that the gold-fields of nature, however rich along certain zones, were necessarily limited by such conditions.

Note.—Having above given the date of the publication in which I compared the "Australian Cordillera," then so named by me (1844), with the Ural Mountains, and that of my invitation to the Cornish miners to work for gold in that Cordillera (1846), I beg to state that English geologists are unacquainted with any other printed documents relating to Australian gold, *excepting my own*, anterior to a notice, by Mr. Clarke, of September 1847, in the Sydney Herald. That comparison of his of Australia with the Ural was, it will be observed, *three years and four months after* my publication on the same topic. His letter to me, an extract from which I gave in the Quarterly Review of September 1850, was long subsequent to his notice of 1847.—[R.I.M.]

February 25, 1852.

The following communication was read :—

On the Classification *and* Nomenclature *of the* Lower Palæozoic Rocks *of* England *and* Wales. By the Rev. Prof. Sedgwick, A.M., F.R.S., G.S.

§ 1. *Cumbrian Series.*

In a former paper*, of which this is a continuation, I endeavoured to ascertain the geological place of some groups of slate-rocks which are seen in certain parts of Westmoreland and Yorkshire near the base of the carboniferous limestone; and I endeavoured to show that the several groups which appeared on one or more of the sections were the equivalents, respectively, of the *Coniston limestone*, the *Coniston flagstone*, the *Coniston grits*, and the *Ireleth slates*, &c. These equivalents are well known, having been described by myself in former published papers†. But a new question may arise respecting their true place in the lower divisions of the whole palæozoic system. In the Cumbrian cluster of mountains, the whole series of deposits below the Old Red Sandstone has been long separated into three great physical subdivisions; the lowest of which included the Skiddaw slate; the middle was represented by a vast development of green slate and porphyry; while the highest included all the rocks of Westmoreland and Lancashire, from the calcareous slates of Coniston to the highest beds that were overlaid by the old red conglomerates, or were covered by the beds of the great Scar-limestone. Such were Mr. J. Otley's three physical groups; and they were adopted as the basis of classification by myself and others who followed him.

So soon as I became acquainted (in 1831 and 1832) with the rocks

* Quart. Journ. Geol. Soc. vol. viii. pp. 35–54.

† See papers, Proc. Geol. Soc. vol. i. p. 399 (*Cumbria*); *ibid.* vol. ii. p. 675 (*Cumbria and N. Wales*); *ibid.* vol. iii. p. 541 (*Cumbria and N. Wales*); *ibid.* vol. iv. p. 212 (*N. Wales*); *ibid.* p. 251 (*N. Wales*); *ibid.* p. 576 (*N. Wales and Cumbria*); Quart. Journ. Geol. Soc. vol. i. p. 5 (*Cumbria*); *ibid.* p. 442 (*N. Wales and Cumbria*); *ibid.* vol. ii. p. 106 (*Cumbria*); *ibid.* vol. iii. p. 133 (*N. Wales and Cumbria*); *ibid.* vol. iv. p. 216 (*Cumbria*).

of the upper and lower Cambrian series*, I hesitated not to identify the Coniston with the Bala limestone; and in a short published scheme† I endeavoured to bring all the rocks, from the Coniston limestone to the Ireleth slates inclusive, into a provisional comparison with my upper Cambrian groups; viz. those groups which, at the south end of the Berwyn chain, are superior to the Bala limestone; and are thence sent off, in great undulations, and form the physical groups of a considerable portion of South Wales. This scheme I now believe to have been very nearly right; and it would have been perfectly right had I not included the Ireleth slates among the equivalents of the so-called upper Cambrian system‡.

During a subsequent year (1841), on my return from Scotland, I paid a very short visit to some of the Westmoreland quarries. Nearly all my old collections (the accumulations of more than twenty years) were at that time inaccessible to myself; but having procured some good Coniston fossils, and having received, from my friend Mr. James Marshall, a still better series, they were carefully examined; and, almost species by species, they agreed with the Silurian fossil lists of the Caradoc sandstone. Nor was this all the evidence on which I then modified my first classification§. The Coniston limestone and calcareous slates appear to pass into the Coniston flagstone by almost insensible gradations; and the flagstone contains *Graptolites* which I referred (perhaps erroneously) to the species *Ludensis*; and in many different places it contains whole beds of *Cardiola interrupta*, and a few other species, which are among the characteristic lists of the upper Silurian rocks. This evidence appeared at that time to be irresistible; and I so far modified my first attempt, that I no longer brought the Coniston and Bala limestones into immediate comparison, but considered the Coniston limestone as the exact equivalent of the Caradoc sandstone. *On this hypothesis* the whole series of rocks (Mr. J. Otley's third great physical subdivision), from the Coniston limestone upwards, formed the *exact equivalents* of Sir R. I. Murchison's Silurian groups, from the Caradoc sandstone to the upper Ludlow rocks inclusive.

I need not detain the Society by any further reference to papers, abstracts of which were published during former years; but it was obvious, from the first, that the Coniston limestone was a bad *physical equivalent* of the Caradoc sandstone; and, on the scheme here

* By Cambrian series was understood the whole great undulating series between the Menai and the edge of Shropshire. Lower Cambrian on my first scheme included all the rocks west of the Bala limestone. Upper Cambrian included the Bala limestone and all the slate-rocks above it. In the present paper the Upper Cambrian series (or great Bala group) is made to commence at a considerably lower level; viz. with the black slates immediately on the east side of the porphyritic beds of the Great Arenig. In this way we avoid an ambiguity arising from the difficulty of tracing the exact equivalent of the Bala limestone through South Wales; and the great undulating system south of Cader Idris and east of Cardigan Bay becomes at once comprehended in the Upper Cambrian series.

† Proceedings Geol. Soc. vol. ii. p. 678.

‡ It appears that the Ireleth slates are very nearly the equivalents of the Wenlock shale.

§ Proceedings Geol. Soc. vol. iii. p. 551.

alluded to, the Coniston grits had *no physical representative* among the typical upper Silurian groups. I ascertained, moreover, in the year 1845, that the Coniston limestone, at its south-western extremity, was actually so interlaced with the green slates and porphyries of the great central system of the Cumbrian mountains, that it could not, at least on physical evidence, be separated from them. Hence I gradually came back nearly to my first interpretation of the phænomena.

The Coniston limestone I again considered as a true Cambrian rock, and the equivalent of the Bala limestone; and its fossils have within the last three or four years been arranged by Professor M'Coy in conformity with this view. But the Cardiola-flags still presented a great difficulty, as I had never seen the *Cardiolæ* but among rocks supposed to be upper Silurian: and, if possible, to clear away this difficulty was one of my objects in my visit, during the past summer, to the flagstones near Horton in Ribblesdale.

On writing to Professor M'Coy on the propriety of classifying the Coniston flags with the upper Bala group, and the Coniston grits with the Caradoc sandstone, I had a reply in which he used the following words:—"I by no means think that we have yet fossil evidence enough for *determining zoologically* the age of the flags and grits in question; nor the age of similar beds in a few other localities which in our MS. lists stand as doubtful; and I am glad you are collecting more evidence. Meanwhile your field-impressions, I have little doubt, will prove correct." At the same time I may remark, that neither he nor I had a shadow of doubt that the Coniston limestone was the equivalent of the Bala; and this conclusion necessarily influenced our opinion respecting the age of the Coniston flags and Coniston grits. If the Coniston limestone and flagstone *could* be brought to the parallel of the upper Bala groups, it followed almost of necessity that the Coniston grits, geologically and physically, must be the exact equivalents of the Caradoc sandstone; and thus would a great physical difficulty be removed; and the Westmoreland series would agree, stage by stage, with the successive groups in North Wales, and with the successive stages of the Silurian rocks, as they had been made out by the author of the 'Silurian System.'

Knowing the importance of these determinations, I engaged, during last autumn, my friend John Ruthven to re-examine, at his leisure, all the fossil-bearing quarries in the Coniston grits and flags; and I hope, before long, to receive from him such a series of fossils as will settle the zoological evidence bearing on the exact age of the two last-mentioned groups, and put an end to any remnant of doubt as to that essential point.

About five weeks after my return to Cambridge I received (Nov. 6, 1851), unexpectedly and to my great pleasure, a note from Mr. Salter (on whose authority the lists of Westmoreland fossils given in my previous papers, in 1845–1846, had been made out*), containing the following critical remarks:—"In your most complete list of

* See also 'Letters on the Geology of the Lake District.' Hudson, Kendal, 1842.

fossils from the Coniston (or Brathay) flags I find the following:—1. *Cardiola*. 2. *Creseis* (*Orthoceras*). 3. Large *Orthoceratites*. 4. *Graptolites Ludensis* (now *G. priodon*). 5. *Astræa ananas*. 6. *Asaphus* (*Phacops*) *caudatus*. 7. *Atrypa compressa*." I may remark, that when this list was examined and determined, these flags were regarded as upper Silurian, and nearly on the parallel of the Wenlock shale. "Let us now (adds Mr. Salter) examine these fossils with a view of putting them in the upper Bala groups. I should not now call them upper Silurian.... For *Cardiola* (1.) occurs in Llandeilo flags at Builth; *Creseis* (*Orthoceras*) (2.) is plentiful in Llandeilo flags; large *Orthoceratites* (3.), species not named, prove nothing, and large smooth species, from what we know of the Scotch series, are quite as characteristic of older rocks; *Graptolites priodon* (4.) is known to be plentiful in Llandeilo flags; *Astræa ananas* (5.) is also found in Coniston limestone; *Phacops obtusicaudatus* (6.) is described, in my appendix to your second Fasciculus of the 'Cambridge Palæozoic Fossils' (now in the press), as a perfectly distinct species, allied to *Phacops caudatus*; *Atrypa compressa* (7.) I do not now know. So you see every quoted species may be as well, nay better, interpreted as belonging to Bala beds...."

He then shortly notices the very meagre list of fossils derived from the Coniston grits, viz. *Cardiola* and *Orthoceratites*; and he adds, "As *Cardiola* is so plentiful in the Coniston flags, no wonder it should often occur in the grits; and as for the *Orthoceratites*, they prove nothing against the grits being Caradoc. The species, if named rightly, is *O. Ibex*, and this occurs in the Coniston limestone; but the grit specimens are not good.... We now know how barren the Caradoc sandstone often is; and that (in Westmoreland and Cumberland) it should contain some fossils from the beds below, is no wonder." The previous quotations from Mr. Salter's letter are given (as far as possible) word for word; and are perfectly to the point.

