

## II. PROCEEDINGS

OF

### THE GEOLOGICAL SOCIETY.

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NOVEMBER 29. 1843.

Joseph Travis Clay, Esq., and Francis W. Jennings, Esq., were elected Fellows of this Society.

The following communication, a part of which had been read at the previous meeting, was concluded:—

*On the OLDER PALÆOZOÏC (Protozoic) ROCKS OF NORTH WALES.*  
By the Rev. A. SEDGWICK, M.A., F.R.S., Woodwardian Professor of Geology and Fellow of Trinity College in the University of Cambridge.

#### § 1. *Introduction.*

IN a paper read before the Geological Society in June, 1843, and intitled, “An Outline of the Geological Structure of North Wales,”\* the author gave a description of those stratified rocks in the northern counties of the principality which are of anterior date to the mountain limestone. Those rocks he separated into the following three principal groups:—

1. Chlorite-slate and mica-slate. These form a band along the north-western side of the promontory of Carnarvonshire from Porth Dilleyn to Bardsea island.

2. Greywacke and roofing slate, often containing calcareous bands, and alternating with Plutonic rocks of cotemporaneous formation: and these rocks the author terms, in his present paper, the *Protozoic*, group. They extend in an east and west direction, from the borders of Shropshire to the western coast of Carnarvonshire; and their north-western boundary, from the confines of Shropshire to Ysppyty Evan, coincides nearly with the Holyhead road; and from Ysppyty Evan to Conway, with the Conway river.

3. An overlying and sometimes unconformable deposit of flag-

\* Proceedings of the Geological Society of London, vol. iv. p. 212.

stone, &c., coterminous along the Holyhead road and Conway river with the last-mentioned principal group; but bounded towards the north-west by an overlying range of mountain limestone.

The present paper communicates the results of new researches which, in the company and with the assistance of his friend, Mr. J. W. Salter, the author made, during the summer of 1843, in the eastern portion of his former field of observation: his remarks on the present occasion being directed principally to the geological position and organic remains of the fossiliferous slates which lie to the east of the great Porphyry range of the Arenigs.

During these excursions, besides correcting the north-western boundary line of the rocks belonging to the second principal group, the author determined their southern boundary. That boundary follows a very sinuous course from the mountain limestone of Llanymynech hill, on the east, to the Dyfi near Mallwydd, on the west; whence it runs in a south-western direction, down the right or northern bank of that river for several miles. The boundary line of the protozoic rocks, both in the north and in the south, was laid down by the author and his companion on the Ordnance Map, from which they have been transferred to the small map annexed to the present Abstract.

The author has also materially improved the details of the sections which he formerly exhibited to the Society, and has greatly extended his lists of fossils. For the determining of these fossils, for the lists of them appended to this abstract, and for the general observations\* which an examination of these lists has given rise to, he expresses himself indebted to Messrs. J. C. Sowerby and J. W. Salter, of whom the latter examined most of the localities where the fossils were obtained.

§ 2. *On the Calcareous Slates and Limestone of Glyn Dyffws on the Holyhead road, West of Corwen and of Rhiwlas, North East of Bala.*

In an endeavour to determine the position of the limestone of Glyn Dyffws, a series of calcareous and fossiliferous slates was traced from Cader Dinmael, on the north, through Glyn Dyffws and Pen-y-Cerrig, southward, to the hills on the left bank of the Merddwr brook, near Llwyn Onn. Here the strike was interrupted by enormous dislocations.

Calcareous slates, passing into limestone, again appear, to the south and west, at Llwyn Jolyn, Craigian-buchan-isaf, Llwyn-y-ci, and again, on the same line of strike, in the high grounds of the Rhiwlas estate N. E. of Bala, and lastly, about a mile above Bala, in the bed of the river Tryweryn. A part of this limestone band has been noticed by Mr. Sharpe. †

\* In this Abstract the observations of Messrs. Sowerby and Salter are annexed to Professor Sedgwick's description of the geological position of the fossils; and, for distinction's sake, are printed in smaller type.

† Proceedings of the Geological Society, vol. iv. p. 10.

The above calcareous rocks, which may be termed those of Glyn Dyffws and Rhiwlas, might be supposed, from their proximity and almost uniform strike, to belong to one deposit; but no proof of such a connection is obtained by the evidence of sections, the interval between the above two series of localities being much disturbed and broken. Moreover, the fossils of the Rhiwlas beds, considered as a whole, appear to differ from those of Glyn Dyffws, which agree with those of the limestone band, known by the name of the "Bala limestone," on the eastern side of the lake. It is clear that the Rhiwlas limestone lies far below that of Bala; for the strike of the former passes a mile to the west of the western shore of the lake; and in that line of strike calcareous beds are found, though not in the form of limestone, agreeing, in respect of their organic remains, with the Rhiwlas series.

The fossils of Glyn Dyffws and Rhiwlas will be treated of in describing the first line of section.

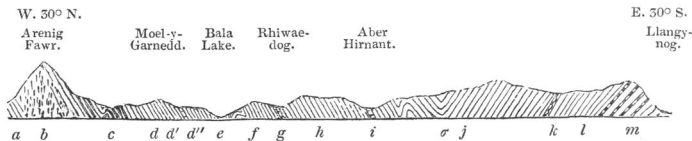
Fossiliferous bands, which occasionally pass into limestone, are also found at several places a little to the north-west of the localities which afford the Rhiwlas limestone. Those places are, 1. the valley above Pentre Cwmda; 2. a spot east of the mountain road between Garw fynydd and Moel Emoel; and 3. Eglws Anne in the forks of the Nant-y-Coegnant. Unless there be an inversion of the beds in all that district (and of such an inversion the author could perceive no indications) these last-mentioned calcareous bands must lie considerably below the Rhiwlas limestone.\*

### § 3. *Transverse Sections across the Southern End of the Berwyn Chain.*†

#### SECTION I.

##### ARENIG FAWR TO THE TANAT RIVER AT LLANGYNOG.

*Horizontal base 15 miles.*



\* At a still lower level, apparently, lie the non-fossiliferous bands of limestone, which occur at the following places:—

1. To the S.W. of Arenig Fawr, in the upper branches of the Lliw.
2. Near Hengwrt Uchaf, on the road from Dolgelly to Bala; the limestone forming three bands, which were at one time worked for lime.
3. On the east flank of Cader Idris.
4. On the road from Dolgelly to Dinas Mowddy.

