites sagittarius*, His. They are not seen again until we reach a small burn that runs down from the hills to the west of Eildon, through a gulley called the Rhymer's Glen, but there are traces of their presence at the south-east end of Cauldshiels Loch, where their associated purple and whitish shales are seen intersected by many dykes of the Eildon porphyry, and from these beds we have procured *G. lobiferus*, M'Coy, i.e., *G. Beckii*, Barr, and *G. Nicoli*, Hark., two varieties of *G. Nilssoni*, Barr, *G. Sedgewickii*, Portlock, *R. triangulus*, Hark., *R. Maximus*, Barr, *R. Linnæi*, Barr., in addition to those mentioned as present in the Lindean burn.

At the Rhymer's Glen the dark shales are to be seen collocated with heavy greywackes, and the purple and blue shales are well exposed, but seem to be unfossiliferous. The black beds have yielded *Siphonotreta micula*, M'Coy, together with a few fragments of *Graptolites*.

After passing beneath the south slope of Eildon and crossing the railway near Newstead, where their course can be made out with difficulty, they are seen for the last time, before they plunge beneath the Old Red Sandstone of Berwickshire, in the north bank of the Tweed about 200 yards above the railway viaduct at Leaderfoot, and are charged with *Diplograpsus pristis*.

The relation of this band of black shale to the associated strata in this district is very obscure, but as we have never been able to detect it either to the north or south of this line, it may be surmised that there is no great dislocation of the strata, and no fold of sufficient intensity to bring the band again to the surface.

Every fossil yet found in these beds belongs to the fauna of Moffat, and there is very little doubt that this line of black shale is the continuation of that which is so persistent in that

district; or if there be more than one band this must be the higher, or that of Dobbs' Linn and Frenchland Burn, which seems characterised by the comparative rarity of *Didymograpsi* and other peculiar Llandeilo forms.

(2.) *The Gala Group.*

[1.] *The Abbotsford Flags and Greywackes.*—These lie to the north of the line of anthracite shale that marks the approach to the summit of the Moffat beds, from which I imagine they are separated by some thick bands of hard conglomeritic grit, which contain small fragments of the black shales here and there in abundance.

These peculiar grits seem to be pretty persistent, for I have met with them in the neighbourhood of St Mary's Loch, thirty miles distant along the strike, apparently holding the same position with reference to the black shales. We have, however, never met with these beds *in situ* in this district, though we have found angular fragments of the peculiar stone strewn over the fields to the north of Cauldshiels. These marked beds seem to point to a want of conformity between the Gala and Moffat beds, locally at least, if not throughout the whole extent of the Lower Silurian of the south of Scotland.

Above this grit, as far as can yet be ascertained, come rapid alternations of flaggy schists and shale, often bluish or dark grey in colour, and containing here and there seams of slightly carbonaceous shale, often tinged with oxide of iron, sometimes finely levigated and apparently unfossiliferous, sometimes of a more arenaceous character, and containing fossils.

These flaggy beds, of which there is no workable exposure in the Gala country, have yielded in the Yarrow, above Selkirk, *G. priodon*, Bronn, *G. Sedgwickii*, Port., *R. triangulatus*, Hark., *G. lobiferus*, M'Coy, *G. Nilssoni*, Barr., and *R. Linnæi*, Barr.

Graptolites priodon distinguishes the beds at once from those of Moffat, and proves conclusively that we are now in a superior set of strata.

These flaggy and schistose beds are succeeded on the north by more solid bedded greywackes, full of innumerable joints, and often separated by beds of slightly arenaceous shale. The surfaces of the joints are often coated with indigo-coloured matter, while the shales weather in nearly all cases with a pale yellow tinge. These beds are exposed along the Tweed, from the junction of that river with the Ettrick, almost to the town of Melrose, wherever the bank or bed of the river is rocky.

The fossils here present a more decided Coniston facies, and include *G. Sedgwickii*, *spinigerus*, Nich., *proteus*, Barr., and *triangulatus*, Hark., *G. lobiferus*, M'Coy, *G. exiguus*, Nich., *G. Nilssoni*, *G. priodon*, Bronn, *G. colonus*, Barr., *G. turriculatus*,

Barr., and *Retiolites Geinitzianus*, Barr., together with *Dictyonema*, *Peltocaris aptychoides*, Salt., *Ceratiocaris* sp. *Orthoceras*, and many indeterminate fossils among which are fragments of a couple of varieties of corals, a reticulated fossil (perhaps *Stromatopora*) *striatella*, Lonsdale, and what Dr Page considers to be the jaw foot of some species of *Pterygotus*.