To avoid all doubt, I sent the previous list of seven species, with an additional query respecting *Orthoceras Ibex*, to Professor M'Coy, who is now in Ireland, in order that he might inform me how he had determined their geological place in the second Fasciculus of the 'Cambridge Palæozoic Fossils.' The proof-sheets of this work have for several months been under revision; the plates and catalogues were finished during the past summer; and the whole work, but for the, perhaps unavoidable, delays of the University Press, would before this time have been published.

His reply (dated Nov. 12, 1851) contains the following critical remarks:—"1. As to *Cardiola interrupta*, you have it, from the black shales north of Builth (Llandeilo group), in your museum. 2. Of the other Coniston flag fossils, *Creseis* (so called) is common enough in the same black shales (Caradoc shale). 3. *Orthoceratites* prove nothing, the species being undetermined. 4. *Graptolites Ludensis* (not *G. priodon*) occurs from the Scotch graptolite-slate up to the Ludlow. 5. *Astræa ananas* (so named in your list) has no generic or specific relation to that Wenlock species. It is a species of Linné, *Sarcinula organum* (first described as British in 'Camb.

Fasc.' p. 37), and is extremely common in the Coniston limestone localities, and not found higher by you. 6. The *Asaphus caudatus* of your list is not that upper species, but is totally distinct. It has been described and figured (*Odontochile obtusicaudata*, Salt. sp.) in the 'Camb. Fasc.,' p. 161, and is very common in the Bala limestone and flags of Coldwell (Coniston group), and not known in any higher position. 7. The *Atrypa compressa* of your list I found so labelled in your collection. It has, however, no generic or specific relation to that fossil, but is the *Siphonotreta Anglica*, Mar., the only other known specimens of which were found in the Wenlock shale. Therefore this fossil list, as now examined, supports your views; for those (very few) upper Silurian species which were correctly identified from the first are well known to exist also in the undoubted Bala beds and Caradoc shale with *Trinucleus*, *Ampyx*, and other characteristic Cambrian forms." I may just remark that Prof. M'Coy has in the first instance used the words *Caradoc shale* incorrectly; for I have never used these words to describe any black shales (although such do sometimes appear) under the Caradoc sandstone. The black shales north of Builth are undoubtedly a part of the Llandeilo or Bala limestone group. "As to the *Orthoceras Ibex* (he adds), the specimens I have named in your museum prove that it occurs, in my opinion, from the *Upper Ludlow* to the *Coniston limestone* inclusive." These determinations had been made by Prof. M'Coy, without a view to any previous hypothesis; and seem also to be conclusive as to the age of the *Coniston flags*. On this point, he and Mr. Salter are in perfect agreement.

Should I receive any new information during this spring respecting the fossils of the Coniston grits, I shall rejoice to communicate it to the Society. But I have now no doubt respecting the true sequence of the deposits between the central group of Cumberland and the Old Red Sandstone. The successive deposits, when arranged in the following corrected order, agree physically and zoologically with the whole sequence of North Wales—Cambrian and Silurian.

Ascending section from the centre of Skiddaw Forest to the Carboniferous Limestone near Kirkby Lonsdale.

1. *Granite*; in some places sending veins into the overlying metamorphic Skiddaw slate.
2. *Metamorphic slate*; near its base resembling, but never a true, gneiss; quartz-rock; mica-slate; chiastolite in mass; chiastolite-slate gradually passing into a dark glossy clay-slate, &c. &c. It is traversed near the granite by many poor metalliferous veins containing abundantly many well-known Cornish minerals, such as wolfram, schorl, apatite, &c.
3. *Lower Cumbrian group, or Skiddaw slate*; of very great thickness. Prevailing rock a dark glossy clay-slate that does not effervesce with acids. Many coarser beds, irregularly distributed, very rarely as coarse as millstone grit. Fossils very rare—*Fucoids* and *Graptolites*. No shells found in it.

4. *Upper Cumbrian group.* (1.) Great stratified contemporaneous masses of porphyry, trappean conglomerates cemented by felstone-porphyry, trappean shales (*schaalstein*)—all frequently alternating with great beds both of coarse and fine chloritic slate; altogether of enormous thickness.
   (2.) *Coniston limestone* and calcareous slate; partly interlaced with the top beds of the preceding. Thickness 200 or 300 feet.
   (3.) *Coniston flagstone*; in its upper beds containing here and there some thin calcareous bands. Thickness about 1500 feet.
   Of these three sub-groups, (1) represents the lower Cambrian rocks of N. Wales; (2) and (3) represent the Bala limestone and the beds over it; and therefore represent, though on a rather degenerate scale, the upper Cambrian groups of North and South Wales.
5. *Coniston grits.* Thickness variable; on the average, not perhaps less than 1500 feet. The exact equivalent of the Caradoc sandstone—the lowest group of which the true relations are made out in the sections of the 'Silurian System.'
6. *Ireleth slates*; composed, in the ascending order, of—(1.) Dark calcareous slates. (2.) Calcareous slates with concretionary bands of limestone. (3.) Upper Ireleth slates. Collectively of great thickness; and the near equivalents of the Wenlock shale and limestone.
7. *Coarse slate, flags, grits, &c.*; not physically well separated from the preceding group of Ireleth slates; but higher in the section, and therefore approximately the equivalents of the lower Ludlow rocks, and of great thickness.
8. *Rocks of Kirkby Moor.* The highest group of the series. Fine and coarse flagstone, coarse bands of slate, grits, red flagstone, &c. It is the equivalent of the *upper Ludlow rocks and Tilestone*, and abounds in *upper Ludlow fossils*.
9. Old red sandstone.
10. Carboniferous limestone.

This arrangement may be more clearly shown in the accompanying table:—

Palæozoic Rocks of Cumbria.

			ft.*	
Carboniferous Limestone.				
Old Red Sandstone.				
Silurian Series.	Flags and grits of Kirkby Moor		800	= Upper Ludlow.
	Coarse contorted slate and gritstone		800	= Lower Ludlow.
	Ireleth slates.	Upper Ireleth slates	500	= Wenlock group.
		Lower Ireleth slates. Calcareous slates	80	
		Lower Ireleth slates. Dark slates	200	
	Coniston grit		2000	= Caradoc sandstone.
Cambrian Series.	(Upper Cumbrian.)	Coniston flagstone	1500	= Upper Cambrian (Bala, &c.) of N. Wales.
		Coniston limestone	300	
		Slates and porphyry	10,000	= Lower Cambrian of N. Wales.
	(Lower Cumbrian.)	Skiddaw slates	6000	
Metamorphic slates.				
Granite.				

* These are given merely as approximate measurements.

The previous arrangements are not without their importance; for in consequence of the general absence of fossils among the Cumbrian slates and porphyries, one might have started the hypothesis, that these slates and porphyries were but an exaggerated development of the upper Cambrian groups, and that the Skiddaw slate was only an expansion of the dark slates at the bottom of the Bala group. Such, indeed, was an hypothesis suggested to me, in conversation, by M. Barrande; but it is clearly untenable.

The descending sections of Cumberland, commencing with the Coniston limestone, are far more vast than the sections of Wales below the Bala limestone; although we include therein the most deeply seated stratified rocks within the limits of the Principality.

§ 2. *Sections of May Hill, Horderley, and Woolhope, &c.*

During the past summer I had the great advantage of visiting a part of the typical Silurian country under the guidance of my friend the Rev. T. Lewis; and, at the time, I had not the remotest hope of adding, during a very short visit, any scrap of information worth recording after the ample details published by Sir R. I. Murchison and Professor Phillips. My only hope was that I might add a few good fossils, new or old, to the Cambridge Museum. I may, however, be permitted to remark, in passing, that the colour for the Caradoc sandstone ought in some places to be a little more extended than it was upon the original map of the 'Silurian System,' for immediately overlying the Caradoc sandstone of the Horderley section is a shale, with abundant specimens of *Ampyx* and *Trinucleus*, which runs down to the bridge over the Onny a little below Cheney Longville. This, perhaps local, deposit might, I think, be conveniently called Caradoc shale; and my occasional use of this term, during past years, has, I suspect, led Professor M'Coy into the slight verbal mistake to which I before alluded.

Again, it seemed, from the copious details published by Professor Phillips, that there were some other doubtful lines of demarcation even among the most typical Silurian groups. To determine any of these minute and critical questions would have required a detailed examination, for which I had no leisure; but I did collect, with the help of Mr. Lewis, a small but good series of fossils from the highest beds of the May Hill section, which rise immediately from beneath the undoubted Wenlock group. This series, determined by Professor M'Coy, was as follows:—

(1.) *Halysites catenulatus* (Dudley).
(2.) *Encrinurus punctatus* (Dudley).
(3.) *Pentamerus microcamerus.*
(4.) *Leptagonia depressa* (Dudley).
(5.) *Leptæna transversalis* (Dudley).
(6.) *Orthis turgida* (?).
(7.) *Spirigerina reticularis* (Bala to Devonian).
(8.) *Strophomena pecten* (Dudley).
(9.) *Hemithyris navicula* (Ludlow).
(10.) *Euomphalus funatus* (Dudley).

In reply to some questions, arising out of this list, he writes as follows:—"Of the above ten species all but two are common Dudley species. One of these two seems to be very local, and the other is of doubtful identification. All the corals, of which I have unfortunately mislaid the list, are Wenlock species; and several of them have not hitherto been described from any lower beds. Several of the above shells are also found in the Caradoc and Bala rocks; but some of them (as *Euomphalus funatus*—very abundant at May Hill—and *Hemithyris navicula*) are not. Lastly, I have not yet found in your May Hill series, *Leptæna sericea*, or any of those *common* Caradoc or Bala fossils which may be considered as characteristic, because not also found in the Dudley and Wenlock series." Shall we then, in such a case as this, strike off the upper beds of the Caradoc group, and pack them with the overlying group under some new name, such as Wenlock-grits? Provisionally I will accept what appears to be Professor Phillips's interpretation of such phænomena; viz. that the faunas of the two groups are not separated by any well-defined geometrical line, but rather by an ambiguous boundary, near which each fauna occasionally overlaps the other. But the above facts do seem to show that the Caradoc group (the lowest Silurian group ever made out stratigraphically by the author of the 'Silurian System') was the true connecting link between the Silurian and Cambrian series.

Lastly, I may shortly notice another minute question, before I go on to more general considerations. In 1846 I spent a few hours with Dr. Davis in looking at the sections near Presteign; and I expressed an opinion that the Presteign limestone must be the equivalent of that at Woolhope. I did not then remember the place assigned to it by Sir R. I. Murchison. Not long afterwards my friend Mr. Davis read a paper before the Society *, in which he briefly alluded to, and controverted, my verbally expressed opinion. In reply, I at the time stated the grounds on which I had arrived at it; viz. that the Presteign limestone *rested immediately on the Caradoc group*, without the intervention of any distinct argillaceous deposit; and that the same limestone was *overlaid by an argillaceous deposit*, which seemed very well to represent the Wenlock shale. The position of this limestone in the section seemed, therefore, to be exactly that of the Woolhope limestone. Mr. Davis also published a copious list of fossils from the Presteign limestone†; and as they agreed generally with the well-known Wenlock species, that fact was considered as almost conclusive in deciding the previous question.

