

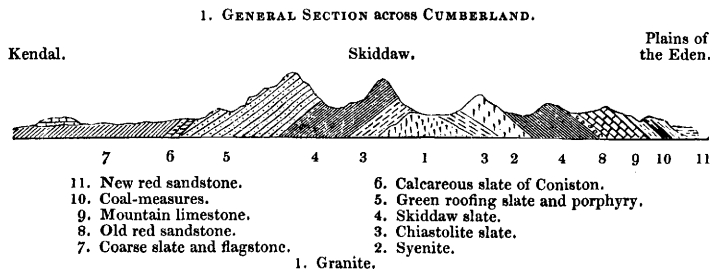
ontology since the lamented death of Baron Cuvier, the opinions of that illustrious philosopher on this subject ought not to be rejected upon such insufficient data as those hitherto obtained. Some of the specimens inspected by Baron Cuvier are not at this time exhibited in the British Museum, nor have I been able to obtain a sight of them to examine them anew; the humerus was not found till after the death of Baron Cuvier. The whole of the evidence which satisfied the founder of Palæontology of the existence of birds' bones in the Wealden strata is therefore not before us: but be this as it may, I contend that it is premature and unphilosophical to pronounce that all the bones belonging to animals capable of flight found in these deposits are to be referred to Pterodactyles; the evidence may be deemed presumptive but not conclusive: surely the great discrepancy between the former and present interpretation of the fossil that has given rise to these observations affords a salutary caution which should not be wholly disregarded.

2. *On the Classification of the Fossiliferous Slates of CUMBERLAND, WESTMORELAND and LANCASHIRE* (being a Supplement to a paper read to the Society, March 12, 1845). By the Rev. A. SEDGWICK, M.A., F.R.S., Vice-Pres. G.S., Woodwardian Professor of Geology in the University of Cambridge.

PART I.

§ 1. *Introduction.*—An abstract of my former memoir on this subject having been published in the first volume of the Geological Journal*, I am spared the necessity of entering on many details by way of introduction. Since however the subject before me is one of great complexity, I may be permitted to enumerate the results I before arrived at, and to illustrate them by sections.

The general section through the great Cumbrian cluster of mountains gives us three distinct groups of slate rocks.



* Vol. i. p. 442.

III. Upper system of slates, with a few calcareous bands full of fossils, the whole deposit more or less fossiliferous.

II. Green roofing slate and contemporaneous porphyry, &c.

I. Skiddaw slate, the lower part of which is metamorphic.

The superficial extent of these three groups is represented on the maps of Cumberland and Westmoreland which I have had the honour to present to the Society, and the lowermost (I.) has no exact parallel in Wales. The one marked II. is put on the parallel of the Snowdonian slates, but in Cumbria contains no fossils. The next (III.) commences with beds of the age of the Caradoc sandstone, and ends with rocks obviously of the age of the Upper Ludlow rocks and tilestone of the Silurian system: it therefore includes the whole or nearly the whole of that system. The subdivisions of this great physical group (III.) were described in detail in the paper just alluded to, and were in the following order:—

6. A great group nearly parallel with the Upper Ludlow rock, and ending on the banks of the Lune with a red flag or tilestone.

5. Coarse slates, flags, grits, &c.

4. Ireleth slates, &c., subdivided into three subordinate groups: viz.

γ. Upper Ireleth slate.

β. Calcareous slate and limestone.

α. Lower Ireleth slate.

3. Coniston or Furness grits. Thickness greater than No. 2.

2. Coniston or Brathay flagstone. Thickness 1500 feet. On the parallel of Wenlock shale.

1. Coniston limestone, surmounted by calcareous shales and slate. Aggregate thickness about 300 feet. Fossils, Lower Silurian.

During the past summer I have re-examined a part of the evidence on which I endeavoured to establish these subdivisions of the fossiliferous slates of Westmoreland, &c., and I still adopt the first four subdivisions almost without change. But No. 5. (coarse slates, flags, grits, &c.) I now consider as forming a sub-group of No. 4, or Ireleth slates, and No. 6. I subdivide into two groups,—a lower and an upper. The lower of these two groups passes into the system of the Ireleth slates in the descending sections, and in the ascending sections passes into the upper group, which ends with the tilestone. This slight change I was compelled to adopt when I endeavoured to lay down the subdivisions of the whole fossiliferous series on the county map; but it is in itself unimportant, and it involves no change of principle. According to this scheme, No. 5, the upper group (on the parallel of the Upper Ludlow rock) is subdivided into—

b. Arenaceous slates, grits and flags, almost without cleavage, and passing in ascending order into green and red arenaceous flagstone (*tilestone*) (c.).

a. Slates, grits and flags, with partial slaty cleavage, and passing into and blending with δ of No. 4.

No. 4. Ireleth slates, &c., includes

δ. Coarse slates, flags and grits, &c.

γ. Upper Ireleth slates.

β. Calcareous slate and limestone.

α. Lower Ireleth slates.

These are followed by No. 3, the Coniston grits, No. 2, the Coniston flagstone, and No. 1, the Coniston limestone, &c.

The scheme here given agrees with the annexed ideal vertical section of the whole Cumbrian series, inferior to the old red sandstone.

IV. { 7 Great scar limestone.
6. Old red sandstone.

III.	{	5. Upper slate of Kendal.	{	c. Red flagstone.
		4. Ireleth slates.		b. Coarse flagstone.
				a. Finer flagstone.
				δ. Coarse slates, flags and grits, &c.
				γ. Upper Ireleth slates.
				β. Calcareous slate and limestone.
3. Coniston grit.	{	α. Lower Ireleth slates.		
		2. Coniston flags.		
		1. Coniston limestone.		

II. Green slate and porphyry.

I. Skiddaw slate, the lower part metamorphic.

GRANITE.

Note.—The letters and figures of reference in this table apply to the different sections accompanying the present paper.

In the following communication it is my object, first, to explain the scheme above given by an appeal to actual sections and lists of fossils; and secondly, by help of this scheme to explain the physical structure and geological relations of a remarkable tract of country, including Howgill Fells, the Fells near the foot of the valley of Dent, and Middleton Fells, which range to the neighbourhood of Kirkby Lonsdale. The latter portion of my task is by far the most important, as it relates to a country with the structure of which I was almost entirely unacquainted before last summer, and which had never before been examined in any detail.

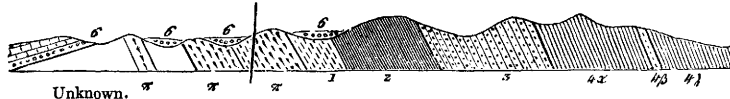
§ 2. *Successive groups.—The fossiliferous series.—Evidence offered by detailed sections, &c.*

1. *Coniston limestone and calcareous slate, &c.*—The general relations, structure and fossils of this group have already been given in some detail; and I should not here attempt to add anything on this head to the published abstract, had I not, during the last summer, visited the north-eastern extremity of the formation near Shap Wells, and the other extremity at the south-western end of Cumberland. At both localities there are phenomena which deserve a passing notice. Near Shap Wells the Coniston limestone is in an indurated, concretionary and altered form, and is repeated twice over in the brook which runs past the wells; while an overlying mass of old red sandstone and a mass of felspar rock occupy the interval (about two or three hundred yards) between the two masses of limestone.

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I formerly explained these appearances by supposing that the altered structure of the limestone or calcareous slate was due to the porphyry and felspar rock, which had burst in upon the line of the limestone and separated it into two masses. New cuttings for a railroad through this part of the country have given me what I think a better view of its structure. I now think the porphyry (like the porphyry found in some places immediately under the range of the limestone) is of an older date, and that the double appearance of the limestone is due to a fault. The accompanying section will sufficiently explain my meaning.