These non-fossiliferous bands are all crystalline; and appear to have been much altered by igneous rocks.

† The lines of section, with their numbers attached, are laid down on the Map, which accompanies this Abstract.

1. Immediately to the west of Arenig Fawr slates occur (*a*), dipping eastward. They contain *Asaphus Buchii*, and a few other fossils.

2. Next occur the Porphyries of Arenig (*b*), which are regarded by the author as old eruptive or recomposed trappean rocks, of cotemporaneous date with the slates with which they are associated. They form, therefore, no determinate base for the protozoic rocks of North Wales.

3. Upon the Porphyries rests a thick deposit of dark earthy slates (*c*) dipping eastward, and extending in that direction about a mile. Towards the upper limit of this bed numerous fossils occur; viz. *Asaphus Powisii*, *Trimucleus Caractaci*, *Leptæna sericea*, Encrinital stems, &c.

4. Immediately over the preceding is a still thicker bed of grey slate (*d*, *d'*, *d''*), which, including the very fossiliferous band, *d'*, supposed to be the equivalent of the Rhiwlas limestone, extends to the western shore of Bala lake. Measured in a direction transverse to the strike, the horizontal distance to the lake exceeds two miles; and as the dip, with one very limited exception, is steadily towards the east, and at a very considerable angle, the thickness of this bed must be great. The whole of the bed is fossiliferous. Near Moel-y-Garnedd were found an *Asterias*, *Orthis flabellulum*, Encrinital stems, &c. Further eastward are the very fossiliferous slates, the supposed equivalent of the Rhiwlas limestone; and close to the margin of the lake, still higher, fossil bands appear.

The total thickness of these fossiliferous beds west of Bala lake, without including the masses of interbedded Porphyry, is estimated by the author at not less than 2000 feet.

[The series of the Rhiwlas limestone, and of the fossiliferous beds west of Bala lake, is characterised by an abundance of Orthoceratites, and by *Asaphus Buchii*, *Ilænus Bowmani* (a new species), and other Trilobites. To these add *Asterias primæva*. Notwithstanding the considerable number of species of Brachiopoda contained in the list of fossils of the Protozoic rocks of North Wales (*vide* List I.), the number of such remains in the Rhiwlas series is very small.]

4. The breadth of the lake is supposed to be occupied by a group of hard quartzose slates (*e*); since further to the south such slates are seen to rest on the beds associated with the Rhiwlas limestone. Their thickness is not less than six or seven hundred feet.

5. The first group on the east side of the lake consists of a series of hard grey slates (*f*), which contain some highly fossiliferous bands. Some of these are much contorted on the line of strike; but their aggregate thickness is computed at not less than 500 feet.

6. Next occurs the Bala limestone (*g*), a complex group about 100 feet thick, containing two bands of impure limestone, one only of which, about 12 feet thick, is worked for lime. In one place it contains a bed of schaalstein.

[The Bala limestone and the Glyn Dyffws beds are marked by multitudes of Orthides, particularly *O. Actoniae* and *O. Vespertilio*, besides *Leptæna tenuistriata*, and, in some places, an abundance of *Asaphus tyrannus* and *A. Powisii*. They contain few species of coral, but specimens are very abundant, and these belong

principally to the genus *Favosites*. (The *Chaetetes petropolitana* is also very common.) The *Ophiura Salteri* has been found both in the Bala limestone and at Cader Dinmael. The series, moreover, furnishes two or three species of *Cypriocardia*, a genus not previously found in Lower Silurian rocks.]

7. Next comes a series of slates (*h*), of very varied colour and texture, which alternate with bands of greywacke. As these beds dip steadily towards the east at a very high angle, and are more than a mile broad, their thickness must be very great.

8. The Hirnant limestone (*i*) follows, and has a remarkable pisolitic structure; but, as a limestone, it is very impure. This group is of considerable thickness. The beds are highly inclined, and dip to the east, a few degrees south. The group was traced by the author from Aber Hirnant southwards, in the direction of the strike, to Bwlch-y-Groes\*, and was laid down on the Ordnance Map.

[The Hirnant limestone is characterised by its containing only a few species of *Orthis*; in which respect it differs in a remarkable degree from the limestone of Bala. Of those which it does contain, two or three (which are new species†, and very flat) are found in great abundance. It abounds in a new plaited *Terebratula*, and in *Encrinital* stems; but contains only a few corals].

9. With the same easterly dip, and at a high angle of elevation, follows a very thick group of slate rocks (*j*). Some are dark and earthy, others grey and siliceous, others glassy and chloritic. They alternate with a few bands of cotemporaneous Porphyry.

[Over the preceding, near the synclinal of the South Berwyns, fossils, resembling those of the Bala limestone, appear here and there, but in no great abundance; and the peculiar species of the Hirnant limestone are lost. These beds seem to possess scarcely any *Conchifera* or *Gasteropoda*, and not any *Orthoceratites*. The fossils belong principally to *Brachiopoda*, and *Leptæna sericea* is abundant, but so also is *Trinucleus Caractaci*. Some of the sandy beds contain *Encrinital* stems, but corals are very rare.]

10. More than a mile to the east of the Hirnant limestone is a synclinal line (*σ*), beyond which the beds dip towards the west. The lower beds, which were found to the westward, are therefore again brought to the surface, and the Bala limestone (*k*) reappears in two places near the top of the descent leading to Llangynog. Both these places are on the eastern side of the watershed of the

\* It has been stated by Mr. Sharpe, in a paper read before the Geological Society (see "Proceedings of the Geological Society," vol. iv. p. 13.), that the line of the Bala limestone, as laid down in Mr. Murchison's map of the Silurian formations, is composed of the Bala and the Hirnant limestones. The Bala limestone, along its whole line of strike, and its several quarries, were examined by Professor Sedgwick in the year 1832; and were laid down by him in colours on Evans's half-inch map of North Wales. The Hirnant limestone was seen by him in the same year, and recognised as a distinct bed. He supposed it to be continued to the east side of Bwlch-y-Groes, but did not mark its course upon any map. Mr. Murchison, in representing the course of the Bala limestone, merely transferred Professor Sedgwick's coloured representation to his own map; and in this transfer from a map in which the physical features of a country are very ill represented, to another map in which they are well represented, it is possible that some errors may have been committed. But for these errors Professor Sedgwick states that he is not responsible.