Never having traversed the beautiful Woolhope sections since 1834, I was anxious to revisit them during the past summer; and in an excursion of a few hours, I examined, in company with Mr. Lewis, several of the quarries in the Woolhope limestone; and obtained from them the following fossils, which have been named by Professor M'Coy:—

Bumastus Barriensis (Wenlock).
Phacops caudatus (Wenlock).

* Quart. Journ. Geol. Soc. vol. vii. p. 432.

† *Loc. cit.* p. 437.

Spirigerina reticularis (Bala to Devonian).
Leptæna depressa (Bala to Carboniferous).
Strophomena euglypha (Wenlock).
Strophomena Pecten (Bala and Wenlock).
Homalonotus Delphinocephalus (Wenlock).
Cornulites serpularius (Wenlock and Ludlow).

Two conclusions seem to follow from such a list; first, that the fossil lists of the Presteign limestone (given by Mr. Davis), do not prove it to be of the Wenlock age; for by the same argument we might identify the Wenlock and Woolhope limestones, although actually separated from one another in the same section; secondly, that the Woolhope limestone might very properly have been called a lower Wenlock limestone, and that it cannot, with propriety, be considered as the highest sub-group of the Caradoc sandstone. These conclusions seem to be in accordance with the published views of Professor Phillips.

§ 3. *Comparison of the three great groups of the Lake Mountains, with the Cambrian and Silurian groups of North and South Wales.*

I will first enumerate (*in ascending order*) the several groups into which the whole Welsh series (Cambrian and Silurian) may, I think, be conveniently subdivided; and I may premise, that I consider all the palæozoic rocks, from the lowest Cambrian to the highest Permian, as one system—the primary or palæozoic system. This primary system admits of three great subdivisions; viz. a lower subdivision, including the Cambrian and Silurian series; a middle, including the Devonian series; and an upper, including the Carboniferous and Permian series. These three subdivisions belong to one great *systema naturæ*, the subordinate parts of which often pass one into another, by almost insensible gradations; although the species in the several subdivisions and subordinate groups often entirely, or almost entirely, change*. But the *primary system*, thus defined, differs entirely from the *systema naturæ* of the *secondary system*; and, in like manner, the *systema naturæ* of the secondary system differs almost entirely from the *systema naturæ* of the tertiary system. Lastly, we have the actual *systema naturæ* of the living world; but between the *tertiary system* and that of living nature no one has yet drawn any intelligible line of demarcation.

I do not pretend to answer a question, whether the primary, secondary, and tertiary systems may not, in progress of discovery, be at length brought in a similar intimate relation; neither do I discuss a question respecting the expediency of any further subdivisions of the secondary system. A good classification only represents the actual condition of our knowledge; and the following remarks relate only to the classification of the subordinate groups of the lower palæozoic system, as above defined. To avoid all verbal ambiguity, or

* This view of regarding all the Palæozoic rocks as of *one system* is not new. It has often been discussed in this Society; and it was formally advanced by myself in 1843.—*Proceed. Geol. Soc.* vol. iv. p. 223.

wrangling about the use or abuse of the word "system," I will provisionally separate the whole *lower palæozoic series* into two great natural subdivisions—Cambrian and Silurian; each of which may be again subdivided into a series of stages or groups, which, collectively, I here designate by the names CAMBRIAN SERIES and SILURIAN SERIES. The Cambrian and Silurian collective groups, thus defined, have a well-marked physical separation; and the Silurian groups are, not unusually, unconformable to the Cambrian: and although several fossils are common to the two collective groups, especially near the planes of junction, yet the fossils of the well-defined lower stages of the Cambrian series are very widely distinct from the fossils of the upper stages of the Silurian series. I believe that this is the case in Wales and Siluria; and I am certain that it is the case in the Cumbrian cluster of mountains. The fossils of the Coniston calcareous slates hardly reappear at all, and certainly not as a group, among the very numerous fossils of the rocks between Kendal and Kirkby Lonsdale (Upper Ludlow). Hence, on mere palæontological grounds, it would produce nothing but confusion were we to designate the Ludlow rocks south of Kendal, and the calcareous slates of Coniston, &c. as one system, while we adopt the restricted use of the word "system" now in common use.

After these preliminary remarks, I proceed to enumerate the several groups into which the whole Cambrian and Silurian series may, I think, be conveniently separated. I profess not to describe the granite and other igneous and unstratified rocks; but I may just notice the metamorphic slates of Anglesea and Caernarvonshire, composed of quartz-rock, quartzose mica-slate, quartzose chloritic slate, crystalline limestone, serpentine, &c. That they are of great antiquity is certain; for they appear to underlie, and they certainly do not overlie, the old rocks in the great S.W. promontory of Caernarvonshire. That they are truly hypozoic, or that they are older than any of the unaltered slate-groups of the Principality, is by no means certain; but these are points quite foreign to the discussions of this paper.

On the eastern side of the Menai Straits is an expansion of some dark slates, which I was at one time induced to consider (hypothetically, however, and without any direct proof) as the lowest unaltered slates in North Wales, and perhaps the equivalents of the Skiddaw slate. In 1846 I changed this view, chiefly on mineral evidence, and arranged the dark Menai slates in the same group with the black slates of Tremadoc. The change, which I made on imperfect evidence, has been since established on better evidence by Professor Ramsay and the gentlemen of the Government Survey.

The whole Cambrian series is exhibited, in vast undulations, from the Menai to the Berwyns; and a part of it, again, in a system of what might be called short independent waves, on the east side of the Berwyns, until the last beds of the series become buried under the carboniferous limestone. But, if we extend our views to the north end of the great undulating series, we find (not, however, without continual breaks and dislocations) the prevailing strike and dip so

changed, that the successive beds are seen to plunge, with a northern dip, under the rocks forming the base of the great deposits of Denbigh flagstone which compose the true Silurian series of North Wales. In this view, the physical separation of the Cambrian and Silurian series is not hypothetical, but perfectly natural; and the zoological separation, taken on the whole, is, perhaps, as complete as the physical. Sections, illustrative of these points, I have exhibited many times before this Society, and I must not now attempt to reproduce them.

The first question which arises, when we attempt to separate the great Cambrian series into subordinate groups, is this:—What is the base of the whole series? Properly speaking, there is no true mineralogical base in North Wales, unless we take the metamorphic rocks as a kind of hypothetical base; but the lowest groups of the whole series may, if I mistake not, be seen on a part of what I have called "the great Merioneth anticlinal," and also among the red-coloured slates which rise from below the great quarries of Nant Francon and Llanberris.

If this conclusion be true, there are two base-lines, on either of which we might construct an ascending section through the Cambrian rocks; and, knowing the importance of putting this view to the test, I employed my friend John Ruthven, in 1846, to seek for fossils in the dark slates of the Menai, and also among the beds which form the great ascending section east of the Bangor slate-quarries. But he failed in finding any fossils in the dark slates, and we both failed in finding the Lingula-beds where I expected them; although it was obvious, from analogy, that they ought to be found a *little above* the coarse grits (Harlech grits) which overlie the Bangor slates.

During the following year I wrote to my friend Mr. Jukes, informing him of my assumed base-line, and of the position I had, from the first, given to the Harlech grits, where they were represented in the Caernarvon chain; but I added that my scheme was defective in fossil evidence, since I had failed in discovering the Lingula-flags above the beds, which seemed very well to represent the Harlech grits. In his reply he informed me that Professor Ramsay and his fellow-labourers had found, and found in their right place, the beds for which I had more than once sought in vain. I have stated these facts, in a few sentences, to show that I have no wish to appropriate to myself discoveries which are due to others, and that I have never put forward any views respecting the grouping of the Cambrian series in a rash and hypothetical spirit. I now consider it beyond all doubt that there are, as stated above, two base-lines (on the same geological horizon), on which we might proceed to construct the successive groups of an ascending natural section through the Cambrian and Silurian series.

The *Bangor group* (No. 1).—In the accompanying tabular view under the term "Llanberris slates" are included not merely the slates of the great quarries of Llanberris and Nant Francon, but a series of slates and hard grits, with a few bands of porphyry, which undulate towards the west, and are partly cut off by a great mass of

felstone-porphyry, and partly buried under drift. The Harlech grits make a well-defined, and sometimes a very striking feature in the chains of Caernarvonshire and Merionethshire. They may be traced almost continuously from Aber, and thence on the eastern side of the line of slate-quarries into the great precipices of Craig Goch; forming great gnarled masses of rock as coarse as millstone-grit, often beautifully jointed, sometimes with traces of cleavage-planes, and often alternating with very thin bands of chloritic slate. Again, they are well seen near Trowsfynydd, and afterwards on both sides of the great Merioneth anticlinal; and they form the most striking features of the Rhinog Fawr chain, dipping towards the N.W. But this dip is reversed by a synclinal curve, and the same great beds of grit are brought to the coast at Barmouth and Harlech, bearing within their trough some of the lower beds of the Festiniog group. On this latter point I ought not, however, to write with confidence, as I have never

Tabular View of the Palæozoic System.

PRIMARY OR PALÆOZOIC SYSTEM.	Upper		Permian series.		
			Carboniferous series.		
	Middle	Devonian series	Petherwin group...	Petherwin slate and Clymenia limestone.	
				Marwood sandstone.	
			Caithness group ...	Hereford sandstone, marl, and cornstone.	
				Dipterus flags.	
			Plymouth group ...	Dartmouth slate.	
				Plymouth limestone and red grit, and Liskeard slate.	
					ft.*
	Lower	Silurian series ...	6. Ludlow group...	*c.* Upper Ludlow	400
				b. Aymestry limestone ...	100
				a. Lower Ludlow	500
			5. Wenlock group..	*c.* Wenlock limestone ...	100
				b. Wenlock shale	800
				a. Lower Wenlock, or Woolhope limestone	100
			Upper: 4. Caradoc group.....	*a.* Caradoc sandstone, limestone, and shale..	1500
			Upper: 3. Bala group..	*b.* Upper Bala (including Bala and Hirnant limestones, shale, flagstone, and conglomerate) ...	4000
				a. Lower Bala; dark slates, flags, and grits	4000
		Cambrian series	Lower: 2. Festiniog group.....	*c.* Arenig slates and porphyry	7000
				b. Tremadoc slates	1000
				a. Lingula flags.....	500
			Lower: 1. Bangor group.....	*b.* Harlech grits.....	500
				a. Llanberris slates	1000
	METAMORPHIC.				
	GRANITE.				