2. SECTION showing the reappearance of the CONISTON LIMESTONE in consequence of a fault.
N. by W. Fault. S. by E.



The phenomena are of great interest, but my limits prevent me from giving more than this passing notice of them; and it is obvious that they involve no principle of classification affecting the fossiliferous slates. Before I quit this subject I may just remark, that where the granite rises through the porphyry there are beautiful and complicated mineral results. Both the porphyry and granite are changed, but the demarcation may be pretty nearly traced, as the main masses are not confounded. About a mile north of Shap Wells the granite appears to have cut off the limestone. It is surmounted by a micaceous glimmering slate (like that so commonly seen close to the granite of Devonshire and Cornwall), which in one place is riddled through by granite veins*. Farther on the ascending section these granular and micaceous slates appear to pass into a hard splintery rock (in some places approaching the character of a felstone slate) of great thickness. These hard slates are only the Coniston flags (No. 2) altered by the granite, and, as is well known, they are traversed by one or two dykes of red quartziferous porphyry of a later date. In the long range of the Coniston limestone, from Shap Wells to the banks of the Duddon, which forms the boundary of the south-west end of Cumberland, I have at present nothing to add to statements given both in former papers of our Transactions and in the abstract in the first volume of the Geological Journal †, to which I must refer. But I was anxious to visit the south-west end of Cumberland, in the hope of deciding three questions. The first is, whether the Greystone House limestone on the hills west of Duddon Bridge is a true Coniston limestone? This bed is underlaid by beds of schaalstein, porphyry, slate, &c.; and

* I believe also that the granite has pushed the upper rocks out of their bearing, so that they are now seen to the south of the line of strike indicated by the same rocks farther south-west.

† *ante cit.* page 442.

similar rocks overlie the Greystone House limestone as far as the borders of the estuary immediately below Duddon Bridge. This fact is indicated in the colours of my field map exactly as I finished this part of it in 1822. My examination during the past summer enables me to answer this question in the affirmative. The limestone, though granular and crystalline, passes into ferruginous, cellular, calcareous slabs with fossils; and the whole development of the group (with the exception of a partial mineral change caused by the association with igneous rocks) is exactly like that of the Coniston limestone, and is very nearly on its line of strike, only a slight deviation having been produced by the valley of the Duddon. These alternations of fossiliferous and igneous rocks are anomalous in this part of England; but the very anomaly brings the formation I am describing into more intimate comparison with the rocks of the same, or nearly the same age in North Wales. Assuming the truth of what has been stated, it follows that the limestone must have been shifted by a vast fault and break of the whole series of strata, more than two miles from its original strike. Those who have studied the great dislocations of the strata near Coniston Waterhead will have little difficulty in admitting what is here stated*.

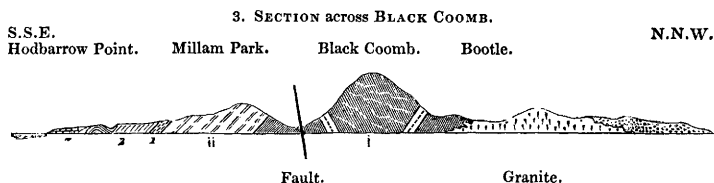
The second question I wished to examine was this,—Is there in the structure of the neighbouring county anything to explain this enormous Greystone House fault? I have already in another place answered this question in the affirmative. Immediately to the west of Greystone House, the rugged hills of green slate and porphyry rise to an elevation of about 1500 feet, and are penetrated by dykes of quartziferous porphyry (π). Similar slates and porphyries are continued farther south at a much lower level, and their beds are shattered in many directions: they then form the well-defined ridge of Millam Park, and range towards the sea along that ridge with a more regular strike, and a dip towards the south-east. Commencing among the shattered masses of slate and porphyry above noticed, and on the west side of the Greystone House fault (which runs nearly north and south), there runs a second enormous fault south-east and north-west down the Whitchamp valley as far as the sea-coast. On the north side of this second fault rises the contorted Skiddaw slate of Black Coomb †, which contains mineral veins (with lead, cobalt, &c.), is pierced by dykes of quartziferous porphyry, and at its northern end is altered by and jammed against the granite of Bootle. Close to the junction the altered Skiddaw slate is pierced with fine veins of true granite, rivalling some of the corresponding phenomena of Cornwall. The upheaval of the system of Black Coomb produced therefore, first, the great Whitchamp fault; and secondly, not being powerful enough to break through the superincumbent slates and porphyries farther to the north-east, shattered a portion of them to

* This enormous fault, produced by an upcast to the south, has been described in my former papers, and is laid down on the coloured county map in the possession of the Geological Society.

† See the annexed diagram, in which the rocks intersecting the slates (i) are of this porphyry.

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fragmentary masses, and then tore the whole system of Millam Park bodily from the other rocks of the same age, and carried them full two miles to the south-east of their original strike; thus producing the second or Greystone House fault, which is marked on the surface by the sudden great shift of the Coniston limestone, as indicated in the previous description. My present limits preclude any further details, but the accompanying section will I trust make this short description intelligible.



The third question I was anxious to solve was this,—Is the Coniston limestone continuous, so as only to disappear (along with all the other rocks) under the drifted matter which fringes the south-west coast of Cumberland? Or is it degenerate, appearing only here and there, in discontinuous concretionary masses, before it is finally cut off near the coast? Judging only by my remembrance of what I saw in 1822, and by the colours laid on my map at that time, I should have said that the Coniston limestone was continuous, and that so far from being degenerate at its south-western extremity near the coast of Cumberland, it was much thicker there than in any other part of its range from thence to Shap Wells. From the marshes south-east of Wander Hill to the pastures south-west of Beck Farm (a distance of full two miles), the Coniston limestone group is magnificently developed, having an aggregate thickness more than double that of the same group (including the overlying calcareous slate) in its range through Westmoreland and a part of Lancashire. There is a great open quarry behind Beck Farm, in thick beds of nearly vertical black limestone with white veins. They form the base of the series, and counting from them to the highest calcareous beds with bands and concretions of limestone, we have a thickness of full 600 feet. Under this limestone is a fine schaalstein passing into porphyry; its beds are perfectly parallel to the limestone, and for some depth below it contain the well-known Coniston fossils. I think this fact of importance, as it shows the uninterrupted continuity of the porphyritic and overlying system. At Water Blain the limestone is cut through by a fault, marked a narrow marshy valley, beyond which the limestone is contorted and traversed by thick veins of red oxide of iron. In another quarry the limestone rests on schaalstein, and is partially altered and penetrated near its base by flakes of serpentine.

Before I quit this discussion on the Coniston limestone, I may be permitted to recall attention to the ridge of High Haume (south of

Dalton), on the other side of the estuary of the Duddon. The rocks are there in a vertical position; and, crossing from the shore of the Duddon estuary towards Dalton, we have the following sequence:—

(1.) Sharp ridges of porphyry and schaalstein (exactly like those under the Coniston limestone).

(2.) Beds of dolomite, broken and shattered, with *Favosites fibrosa* (but fossils extremely rare).

(3.) Calcareous slate, with many fossils of the Coniston limestone.

(4.) Thin bands of schaalstein, slate and porphyry.

(5.) Obscure bands of vertical slate, ill-exposed, and with no well-defined fossils.

Taking the mineral structure and fossils into account, I had no hesitation, during my preceding visit in 1844, to class a part of this calcareous mass with the Coniston limestone. From the great thickness of the shattered dolomitized limestone, I was disposed to think it probably a mass of mountain limestone (for that formation is close at hand) entangled among the porphyries. I now feel assured that it is only an altered form of Coniston limestone, and its thickness is perhaps not greater than that of the same limestone on the Cumberland side of the Duddon estuary. Let it be borne in mind that there is the enormous dislocation already alluded to, and that we have in this very district the indications of great but anomalous eruptions of contemporaneous porphyry both immediately before and after the formation of the Coniston limestone, and all difficulty will, I think, vanish. With the exception of the dislocated mass above described, there are no Lower Silurian rocks to the south of Duddon Bridge. The statements in the abstract of my former paper amply define the general age of the Coniston limestone, and enable us to class it with the highest portions of Caradoc sandstone.

2. *Coniston flags*.—Respecting this group I have not many details to add to those of my former paper. It forms the true base of the Upper Silurian rock of this part of England. I have now traced it through parts of the valleys of Dent, Sedbergh, and Ravenstone Dale, on the eastern skirts of the fossiliferous slates, and in several places it contains *Cardiola interrupta*, along with the Upper Silurian fossils (*Graptolites ludensis*, &c.), mentioned in the abstract of my paper of last March. There can therefore be no doubt about its true place in the series. Among the highest beds of this group on the road between Hawkshead and Coniston are *Orthoceratites subundulatus*, Portlock, and another species not yet described.