† Some of these resemble the new species which were found at Cynr-y-brain, N. of Llangollen.

Berwyns; and, consequently, on this line of traverse, the Bala limestone dips under the Berwyns, as Mr. Murchison\* has correctly stated. Further northwards that is not the case.

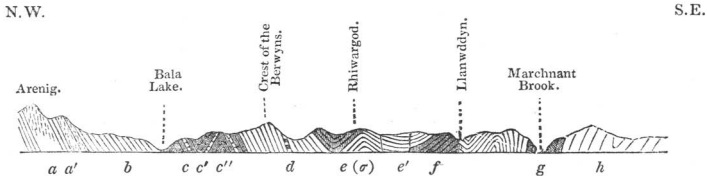
[The series of fossils on the line from Llanwddyn to the head of the Pennant valley, and thence to the top of the pass west of Langynog, is the exact counterpart of the list from the limestones of Bala and Glyn Dyffws.]

11. The limestone is followed in descending order, 1st. by fossiliferous slates (*l*); 2dly, by slates without fossils alternating with beds of Porphyry (*m*). These are supposed to represent a part of the series between the Bala limestone and Arenig at the western end of the section; and they are cut off, near Llangynog, by a complicated series of faults. The author here takes occasion to remark on the very great aggregate thickness of the fossiliferous beds which are traversed by the line of section just described; although, on the one hand, the section has no determinate base, and, on the other, does not reach to the highest of the protozoic rocks; since it is impossible to tell how many hundred feet may be wanting to connect the highest beds which are traversed in this section, with the base of the Denbighshire flagstones.

## SECTION II.

## The ARENIGS to LLANWDDYN.

Horizontal base 20 miles.



This section, like the former, commences on the west side of Bala lake, and with a ridge of porphyry (*a a'*); but the porphyry appears at a higher geological level than in the former section. The section passes through the grey slates (*b*) on the west side of the lake, and on the east side, through the Bala limestones (*c c' c''*), which, on this line, are very much contorted. It then traverses the strike of the Hirnant limestone (*d*), and exhibits in great perfection the beds (*e*), above that limestone. The synclinal axis ( $\sigma$ ) lies here considerably to the east of the mountain crest: and, to the west of that axis, the same beds are again repeated; but they are now much faulted and broken (*e'*). The beds (*f*), supposed to represent the Bala limestone, reappear in the hills near the village of Llanwddyn; from whence they may be followed northwards in the direction of their strike, through the head of the Pennant valley, and thence to the top of the pass

\* See "Proceedings of the Geological Society," vol. iv. part i. p. 11.

between Llangynog and Bala, dipping westward beneath the chain of the southern Berwyns.

Below the village of Llanwddyn there continues a prevailing westerly dip; but the derangements are enormous, and, at the great bend in the Fyrnwy river, the lower Silurian rocks (*g*) are seen resting upon the upper (*h*) in a reversed position.

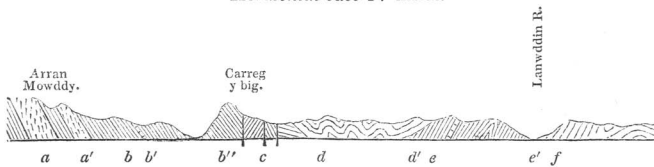
In this section, as in the former, the protozoic series is of great thickness.

## SECTION III.

## ARRAN MOWDDY TO LLANLIHANGEL.

Direction of the Section, W.  $10^{\circ}$  N. to E.  $10^{\circ}$  S.

Horizontal base 17 miles.



This section commences with cotemporaneous porphyries (*a a'*); but they break out at a still higher geological level than in Section II. The porphyry is succeeded by grey slates (*b b''*) containing the Bala series (*b'*), which may be followed southward in the direction of the strike, down the western bank of the Dyfi. The beds dip east by south, except to the extent of a faulted interval (*c*) on the east side of Carreg-y-big. We have in this line of section a great thickness of the fossiliferous portions of the protozoic series, but not the whole thickness; since these beds are succeeded in the line of section by a trough of overlying and unconformable Upper Silurian rocks, *dd'*. These rocks accord with the type, not of the Denbigh or Montgomery flagstones, but of the coarse-grained greywacké and flagstone which form the base of the upper system near Cernioge.

Beyond this trough, the older beds (*e e'*) again rise out, but with a reversed or northwesterly dip, and at a very high angle of inclination. At the east end of this, as of the former section, the Upper Silurians (*f*) pass under the Lower (*e*), owing to inversion.

In following the fossiliferous beds of the southern Berwyns to the neighbourhood of Mallwydd, the author found those beds overlaid by Upper Silurian rocks of the Cernioge type; a fact which had previously been noticed by Mr. Sharpe. Mr. Sharpe, however, considers that these Upper Silurians rest *conformably* on the Lower, and that the entire upper part of the Lower system is here displayed.\* The author considers that the upper system wraps round the southern end of the Berwyns *unconformably*; and that the upper part of the lower system is incomplete. †

\* Proceedings of the Geological Society, vol. iv. p. 13.

† The errors committed in certain parts of Mr. Murchison's map, in the neighbourhood of Mallwydd, by spreading the Cambrian colour over an area



§ 4. *On the Structure of the Berwyn Chain.*

1. This chain is considered as commencing, on the south, in the ridges above Mallwyd, to the east of the river Dyfi, and as stretching from thence in a north-westerly direction to the hills which overhang the Dee below Corwen.