* These measurements, like those in the preceding table of the Cumbrian Rocks, p. 141, are merely approximative.

crossed the Rhinog Fawr chain since 1832. Lastly, the Harlech grits form the extreme point of the promontory south of Tremadoc; and they may be traced round the great southern headland of Caernarvonshire from St. Tudwal's Island to Hell's Mouth. I have thought this short explanation necessary, in order to show what is here meant by the lowest Cambrian group of the Tabular View.

The *Festiniog group* (No. 2), taken collectively, and where it is well developed, is not, I think, less than 9000 or 10,000 feet in thickness. Its lowest sub-group (Lingula-flags) is best seen to the south of Festiniog and Tremadoc; but for details respecting it, I must refer to my former papers. The mineral structure of the Tremadoc slates is very peculiar. It is sometimes penetrated by metalliferous veins, and it contains beds or large concretionary masses of magnetic and pisolitic iron ore. This iron-ore is a good finder for the group, as I can assert on personal experience. It exists, for example, in the country east of St. Tudwal's Road, in the black slates between Clynog and the Rivals, at Tremadoc, on the east side of the Merioneth anticlinal, and on the N.W. flank of Cader Idris; and in all these places it defines the position of the sub-group, whatever other mineral modifications it may have undergone.

The third sub-group, Arenig-slates and porphyries, is of vast thickness, and in general structure is almost the exact counterpart of the green-slates and porphyries of Cumberland. The whole mass is stratified very regularly, and in its upper portion are irregular concretionary beds of dolomitic altered limestone, without fossils. The trappean beds, whether erupted or recomposed (such as trappean conglomerates, trap-shale, &c.), are of very variable thickness; and where they are degenerate, the regular slates expand, and sometimes contain fossils. Arenig and Cader Idris may, perhaps, be near the centres of plutonic eruption; but they are regularly stratified, and I never found among them any which I thought true subaërial products.

The *Bala group* (No. 3) is also of great thickness. It may be divided into two sub-groups, the lowest member of which is finely developed in a mountain-ridge of dark pyritous and rather earthy slates (in some places, however, forming a good roofing-slate), which overlies the S.E. flank of Cader Idris: the same dark slates appear on the east side of Arenig. But I must not here describe the great succession of earthy and arenaceous deposits, slates, flag-stones, &c., often highly fossiliferous, and more or less calcareous, which form the lower Bala group, and conduct us to the Bala-limestone. For details I must refer to my published papers and abstracts.

The Upper Bala group (No. 3, *b*), in North Wales, cannot, I think, be less than 4000 feet in thickness; it begins with the Bala-limestone, to the east of Bala, and includes the Hirnant limestone and shelly sandstone; and it includes, near its upper surface, some arenaceous flagstones; and (if I have not misinterpreted some obscure sections) ends with dark indurated shales, here and there passing into a bad pyritous roofing-slate.

Over the group last-noticed is a series of beds of considerable

thickness, made up of arenaceous flags and grits, sometimes of coarse structure. It occupies a trough, on the east side of which the Bala-limestone is repeated over again. This arenaceous deposit was the highest member of my original Cambrian series; and I need not inform the Society that it is now identified, in the Government Survey, with the *Caradoc sandstone.*

Beyond this eastern line of the Bala-limestone, there is an outcrop of older Cambrian rocks*; after which the whole sequence is broken by enormous faults. The strike of the beds is suddenly shifted; irregular and newer fossiliferous beds appear on the east side of the Berwyns in a state of extreme contortion, and with a new strike. But through the range of these contorted beds runs an irregular axis of an older Cambrian group, which throws the shelly masses on one side towards the north, and on the other towards the south. On the north side they are finally carried under the Denbigh flagstone; to the south, after many undulations, they pass under the flagstone series of Meifod and Welsh Pool.

That the flagstones of Welsh Pool and Denbighshire were nearly on one parallel, I never had a doubt since 1832. They both belonged to one series, afterwards called "Upper Silurian." But what were the limestones and shelly sandstones of Meifod and Llansainffraid? I could connect the Llansainffraid beds with the beds at the north end of the Berwyns by an unbroken line of strike; and therefore the Llansainffraid beds (and consequently the Meifod beds) were a part of the Cambrian series; and the fossils seemed to sanction this conclusion, for the Meifod fossils and Bala fossils seemed to be almost identical in species.

Such is the *great Cambrian series,* as determined by myself, after nearly nine months of hard labour, during the summers of 1831 and 1832; and such was, on all essential points, the account I gave of it before the British Association in 1833,—a great series of deposits, commencing to the east of the Menai, and rolling through the mountains in rapid undulations, till the base-line is repeated in the Merioneth anticlinal. From this base-line to the top of a portion of the Berwyns, the whole series is exhibited in an ascending section, which displays, in order, the four successive groups of the tabular view, collectively not less than 20,000 feet in thickness.

We now know, through the noble map published under the direction of Sir H. De la Beche, that the *highest group* of the great ascending section is the equivalent of the Caradoc sandstone of the "Silurian System." Hence this group, as interpreted by the Government Surveyors, would be common to the Cambrian and Silurian rocks, described by Sir R. I. Murchison and myself,—the highest Cambrian group of my section being coincident with what they regard as the true Caradoc sandstone; and it is this supposed overlap which introduces the only real ambiguity in the development and nomenclature of the lower palæozoic rocks of North Wales †.

* Proceed. Geol. Soc. vol. iv. p. 253.

† To make this more clear, I may state, that the Caradoc sandstone of the well-known Horderley section contains numerous fossils of the Bala group, and none of

After these remarks, we are at once prepared to compare the rocks developed in the great transverse sections of the Welsh and Cumbrian mountains. The lower Cambrian groups (Bangor and Festiniog, Nos. 1 and 2 tabular view) are amply represented by the green slates and porphyries of Cumberland. The upper Cambrian groups (Bala and Caradoc, Nos. 3 and 4) are (however imperfectly in thickness) clearly

Diagram illustrating the Comparative Development of the Silurian and Cambrian Rocks in Wales and Cumbria, respectively.

represented by the Coniston limestone, flagstone, and the hard coarse grits of the Westmoreland sections.

The equivalents, in the North of England, of the Wenlock and Ludlow groups (Nos. 5 and 6) have already been noticed. Using the words "Silurian System" in any definite sense, these are the groups which truly and exclusively belong to it as a system; for the Caradoc

the characteristic Wenlock species; while the so-called Caradoc sandstone of May Hill contains the Wenlock fossils in abundance, and none of the characteristic Cambrian types. But is there a single section in which these two distinct groups of fossils appear together in one stage? If no such section can be found, why may we not suppose that the Caradoc sandstone of May Hill is a group superior to the Caradoc sandstone of Horderley? Should we ever be able to answer this question in the affirmative, the ambiguity alluded to in the text would be at an end. The staement here given is drawn from the fossil evidence supplied by the Cambridge Mtseum.

group (No. 4) belongs, palæontologically, more to the Cambrian than to the Silurian series.

Before I left the Principality in 1832, I made some hasty traverses through the lower palæozoic rocks of South Wales, between the "Silurian System" and the coast of Cardiganshire. In each traverse I met with the same kind of perplexing undulations,—slate-rocks, flagstones, grits, sandstones, and conglomerates repeated again and again. As a general rule, the conglomerates seemed most largely developed near the western limits of the several sections, where the higher mountain-ridges ended, and lower ridges of rocks, afterwards called Silurian, began; and, as another *general rule*, the rocks forming the immediate outskirts of the mountain-ridges dipped towards the interior, so as not (at least in appearance) to pass under these Silurian rocks.

What then was the age of this undulating system of Cardiganshire, &c.? It was superior to the great group of Cader Idris (No. 2, *c.* of the tabular view). Many portions of it were superior to the Bala limestone. This was proved to demonstration by the sections at the south end of the Berwyn chain near Mallwyd. Hence the whole system represented No. 3 and No. 4 of the present tabular view; and, agreeably to a nomenclature I afterwards adopted, was a great expanded development of the *Upper Cambrian* series*.

I had two objects in making these rapid traverses through the older rocks of South Wales; viz. to make out so much of the general structure of the country, as to learn how I might best attack it during the following summer; and especially to find the prolongation of the Bala limestone or its equivalents. Another summer came, during all the early months of which I was crippled and unable to wield a hammer; and, as for the Bala limestone, I neither found it, nor could I ever make out with any certainty what was its exact representative among the undulating masses of South Wales. As to the groups afterwards called the Llandeilo flags, and the other beds afterwards coloured Silurian in the 'Silurian System,' it formed no part of my task, nor had I any time to study their relations. I knew that the author of the 'Silurian System' had placed them *over* the great undulating slate-rocks of South Wales; and in two places, where I gave them in 1832 a passing look, I saw them apparently dipping under undoubted newer groups, now known as Upper Silurian.

My object in this retrospect is to show, that before I studied a single section under the guidance of the author of the 'Silurian System,' and long before I had exchanged a word of amicable controversy with him, my conception of the relations of the great Cam-

* In formerly using the terms "Upper Cambrian System" and "Lower Cambrian System," I neither asserted nor believed that the two series were capable of being separated by distinct groups of fossils. All the evidence I had before me rather tended to an opposite conclusion. The terms seemed, however, convenient, as giving us a good physical subdivision of a great complicated series of deposits, and, at the time I first adopted them, were perfectly in agreement with the language current among geologists,—simply designating a series of groups considered, as a matter of convenient arrangement, apart from the rest of the groups in a general section.

brian series was exactly what it is now. At the end of the summer of 1832 I had *made no mistake in principle* in my interpretation of the phænomena of North and South Wales, so far as I had studied them; and most of my best sectional illustrations of the structure of Wales, published afterwards in successive papers, have been copied, line for line, from sections made in the field during the summers of 1831 and 1832.

§ 4. *Historical retrospect of attempts to unite the Cambrian and Silurian rocks in a continuous section.*

In 1834 I studied for the first time the Silurian types under the guidance of my fellow-labourer and friend, the author of the 'Silurian System'; and I was so struck by the clearness of the natural sections and the perfection of his workmanship, that I received, I might say, with implicit faith every thing which he then taught me. We did not, however, discuss or examine together the base-line of his system; nor did I then, or ever afterwards, comprehend the evidence on which he attempted to define its limits. The whole "Silurian System" was, by its author, placed, as before stated, *above* the great undulating slate-rocks of South Wales; although the only sections I had personally examined in 1832 rather seemed to indicate a contrary position. I knew the labour he had bestowed on his Map, and that he had traced his base-line through a distance (following its sinuosities) of at least 200 miles. Hence, although I saw no good reason, either physical or palæontological, for fixing the base-line of his system exactly where he placed it, I did not at that time entertain a thought that he might perhaps have mistaken the geological relations of his lowest groups.