3. *Coniston grit*.—The beds of this group, consisting of hard grits, &c., have a remarkably uniform character, considered as a whole,—only at their northern end they are degenerate so as to give a less impress to the features of the country. They reappear in the great undulations of Howgill Fells and Middleton Fells, &c. Throughout they show a remarkable association with spherical concretions often more or less calcareous, in which respect they offer analogies with many of the harder Upper Silurian grits of North

Wales*. Fossils are extremely rare in this group; but, after a careful search, some have been discovered. Among these are *Cardiola interrupta*, *Graptolites ludensis*, and fragments of Trilobites. To which may be added, *Orthoceratites Ibez*, and *O. subundulatus* of Casterton Low Fell which belongs to this group.

4. *Ireleth Slates, &c.*—These beds are thus subdivided:—

- δ. Coarse slate and flags, &c.
- γ. Upper or great Ireleth slates.
- β. Upper limestone.
- α. Lower Ireleth slate.

To enter on any elaborate description of this most complicated group would involve me in almost endless details, and I must content myself with little more than an enumeration of leading points, and refer to sections.

4 α, or *Lower Slates*, occupies a band of very highly inclined beds more than half a mile broad, between the upper limestone of Tottlebank Fell and the zone of the Coniston grits. Under the line of the same upper limestone (β) there is at least an equal thickness of slaty beds in the Ireleth country, on the south side of the Duddon estuary. I refer the slates of Bannisdale Head and Bretherdale to this sub-group. In general mineral structure it is almost identical with the group (δ) of higher slates, and there is indeed no definable difference. I know of no fossils in this group in the Ireleth country except *Graptolites ludensis*; but, from the general absence of quarries, they may exist and yet have escaped notice.

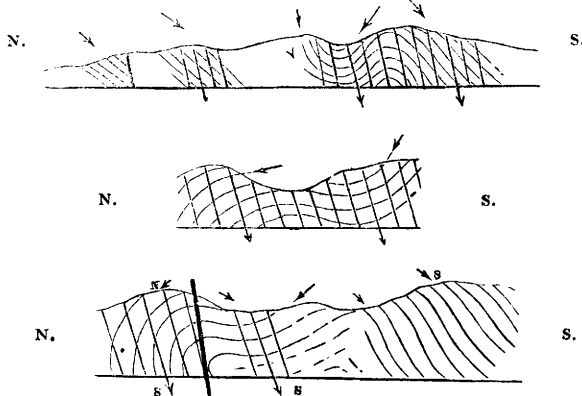
4 β, or *Upper Limestone*.—This limestone appears in five places on the south-east side of the Duddon Sands. In this part of the range it is of considerable thickness, and is still worked at Meer Beck in a fine open quarry †. Most of the old quarries are deserted, as good mountain limestone is found by the sea-side close at hand, for economical use. Farther towards the north the band appears to thin out; but it re-appears on the south face of Tottlebank Fell, in the places indicated in my former paper. It is there very degenerate. The limestone is shelly, but extremely impure. It is composed of irregular discontinuous concretions, and it dies away on its line of strike before it reaches Coniston Lake, and is not seen again, in any appreciable form, farther towards the north-east. Fossiliferous bands (with *Terebratula navicula*, &c.) do however break out farther to the north-east, nearly on the strike of this limestone, *e. g.* on the right side of the road from Windermere Ferry to Hawkshead.

* These balls, both in the grits and slaty bands, are of various sizes,—sometimes true septaria, sometimes filled with earthy ferruginous rotten-stone. They follow the beds and not the cleavage planes, and among the more slaty masses they are spheroidal, with their longer axes in the direction of the beds. On the contrary, in the Millam quarries, the calcareous concretions of the Coniston limestone are formed on the cleavage planes, and not on the beds.

† In one quarry there occur numerous specimens of a square-stemmed Encrinite (*Tetracrinites*?).

4 γ. The great Ireleth slate quarries were noticed in my former paper. The whole hill, in which these quarries are very largely worked, is thrown into most complicated contortions. But through all these complicated curves the planes of slaty cleavage pass continuously, and almost without any deviation in their strike and dip. I hope to return to the description again, in a paper devoted to the examination of the phænomena of slaty cleavage. But I subjoin several diagrams to convey some notion of the physical conditions of these most instructive quarries.

4. IRELETH Slate Quarries.



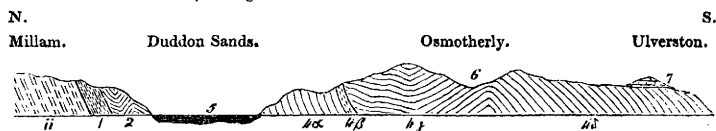
NOTE.—In the above diagrams the arrows below the base line point to the direction of the cleavage planes and those above the section to the bedding.

Most of the beds show spherical concretions,—sometimes filled with an earthy ferruginous matter like the Derbyshire rotten-stone ; sometimes in the form of septaria, with calcareous veins. In these balls are found a few ill-preserved fossils, such as Encrinite stems, Graptolites, corals, and Orthoceratites. Mr. Salter has identified one Orthoceratite with *O. subflexuosum* of Münster. Of Graptolites there are probably two very nearly allied species,—one is *G. ludensis*. Among the corals is *Favosites alveolaris* and a *Cyathophyllum*.

4 δ. To the description of the coarse upper slates I have little to add to the details before given. Many parts of it can hardly be distinguished from the preceding group. It contains numerous concretionary balls, with *Graptolites ludensis* and corals like those of the preceding sub-group (γ). It also contains (though rarely) *Cardiola interrupta*, as is stated in the published abstract of my former paper. The previous descriptions apply only to the country of Low Furness. To assist in making them understood I here give two sections,—one from the Coniston limestone at the south-west end of Cumberland, thence across the Duddon estuary, and over the hills of Furness to the sea near Ulverston (see diagram 5).

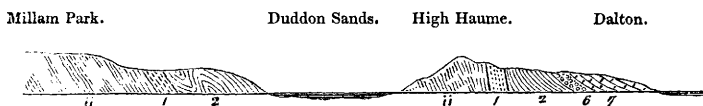
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5. MILLAM, through DUDDON SANDS to the sea near ULVERSTON*.



The other section (No. 6) commences with the same limestone, and crosses the sands about two points of the compass farther towards the south, so as to reach the south-east shore on the south side of a great fault or contortion which has repeated the Coniston limestone in High Haume near Dalton.

6. MILLAM through DUDDON SANDS to DALTON.



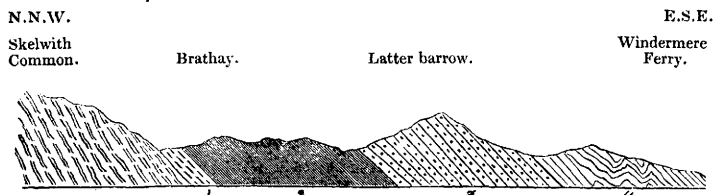
The preceding descriptions apply to the group No. 4 ($\alpha, \beta, \gamma, \delta$), as developed in Furness; and the aggregate thickness is very great—certainly several thousand feet. If the section were prolonged across Leven Sands, over the hills to Cartmell, it would probably bring in still higher beds. All the accidents of structure are however repeated, and are precisely like those on the Ulverston side of the Sands. Again, it is easy to make a section farther north from the Coniston limestone down Russland to Newby Bridge, and thence as far as Lindal. The lower part of such a section would give the groups 1, 2, 3, 4, in great perfection and clearness, and would cross three distinct lines of porphyry dykes; and near Newby Bridge the section would terminate in some part of the group 4 δ . This last part of the series has however very few fossils, but in the abstract before referred to I have already mentioned *Cardiola interrupta*. Starting with this section the strike is north-east; at Newby Bridge the strike is various, and the masses are enormously shifted at the intersection of three valleys. The prevailing strike is about N.N.E. or north by east; thence passing over the ridge to Lindal there are perhaps twenty anticlinal and synclinal lines. At Allithwaite the chain is broken, and beyond that village, down to Lindal, the strike becomes north by west or N.N.W. I conceive it therefore almost impossible to connect this end of the section correctly with any section from Coniston down Russland to the foot of Windermere. Still, on the whole, the sections are in the ascending order towards the south-east, and we gradually reach the upper limits of No. 4.