2. If a line be drawn from the summit of the mountain pass between Llangynog and Bala to the great bend in the valley of the Dee between Llandrillo and Bala, the south-western portion of the chain, extending as far to the north-east as that line, constitutes a great trough. The subordinate groups of this southern portion of the chain are made up of the fossiliferous rocks of Bala; but its crests consist of beds far above the Bala limestone. On the eastern side of the trough the beds are partly vertical, and partly inverted; and on the south-eastern extremity of the chain, for several miles along the boundary between these disturbed rocks of the lower system and the co-terminous upper Silurians, the inversion affects also the upper system of rocks.\*

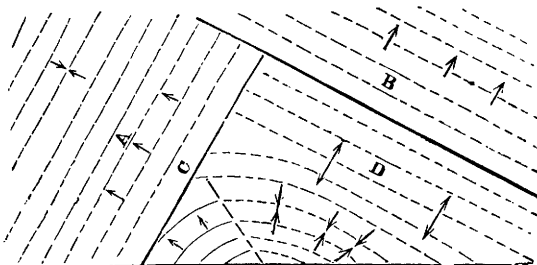
3. A longitudinal fault, with a great upcast to the west, ranges, on the eastern side of the chain, from the vertical and inverted beds above-mentioned to the northern end of Cader Ferwyn; in consequence of which, the Berwyn chain, for the distance of more than 4 miles north of the Llangynog pass, is no longer in a trough of rocks belonging to the Bala series; but the crest of the chain consists of rocks which are lower than the Bala limestone, but not lower than the fossiliferous slates on the east of Bala lake.

4. The strike of the higher ridges of the Berwyn chain varies from N. and S. to N. E. and S. W.; but N. N. E. and S. S. W. is about the mean strike.

which is actually covered by Upper Silurian rocks, has been pointed out by Mr. Sharpe. The same observation may be applied to a district extending along the south end of the Berwyns as far as the tributaries of the Severn. Professor Sedgwick observes, that since he had never either examined, or professed to have examined, this part of North Wales until the year 1843, he does not hold himself responsible for the colouring adopted in that part of the map in question.

\* The following diagram has been prepared by the author, in illustration of his views respecting the structure of the North Berwyns.

Part of the Berwyns, N. of  
Pass to Llangynog.



A. System of the North Berwyns. C. Line of fault, North Berwyns.  
B. Line of fault, North end of the Berwyns. D. Llanrhiadr, anticlinal.

5. The beds, on the two opposite sides of the great upcast fault, are in a most anomalous position. On the west side, they strike about N. by E.; but on the east side, nearly E. and W.

6. At Bwlch Maengwynnedd, above a mile north of Cader Ferwyn, is another great fault or flexure. To the north of that point all the beds, to the further extremity of the chain, dip either N., or N. by E., and strike either E. and W., or E. by S., and W. by N. This strike is continued towards the east, as far as the mountain limestone on the confines of Shropshire; and, towards the west, to the hills north-west of Llandrillo, on the left bank of the Dee, between that river and the brook, Nant Ffrauan.

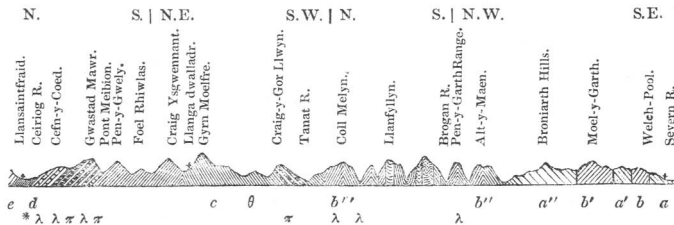
This position of the strata on the eastern side of the Berwyn chain gives a regular ascending section from the lower series to the upper, in advancing towards the Dee from south to north, along a meridian passing to the east of Llangynog.

### § 5. Sections East of the Berwyns.

#### SECTION IV.

WELCH-POOL ON THE SEVERN TO LLANSAINFRAID ON THE CEIRIOG.

Mean Direction of the line of Section, S. to N.  
Horizontal base 24 miles.



1. At the southern extremity of Section IV., we have the Upper Silurian flagstone of the Severn (*a*), which formation, after two intervening portions of lower Silurian rocks (*b b'*), re-appears in the Broniarth hills (*a''*).

2. Then occurs a great undulating series of Caradoc sandstone (*b''*, *b'''*), with innumerable fossils; but among these the author discovered no trace of *Asaphus Buchii*, nor of some of the other characteristic species of the lower rocks in the Bala sections. These beds extend as far as the Tanat river, where the strike is nearly east and west.

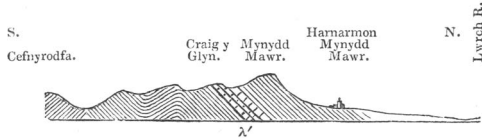
3. From beneath the Caradoc sandstone, there rises, north of the

\* Those points where, either in the author's sections or coloured copy of the Ordnance Map, calcareous beds are marked as occurring, are denoted by the letter λ; those points where porphyry is marked as occurring, are denoted by the letter π.

## SECTION IV. a.

CRAIG-Y-GLYN, three miles and a half to the west of the line of Section IV. at the point marked  $\theta$ .

Horizontal base  $2\frac{1}{4}$  miles.



Tanat, a series of slates ( $\theta$ ), not differing in their mineralogical character from the slates of the higher Berwyns; and in these, at a great depth as measured from the Caradoc sandstone, are found calcareous bands, full of fossils, among which are *Asaphus Buchii*, &c. The Craig-y-Glyn limestone (*vide* Section IV. a.), which appears to the north of Llanrhaiadr, at the distance of nearly four miles to the west of the line of Section IV., the author regards as belonging to these bands.

[The Craig-y-Glyn limestone has most of the species of the Rhiwlas limestone; but the abundance of *Asaphus Buchii*, of *Orthis compressa*, of a new species of *Orthis*, and of Encrinital stems, give it a peculiar character.]

4. Still lower in the series are similar slates; but they are without fossils, and, after several breaks or undulations, the beds, about two miles further to the north, are found to have acquired a steady northern dip.