After making a partition of the country, in which all the formations to the north of Meifod fell to my lot, my fellow-labourer, at my request, made a traverse with me through the undulating calcareous and fossiliferous rocks between Meifod and Llanrhaidr; and he identified, without any reserve, the Meifod series with his most typical form of Caradoc sandstone; and an outlying mass of calcareous slate above Llanrhaidr, he pronounced to be Llandeilo flag. I reluctantly accepted these two determinations; for they involved the upper divisions of my Cambrian sections in most perplexing difficulties, respecting which I had no misgivings, when in 1833 I explained my sections of the Welsh series to the British Association.

We then traversed the Berwyn chain to Bala; and from the top of the pass I explained to him the position of the whole Bala group, extending to the foot of the Great Arenig, the position of the Bala limestone in the group, and the beds *over* the Bala limestone, which at the south end of the chain were sent off in great undulations, and formed a considerable part of the Upper Cambrian groups of South Wales.

We then collected fossils from the limestone-quarries near Bala; and a glance of the eye was enough to show, that, as a group, they nearly agreed with the (so-called) Caradoc fossils of Meifod. Yet such was the conviction produced by the sections from the top of the

Berwyns to Bala, that my friend left me (and it was the last time we ever met to work together in North Wales) with a most express declaration that *the Bala groups could not be brought within the limits of his system.* At that time therefore (1834) he knew that the lower beds of the Silurian series, and the upper beds of the Cambrian series, could not be at once separated by their fossils. And this opinion has been expressed by me, again and again, in my published papers, as well as in the reiterated discussions before this Society.

Such was my confidence in the decisions of my friend on any question respecting Silurian rocks, that I accepted his determination of the Meifod group, I might say, with implicit faith, and set it down as Caradoc. But, in that case, the beds of Glyn Ceiriog, and many other beds on their strike, and skirting the northern limits of my Cambrian series, must also be Caradoc. I supposed, therefore, that several masses of calcareous slate (such as those of Cader Dinmael, Penmachno, &c.) *might* have been put in a false position in my field-sections; and that in truth they *might be subordinate* to the conglomerates, grits, and flagstones, &c., which range not far from the Holyhead Road, at the base of the Denbigh flags; in which case they must come into a true Caradoc group. Such was the hypothetical conclusion to which I was driven.

I had then no opportunity of putting this hypothesis to the test; but the next time I visited North Wales (1842), in company with Mr. Salter, I found at once that the calcareous slates above-mentioned were not subordinate to the group I had called Caradoc sandstone. On the contrary, they were all undoubtedly subordinate to the great Bala group, and therefore a part of my Cambrian series. It followed, therefore, that I had hypothetically tortured the upper groups of my Cambrian series to make them fit to the lower groups of the Silurian series. In this I had done wrong; for the event has proved that my Cambrian sections were right in principle, while the lower groups of the Silurian sections were wrong. From this time (1842), I began to lose my confidence in the stability of the base-line of the "Silurian System."

From 1834 to 1842 I had accepted Sir R. I. Murchison's conclusion, and made the Meifod beds Caradoc or Silurian, and the Bala beds Cambrian; but the only hypothesis on which this conclusion could be maintained was dissipated at the first so-called Caradoc quarry which I examined in 1842 in company with Mr. Salter. I need not allude to our joint labours in 1842 and 1843. I did not during those two summers alter a single important line in my Cambrian sections; but what did the subdivisions of the sections mean? That was to be settled by the fossils, and I had a friend with me who could give me, I thought, an oracular response. He concluded on fossil evidence, and the conclusion was borne out by the sections, that the Meifod and Glyn Ceiriog and Bala beds were nearly on one parallel. Hence, if the Meifod beds were Caradoc, the Bala beds must also be Caradoc, or very nearly on its parallel. But if so, it followed almost of necessity, that the great undulating masses of sandstone between Mallwyd and Can Office must be Upper Silurian. And, by

like reasoning, it also followed, that the grits, conglomerates, coarse slates, &c., which ranged under the Denbigh flags on the north side of the Holyhead Road, and then ran down almost to Conway, must be Upper Silurian. The fossils of these rocks were examined, and they were determined to be Upper Silurian. With one exception (the quarry of Plas Madoc), they were few in number and ill-preserved; and, as they belonged to a group like that of May Hill (above alluded to), no wonder that they were called Upper Silurian.

In my own unassisted examination of these rocks in 1831 and 1832, I called the beds over the calcareous slates of Mallwyd, which extended in undulations to Can Office, Upper Cambrian; and my Upper Cambrian, as before stated, did include the Caradoc sandstone. The grits, conglomerates, &c. under the Denbigh flags, I set down as Caradoc, partly on what I was able to make of the fossil evidence; but mainly on the fact, that the beds in question seemed to overlie my Cambrian series unconformably. My previous determination (in 1832) was right, and our new determination in 1843 was wrong. But far be it from me to blame my friend Mr. Salter for it. He rightly translated the rocks we saw into the Silurian tongue; but that tongue misled us both. In point of fact, we were attempting an impossibility,—we were endeavouring to join my Upper Cambrian series, which was rightly interpreted, to the lower beds of the Silurian series which had been wrongly interpreted and shifted out of their true place in the great continuous Cambrian sections.

All my papers, of which there is any notice in our Proceedings, or Journal, between 1843 and 1846, necessarily partake of the mistakes to which I have just pointed. If the Bala limestone was a Caradoc limestone, the Upper Cambrian system must vanish from my map. I therefore adopted a new nomenclature in my paper in the first number of our Journal *. The whole series, Cambrian and lower Silurian, I called Protozoic. The *Upper Protozoic* groups were on this scheme the equivalents of the *Lower Silurian rocks*. The *Lower Protozoic* groups were what I had before called *Lower Cambrian*; and these groups were the only Cambrian series that remained in this new scheme of nomenclature. But when I speak of my paper in the first number of our Journal (and vol. iv. of the Proceedings), I speak inaccurately. The paper is not mine, and I disclaim its authorship. It is a condensed abstract, made by Mr. Warburton (when President) of two papers read by myself to this Society. This abstract was printed while I was in residence at Norwich. I applied, again and again, for a sight of the proof-sheets as they were passing through the press; but I applied in vain. The President refused my application, and for what reason I never could divine. The abstract is, however, very carefully made; but from a want of a short running comment, which I could have given in a few lines, it is hardly possible to make out the comparative meaning of the sections; and there are a few mistakes introduced into them, perhaps not worth noticing in this place. But the map, with its explanation of the colours, plainly shows that Mr. Warburton did not comprehend the very drift and object of my

* See also Proc. Geol. Soc. vol. iv. p. 251–268.

papers. I used the word *Protozoic* to prevent any wrangling about the words *Cambrian* and *Silurian*. I gave one colour to the whole Protozoic series, only because I did not know how to draw a clear continuous line upon the map between the upper Protozoic (or lower Silurian) rocks and the lower Protozoic (or lower Cambrian) rocks. This was stated to the Society when my papers were read; nor did I ever dream of an incorporation of all the lower Cambrian rocks in the system of Siluria. Yet as I discovered (to my no small astonishment), for the first time during the past week, he has, in an explanation of the Protozoic, and colourless, portion of the map, written "Lower Silurian (Protozoic)," thereby stultifying my whole paper, the very gist and object of which was to show that there was a great series of groups—lower Protozoic (or lower Cambrian)—below the lowest rocks of the "Silurian System *."

After the erroneous identification of the Upper Bala and Caradoc groups in 1843 (to which I was driven by the identification, above mentioned, of the Meifod and Caradoc groups), I believed that many of the South Welsh undulating slate-rocks would prove to be upper Silurian. I put the hypothesis to the test in several traverses through South Wales, made along with my friend John Ruthven in 1846. In this country, which I had never visited since 1834, we found fossils on every line of traverse, and all of them were of the, so called, lower Silurian types. It was plain, therefore, that the Bala limestone was not Caradoc; and thence it also followed, that the Meifod beds did not belong to the Caradoc group, but to that of Bala. It then became obvious, to demonstration, that in the extension of the Silurian system towards the south-west, beyond the limits of the typical Silurian country, the author of the "System" had made a double mistake,—first, in identifying certain shelly beds of his Llandeilo group with the Caradoc sandstone; and secondly, in placing the same group stratigraphically above the undulating beds I had (I think, very properly) called Upper Cambrian.

This comment would have been uncalled for, had he not made his own mistake a part of the ground for sweeping out all the Cambrian groups from North Wales. I repeat, emphatically, that before 1834

* The map (Proc. Geol. Soc. vol. iv. p. 268) is a mere sketch, which pretty well represents my conceptions of the structure of North Wales in 1843. But it contains some grave errors, which I could have corrected at the first glance: *e. g.* a range of Bala limestone northwards from Llanwddin is properly laid down; but a second band of the same limestone farther to the east (which unites with the former to the south of Llanwddin, in a district where all the beds are inverted) is unfortunately omitted, although it was plainly traced and coloured on my field-map. I suspect that, in the explanation of the blank portion of the rough map exhibited in illustration of my paper, I had written *Lower Silurian and Protozoic*, and that Mr. Warburton, erroneously conceiving the two terms identical, changed the words into *Lower Silurian* (*Protozoic*). Had the published map been allowed to pass, *in its present form*, after a revision by myself, I should virtually have surrendered the whole question now in debate. I do not by any means accuse Mr. Warburton of any *intentional* injustice—quite the contrary: for I know that he gave his best efforts to the abstract. But he had undertaken a task for which he was not prepared, inasmuch as he had never well studied any series of rocks like those described in my papers.

I made no mistake in my general interpretation of the Cambrian series, upper as well as lower. To join the Cambrian series to the Silurian was physically impossible, because a great error had been committed at the point where the upper end of the one and the lower end of the other ought to tally. By whom had this error been committed? Not by myself. But I did all honour to the author of the 'Silurian System.' For twelve years, during which I never revisited his typical country, I believed his base-line to be unassailable; not because I had examined it critically, but because it was he who had laid it down. Twice (in 1834 and in 1843) I changed the nomenclature of some of my upper groups, to bring them into a *supposed* accordance with his Silurian types, and each time I was driven from my hypothesis by a downright *reductio ad absurdum*; and I afterwards returned to my first nomenclature, because I found my sections consistent and true in principle, however imperfect some of them might have been in finish, and in the exhibition of minute details.