[2.] *The Gala Grits*.—Overlying the Abbotsford beds and divided from them by a persistent set of laminated or tiley beds (the Bridgend flags), and also surmounted by another band of nearly the same nature (the Ellwand slate), come the Gala grits. They consist generally of heavy greywackes with shaly partings, and contain occasionally seams or beds of varying colours, generally yellow or reddish.

Fossils are comparatively rare, and where found are those of the Abbotsford greywackes.

[3.] *The Buckholm Sandstones*.—These beds are characterised by the evidence they afford of having accumulated in shallow water. They consist generally of red gritty greywackes and light green or red, sandy, incoherent shales and mudstones.

The greywackes are usually schistose or thick bedded, of purple or blue colours, and contain much mica, while the shales are replaced at times by beds of mudstone covered with the trails of annelides, or spotted with little discolorations due to the former presence of organic matter; while the whole set of strata is marked by its arenaceous and generally incoherent character, and the warm coloured or 'rusty' appearance of the rocks, so different from the cold, hard, forbidding aspect of the other strata. Yet, in spite of these more inviting characteristics, there are not many fossiliferous spots, though they are far more common than in the other beds. These beds are well exposed along the flanks of Buckholm and Meigle to Caddonfoot, and thence in the railway cuttings to Thornilee, and are recognisable at once by their peculiar character and the narrow ribbons of white or bright coloured shale seen here and there among the dingier strata.

These beds, as might have been expected, are by far the most varied in their organic remains, and contain *Graptolites priodon*, *G. Sedgwickii* (principally *proteus*, in varied form, the fine rastrite looking bases are found in exquisite preservation), *G. colonus*, Barr., *G. turriculatus*, Nicol, *G. exiguus*, Nich., which is found in myriads in some of the beds, *Retiolites perlatus*, Nich., and *R. Linnei*, Barr., together with some small forms of *Diplograpsus* as yet undetermined: *Crossopodia Scotica*, M'Coy, *Nereites Cambrensis*, Murch., *Nemertites tenuis*, M'Coy, *Trichoides ambiguus*, Hark., *Protichnites* sp. *Protovirgularia*; traces of the swimming paddles of *Crustacea*, *Pterygotus*? sp. *Ceratiocaris*, large species, *Tentaculites* sp. *Discinocaris Browniana*, Wood, *Dictyonema*, together with much that is as yet indeterminable.

[4.] *Slates of Thornilee and the Grieston*.—I have placed these together because of their general similarity lithologically, both consisting of fine grained shales splitting into thin layers along the original lines of bedding, and from the circumstance that they both appear to be underlaid by the Buckholm beds or their representatives, and also from the fact that they both contain a fauna which most nearly approaches that of our higher beds. But I am compelled to admit that they may be two distinct deposits, separated by an enormous interval of time. In fact, much of the evidence points in the latter direction. The Thornilee slates seem to have been formed in shallow water, and are covered with tracks of Annelides, are often of a bright red or purple colour, show not the slightest trace of calcareous matter, and contain exceedingly few Graptolites. On the other hand, the Grieston slates have generally a greyish blue appearance, have few traces of Annelides, contain pockets of calcareous matter, in certain beds are crowded with Graptolites, and are of more than double the thickness of those of Thornilee.

We have added nothing but *Protovirgularia Harknessi* to the fauna found at Thornilee by Professor Nicol.

In the Grieston, in addition to the fossils mentioned by Nicol (*G. Sedgwickii*, *prionon*, and *Griestoniensis*), my friend Mr James Wilson detected *Retiolites Geinitziannus*, Barr, and I have now to add *G. colonus*, Barr; the small species of *Diplograpsus* of the Buckholm beds, the peculiar sponge-like reticulated fossil of the Abbotsford greywackes, associated with many others whose identity I have not as yet sufficient evidence to determine.

Of the beds that lie to the north of the Grieston slates, I shall say nothing at present, as they seem to be entirely absent from the Gala district, and the Gala group may provisionally be considered as terminated by the Thornilee slates, which appear to form the centre of a syncline. Beyond them the beds to the north, as a rule, have a southward dip, and the Moffat shales are no doubt brought up again, as we have found pieces of black shale in the drift and water-laid gravel of Gala, containing *pristis*, *teretiusculus*, His., *tamariscus*, Nich., all fossils of the Moffat shales.