5. South of Pont Meibion, on the Ceiriog, fossils again appear, conforming to the types of the lower portion of the protozoic group.

[The lower part of the series near Pont Meibion may be only a repetition of the Craig-y-Glyn series, with a reversed dip. But the higher part of the series, which ranges over the crest of the Berwyns by Bwlch Llandrillo, contains only Bellerophons, particularly a new species, *B. nodosus*, found also at Soadley, in Shropshire, by Mr. Salter. At Bwlch Llandrillo, a new *Orthis*, *O. cambriensis*, which is also found in the Bala series, is abundant; and to this may be added many other species of *Orthis*, which that series contains.]

6. Then follows, in the ascending section, a great series of beds full of fossils, and these beds alternate with bands of cotemporaneous porphyry, schaalstein, &c.

7. Lastly, there is a well-defined thick group, whose width, measured transversely to the strike, is about a mile. It is composed of calcareous slates, and contains two bands of limestone, both of which have been worked for lime. It passes upwards into pale-coloured earthy slates ( $d$ ), and these seem to pass, without a break, into the overlying Denbigh flagstone ( $e$ ), which just appears on the southern bank of the Ceiriog, and extends northward from that river towards the vale of the Dee. The fossils both of paragraphs 5 and 6, are entered in the list of the Ceiriog fossils.

[The Llansaintfraid series, including the slates and two bands of limestone, lies above the porphyries of the Teirw river, and, consequently, far above the fossiliferous beds of Pont Meibion. It is distinct from any other part of the series, with the exception, perhaps, of the beds on the western bank of the Fyrnwy river, above Meifod. (*Vide* Section VI.) It is loaded with shells of the Wenlock limestone; among which are *Orthis sinuata* and *O. inflata*; *Spirifer crispus*, *Terebratula crispata*, *Atrypa affinis*, and *Euomphalus funatus*. It also contains nine or ten Wenlock corals, such as *Catenipora*, &c. Among the Orthides is a new species, which is found also at Coniston. Several of the corals belong to new species. Besides the above, are several well-known Caradoc sandstone species of shells.

In addition to the above positive characters, the group is distinguished by the following negative one — that it contains apparently none of the species which are characteristic of the lower parts of the Protozoic series, such as *Asaphus Buchii*, *Agnostus pisiformis*, *Illenus Bowmanni*, *Spirifer crucialis*, &c.

This group, then, seems to form a kind of passage between the lower and upper systems.

To judge from the fossils only, the Coniston limestone appears to be intermediate between the Llansaintfraid and the Bala limestones.]

On the evidence of this Section and of the lists of fossils which belong to it, the author concludes:—

1. That the highest or Llansaintfraid group cannot be identified with any of the groups in Sections I., II., and III.; and that if it ever be brought into comparison with any group in those Sections, it must be with the highest group, namely, with that which is found near the crest of the southern Berwyns; and, therefore, that it lies far above the Bala limestone.

2. That the rocks from Pont Meibion southwards, and those of Craig-y-Glyn, may be brought into comparison with the lower parts of the Bala series, to the west of the lake, and with the slates east and west of Arenig, which contain *Asaphus Buchii*.

The preceding conclusions the author proposes, subject to the modifications which they must necessarily undergo, when his sections and lists of fossils come to be compared with those obtained by the gentlemen employed on the Ordnance Geological Survey, from an examination of the mountains of South Wales west of the district surveyed by Mr. Murchison.\*

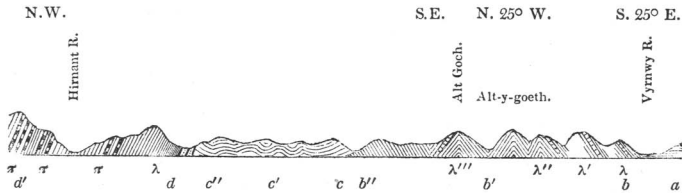
They exhibit no traces of the lower beds such as occur in North Wales, containing *Asaphus Buchii*, &c.; and they disappear when the Porphyries begin. The Coniston limestone appears to be very little lower than the limestones of the Ceiriog, and is therefore probably higher in the series than the Bala limestone. In North Wales, on the contrary, the fossiliferous series has no well-defined base, since fossiliferous beds of vast thickness, extending far below the Bala limestone, there alternate with porphyries.

\* The sections of Cumberland and Westmoreland are not of a nature, in the author's opinion, to throw light on questions having reference to minute points in the classification of the different members of the Protozoic series of rocks. For, in those countries, the Lower Silurian rocks, containing fossils, are of comparatively small thickness, and have a well-defined base, which the author has formerly described. See "Proceedings of the Geol. Soc." vol. iii. p. 551.

## SECTION V.

The VYRNWY RIVER, 1 mile S.W. of Meifod, to HIRNANT, about 2 miles S. of Llangynog.

Mean Direction of the line of Section, S. 40° E. to N. 40° W.  
Horizontal base 10½ miles.

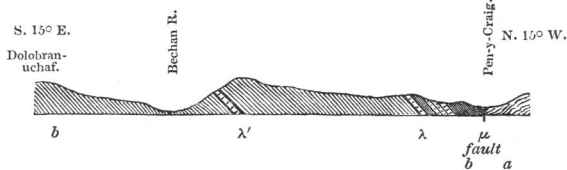


This section commences with the upper Silurian rocks (*a*), which extend southward from the Vyrnwy river to the Severn. It is followed by rocks of the lower series (*b*, *b'*, *b''*), containing calcareous bands (*λ*, *λ'*, *λ''*, *λ'''*). The lower fossiliferous bands near Meifod agree generally in their fossil species with the limestone of Bala, and with the fossiliferous beds on the line of the Teirw river occurring below, and associated with the porphyries, as described in Section IV. The line of section afterwards again cuts the overlying upper Silurian rocks (*c*, *c'*, *c''*), a little within the line of their northern boundary. The lower system appears to the south of Llangynog, alternating with beds of cotemporaneous porphyry.