This historical statement was absolutely necessary to my present purpose; for all I have published on the questions discussed in this paper has appeared, I might almost say, in a fragmentary form in our Proceedings and Journal. Without this statement it might seem that there had been no steadiness or consistency in my views. But I have been so far consistent, that I never shifted a single group below the Bala limestone. And as to my *upper groups*, though I twice shifted their place, hypothetically, in the hope of bringing them into more near coincidence with the Lower Silurian groups, yet each hypothetical adjustment was abandoned after trial; and I returned to my first grouping and nomenclature because my original sections were right, and because the Silurian sections, at their base, were not merely imperfect, but positively erroneous.

§ 5. *General conclusion.*

It is plain that the author of the 'Silurian System' had gradually lost his confidence in his own base-line; for, in a short sentence of his great work (p. 308), he tells us of the possibility of being induced, at some future time, to move his Silurian base to some greater depth*; yet in the next page he tells us that Moel-ben-tyrch is undoubted Cambrian, although it is superior to the Bala limestone. But questions might have been asked, which, if I mistake not, ought then to have been answered in the affirmative. Would not a change of the base-line necessarily imply some change of nomenclature?—

* In 1834, my friend, on the evidence of the sections, ***unequivocally excluded*** the Bala limestone from his lower Silurian rocks, although this limestone was filled with well-preserved lower Silurian fossils. Assuming the truth of the Silurian sections, this evidence was perfect demonstration; for the Llandeilo flags were in the Silurian sections placed *above* all the undulating slate-rocks of South Wales, while the Bala limestone was obviously ***below*** a considerable portion of them. That all the older rocks of the Cambrian series were to be called Silurian, provided they contained certain Silurian species, was, therefore, an ***after-thought*** with which I had no means of becoming acquainted; and I believe that this ***after-thought*** could never have been seriously entertained, had he not discovered that he had mistaken the sectional place of his Llandeilo group.

and, would it not have been wiser and better to retire one step, and to expunge the Llandeilo group from the Silurian rocks, and to base the system on the Caradoc sandstone of the unambiguous sections? Had that step been taken, the Silurian groups would at once have taken their right and undisputed place; and there would have been nothing to stand in the way of the true arrangement of the whole Cambrian series, so far as it is known *. Such a change would only have sacrificed one single group, the relations of which, as we now know, had most certainly been misunderstood by the author of the 'Silurian System'; but instead of this, he shifted his own base-line to the base of the whole Cambrian series†. Thus the name I had given to the Cambrian series, in the elaboration of which I had made no mistake, was to be sponged out; and the series was to receive a new name that was utterly inappropriate.

Our whole scheme of nomenclature of the lower Palæozoic rocks is geographical. This scheme was followed out, from first to last, in the "Silurian System." The system, and all the subordinate groups, were defined by geographical names. Now it is surely an axiom in geological nomenclature, that if we give a new geographical name to any group of strata, that name must refer us to a spot near which we find the group well-developed. In Cambria the whole series of the oldest palæozoic division is more nobly developed than in any other part of Britain (on this point I can speak from my own experience); while in Siluria we find only the highest group of the whole series. This would have been a sufficient reason for changing the name Silurian into Cambrian, had, by any caprice or accident, the name Silurian been first given to the older Cambrian rocks; but it seems to me a very strange reason for changing the name Cambrian (a right name for a great series of rocks well-developed in Cambria, and a name which had the undoubted priority) into Silurian. If indeed we had a good and perfect series of the older palæozoic groups in Siluria, then the words "Silurian System" might be stereotyped as a general designation of all the lower palæozoic rocks of Britain. But Siluria shows us no such typical series, while Cambria does. On the ground, therefore, of geographical propriety, as well as of priority, I vindicate the claims of the Cambrian series for a place in our nomenclature.

* The section from the Menai, over the Berwyns, and to the coast of Shropshire, as explained to the British Association in 1833, differed in no essential respect from the ideal section of the Cambrian series given above in the Tabular View. At the same time I identified (provisionally) the coarse grits near the line of the Holyhead road (Cernioge, Modwl Eithen, &c.) with my friend's shelly sandstone (Caradoc): and as for the Denbigh flagstone, there never was, from the first, any doubt of its identity with the Silurian flags of Welsh Pool and the Long Mountain. My section, therefore, through the whole series (Cambrian and Silurian), was in 1832, excepting in small details, nearly as good as it is now; but the identification (in 1834) of the Meifod beds, by my friend, with his typical Caradoc sandstone, threw the general section into confusion, and destroyed the true keystone that held the Cambrian and Silurian portions together.

† It has been said (but never by Sir R. I. Murchison) that I was a consenting party to this change. The statement is contrary to fact. The change took place (I believe in 1843) two or three years before I was acquainted with it. Had it been known to me at the time, I should probably have entered a public protest against it.

But my friend and fellow-labourer, and in this instance my antagonist, has told the Society, more than once, that in his final scheme of nomenclature he has only been following out the principles of the Father of English Geology—William Smith. Now this I unequivocally deny. Smith never gave the name to a group first, and made out its place in his sections afterwards. In every instance in which he gave us geological names, his actual sections had the priority of his names by many years: and he never gave a name to any group until he had determined its relations to the groups above it and below it. From his several ascertained groups he collected fossils which he affirmed to be characteristic, and, therefore, a means of identifying distant contemporaneous groups. He used palæontology as a principle of identification only where a typical group had been already well established: but palæontology was not the foundation of his nomenclature; for his names were local or provincial. He never gave a premature name to a local group; and then, on finding that his fossils were not confined to it, proceeded to develope this local group, upwards as well as downwards, through many thousand feet of strata, without changing its original and local name.

In establishing the upper groups of his "Silurian System," the author nobly followed out the principles and practice of Smith. His Silurian sections and fossil lists were side by side; the groups and their relations were well made out; and his names were local or provincial. Thus we all admit the groups in Siluria, so far as they were made out on the principles of Smith; and from Upper Ludlow down to Caradoc they have become typical and classical. But below the Caradoc group the whole base-line of the "Silurian System," from one end of the map to the other, is laid down upon an erroneous interpretation of the real position and relations of both the "Lower Silurian" groups,—first by a mistaken identification of the Caradoc sandstone with a portion of the Llandeilo group; and secondly, by a fatal mistake as to the position of his Llandeilo group, which the author placed *above* the whole undulating series of South Wales*.

* It has been insinuated (not however by Sir R. I. Murchison) that I was the author of this mistake: but I deny the charge should any one repeat it. When I visited the Silurian country in 1834, I did not go to criticise the "System," but to learn the Silurian alphabet from its author. As a matter of fact, we critically examined the base-line together only at one single point, on the north side of Noedd Grugg, where we probably misinterpreted the phænomena; for on revisiting the Noedd Grugg section in 1846, I drew a conclusion from it very different from that at which we had arrived in 1834. My friend has told us that the boundary-line marked on his Silurian map "was simply a geographical and not a true geological line" between the Cambrian and Silurian rocks. That it was not a true geological line is most certain; but was it without meaning? Has he not repeatedly stated the evidence on which the base-line was determined by himself? Assuredly it conveyed the author's views that the rocks on one side of the line were older than the rocks on the other,—that the country coloured Cambrian was older than the country coloured Silurian. Yet through a great part of South Wales the colours are absolutely erroneous, not simply in their geographical distribution, but in their geological conception. Precisely the same error is exhibited in the ideal fundamental section upon which the whole scheme of the Silurian nomenclature is erected (see Map of the Silurian System). There is not either in North or South Wales a single actual section corresponding with the fundamental and ideal section

When this mistake (for years the only stumbling-block in the way of a good arrangement of the lower palæozoic groups) was removed, the author made no new adjustment of his Silurian nomenclature, but proceeded to develope his Llandeilo group—upwards through more than 3000 feet, and downwards through more than 20,000 feet—until at length his Silurian System was spread over all Cambria. Where do we find any proceeding like this among the generalizations of Dr. Smith? My friend and antagonist utterly deserted the principles of Smith, by virtually discarding the force of sectional evidence, and by endeavouring to establish his nomenclature on the mere evidence of fossils; and by then proceeding (through what was called a *downward development* of the Llandeilo flagstone) to involve all the lower rocks of Wales under his lowest Silurian group; although that group was avowedly misplaced and misinterpreted within the comparatively narrow limits of his published sections. Anything in more direct antagonism to Smith's sober inductive habits and scheme of nomenclature could hardly be expressed in language: and this was done while the author was aware that another name (and, I affirm, the right name on the principles of Smith) had been given to that vast and most difficult series of Cambrian rocks which he had not personally examined, yet which he was thus identifying—by a downward and unnatural process of development—with his lowest Silurian group. Nor was this done at all after any assumed right of a second conquest; for, on his part, it was a development of the closet and not of the field.

The author of the 'Silurian System' has informed the Society, in a former controversial paper*, that he himself suggested a name (Snowdonian) for the great series of Cambrian rocks; and from thence he seems to argue that he has a right to change the name. But he did not then know, what was well-known to myself, that the term Snowdonian was quite inapplicable, and that the position of the crest of Snowdon in the general section was doubtful; inasmuch as it merely formed one trough among the undulations of North Wales, between the two, above-mentioned, base-lines of the lower Cambrian series. I readily adopted the good geographical term *Cambrian* to designate the most noble and difficult sequence of rocks within the limits of England and Wales†; but at the same time I strenuously objected to the word *system* (both on geological and palæontological grounds), whether applied to the collective Silurian or Cambrian rocks. This Society heard these objections urged by myself (and I may add by others —especially by Professor Phillips) again and again. I objected to the word *system*, as too definite for our state of knowledge, and I always affirmed that the *Silurian System* was without any good palæontological base.

Since the year 1835 I have repeatedly used the words *upper*

in which the Llandeilo and Caradoc groups are placed in an entirely false position (Quart. Journ. Geol. Soc. Jan. 6, 1847, vol. iii. p. 167). Surely (and quite independently of any question of priority) a nomenclature constructed upon such an erroneous base cannot be considered final, but requires revision and correction.

* Quart. Journ. Geol. Soc. 1847, vol. iii. p. 167.

† I the more readily adopted the word *Cambrian* because it was a very slight change from the word *Cumbrian*, by which I had long been in the habit of designating the corresponding part of the palæozoic series in the north of England.