* It is proper to state that in this and some of the other diagrams illustrating the present memoir, the appearance of a want of conformability (e.g. between 4 β and 4 γ *supra*) is an error in the engraving. All the beds, from No. 1 to No. 5 inclusive, are in fact conformable throughout the district.

Nor is this the only difficulty. From the absence of the calcareous band (4β), all the subordinate groups are packed in one mass; and the impress of slaty cleavage, notwithstanding the extraordinary contortions and dislocations, affects them all. These cleavage planes strike, in almost undeviating lines, through all the complicated curves and broken masses, in a direction on the average within a point of magnetic east and west. In the Ireleth ridge the cleavage planes hang toward magnetic south; but further north, the same planes (nearly with the same strike) hang within a point of magnetic north, generally inclining towards true north. I think these phenomena theoretically important, and I hope to return to them in a future communication.

These reasons are sufficient, mineralogically, for grouping together all these slaty masses over the hard grits (No. 3). Neither do the fossils indicate the expediency of any further subdivision under the name of Windermere rock, or any other local name. The more slaty masses out of which roofing-slate is extracted, may in a general way follow particular zones, but they are not continuous, and I believe they often shift their parallels. This is the case in the older Cumbrian slates, and also, I believe, in the group I am describing (No. 4 γ). Still we may in an approximate way follow on the strike the lower slates (4α), and the higher (4γ). The latter I would place near the foot of Coniston Water, and thence across Hawkshead valley to the shore of Windermere, a little below the Ferry. This is, I think, nearly the range given in Mr. Sharpe's last abstract. But if this be true it follows that the slaty beds extending to Latterbarrow must represent the group (4α).

7. SECTION from SKELWITH COMMON to WINDERMERE.

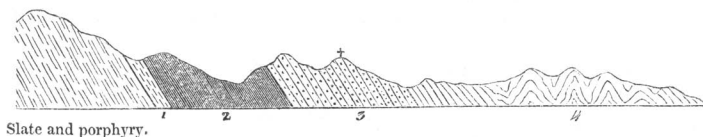


Now in this group we have fossils; and in some bands on the right-hand of the road from the Ferry-house to Hawkshead, we find several species of fossils, and the *Terebratula navicula* in vast abundance. I do not contend that the bands with *T. navicula* exactly represent (4β) or upper limestone; neither would I bring them into exact comparison with the Aymestry limestone of Siluria. The comparison would be too wiredrawn to be of any use; and, by like reasoning, we might prove the existence of three or four bands of Aymestry limestone on different geological parallels. Following the several groups along the line of strike over Coniston Water and Windermere, and thence through an undulating country of singularly contorted strata into the valleys of Kentmere and Long Sled-

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dale, and to Bannisdale Foot, on the road from Kendal to Shap, we have repetition upon repetition of the same phænomena. None of the groups die away; and there is no unconformable overlap (as has been stated) whereby the highest group (4 δ), under the name of Windermere rock, is made to pass over the edges of the older groups α , β , γ . The hypothesis is, I think, positively contradicted,

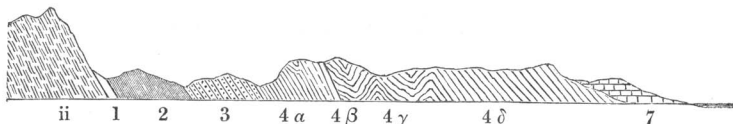
8. SECTION from WANSFELL PIKE to CROOK MILL.
N.W. Wansfell Pike. Troutbeck. Station. S.E. Crook Mill.



9. SECTION through CROOK and UNDERBARROW to KENDAL.
N.W. by N. Ambleside Turnpike. Crook Ch. Underbarrow Ch. E.S.E. Kendal Fell.



10. SECTION from near BROUGHTON to ULVERSTON.
N.W. Broughton. S.E. Sea near Ulverston.



both by the sections and the groups of fossils. I cannot describe this complicated region in detail; but I appeal to the accompanying sections 7, 8, 9, 10, and to the list of fossils published in the abstract of my paper before referred to*. Beyond Bannisdale we become entangled among a series of undulations and breaks connected with the disturbances on the eastern side of the great fault of the Lune, which will be described presently. I may also here refer to the coloured map of Westmoreland†. The colours are meant to illustrate this paper, but the phænomena are only local. Were I employed in colouring a geological map of England on the scale of that by Mr. Greenough, I should still use one simple colour for the whole series of four groups, No. 1 having a distinct colour, as it would I think be impossible to follow these subdivisions from one county to another in the subordinate details, so as to lay them down on a map, however great the scale.

* Journal, *ante cit.* vol. i. p. 442 *et seq.*

† Presented to the Geological Society.

5. *Upper Slate of Kendal and Kirkby Moor*.—This group is divided into three sub-groups, 5 *a* surmounted by 5 *b*, and 5 *b* terminating in the ascending order with a red, grey and greenish flagstone (5 *c*), overlaid by conglomerate of the old red sandstone.

(5 *a*).—The lower subdivision is ill-defined, especially at its lower extremity, because it forms a passage (both in its mineral structure and its fossils) into No. 4. If we commence near the ridge (above alluded to at Lindale), and cross the marshes to the great outlier of Witherslack (mountain limestone); or if we cross from Underbarrow by the turnpike-road to the great limestone outlier of Kendal Fell; or lastly, if we start from Bannisdale Foot from an ill-defined base affected by the great troubles of the Lune, in each of these cases we cross the several beds of the sub-group 5 *a*.

The lower beds are affected by slaty cleavage, but among them occurs the *Terebratula navicula*. The upper beds are less and less slaty, and contain so many fossils of the well-defined upper group between Kendal and Kirkby Lonsdale, that my friend Mr. Salter could hardly make out any palæontological difference between this group (5 *a*) and the upper (5 *b*). But considered in its details, there is a difference. The upper part wants the hard micaceous gray and greenish-gray sandstones with the species of large *Avicula*, *Cypricardia*, &c.; and it contains abundantly several fossils, such as *Asterias*, *Ophiura*, &c., very rarely if ever found in the hills between Kendal and Kirkby Lonsdale.

The best illustration of this ill-defined sub-group is between Underbarrow and Kendal Fell, and I hope hereafter to describe this section in more detail (see *ante* fig. 9). It is enough for my present purpose to mention the following facts.

1. Commencing at Underbarrow among the faulted beds of the valley, we have slate and flag, with a rude cleavage whose direction is magnetic north. In this series is *Terebratula navicula*. This species, counting from the beds north-east of Windermere Ferry, must therefore have a very great vertical range. These beds terminate in ascending order near a farm called High Thorns.

2. A thin bed with *Asterias* (six or seven feet), above which the *Terebratula navicula* is not found. [Here is the last appearance of *Turbinolopsis*.]

3. Flags, *sheer bate* (*i. e.* without cleavage), some red calcareous bands with very many fossils. Many Trilobites (one like *Calymene Blumenbachii*.)

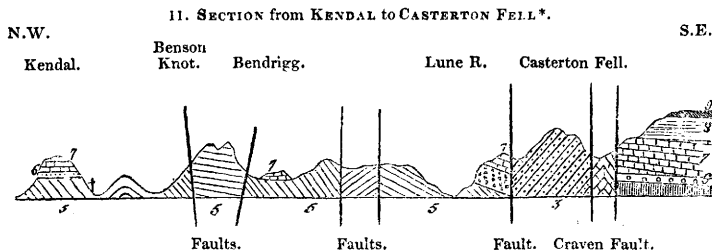
4. Striated hard grits and *sheer bate* flags, with many fossils like those under the great *Avicula* beds of Benson Knot, on the north side of the Kent.

The *Asterias* beds (No. 2 of this section) are found at Docker Park, in the beds under Benson Knot, in the valley above Kendal near Redman Tenement, and in the Sprint rivulet about a mile below the Tenement. Here, therefore, we have a passage into the upper and higher sub-group 5 *b*.