(3.) *Mode of Occurrence of Fossils in the District.*

The fossils of the Gala group are exceedingly rare, a careful examination of every foot of the shalier strata for a hundred yards sometimes failing to reveal even the trace of an organism. It seems as if the bed of the Silurian sea was generally unfitted for supporting animal life, and it is only when we get an interruption of this normal condition that we find the least trace of its existence. Whenever the almost universal argillaceous character of the shales is exchanged for one slightly more arenaceous,

then the fossils begin to appear, and they are found in a thin sandy or micaceous layer of this kind, of a fraction of an inch in thickness when they are entirely absent from all the adjacent strata. Again, they are never wholly absent from the thin seams of slightly sandy carbonaceous shale that are more common towards the base of these deposits. In the finely levigated shales, if we except those of Buckholm, they are never found.

The whole formation is remarkably deficient in calcareous matter. A few of the shales in the Gala grit effervesce when treated with acids, and there are a few limy pockets in the Greiston, but not a yard of strata as yet exposed deserves the name of calcareous.

The following table shows the range and distribution of the fossils of the Gala group, and I have inserted a couple of additional columns, the first showing if the fossil be found in the Coniston series; the second, if it be present in the Moffat group:—

4. Table showing the Range and Distribution of the Fossils of the Gala Group.

	Black Shale.	Abbottford Flag.	Abbottford Greywacke.	Gala Grits.	Buckholm Sandstone.	Thornlee.	Greiston.	Coniston.	Moffat.
<i>Hydrozoa, Graptolites, &c.</i>									
<i>Cladograpsus capillaris</i> (Carr)	×	×	×
<i>Climacograpsus teretiusculus</i> (His.)	×	×	×	×
<i>Diplograpsus pristis</i> (His.)	×	×	×	×
<i>tamariscus</i> (Nich.)	×	×	×
<i>vesiculosus</i> (Nich.)	×	×	×
<i>folium</i> (His.)	×	×	×
<i>sp.</i>	×
<i>Rastrites maximus</i> (Barr)	×	×	×	×
<i>Linnei</i> (Barr)	×	×	...	×	×	×
<i>Graptolites Sedgewickii</i> (Port.)	×	×	×	×	×	×	×	×	×
(v.) <i>triangulatus</i> (Hark.)	×	×	×	×	×
(v.) <i>proteus</i> (Barr)	×	×	×	...
<i>Nilssoni</i> (Barr)	×	×	×	×	×
(v.) <i>minor</i> (Nich.)	×	×	×	×	×
<i>lobiferus</i> (M ^c Coy)	...	×	×	×	×	×
<i>exiguus</i> (Nich.)	×	×	×	×	...
<i>prionon</i> (Bronn)	...	×	×	×	×	×	×	×	...
<i>colonus</i> (Barr)	×	×	×	?	×	×	...
<i>sagittarius</i> (His.)	×	×	×	×	...	?	?	×	×
<i>Greistonensis</i> (Nic.)	?	...	×
<i>turriculatus</i> (Barr)	×	×	×	×	...
<i>Retiolites perlatus</i> (Nich.)	×	×	×
<i>obesus</i> (Lapw.)	×
<i>Geinitzianus</i> (Barr)	×	×	...
<i>Protovirgularia Harknessi</i> (Lap.)	×	×
<i>Triochides ambiguus</i> (Hark.)	×	...	×	...	×

Table showing the Range and Distribution of the Fossils
of the Gala Group—continued.

	Black Shale.	Abbotsford Flag.	Abbotsford Greywacke.	Gala Grits.	Buckholm Sandstone.	Thornliee.	Griston.	Coniston.	Moffat.
<i>Crustacea.</i>									
<i>Pterygotus</i> sp.	×	...	×
<i>Discinocaris Browniana</i> (Wood)	×	...	×	...	×	...	×
<i>Peltocaris aptychoides</i> (Salt.)	×	×	×
<i>Ceratiocaris</i> sp.	×	×	×
large sp.	×
<i>Annelida.</i>									
<i>Crossopodia Scotica</i> (M'Coy)	×	×	×
<i>Nereites Cambrensis</i> (Murch.)	×	×	×
<i>Nemertites tenuis</i> (M'Coy)	×	...	×
sp.	×
<i>Siphonotreta micula</i> (M'Coy)	×	×
<i>Polyzoa.</i> <i>Dictyonema</i>									
Coral sp.	×	×	×
<i>Stromatopora striatella</i>	×	×	×	...	×
<i>Protichnites</i> —sp.									
Tracks of swimming Crustacea, &c.	×