## SECTION VI.

PEN-Y-CRAIG, 3 miles S.W. of Meifod, ACROSS THE BECHAN RIVER TO DOLOBRANUCHAF.

Horizontal base 1¼ miles.



At Pen-y-Craig, south of Mathyrafal, just at the base of the overlying upper Silurian flagstone (*a*), there is a higher fossiliferous group (*μ*) than any which has yet been described. The upper part of this passage consists of calcareous shale, and the lower part of conglomerate, sandstone, and limestone. Further to the north we have the lower series of the ordinary type in the neighbourhood of Meifod, with two calcareous and fossiliferous bands.

[Note on the Fossils of the Limestone of Pen-y-Craig. — *Leptæna tenuistriata*, which was abundant in the lower fossiliferous group (*λ*), is not seen in the limestone. Corals are very abundant, and are nearly the same with those

of the upper limestone bands on the Ceiriog (*vide* Section IV.), but are very different from the corals of the lower group of the Meifod country. There are very great numbers of *Turbinalopsis bina*, of *Favosites polymorpha* and *F. alveolaris*, of *Cyathophyllum*, and *Stromatopora*.

On the Fossils of the *calcareous shale* of Pen-y-Craig. — In the very remarkable list of fossils (List I. column 13.) obtained from this shale, we have *Terebratula marginalis*, a Wenlock shell, associated with *Leptaena duplicata*, *Atrypa undata*, *A. globosa*, and *Orthis lata*, shells which have been considered as characteristic of the Llandeilo flags.]

From a review of all the preceding facts, the author concludes that the Protozoic series of North Wales is of enormous thickness; that it has no defined base, the fossils disappearing in the descending section, not suddenly, as in Cumberland and Westmoreland, but gradually; that many species are found in every subordinate group from the top to the bottom; and that some species, especially certain Trilobites, characterise the lower group.

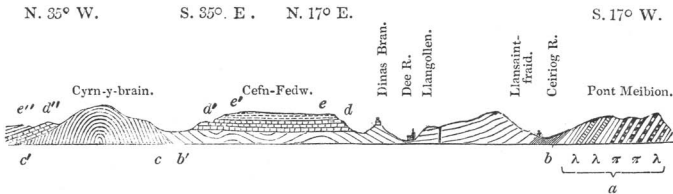
### § 6. *Upper Silurian Rocks of Llangollen, Cernioge, &c.*

The geological structure of this part of North Wales the author illustrates by three sections, which he exhibited to the Geological Society on a former occasion; but which, with the help of Mr. Salter, he is now able to present in a more accurate shape.

#### SECTION VII.

LLANSAINTFRAID, GLYN CEIRIOG, across the valley of the Dee, to CYRN-Y-BRAIN, near the head of the vale of the Clwyd.

*Horizontal base 12 miles.*



This Section may be considered as a continuation, northwards, of Section IV. To render clear the position of the upper Silurian flagstones of the Dee (*b b'*), lying as they do in a trough which is bounded, both to the north and to the south, by a mass of palæozoic rocks (*a* and *c c'*), a portion (*a*) of the older series of rocks, which lie to the south, and were before represented in Section IV., is here repeated. On the northern side of the trough, at Cynr-y-brain, the existence of a mass of older rocks (*c c'*), which was before suspected by the author, has been ascertained; with the help of Mr. Salter, its extent has been laid down upon the Ordnance Map; and it has been inserted in the section.

In his paper, read before the Society in June, 1843, the author described the Upper Silurian Denbighshire Flagstone series as consisting of three subdivisions; which may be termed the Lower, the Middle, and the Upper Flags.

The lower flags consist of flagstone, passing into hard quartzose sandstone and earthy semi-indurated shale. Since it is only in the lower flags that an abundance has been found of Orthoceratites, and of the fossil found by Professor E. Forbes to be a *Creseis*, the name of 'Creseis flagstone' might serve as a good local name to give to this lower group. At nearly the base of the series, together with the *Creseis*, *Leptaena lata* has been found; but it is scarce. The uppermost portion of the lower flags (which has sometimes been described as non-fossiliferous) contains, though rarely, *Cardiola interrupta* and *Terebratula Wilsoni*.

The lowest upper Silurian rock exposed in this line of section is dark roofing slate, containing a few of the *Graptolites ludensis*. But this is a fossil which extends upwards, through the whole series of lower, middle, and upper flags.

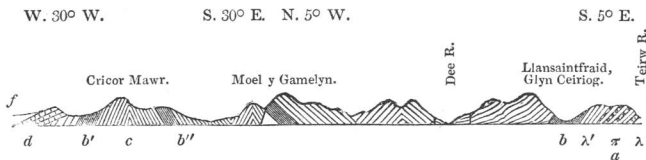
All the upper Silurian rocks (*b*) upon this line of section, from the Ceiriog river to Castle Dinas Bran inclusive, are now considered by the author to belong to the lower flags. The character of the Llangollen fossils, taken as a whole (see list of them, Proc. Geol. Soc. vol. iv. p. 221.), and particularly the abundance they contain of *Terebratula navicula*, have led the author to come to this conclusion.\*

These upper Silurian rocks are overlaid by unconformable and nearly horizontal beds of mountain limestone (*dd'*); and these are crowned at Cefn Fedw by a capping of millstone grit (*ee'*). At the north-western base of Cefn Fedw, the upper Silurian rocks (*b'*) again appear, and are succeeded by the palæozoic mass of Cynr-y-Brain, full of Caradoc sandstone fossils. On the north-western flank of this mass the mountain limestone, crowned by millstone grit, again appears, and in an inclined position.

## SECTION VIII.

The TEIRW RIVER, across the valley of the Dee, to CRICOR MAWR, near the head of the Vale of the Clwyd.

Mean direction of the line of section, S. 20° E. to N. 20° W.  
Horizontal base 11½ miles.