(5 *b*).—Respecting this group there has been no difference of opinion. It must be nearly on the parallel of the Upper Ludlow, and

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it ends near Kirkby Lonsdale with a tilestone (5c), the upper part of which (on the banks of the Lune) contains red calcareous concretions, immediately under Red Scar (old red sandstone). The map and the accompanying section (diagram 11) will explain the manner in which



this formation has been shattered into vast fragmentary masses. The collocation of the masses can only be explained by the interference of two or more lines of dislocation. But among all these dislocations, we may often trace the rudiments of the original north-east strike of the Lake mountains. As far as I know the sections, no older beds are brought up between Kendal and Kirkby Lonsdale. I have not at Lupton Fell, or anywhere else in this district, seen a trace of the groups of (No. 4): all here is Upper Ludlow. I may here call attention to a patch of mountain limestone (at High Bendrigg) which has been laid bare by the bursting of the canal reservoir, and is a striking instance of the vast denudations and convulsions which have affected this singularly broken region. A large list of fossils obtained from this sub-group has already been given, and I could now add considerably to it. In one word, then, the whole fossiliferous series above-described begins with rocks of the Lower Silurian type, which are only a few hundred feet thick (200 or 300 feet on the average, and 600 feet at the maximum), of the age of Llan-saintffraid and Mathyrafal beds, and these are not, as I once supposed, on the parallel of the Bala limestone. All the other rocks are Upper Silurian, and there is no unconformable overlap of Windermere rocks to be distinguished from the general series from No. 2 up to No. 5. The subdivisions of the groups do not resemble those of Siluria, neither does the minute arrangement of the species; but there is a general resemblance amongst the species and Upper Siluria and Westmoreland, which considered as one great group, are almost identical, and both end with the same mineral type, viz. a red flagstone or tilestone.

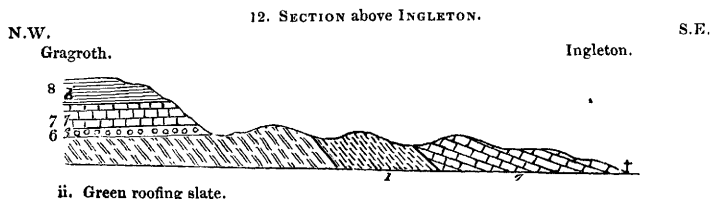
Lastly, the development of the Upper Silurian series (not resembling that observed in Siluria) does, on the other hand, resemble that in South Wales, nine-tenths of the higher slate mountains of which, I doubt not, will prove Upper Silurian.

* In this diagram the number (5) refers to the upper sub-group (5b), and the lines projecting beyond the outline of the section represent the faults. The number 8 refers to the great limestone shale ('Yoredale series' of Phillips), and number 9 to the lowest millstone grit.

§ 3. *Structure of the Mountain-chains of Howgill, Ravenstonedale and Middleton, on the east side of the Valley of the Lune.*

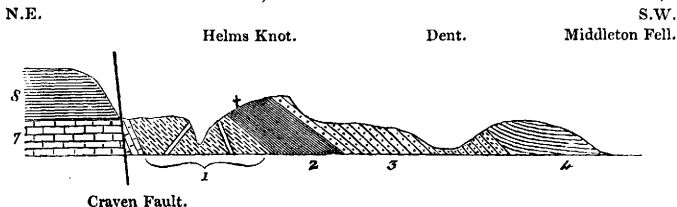
I will not here detain my readers with any account of the picturesque features of these beautiful mountain-chains, or my rambles through their defiles and precipices. The great undulations of the district are among the most remarkable I have ever studied; and I would also refer to that break of the strata which ranges up the valley of the Lune, and in the upper part of the valley deflects towards the north-west, and is connected with a great trouble which brings up the hard grits (No. 3) at Whinfell Beacon.

The great difficulty among these extraordinary undulations is to find a true geological base-line on which we may construct a regular and consistent system. Indications of such a base-line I have already pointed out in my former paper; viz. the appearance of Lower Silurian fossils near the range of the great Craven fault through the valley of Dent. A careful examination of the whole fault, and of the slate rocks near it, enables me now to state that there is a good base-line nearly all along the eastern skirts of the troubled district, that base being the Coniston limestone (No. 1). The evidence will be best understood by sections.



This section unfortunately gives us no fossils*.

13. SECTION in the VALLEY OF DENT, from RISSELL and HELMSGILL to MIDDLETON FELS, &c.

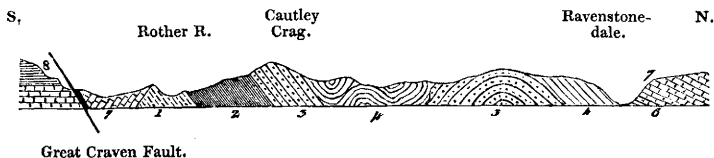


8. Limestone shale.
7. Mountain limestone showing the passage of the Craven fault.
4. Slate, &c. of Middleton Fell.
3. Hard grits—at bottom passing into flagstone, and with many specimens of *Cardiola interrupta* and *Graptolites ludensis*; together with three species of *Orthoceratites*, *Spirorbis Lewistii*, *Alveolites*, &c.
2. Calcareous flagstone with *Graptolites ludensis* and *Cardiola*.
1. Shale and limestone with fine series of Coniston fossils intersected by porphyry dykes.

* The Craven fault must pass somewhere between the two masses of mountain limestone to the extreme left and extreme right of the section, but its exact place is not laid bare.

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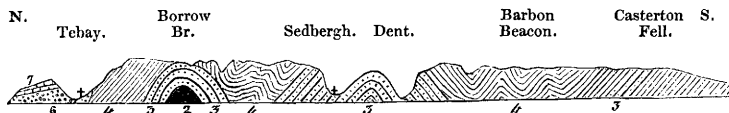
14. SECTION from the higher part of the VALLEY OF SEDBERGH, over CAUTLEY FELS to RAVENSTONEDALE.



8. Limestone shale overlaid by millstone grit.
7. Mountain limestone broken by the Craven fault.
6. Contorted slates, &c., ending with old red (6) and mountain limestone of Ravenstonedale*.
5. Hard grits.
4. Flagstone with Graptolites:—*Orthoceratites* with an encrusting coral.
3. Calcareous slates and limestone with fossils. A little above the line are many porphyry dykes, and farther on the strike of the same beds, a magnificent series of Coniston fossils, perhaps the richest deposit of this age in the north of England.

These are instructive sections, and tell a very plain story. They enable us also to interpret other sections, which might be considered doubtful and obscure without their help.

15. Great North and South SECTION from TEBAY to CASTERTON FELL.

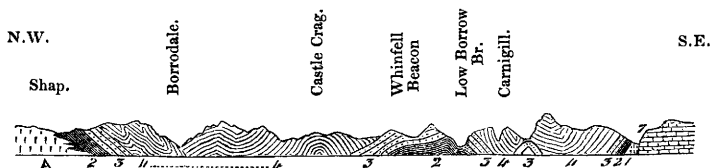


From this section it appears that the Coniston grits (3) and Ireleth slates (4) are repeated by great undulations. In one spot the calcareous flag (No. 2) (with *Graptolites ludensis*) makes its appearance; and the whole series at the north end is overlaid by old red conglomerate (6) and mountain limestone (7).

In the grits (No. 3) of Casterton Fell are *Orthoceratites subundulatus*, *O. Ibez*, and *Cardiola interrupta*.

In the slates of Middleton Fell and Howgill Fell (No. 4) are *Avicula*, a small species; *Orthoceratites subundulatus*, a coral resembling *Monticularia* and *Alveolites fibrosa*.

16. Great connecting SECTION from the SHAP GRANITE to BAUGH FELL above SEDBERGH.



4. Ireleth slate series.
3. Coniston grit.
2. Coniston flag much indurated near the granite.
- A. Shap granite throwing veins into No. 2.

* At the end of the slate series (4) in Ravenstonedale *Calymene* (*Downingia*?) occurs.

The north-west end of this section which passes through Nos. 2, 3 and 4 of the tabular section (see page 108), is intersected by three or more porphyry dykes; and at its south-east end it traverses the Howgill range, and descends into the valley above Sedbergh through the beds described in section 14. The whole country through which these sections pass is extraordinarily faulted and contorted, and the higher elevations, which are traversed by numerous porphyry dykes, exceed two thousand feet. Among the valleys indenting Howgill Fells is some wild and noble scenery, with two of the finest waterfalls in the north of England. Thus it appears, that in the remarkably contorted chains east of the great Lune fault, we have No. 1, 2, 3 and 4 of the tabular section in regular order, and that no higher rocks appear in the chains, which at both ends are overlaid by the conglomerates of the old red sandstone and by mountain limestone.