5. Deductions.

Of the various species named in the above list, *Crossopodia Scotica*, *Nereites Cambrensis*, and that peculiar fossil *Trichoides ambiguus*, have all been discovered in the Moffat country, in the quarry at Hunterbeck; but if Professor Harkness be correct in ascribing the repetition of the anthracitic shale to great parallel faults, these beds may form part of the Gala series.

The presence of *Peltocaris aptychoides* and *Discinocaris Browniana* indicate a proximity to the Moffat beds, but the evidence they afford is more than counterbalanced by the presence of *Ceratiocaris* and other allied Caradoc forms.

Protovirgularia Harknessi and the *Eurypterus* are peculiar to the Gala Group, and of no value in fixing its age, and thus we are driven to depend upon the well-marked set of Graptolitidæ for more certain evidence, and fortunately this is very decided. Taking this as our main guide, we notice the following facts:—

(1.) That there are two distinct and characteristic faunas in the district; the one peculiar to the black shale, the other to the Gala group.

Of the 13 fossils tabled above as being found in the shales, every one belong to the Moffat beds, and three are peculiar to

that formation (*C. capillaris*, *R. maximus*, and *S. micula*), having never yet been found in the Caradoc.

Above the dark shales all are Coniston Graptolites, and at least four have never yet been found below the equivalent of the Bala limestone.

The foliaceous species of Graptolites constitute more than a third of the fauna of the shales. Above the anthracitic schists, on the contrary (if we except the small form of the Buckholm beds), all are mono-prionidian—*Grap. teretiusculus* alone surmounting the Moffat beds, and dying out apparently before the formation of the Gala grits. This is, I know, but negative evidence, but the same rule seems to obtain in Cumberland also, where none of the *Diplograpsi* survive even into the higher Coniston flags. This phenomenon may of course be due to conditions of sea-bottom, and can at furthest be merely local, as both forms of the Graptolite expire together in Barrande's Upper Silurian; yet the circumstance is very noteworthy, and may serve here or in England to distinguish between the higher and lower beds of the series.

(2.) The upper fauna is pre-eminently of the Coniston or Bala type.

In the Abbotsford flag, for the first time in the age of the Lower Silurian of Scotland, do we meet with *G. priodon*, a fossil that has never yet been detected below the Caradoc, proving at once that we are in a superior division to that of the Moffat series. *G. colonus*, a Lower Ludlow fossil in Siluria, soon becomes associated with it, and the two run together to the summit of the series, as in the Coniston group, proving the unity of the whole deposit. To these that pretty little fossil, *G. turriculatus*, is soon added. This *graptolite* has only been found in Britain in the Coniston flag, and is one of the many forms added to the British *Graptolitidae* by Dr Nicholson; and lastly we have *Retiolites Genitzius*, an Upper Silurian fossil of the Pentlands and Siluria, till the researches of Professor Harkness and Dr Nicholson placed the Cumberland beds in the Upper Caradoc.

Thus we have four forms in the Gala group which have never been detected below the Bala beds, and are peculiar to the Caradoc, or found only in that and higher deposits.

Professor Sedgwick and the Geological Survey of England place the Coniston beds in the Upper Silurian, but even should this turn out to be the correct theory, it will merely clench the evidence before adduced to show that the Gala beds must be high in the Lower Silurian, and will strengthen the probability of their forming part of the Caradoc.

A careful comparison of the list of Moffat fossils, given by Mr Hopkinson in the "Geological Magazine" for Feb. 1870, shows the clear separation of the Moffat and Gala series. Of the 41

Graptolites in Hopkinson's list 8 (*i.e.*, the *Didymograpsi*, *Cladograpsi*, *D. pristiniiformis*, *mucronatus*, and *C. bicornis*) are peculiar Llandeilo forms, while only 16 of the Graptolites of Moffat are found in the Coniston Group; or, in other words, $\frac{1}{3}$ d of the Graptolites of Moffat found elsewhere in Britain are peculiar to the Llandeilo. On the other hand, of the 12 known species of Graptolites given above as being found in the Gala group, 4 only are common to the Gala and Moffat beds, the whole 12 have been found in the Coniston series, and 4 have never been found below the Caradoc, while every one is an Upper Silurian form in Bohemia.