Cambrian System and *lower Cambrian System*, in conformity with a language in common use—to designate two great collective groups of Cambrian rocks; but I always used these terms in a geographical and geological, and never in any strictly palæontological sense: and that these two collective groups were inferior to all the Silurian rocks I assumed on what I thought an irrefragable authority—that of the author of the 'Silurian System.' That the author's views respecting the meaning of his word "System" were *at first* nearly the same with my own, I am morally certain; otherwise he could not, on the evidence of sections which we examined together, have excluded the Bala limestone from his lower Silurian groups. Had he identified the Bala limestone with his Llandeilo flag, he must inevitably have admitted that his base-line in South Wales was entirely erroneous; but in 1834 (and afterwards in 1839) he was prepared to make no such admission. The strange, and, I may venture to say, the unnatural, hypothesis, that a single group—the Llandeilo flag—might be developed downward through all lower Cambrian groups, and that every rock with the (so-called) lower Silurian fossils (no matter what its place in the great Cambrian series) might "be included in the Lower Silurian group*," was therefore, as I have stated before, *an after-thought*; which never could, I believe, have arisen in his mind, had he not discovered that his own base-line was not merely ill-defined, but founded on a positive misinterpretation.

When, in 1842 and 1843, I had the pleasure of traversing the fossiliferous parts of North Wales with Mr. Salter, I had no expectation whatsoever of finding many fossils specifically or generically different from those which had been delineated by Dalman, Murchison, and other authors who had described the older fossil types. After the Devonian fossils (for many years the opprobrium of the lower palæozoic series) were removed to their proper place in the palæozoic system, there was no longer the shadow of a difficulty in defining the leading palæontological characters of the lower palæozoic rocks. The real and only difficulty was in defining the number and sectional place of their subordinate groups. Their upper groups had been admirably determined in the "Silurian System." But their lower groups were, in that system, either not defined at all, or defined by a reference to local sections which have been proved erroneous. My only hope (in 1842–1843) was—that, through the able assistance of my friend Mr. Salter, I might establish, in the field, a series of fossil groups that would enable me to split up the great Bala and lower Cambrian series into separate stages resembling those of the true "Silurian System." In this attempt we failed. But this failure did by no means prove that there was not a great Cambrian series below the defined groups of Siluria. It did, however, prove—what had often been urged before—that the word *system*, as applied *palæontologically* to the collective groups of Siluria, had been not merely premature, but erroneous.

Should any one ask, what matters it by what name the Welsh series of rocks may be called, so long as we define the meaning of our terms? I should at once reply that good names are of great consequence. That

* Quart. Journ. Geol. Soc. 1847, vol. iii. p. 170.

above all they ought to be historically just; and that, if geographical, they ought not to involve and perpetuate most palpable geographical contradictions. So far as regards the present controversy, between my friend and fellow-labourer and myself, it resolves itself into this: whether I should retain a true geographical name for a country I have explored and reduced to good order, after the hard and long-continued work of years; or he should throw down its fences, claim it for his own, and, in defiance of geographical propriety, call it Silurian, without the shadow of pretence from any right of conquest over it, or any correct original knowledge of its relations to that Silurian region he had won for himself by a like labour, and to which he had a lawful title, acknowledged, I might say, with acclamation, by every geological school of Europe.

The personal question is indeed a paltry matter; but it does involve a very important principle. Philosophical names are not to be given rashly; and premature names ought to be abolished; otherwise we barbarize our language, and retard the true progress of science. Scientific names are, or ought to be, the abstract representations of the highest conceptions of the human mind; which first dealing analytically with facts, then groups them together synthetically under their most general conception. The analysis of the phænomena comes *first*,—the philosophic names come, or ought to come, *last*. Nor are philosophical names ever unimportant, even in mixed and progressive subjects like our own; for they are the very circulating medium of science; and if our coin be base, our scientific dealings can never prosper. And is it not true that in science, as in other things, names are often all that the greater part of mankind ever care about in their commerce with the world, especially on questions like the present?

On grounds such as these, I contend that the very conception of a *downward development* of the Silurian System into the Cambrian is a contradiction of the ordinance of nature; as, ever since the world began, her *systems* have been developed upwards and not downwards; that the description of such a *downward development* under the word *system* is a most anomalous use of scientific language; and that such a word as *system*, in geology, cannot logically be made use of while the analytical process is going on, and before it has led us to a resting-place on which we may commence the true synthetical process of constructing a system.

I do not assert that the word *system* was *at first* used illogically by my friend; because he, no doubt, at first thought that he had found a good base-line for it. But in this we now know that he was mistaken; and from the moment that mistake was proved, his *system* (as a *system*) was at an end. It was then a mere group of strata, which admitted of no collective name, except so far as it was capable of definition; and the parts of it which were before mistaken and ill-defined must afterwards be referred to some new base-line, and find their resting-place in some new arrangement. But changes of this kind imply also a change of our verbal definitions, or we utterly destroy the symmetry of our scientific language.

My proposed general term—the Lower Palæozoic division of the "Primary System," including the Cambrian Series and the Silurian Series—may at present serve our purpose, until our views become better defined by better knowledge. There is not a single known palæozoic rock of Britain that I have not studied; and this at least I may assert, as the result of this study, that it is from the Cumbrian and the Welsh mountains that we must construct our British types: and the phænomena of these mountains are the foundation of everything I have offered in this paper in the way of classification and nomenclature.

Since the extension of the lower Silurian colour over the whole Cambrian series by Sir R. I. Murchison, there has, I know, been a general opinion, that I had made some great mistake in my estimate of the palæontological characters of the Cambrian series; that in using the words Cambrian System, I had supposed that the Cambrian fossils formed an entirely distinct zoological group from the Lower Silurian *. Now this I never once asserted; and, from the first, I knew that the very contrary was the case; and it was this knowledge which made me many times in this room object to any strict palæontological use of the word *system*, when applied to Cambrian and Silurian rocks. Although my great Welsh series of rocks and fossils was inaccessible to myself until my new museum was opened for the reception of a vast, and till then unapproachable, collection, yet I had in reserve a small series of specimens from Bodean, Snowdon, Moel Hebog, Bala, Meifod, &c.; and these, as well as my field notes and sections, led me to assert, many times, during the discussions in this room, that the word *system*, as used by its author, was not philosophically applied to Silurian rocks which had not, so far as I could discover, either a good physical or palæontological base. Turn, for example, to the Proceedings (May 1838, vol. ii. p. 679), where, writing of the "Upper Cambrian System," I use the following words: This system "commences with the fossiliferous beds of Bala, includes all the higher portions of the Berwyns, and all the slate-rocks of South Wales which are below the Silurian System."... "Many of the fossils are identical in species with those of the lower division of the *Silurian System*, nor have the true distinctive zoological characters of the group been well ascertained." In the same page I add as follows: "At the north end of the Berwyn chain it" (the *Upper Cambrian System*) "appears to pass by insensible grada-

* This error regarding my own meaning, whenever I made use of the words *Cambrian System*, originated, I doubt not, in the writings of my friend, after he had detected his sectional mistakes, and began to change his own views respecting the relations of his Silurian rocks to the great groups which he had placed below them. Thus, when he tells me (Quart. Journ. Geol. Soc. 1847, vol. iii. p. 173) that "the recognition of a Cambrian System has been considered to be exclusively dependent on the discovery in it of a peculiar type of *life* distinct from that formerly described as Silurian," he writes in direct contradiction to his own interpretation of phænomena made, along with myself, in the field (in 1834), and in apparent contradiction to various passages of his great work; and he now endeavours to saddle me with a *technical* meaning of the word *system* which I never once made use of, and *against* which he had heard me enter my protest *long before* there was a word of controversy between us.

tions into the lower division of the Upper System (the *Caradoc Sandstone*)." Again, in the Proceedings (Nov. 1841, vol. iii. p. 548) I gave the same definition of my *Upper Cambrian group*, and added: "Many of the fossils are identical in species with those of the lowest divisions of the *Silurian System*."

Again, in the next page (p. 549), I give a list of Snowdonian fossils, some of which I collected in 1831. The list was named by Mr. Sowerby the year before Mr. Salter had become my fellow-labourer; and in 1832 I had at least two species of *Orthis* from Snowdon, which I believed identical with two Bala species. Lastly, I will quote the third edition of the Syllabus of my Cambridge Lectures, which was drawn up in 1836 and published very early in 1837, and therefore appeared two years before the publication of 'The Silurian System.' Describing the Upper Cambrian rocks, I used, in this Syllabus (p. 51), the following words: "Associated with them are calcareous slates. *Corals, Encrinites, Trilobites, Orthoceratites, Orthis, Producta, Spirifer*, &c. Many shells of the same species with those of the *Lower Silurian* rocks." Again, in the same page, I affirm, "that the Bala limestone contains *Bellerophon bilobatus, Producta sericea*, and several species of *Orthis, all of which* are common to the *Lower Silurian System*." This third edition of my Cambridge Syllabus was withdrawn from publication in 1840, in consequence of the new palæozoic arrangements become necessary by the introduction of a Devonian series. But the extracts from it above-given, as well as the quotations from our Proceedings, however unimportant in themselves, do bear upon my present question, and prove what I am now asserting,—that I never presumed to separate, palæontologically, the Cambrian from the lower Silurian rocks. If their fossils were of the same general type, the fact would only prove that Sir Roderick's "Silurian System" never was a system in the sense in which he had expounded it; but the fact would by no means prove that he had any right to make good his system by extending it over a province already legitimately occupied, and over which he had no personal claims whatsoever.

On this point I may conclude my remarks, by affirming that my argument is greatly misrepresented by Sir R. I. Murchison *, when he recommends me to abandon the term Cambrian System as applied to the physical groups of North Wales, because such name was used before their fossil contents were known. His advice, whatever may be its worth, is founded in mistake, and obliviousness as to some facts we studied together in the field; and he has little reason to fix on me his own meaning of the word "System," which I never believed correct, and against which I have, as above stated, very often protested in the former discussions of this room.

In 1834, when I, for the last time, met my friend in Wales, that we might compare notes and determine the limits of our respective surveys, he made no difficulty in excluding the Bala limestone (in spite of its fossils) from his "System," and this was done on the supposed evidence of sections. The fact of this exclusion proved that

* Quart. Journ. Geol. Soc. vol. iii. p. 175.

the author *then* thought the evidence of sections necessary to his "System," and that it did not necessarily include every group with Silurian fossils. At that time the important point between us was to determine the limits of our respective sections. He afterwards shifted his ground of classification altogether, but on principles not communicated to myself; and ended by demanding from me a proof that my Cambrian series contained a group of fossils entirely distinct from those of his lower Silurian rocks. He required of me what I had shown him to be impossible before his System had a name. As to the palæontological relations of the Cambrian groups, my views, though expanded during the progress of discovery, never underwent any fundamental change. This progress did, however, prove that the word *system* was, from the first, applied by the author incorrectly to his "Silurian" groups. I worked upwards through the whole Cambrian and Silurian series: my friend worked downwards into the upper part of the Cambrian series, and there came to a fault. There was an undoubted overlap in our ascending and descending sections, producing no small confusion, but this confusion was simply caused by his own mistakes and not by mine: yet is this confusion, on the scheme of my friend, to end by subordinating Cambria to Siluria—by a system of grouping, in the upper part of which the spirit of subdivision is carried, perhaps, to excess, while in the lower part all subdivision, based on good sectional evidence, is discarded—by making more than 20,000 feet of strata the equivalents of one "Silurian" group! No power on earth can stereotype and perpetuate a nomenclature so utterly incongruous, —one part simply geographical and sectional,—the other part neither geographical nor sectional; but evolved through a *downward development* which is out of nature, and strikes at the root of every principle of philosophical arrangement. We may, no doubt, analyse the successive deposits of a new country in the descending order, and this may sometimes be the very best method. But when we proceed to systematize the deposits and give them names, we are absolutely compelled to reverse the process; otherwise we build without a foundation, and violate the historical development of nature.