JANUARY 21, 1846.

Alfred Tyler, Esq., and Bland Hood Galland, Esq., were elected Fellows of the Society.

The reading of Professor Sedgwick's communication was resumed and completed.

PART II.

THE former part of my paper, containing numerous detailed sections, did not include the conclusions I wished to draw from them. I there described the whole series of fossiliferous slates extending from the Coniston limestone to the valley of the Lune, as subdivided into five primary groups, viz. :—

5. Upper Ludlow rocks, including tilestone, extending from Kendal to the banks of the Lune, near Kirkby Lonsdale.
4. *Ireleth slates*, divided into four sub-groups (α , β , γ , δ).
3. *Hard gritty beds* approaching a conglomerate form, with subordinate slaty masses, having numerous spherical concretions arranged parallel to the beds. Fossils rare, but of Upper Silurian species.
2. *Coniston or Brathay flagstone*, having Upper Silurian fossils, and developed to a thickness roughly estimated at 1500 feet. The mineral structure almost identical with that of the flagstones of the Upper Silurian rocks of Sir R. Murchison, and yet more nearly resembling the Lower Denbigh flagstones of North Wales.
1. *Coniston limestone and calcareous slate* having Lower Silurian fossils.

Respecting the upper part of the great formation of the Ireleth slates (No. 4 δ) there is no difference of opinion, as it contains several well-known Lower Ludlow fossils, and has already been compared,

in a general way, both by Mr. Sharpe and myself, with the Lower Ludlow rocks. It forms a part of his Windermere rocks.

I formerly considered the three lower sub-groups (4α , 4β , 4γ) as Lower Silurian; but I did so before I had re-examined the country (the most important part of which I had never seen since 1822), and I was, I believe, misled by confounding the High Haume limestone (south of the Duddon) with the upper calcareous band (4β). I need not repeat what I have before stated on this head; but as Mr. Sharpe still appears to adhere to the supposition that these three lower sub-groups are *Lower Silurian*, I have lately re-examined my fossil evidence, as well as my field sections; and I adhere to my previous conclusions. In the first place, there is no evidence of any unconformable overlap (as stated, if I mistake not, in Mr. Sharpe's paper,) among the beds of the four sub-groups, and they form one unbroken continuous mass. And in the second place, the fossils of the four sub-groups compel us to class them all as one formation—nearly on the parallel of the Lower Ludlow rocks. The fossils of the rocks north of the Ferry House at Windermere have been re-examined by my friend Mr. Salter; several large fossiliferous masses which I brought away from these rocks have now been broken up, and the following is the list of fossils Mr. Salter has derived from them.

List of Fossils from the Rocks north-east of the Ferry House.

1. *Encrinites*, one or two species. One remarkable undescribed species also found in the valley of the Kent above Kendal, just under the Upper Ludlow rocks.
2. Fragments of a *Calymene*.
3. *Turbo carinatus* or *corallii*.
Turbo? like a species in the Upper Ludlow of Kirkby Moor.
Turritella obsoleta.
———— *conica*.
Terebratula semisulcata (*T. lacunosa* of the Ludlow rock in the 'Silurian System').
Orthis orbicularis.
———— *lunata*.
Leptæna lata.
Nucula, resembling *N. ovata*.

Here are twelve species—none of which are known Lower Silurian, and eight of which are known Upper Silurian species. And to this list we may add *Terebratula navicula*, obtained from the immediate neighbourhood. It appears therefore that there is no room for doubt; for these fossils are all derived from the *lower part* of the great group (No. 4).

It was however stated that the upper limestone, near Coniston Water-foot, contained Lower Silurian fossils; and the authority of Mr. J. Marshall was appealed to. Now I examined this part of the country during last summer in company with Mr. J. Marshall, and I venture to affirm that he did not show me a single Lower Silurian

fossil in this *upper limestone*; neither did he appear to have ever seen any. In quoting his authority there must, therefore, have been some mistake. Of the singular High Haume limestone I may just remark—that it is mineralogically unlike this upper limestone—that it is associated with a different series of rocks—that it contains a distinct series of fossils (*viz.* Lower Silurian), and that it is not on the line of strike of the upper limestone. But if we endeavour to identify the two limestones, (as I did myself in 1822, before I had studied the structure of the neighbouring country, or knew the fossils,) what then follows? That through a thickness of not less than 4000 or perhaps 5000 feet, there is an utter confusion of Upper and Lower Silurian types. I do not accept this conclusion: and I have now gone over the reasons for the classification I adopted in 1844, and confirmed by my examination of the same country in 1845.

I next examined the rocks of Ravenstonedale, Howgill Fells, and Middleton Fells. Their geological base is formed of a calcareous slate with impure beds of limestone, which in two or three places (especially Helmsgill in Dent, and Ravenstonedale, above Rother Bridge,) contain many fossils. I collected in about an hour at one small quarry in Ravenstonedale not less than twenty-five or thirty species*. From the very near agreement of these with Coniston limestone (Lower Silurian) fossils, we have a true geological base-line for the contorted region of Howgill Fells, and we have no lower rocks brought up in that mountainous region. Were these rocks of Ravenstonedale by themselves, and dissociated from the upper groups, there might perhaps be some doubt of their exact age. But they pass upwards into the most characteristic Coniston flags, with *Graptolites ludensis* and *Cardiola interrupta*; and these flags are in their turn surmounted by the hard grits (2) and the Ireth slate (4). Hence the Howgill Fell system is only a repetition of the four lowest groups on the north-west side of the great fault of the Lune, folded over and over again by vast local undulations; and hence also it follows that the highest rocks of the Westmoreland series occur in a kind of irregular hollow or basin, with older rocks expanded along their whole eastern extremity: but there is no direct and unequivocal proof of any want of conformity in any part of the series till we reach the old red sandstone and the carboniferous limestone.

* Mr. Salter has given me the following extract from his list of these fossils:—

Orthis Actoniae.
—— *fiabellulum.*
—— *elegantula* (formerly *O. canalis*).
—— *alternata*, &c.
—— like *O. Pecten* (repeated at Coniston).
Leptæna transversalis.
—— *depressa.*

All the above are known Coniston fossils. The Ravenstonedale list also resembles the Coniston in the rarity or absence of certain fossils which abound at Bala, e. g. *Orthis vespertilio*, *Leptæna tenuistriata*, *Crania catenulata*, and a new species of *Orthis*. To these may be added some peculiar species of univalves and six or seven species of bivalves which occur neither in the Caradoc of Sir R. Murchison nor in the Coniston limestone.

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The anomalous position of the masses has been probably caused by great faults and partial dislocations. I here subjoin a comparative view of the fossils in the Upper and Lower Silurian rocks of the country here described.

*Comparative view of the Fossils in the Upper and Lower Silurian
Rocks of Westmoreland.*

Orders.	Species peculiar to Upper Silurian.	Common species.	Species peculiar to Lower Silurian.
Pisces	3 ?	—	—
Cephalopoda	17	1	3
Gasteropoda, Pteropoda, &c.	17	1 ?	2
Lamellibranchiata	34	—	—
Brachiopoda	15	2	19
Tunicata	2	—	1
Crustacea	5	1	11
Annelida	4	—	3
Echinodermata	4	—	2
Zoophyta	7	5	11
Total peculiar to Upper S.	108	10	52
— common species	10		
— peculiar to Lower S.	52		
Welch.			
170 + 180 = 350 species { in North Wales and			
To these may be added from other localities } 150 species. Westmoreland.			
about			
Probable total of British Silurian species } 500*			
described			

When it is considered what a fossil impress is given to these old rocks by the Cephalopoda, Gasteropoda, Lamellibranchiata and Brachiopoda, and that of these four families we have eighty-three species in the Upper Silurian rocks, and twenty-four in the lower, and only three species in common, the list shows a most marked difference between the two systems. On the whole, the list indicates a progress towards a higher organic structure as we ascend from the lower to the upper rocks. Again, the Crustaceans peculiar to the old rocks began in the earliest time, reached their maximum of development at a very early period, and then began to decline, so as not to pass the carboniferous epoch. Lastly, I may remark that the difference indicated in the list between the Upper and Lower Silurian fossils of the Lake mountains is probably greater than will be found true on further examination; because most of the fossils have been derived from the two extremes of the general section, viz. No. 1 and No. 5 of the tabular list, the intermediate parts not having been so well explored by the fossil collectors.