III. CONCLUSION.

From the description of the rocks given in the foregoing pages and the list of fossils given above, it is plain that the whole set of beds considered as the Gala group belong to one and the same formation, even if they be properly separable into subordinate divisions. The constant repetition of greywackes and shales, with alternating bands of flag or tiley strata, all bearing a remarkable similarity, renders it next to impossible to distinguish the position of any given bed here; and where the conditions of the sea bottom were different, as they were necessarily in an increasing ratio as we depart from the typical area, the deposits must have taken place under altogether different conditions, and the chances are that these divisions will be no longer recognisable lithologically, and we shall be driven to depend upon fossil evidence alone. But here the difficulty is increased, and the very facts that prove so conclusively the unity of the formation, militate against our attempt to distinguish its different beds. From the Abbotsford greywackes to the Grieston slates not a single new Graptolite seems to make its appearance, and not a fossil appears to have died out, though a change in the character of the sea bottom has introduced a swarm of Annelides and those forms found in the mud of shallow seas. Hence in effect the Gala group may collectively be considered as a thick and almost inseparable series of greywackes and shales superior to the Moffat series and of Lower Caradoc age. The Gala group is plainly recognisable from the description given by Mr Geikie (*Mem. Geol. Surv.*, sheet 34) as being present in the troughs of the strata along the Berwickshire coast, where it has been rightly considered by him as of Caradoc age. It is seen again along the valley of the Dye water (*Mem. Geol. Surv.*, sheet 33). The description of the section in this highly perplexing district shows a remarkable lithological similarity between the beds of the Lammermuirs and those of Gala. It seems to be present also in the cuttings of the Caledonian Railway above Moffat, and the rise of the sea bottom, in the upper part of the series, seems even to have extended to Barlae.

Hence from a consideration of all these facts I am of opinion,
1st, That the Gala group forms a well-marked continuous sub-division of the Lower Silurian of Scotland.

2d, That it is immediately superior to the Moffat schists in the order of these Lower Silurians.

3d, That in virtue of this position, and by its peculiar fauna, it is proved to represent part of the Caradoc formation of Siluria.

I have gratefully to acknowledge repeated encouragement and help from Dr Page and Mr D. J. Brown, and also the obligations I am under to Dr H. A. Nicholson, for assistance, not only from his published writings, but also in personal correspondence.

III. *On the Old Estuarine Beds of the Carse of Stirling.** By
JAMES HASWELL, M.A., W.S.

The valley of the Forth, comprehending the Carse of Stirling and Falkirk, extends from near Grangemouth to Gartmore, and round by the Lake of Menteith by Bridge of Allan to Alloa, and occupies an area of say seventy or eighty square miles. It is bounded on the north by the Ochils, and on the south by the Campsie hills. At its north-western extremity are the lofty hills which surround the lakes of the Trosachs, and from which probably proceeded the glaciers which have smoothed and striated the rocks to the east, given to the Castle Rock of Stirling, the Abbey Craig, and Craig Forth, their crag and tail appearance, and formed the boulder clay of the valley of the Forth. To the east, again, this valley faces the estuary of the Forth. Blackadder gives a very good map of this district in vol. v. of the Wer. Soc. Memoirs. The two principal rivers which traverse it are the Forth and the Teith, the former having its source in Ben Lomond, the latter in Loch Vennachar.

The portion of this district which I propose to describe in this paper, being all that I have yet been able to overtake, extends from a little above the junction of the Forth and the Teith on the west to Stirling Bridge on the east, and from the mouth of the Allan on the south to the town of Bridge of Allan on the north. My first examination of these beds was made in 1864, the results of which I laid before the Society in a paper read on 2d February 1865. During the past summer I made a careful examination of all the sections I could find. Beginning with the shell-bearing clay at Cornton, which I formerly described, I traced it in the bed of a small tributary of the Allan called Cockmalane or Sawmills Burn, which runs into the Allan near the railway bridge opposite Cornton Brick Work. I found the same shell bed in the Allan at several places all the way down

* Being Part II. of a paper "On some Sections in the Clay of the Carse of Stirling and in Stratified Drift at Bridge of Allan."