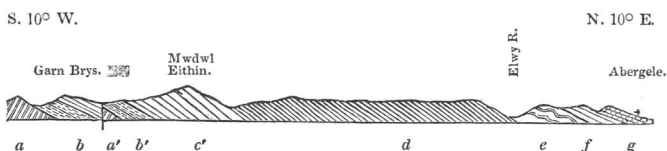
This Section is nearly the counterpart of Section VII., and runs nearly parallel to it: it passes the Dee about 3 miles W. of Llangollen. At the southern extremity, on the Teirw river, we have the limestones ( $\lambda \lambda'$ ), and porphyries of the Palæozoic series (*a*). Then follows a trough containing the dark roofing slate and the

\* In this view the author differs in opinion from the late Mr. Bowman, who separated this part of the upper series into subdivisions, which he compared with those of the entire Ludlow series of Mr. Murchison.

lower flags (*b b'*), of the upper Silurian series. Towards the northern extremity of the trough, a mass of the older rocks (*c*), abounding, like the similar mass of Cynr-y-brain, in fossils of the Caradoc sandstone, breaks out at Cricor Mawr. This mass is covered, on its north-western flank, by upper Silurian rocks; and these are overlaid by mountain limestone (*d*), a range of which bounding the vale of Clwydd on the S. E. runs from the point represented in the Section, beyond Abergele. The mountain limestone is followed by new red sandstone (*f*).

## SECTION IX.

FROM GARN BRYN, S. W. of CERNIOGE, to ABERGELE.

*Horizontal base 20 miles.*

In this Section, we have, near Cernioge, first, the rocks of the older series (*a*), abounding with fossils of the Caradoc sandstone; and secondly, lying unconformably on the preceding, are the conglomerates and sandstones (*b*) which there constitute the base of the upper Silurian flagstones. These conglomerates, &c., the author compares to the coarse greywacké and flagstone which constitute the unconformable base of the upper series at the south-eastern extremity of the Berwyns. These coarse mechanical rocks do not appear in any distinct form in the country traversed by the two former lines of section. The conglomerates pass into sandstones of a finer structure, which alternate with bands of dark coarse slate having occasionally true slaty cleavage.

In this part of the Section, the author interpolates a fault, by overlooking which, he was led, when he first exhibited this Section, to estimate the conglomerates and sandstones at too great a thickness. To the north of this fault, the finer sandstones (*c'*) are repeated.

The lower sandstones have been already mentioned. The middle flags, the author formerly described as consisting of beds resembling those of the lower flags; but these beds are more indurated, and contain, here and there, many fossils. In this middle division he now proposes to include the coarse greywacké and slates of Bronhaulog (*e*); whereupon he takes occasion to remark that, in North Wales, slates arising from transverse cleavage extend to a higher geological level than they do in Westmoreland, and to a still higher level in Devonshire than they do in North Wales; and, consequently, that such cleavage does not define the age of any rock, but serves only, like other peculiarities of structure, to mark the existence of certain physical conditions.



TABLE I. — FOSSILS OF THE OLDER PALÆOZOIC (PROTZOIC) ROCKS IN NORTH WALES, IRELAND, CALIFORNIA, MISSISSIPPI, AND J. DE CARLE SOWERBY.

NOTE. — Columns 1, 2, and 3, are added to this List on the authority of Professor Sedgwick's paper: other Fossils belonging to those Columns are to be found in Column 4. [Ed.]

NAMES OF GENERA AND SPECIES.	Localities taken in the Ascending Order. See Section I.								In the Descending Order, from Col. 8. See Sec. I.	In the Ascending Order. See Sec. IV.			Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	OBSERVATIONS.
	1.	2.	3.	4.	5.	6.	7.	8.		9.	10.	11.	12.	13.		
	Slates West of Arenig Fawr.	Dark earthy Slates E. of Arenig Fawr.	Gray Slates E. of Arenig Fawr.	Rhiwlas and Moel-y-Garnedd, W. of Bala Lake.	Cader-Diunmael and Glyn-Diifwus.	Rhiwaeog, E. of Bala Lake, to Bwlch-y-Groes, &c.	Aber Hirnant to Llan-Mowddy.	Pass to Llangynog and Rhiwargor.	From Llangynog to Pennant and Llanwddyn.	Craig-y-Glyn.	Pont-y-Meibion to Bwlch Llan-drillo.	Glyn-Ceiriog.	Pen-y-Craig Limestone.	Pen-y-Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
<i>Crustacea.</i>																
Agnostus pisiformis - - -			+		+		+	++			+					
Ilænus Bowmani (n. s.) - - -			+					++								
Paradoxides (n. s. ?) - - -			+													
Trinucleus Caractaci - - -		+		+	+		++?	+	+	+	+					
fimbriatus - - -				+	+		+	+								
Asaphus Buchii - - -	+			+	++?				+++		+					
tyrannus - - -				+	+			+	+++		+					
Powisii - - -		+		+	+		+	+			+					
caudatus - - -											+					+
(n. s.) - - -							+				+					+
Calymene Blumenbachii - - -					+			+								+
(n. s.) - - -																
n. s. ? with granulated head - - -				+												
Entomostracites punctatus - - -																+
<i>Mollusca. — Cephalopoda.</i>																
Nautilus primævus - - -								+								
Lituites cornu arietis - - -												+				
Phragmoceras ? (n. s. ?) - - -				+								+				
Orthoceras, smooth and distant septa - - -				+				+								
smooth and close septa - - -				+												
smooth and conical - - -												+				
<i>Heteropoda.</i>																
Bellerophon bilobatus - - -				+					+	+	++	+				
nodosus - - -											++					
<i>Pteropoda.</i>																
Conularia quadrisulcata - - -								+								
<i>Gasteropoda.</i>																
Pleurotomaria (n. s. angular) - - -				+				+								+
Murchisonia (de Vern.) - - -																
(n. s. ? large) - - -												+				
Turbo Pryceæ - - -								+								
Littorina striatella - - -								+								+
Euomphalus funatus - - -												+				
(n. s.) - - -												+				
<i>Conchifera.</i>																
Area Eastnori ? - - -																
Nucula ? (n. s.) - - -																
Cypricardia (n. s.) - - -				+	+		+		++							
(n. s.) - - -					+											
(n. s.) - - -					+											
<i>Brachiopoda.</i>																
Lingula (n. s. ?) - - -								+								+
Terebratula decemplicata - - -				+	+											
tripartita - - -								+				+				
crispata - - -												+				
marginalis* (imbricata) - - -												+		++		
(n. s.) - - -													+			
(n. s.) - - -																
(n. s.) - - -																
Atrypa affinis - - -								+				+		+		+

Wenlock Lime-  
stone.