In confirmation of the preceding view, I subjoin another interesting table, supplied by Mr. Salter from Sir R. Murchison's descriptive lists.

* Several new species have been discovered since this list was made out.

Synopsis of the Silurian fossils as given in Sir R. Murchison's Work.

Of 267 species of *Mollusca* and *Articulata* described from the Silurian rocks,

106 are found in the Ludlow series, and 83 are peculiar to it.

55	"	Wenlock limestone,	"	30	"
41	"	Wenlock shale,	"	21	"
75	"	Caradoc,	"	40	"
39	"	Llandeilo flags,	"	15	"

	Species common to the various parts of the series in the				
	Ludlow.	Wenlock limestone.	Wenlock shale.	Caradoc.	Llandeilo flags.
Ludlow rocks	19	15	2	1
Wenlock limestone.....	19	...	15	7	3
Wenlock shale.....	15	15	...	10	5
Caradoc	2	7	10	...	20
Llandeilo flags.....	1	3	5	20	

NOTE.—In this synopsis the corals are rejected as too widely spread; the Crinoidea as being imperfect, and therefore difficult of identification, except in the Wenlock limestone; so that Trilobites and shells only are taken for the comparison.

It appears from the other tables, that out of fifty-five species in the Wenlock limestone, nineteen are common to the Ludlow series and fifteen to the Wenlock shale; and that out of forty-one species in the Wenlock shale, fifteen are common to Lower Silurians, ten being Caradoc and five Llandeilo species.

6. If we take the Wenlock limestone and Wenlock shale together, we have only sixty-four species, nineteen in common with Ludlow rocks and nineteen with the Lower Silurians; or in other words, about one-sixth of the whole Ludlow series, and more than one-fourth of the Lower Silurians. The Wenlock series is therefore truly intermediate; but it is very imperfectly represented in the north of England for want of any rich bands of limestone of the Wenlock age.

To the comparisons I have instituted in former communications between the Upper Silurian series of Westmoreland and North Wales I have little to add. The lower part of the Denbigh flags appears to be exactly on the same level with the Coniston flags (No. 2), and the whole development of the Upper Silurian rocks in North Wales (with many points of local difference) has many points of general resemblance. The sequence in Westmoreland is however more perfect than in North Wales, and in neither county is the development at all resembling that of Siluria. Beautiful as the sequence of that county is, it is not the true mineral type either for England, Wales, or Ireland. As a general rule, I believe that all limestone bands below the carboniferous series are mere local phenomena, appearing at intervals, which are perfectly irregular in countries remote from one another. This remark is meant to include Devonian limestones, and all Silurian limestones, both upper and lower, and many other limestones far below those which mark the beautiful sections of Siluria. Hence we can only identify large subdivisions; and any attempt at the comparison of subordinate parts must often end in positive error. Whether this remark applies to the older rocks of

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North America, I do not presume to judge; but it applies to the general European type as far as I have any knowledge of it.

South of the Berwyn chain and the valley of the Upper Severn, the comparison of the Westmoreland sections with the Upper Silurian rocks is more difficult. They there appear partly as flagstones, but more generally as coarse greywacke and greywacke slate, in vast alternating masses thrown into continual undulations. These undulating masses run far towards the south, and, if I mistake not, cover very large tracts of the higher parts of South Wales. Mineralogically they are almost identical with the hard grits (No. 3) and the Ireleth slate (No. 4) of the sections of Westmoreland and North Lancashire. I formerly identified them in the countries above mentioned under the name of Upper Cambrian. During the past summer, Mr. Salter, at my suggestion, paid a visit to the part of Wales last indicated, and the result of a traverse he made from the neighbourhood of Builth to Aberystwyth was rather negative than positive. He found hardly any fossils*; and he was thus unable to separate the great series of undulating strata, including Plynlimmon, from the undulating grits and slates at the south end of the Berwyn chain. This was what I expected, and what I had before affirmed as probable; and it induces me to place (at least provisionally) all the Plynlimmon system among the Upper Silurian rocks of Sir R. Murchison; and I believe (though I must acknowledge upon a very imperfect examination, carried on only during a few days in 1832) that the same upper rocks extend much farther south, and occupy by far the greater part of the higher regions of South Wales; of course excluding from this remark the country of the Old red sandstone and the carboniferous series. But how reconcile this with the statement more than once made by Sir H. De la Beche, that the *Llandeilo flag* was repeated more than once in the undulations of South Wales, and far to the north of the line of Llandeilo flag drawn on Sir R. Murchison's map? The answer to this question involves another—what is the age of the Llandeilo flag?

Sir H. De la Beche has stated repeatedly that the *Asaphus Buchii* is found in some parts of South Wales among Wenlock shale fossils: and among the highest beds of the Caradoc sandstone, just where at Mathyrafal it passes into the upper flagstone, Mr. Salter, in the year 1843, pointed out to me three or four good Wenlock shale fossils, which also occur in the Llandeilo flag†.

* A Lower Silurian *Pleurotomaria* however occurred at Dol-fan.

† The following species are common to the Mathyrafal series and the Llandeilo beds:—

<i>Orthis lata.</i>	<i>Atrypa lens.</i>
<i>Atrypa crassa.</i>	<i>Leptæna transversalis.</i>
— <i>undata.</i>	— sp. n.
— <i>globosa.</i>	

The following are common to Wenlock and Llandeilo beds:—

<i>Orthoceratites subflexuosum.</i>	<i>Leptæna euglypha.</i>
— <i>annulatum.</i>	— <i>transversalis.</i>
<i>Orthoceratite.</i> A smooth species (s. n.).	<i>Calymene Blumenbachii.</i>
<i>Lituites Cornu Arietis.</i>	<i>Trinucleus Caraciaci.</i>
<i>Leptæna depressa.</i>	<i>Paradoxites bimucronatus</i> , &c. &c.

At the time, this surprised me greatly; but the fact is quite in harmony with the statements of Sir H. De la Beche. All the sections of the Silurian system south of the Severn are made on the hypothesis that the mountains on the north-west side of the lines of section are older than the Silurian rocks. Now, as a general rule, this hypothesis is not correct, and it in some measure vitiates the base-lines of the several sections, and so destroys a part of their meaning. But the section at the east side of the Berwyns, ending with Craig y Glyn, is appealed to by Mr. Murchison as proving the low position of the *Asaphus Buchii* and the Llandeilo flag. For several years I myself put this interpretation upon the section in question. But since a doubt has arisen about the age of the Llandeilo flag, Mr. Salter has re-examined the specimens both from Craig y Glyn on the east flank of the Berwyns, and also from one or two localities near Grat Arrenig and in the Rhiulas limestone; and he now retracts his identification of any of the fragments with *Asaphus Buchii*. The only fragments he can identify belong to *Asaphus tyrannus*, which certainly has a very low range among the fossiliferous slates. The evidence therefore supplied by my sections in North Wales gives us no help in determining the age of the Llandeilo flag. Mr. Salter also examined during the past summer one or two sections of the Silurian series of South Wales. I cannot give his remarks in detail; but I may state the result of them. They go to prove either that the Llandeilo flag is not inferior to the Caradoc sandstone (*e.g.* at Builth), or that it is associated with the upper part of it, a part containing several fossils of the Wenlock shale or limestone. Hence, coupling these remarks with what has been stated by Sir H. De la Beche, I should class the Caradoc sandstone and Llandeilo flags of South Wales, the Caradoc sandstone of the Malverns, that on the south-east side of the Berwyns, and lastly, the fossiliferous bands of Glyn Ceiriog and Mathyrafal, all in one group, and compare it with that of the Coniston limestone; perhaps including with the Coniston limestone also the Coniston flags*. If this view be correct, we cease to be surprised at finding the Llandeilo flags among the great folds and undulations of the Upper Silurian rocks of South Wales. The *Calymene Blumenbachii* ranges from the Ludlow and Wenlock limestone down to the rocks under the Caradoc sandstone, &c. The *Trinucleus Caractaci* is a most abundant Caradoc sand fossil, yet it ranges into the Wenlock shales under Wenlock Edge; and were I to seek for the *Asaphus Buchii*

* Of 45 species of Trilobites and shells found in the Llandeilo flags—

3 are Wenlock species exclusively.
10 common to Wenlock, and the Glyn Ceiriog and Mathyrafal series.
10 Mathyrafal and Glyn Ceiriog.
1 Coniston only.
1 Irish Wenlock—Kerry.
5 found in the Caradoc.

—
30, leaving 15 as peculiar to it.

Only 9 Coniston species are contained in the Llandeilo series. The additional species were added by myself (39 is Sir R.M.'s number) at Builth last year.—J.W.S.

in the Cumbrian mountains, it would be among the flagstones associated with or overlying the Coniston limestone*.

Though there are several remarkable species of mollusca and crustacea common to the Wenlock, Caradoc and Llandeilo series, there are other beds far below them which, I believe, contain none of these common species. These beds are subordinate to the most remarkable physical group of England. I have in former papers called it the *Protozoic group*; or the lowest and greatest division of the rocks with Lower Silurian fossils. Now that I have no evidence of the existence of *Asaphus Buchii*, and other Llandeilo characteristic fossils in this vast group, I am no longer embarrassed for its name. I cannot speak of a *Cambrian system*, with peculiar fossils found in no other; but I may speak of the lower or great *Cambrian group*; and it is, I think, on very probable evidence, placed on the same level with the green slates and porphyries of Cumberland, which I once called the great *Cumbrian group*. In this great Cambrian group began the lowest fossil species we know in the British Isles. Many of the lowest species lasted throughout the whole Lower Silurian period; but new species were added, as conditions gradually changed, during the epochs marked in the ascending sections; so that the lower fauna reached its maximum of development in the Caradoc sandstone and Llandeilo flagstone. Afterwards the fauna underwent a much more rapid change, certain tribes of *Brachiopoda* diminishing in numbers, and being replaced by other forms, while, as far as our evidence goes (at least in the north of England), the *Lamellibranchiata*, though beginning low in the Cambrian group, also formed a more important part of the fauna of the Upper Silurian rocks. Geology tells us of the successive revolutions and changes in the crust of the earth. Organic changes are our surest guides in making out this history; but they form only a part of our evidence, and the great physical groups of deposits, however rude and mechanical, are historical monuments of perhaps equal importance in obtaining any true and intelligible history of the past ages of the earth; and after we have descended through a certain number of stages, they become indeed our only monuments and indexes of past events. This is true in North Wales,

* Of the Coniston Lower Silurian fossils (including Helms Gill, &c.) we find in North Wales—

Peculiar to the Bala limestone and beds below it.....	6 species.
Common to the Bala series and the passage beds.....	16 „
Peculiar to the passage beds	17 „
Peculiar to Westmoreland	21 „
	—
	60

By 'passage beds' are meant the highest beds of the Caradoc sandstone (*e.g.* those of Glen Ceiriog, &c.), which form a passage into the Upper system.

Of the 21 species which are peculiar to this series in the north of England, two occur in the beds on top of the Berwyns (Rhiwargor); two in Ireland, in beds referable to Wenlock limestone and shale; and three are characteristic Wenlock fossils, namely *Cyathophyllum cespitosum*, *Cornulites serpularius*, *Tentaculites ornatus*.

Of course this list is not absolute; and the probability is, I think, that there will be no species "peculiar to the Bala series" when we know more.—J. W. S.

and still more emphatically in Cumberland, where the Skiddaw slate is without fossils.

Taking the whole view of the case therefore as far as I know it, I would divide the older palæozoic rocks of our island into three great groups—each (in local descriptions) to be further subdivided. They would then stand thus :—

3rd, Upper group, or *exclusively Upper Silurian*.

2nd, Middle group, or *Lower Silurian*, including Llandeilo, Caradoc, and perhaps Wenlock.

1st group, or *Cambrian*.

This arrangement does no violence to the Silurian system of Sir R. Murchison, but takes it up in its true place ; and I think that it enables us to classify the old rocks in such a way as to satisfy the conditions both of fossil and physical as well as of mineralogical development.

The general conclusions which I obtain from the details given in the former paper and the present one are briefly these :—

The fossiliferous slates, extending from the Coniston limestone to the valley of the Lune, are subdivided into five formations or primary groups.

5. Coarse slates, generally without transverse cleavage planes, grits, flagstones, &c., divided into three sub-groups.

γ. Greenish-grey and red flagstones (*tilestone*).

β. Grits and slates without true cleavage planes, with numerous Upper Ludlow fossils.

α. Coarse slates passing downwards into 4 δ.

4. A formation of very great thickness (*Ireleth slates, &c.*), divided, for convenience of description, into four sub-groups :—

δ. Coarse slates and grits,—often passing into the structure of the lower sub-groups, and not to be separated from them.

γ. Upper or great Ireleth slate zone.

β. Upper limestone.

α. Lower Ireleth slates.

Respecting the upper part (δ) of this great formation there is no difference of opinion. It contains beds of *Terebratula navicula* and several other well-known Lower Ludlow fossils ; and has already been compared, in a general way, with the Lower Ludlow rocks, both by Mr. Sharpe and myself.

3. A great deposit of hard gritty beds, sometimes even approaching a conglomerate form, with subordinate slaty masses, and with numerous large spherical concretions arranged parallel to the beds. The fossils are very rare in this group, but among them are *Graptolites ludensis*, *Cardiola interrupta*, *Orthoceras ibex* and *O. subundulatum*. All the species are Upper Silurian.

2. *Coniston Brathay flagstone*. Thickness roughly computed at 1500 feet. Its most characteristic fossils are *Graptolites ludensis*,

Cardiola interrupta, *Orthoceratites* (including *Creseis*), and a few *Trilobites*. The species are all Upper Silurian,—using that term in the sense given to it by Sir R. Murchison. The mineral structure of this formation is almost identical with that of the Upper Silurian flagstones of the Lower Severn, described by Sir R. Murchison, and still more exactly identical with the lower Denbigh flagstones described in my paper on North Wales.

1. *Coniston limestone and calcareous slate*. On an average not more than 200 or 300 feet thick; at a maximum (in Millam) about 600 feet thick. The fossils of this group are Lower Silurian, and I need not repeat the well-known list of species.

The whole series is overlaid unconformably by the old red sandstone and mountain limestone.

Note.—It is right to state that in this paper the localities of Wenlock fossils and those of Llandeilo flags, &c., are taken from Sir R. Murchison's descriptions (excluding Marloes Bay). One or two species were added from Builth by myself.—J. W. S.

2. *On the Strata called "JACKSTONES" at MERTHYR TYDVIL.*
By JOS. DICKINSON, Esq., F.G.S.

CONSIDERING these stones in connexion with the ironstones and other strata with which they are associated, they are chiefly remarkable for the peculiarity of their structure and the great quantity of carbonate of lime which they contain. Few of the ironstones and scarcely any of the other strata in the coal-measures in this locality contain five per cent. of carbonate of lime, whilst these Jackstones contain forty-five.

Their usual structure is conical, the stones being made up of a series of distinct cones with serrated edges inserted into each other, having the apex of each cone directed towards the top of the stratum, although this is not invariably the case. The height of the cones is various, but those most perfectly formed seldom exceed four inches. Towards the upper and lower surface of the stratum, the conical structure frequently disappears and an even arrangement ensues.

These stones are disposed in seams similar to those of clay ironstone. They are of a brown and sometimes of a grey colour. They generally lie underneath and in contact with ironstone, and occasionally they intervene as a band in the middle of a seam, in which case, as well as in the former, there is generally a distinct line of division at the junction of the two stones. In many examples, however, the two stones blend imperceptibly with each other.

The thickness of a stratum of Jackstones seldom exceeds nine inches, and probably not more than three or four different strata could be enumerated in one section. They are generally situated amongst the ironstones lying below the workable coal-seams, the lowest of which is about 210 yards above the mountain limestone.