\* The names marked with an asterisk are names substituted for those given in the Silurian system, in consequence of the examination of a collection from Sweden, in the possession of Mr. Murchison.



The upper flags have been described by the author in his former paper as composed of softer beds than the lowest and middle subdivisions; those beds being more or less slaty, and containing few fossils. To this subdivision the author refers a bed, near the northern extremity of this Section, which contains *Graptolites ludensis*. Also at the end of the Section occurs a thick mass (*f*) in which are a number of beds like those of the lower groups, but often passing into rotten slate or *mudstone*. The last bed (*g*) in this Section is mountain limestone.

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On the fossils of the lower, middle, and upper flags, as a whole, it may be remarked, that they agree very nearly with those from the upper Silurian rocks of Mr. Murchison; but that the distribution of species is somewhat different. Thus, in the list of fossils from the Lower Flags (*vide* list of fossils from Plas Madoc, Proc. Geol. Soc. vol. iv. p. 221.), species are found which were once supposed to be characteristic of the *tilestone* of Shropshire, a bed above the upper Ludlow mudstone. This may be accounted for by the circumstance, that both the tilestones and the Plas Madoc beds belong to an arenaceous deposit; and hence, though widely separated by intervening slates and flagstones, they have in common some species not found in the intermediate beds.

## TABLE II.

*Fossils of the Denbigh Flagstone and Sandstone Series, found in various Parts of North Wales.*

[Drawn up by Messrs. J. W. SALTER and J. DE CARLE SOWERBY.]

<p style="text-align: center;"><i>Crustacea.</i></p> <p>Calymene Blumenbachii. Downingiæ. one or two new species.</p> <p>Asaphus caudatus. longicaudatus. Cawdori. (subcaudatus).</p> <p style="text-align: center;"><i>Annelida.</i></p> <p>Serpulites longissimus.</p> <p style="text-align: center;"><i>Cephalopoda.</i></p> <p>Lituites Ibex. Orthoceras striatum. articulatum. virgatum. annulatum.</p> <p>* Creseis tenue † (Vahl). (primæva). * a conical species.</p> <p style="text-align: center;"><i>Heteropoda.</i></p> <p>Bellerophon carinatus. globatus. trilobatus. n. s.</p> <p style="text-align: center;"><i>Gasteropoda</i></p> <p>Turritella obsoleta. conica.</p> <p>Natica parva. Trochus helicites.</p> <p style="text-align: center;"><i>Conchifera.</i></p> <p>* Avicula (fragments). Nucula. Cucullæa antiqua. a large n. s.</p>	<p>* Cardiola interrupta. * Cardium? Cypricardia (several imperfect).</p> <p style="text-align: center;"><i>Brachiopoda.</i></p> <p>Terebratula navicula. † semisulcata. (lacunosa. Sil. Sys. p.5.) Nucula. Wilsoni. bidentata.</p> <p>Orthis lunata. orbicularis. two or three new species.</p> <p>Spirifer ptychodes. interlineatus.</p> <p>Atrypa affinis. two or three new species.</p> <p>Leptæna lata. † euglypha. depressa.</p> <p>Orbicula rugata?</p> <p style="text-align: center;"><i>Radiata.</i></p> <p>Crinoidal remains abundant. * Actinocrinites (n. s. highly ornamented. — Llangollen).</p> <p style="text-align: center;"><i>Polyparia.</i></p> <p>Stromatopora. Fenestella. Cyathophyllum (several species). Favosites (several species, one very slender). * Graptolites ludensis.</p>
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\* Denotes the species characteristic of the Denbigh flagstone series.

† Names substituted for those given in the Silurian system, in consequence of the examination of a collection from Sweden, in the possession of Mr. Murchison.

‡ Denotes the species which have hitherto been found only in the more calcareous beds at Plas Madoc, Llanrwst.

TABLE III.  
TABULAR VIEW of the PROTOZOIC ROCKS of NORTH WALES, in the ascending Order.

West of the Berwyns.	Chlorite Slate. (From <i>Porth Dinlleyn</i> to <i>Bardsea Island</i> , in the S. W. of <i>Carnarvonshire</i> .)	Slate and porphyry, with crystalline limestone and a few fossils, e.g. <i>Asaphus Buchii</i> . (W. of <i>Arenig Faur.</i> )	Porphyries, with a few bands of slate. ( <i>Arenig Faur.</i> )	Slate with bands of limestone, and many fossils: <i>Asaphus Buchii</i> , (g.c.) ( <i>Rhizolas</i> , g.c.)	Slate, with a few trap-pean bands, and a band of limestone, a calcareous slate. ( <i>Glyn Dyffrynys east side of Bala Lake.</i> )	Slate, and band of limestone. ( <i>Hirnant River.</i> )	Slates, with a few fossils. ( <i>Crest of the Southern Berwyns, and east of the Crest.</i> )	Upper Silurian.
	East side of the South Berwyns.		Soft earthy slates.	Soft earthy slates, with arenaceous bands, and a thick mass of calcareous slate. ( <i>Craig-y-Glyn.</i> )	Coarse sandstones and earthy slates; the lower part with the fossils of the <i>Bala</i> limestone. ( <i>Tyrnwy R., above Meifod.</i> )	Coarse sandstone, with a band of limestone and calcareous shale. ( <i>Pen-y-Craig, S. W. of Meifod.</i> )		
East side of the North Berwyns.			Soft earthy slates.		Earthy slates, with arenaceous bands and fossils. ( <i>Pont-Mebion, Bulch Llan-drillo.</i> )	Coarse slate and porphyries. ( <i>Trew River, falling into the Ceiriog.</i> )	Calcareous slates, with bands of limestone. ( <i>Glyn Ceiriog.</i> )	Upper Silurian.