My friend and opponent tells me (*loc. cit.* p. 173), that, *before his Silurian System was fixed*, foreign geologists had applied the term "greywacke" indiscriminately to the Devonian and other palæozoic groups. This is very true. The upper Silurian groups *were fixed* on right principles, and this was a very great boon to geology, and soon led, almost by a philosophical necessity, to the fixation of the Devonian series. But the lower Silurian groups were *not fixed* by the author. His nomenclature was premature, and his base-line was sectionally wrong; and, so far from leading to discovery, it retarded the progress of palæozoic geology for, I believe, not less than ten or twelve years.

I accept at once the canon, "that a good nomenclature can only be based on a conformity of successive and similar organic remains *." For we all admit that a good geological nomenclature is, not simply

* *Loc. cit.* p. 173.

a zoological question, but a question depending on the *evidence of sections, aided by the evidence of fossils.* But where was the author's "conformity of succession," proved by the evidence of good sections, among his lower Silurian rocks? He mistook the relations of these rocks to the Cambrian groups, and his fundamental general sections are wrong in details as well as in principle. What then becomes of the lower Silurian rocks, if their names are to be tested by this canon? I can conceive but one rational answer to this question.

Again (*loc. cit.* p. 170), he tells us that "his nomenclature is founded on the principle of *strata identified by their fossils.*" If we are dealing with elements of which we know the limits, the principle stands good; but while we are dealing with the nomenclature of a new series, of which we have not made out the limits, the application of this principle would be nothing better than a specious fallacy. I should give an illustration of this fallacy had I attempted to call the whole Cambrian series by the name of Bala Limestone; and the author has given us a frequent illustration of it in identifying the same series with the Llandeilo flagstone. Were we to take the palæontological evidence *alone*, and sink all other means of classification, I believe that the massing of all the Lower Palæozoic Division of my Tabular View (see p. 147) under one system of animal type would turn out to be a palæontological blunder. There is a magnificent development of this Lower Division in North America capable of separation into two very distinct collective groups (like the Cambrian and Silurian groups of the Tabular View), the upper of which is (if I am rightly informed) sometimes unconformable to the lower; and although many species may be common to the two collective groups—especially near their junction—yet the species most abundant in, and most characteristic of, the lower are not found in the upper; nor are the most abundant and characteristic species of the upper ever found in the lower. If so, the development of animal types, from the early dawn of a living world, appears to have been carried on in North America in strict analogy with the development now exhibited in the British Isles; and I am greatly mistaken if the scheme of development, given in the Tabular View, be not more acceptable and intelligible to the American Geologists than any other scheme of arrangement of the British rocks which has yet been published.

Out of this Lower Palæozoic division M. D'Orbigny makes *two palæontological systems*; M. Barrande did the same virtually, though not in words; and if I may judge from my Cambridge collection, as arranged by Professor M'Coy, there is as wide a separation between the Silurian and Cambrian groups, as between any two consecutive members of the whole Palæozoic System of the Tabular View. But I do not rest my conclusions upon this last statement; but rather upon such evidence as I have given in the previous pages of this paper, and especially on the broad fact—that my original Cambrian sections were right in principle; while Sir R. I. Murchison's sections were, in the exhibition of his lower groups, wrong in principle and conception.

So long as my friend worked upon the plan of Dr. William Smith

and the geologists of his school—combining sections with fossils, and never using fossil evidence as definitive until his physical groups were well in hand—he made no mistake in principle; his system was worked out with consummate zeal and skill; and in the true typical country of Siluria he left but few gleanings for those who followed him. But on leaving his true typical Silurian region his good fortune left him; and in following down the lowest beds of his system, he hit off, both to the north and the south, a wrong type for the Caradoc sandstone. It might be called a small mistake to have regarded the Meifod beds as typical Caradoc sandstone, and to have figured some of its fossils as characteristic specimens of that group. But, small as was the mistake, it led Mr. Bowman, Mr. Sharpe, and myself into a very wrong interpretation of certain sections in North Wales. To them the mistake was of small moment, as it only led them to give a wrong name to a single fossiliferous group: but to me the mistake was far more mischievous; as it led me to take my very keystone from an arch I had constructed on right principles and after the hard and successful labour of two summers; and it threw into confusion the whole plan on which I had constructed my upper groups. But this fact surely proves, how unmeaning fossils are in determining the true, detailed, geological sequence of any new country without a continual check from sections.

But the great mistake of the "Silurian System,"—and so far as regards its effects upon my own work, the most perplexing mistake,—was the placing the Llandeilo group *over* the upper Cambrian series of North and South Wales; and until this mistake was corrected, all further progress in arrangement and nomenclature of the older palæozoic groups became impossible. Near the end of the summer of 1843 I found it impossible to separate the Bala limestone from the calcareous groups of Glyn Ceiriog and Meifod; but, if the Meifod group were, on the interpretation of Sir R. I. Murchison, a typical form of the Caradoc group, it followed that the Bala limestone must also belong to the true Caradoc group. Nor was this all,—a great group over the calcareous slates of Bala, which I had before described as upper Cambrian, was called, both by Mr. Salter and Mr. Sharpe (on supposed fossil evidence), upper Silurian. Again, on like evidence, Mr. Salter was compelled to call the (Caradoc) group under the Denbigh flags upper Silurian. If all this were true, I knew well, on the evidence of my own sections in South Wales, that a considerable portion of the undulating beds in that part of the Principality, as well as the gritty beds in the highest trough of the Berwyn chain, must also be called upper Silurian. As before stated, these conclusions were put to the test by myself in 1836, and found to be erroneous. I then had a demonstrative proof that the Bala limestone was not Caradoc—that the Meifod beds were wrongly classed and named,—and that the geological relations of the Llandeilo group were mistaken by the author of the 'Silurian System.'

It was during the interval of uncertainty, between 1843 and 1846, that I was willing to modify my nomenclature,—believing, during that interval, that my upper Cambrian group must disappear; inas-

much as I knew that the Silurian groups were well made out in unequivocal sections to the base of the Caradoc sandstone; and, therefore, as far as that base descended, that the author had an apparent right to claim every rock of North Wales as a member of his own system. But in the published map, prepared by Mr. Warburton, and not seen or revised by myself, my concessions, as above-stated, are greatly mistaken and greatly misrepresented. When all previous doubts were cleared up in 1846, I returned, as a matter of course, to my old nomenclature; for my original sections of North Wales were right, and my nomenclature was natural and true. Meanwhile (and, strange as it may seem, unknown to myself, for, I believe, nearly three years) my friend had extended his Silurian colours to the western coasts of Wales; and hence the origin of whatever words of amicable controversy have ever passed between us.

What I finally affirm is this,—that the whole scheme of my sections (from the very first which I exhibited at Oxford in 1832, and at Cambridge in 1833) was physically, and (so far as my fossils went) palæontologically right—that I was never led into a false or incongruous classification by any section of my own—that in every instance in which I was led into hypotheses in any way incongruous with the order of superposition indicated by my sections, I was so far led into positive error—and that every instance of doubt or wavering on my part arose, at the time, from a belief (I now know to have been erroneous) that the author of the 'Silurian System' could not have mistaken the relations of his normal lower types, but that I might, perhaps, have mistaken the true relation of one or two of my highest Cambrian groups.

All doubt on this head is now at an end, and I continue to place my *Upper Cambrian series* (a little extended, not from any change of my sections, but merely as a matter of symmetrical convenience, and termed the *Bala group*) where I placed it in 1833. The relations of the Bala limestone to the groups above it and below it are not, in this scheme, mistaken; nor was I ignorant of its fossils *before* the publication of the 'Silurian System,' as I have proved by previous quotations.

It is true that the Llandeilo flagstone is, on this scheme, removed out of the Silurian groups; for the Llandeilo flagstone is the undoubted equivalent of the Bala limestone. It is also true that my friend has published a magnificent series of fossils from the Llandeilo flagstone, including therein a group he has mistaken for Caradoc sandstone. But no published group of fossils entitled the author, on *his own canon* of classification and nomenclature, to claim the Llandeilo group as his own and to give it a permanent name, until he had made out its relations to the groups above it and below it; and in this last condition he entirely failed. The author has, in his great work, published many admirable details respecting the development of the Llandeilo groups among the Plutonic rocks of Shropshire and other tracts of country on the frontiers of Wales, and for these details, and the good theoretical suggestions arising out of them, he is entitled to the lasting gratitude of this Society. But none of these details

touch upon the real question in debate. They do not give us the means of establishing the relations of the Llandeilo group to the groups above it and below it, in any general sections which define the lower Palæozoic series. This fatal objection does not apply to the Bala limestone; which becomes a true typical group, and is capable of receiving a permanent name, because its place is well defined in the grand development of the older Palæozoic series of Wales; and on that account it obtains its place in the Tabular Section.

I accept the interpretation of the structure of Wales as given in the great map, published under the direction of Sir Henry de la Bèche, which is one of the noblest works of its kind that has appeared since Geology was a science. In this map we have the superficial delineation of the true system of Siluria perfectly represented in its most minute details; and the authors have, for the first time, laid down the range of the Caradoc group in a manner that is intelligible and complete. But they have given the name "Lower Silurian" to all the vast series of rocks in Wales, which are below the Caradoc Sandstone. I do not believe that their authority, great as it is, can permanently establish a name that is geographically incongruous and historically unjust. Passing over the strange geographical and geological incongruity of merging all Cambria in Siluria, although the groups of the former include the whole lower palæozoic series, and the groups of the latter country include only the upper members of that series,—and passing over the palæontological objection based on the assumed fact that there are two systems of animal life in the upper and lower divisions of the same great series sufficiently distinct to require separate zoological names,—dismissing these considerations from the question, I affirm that the name "Silurian" given to the great Cambrian series below the Caradoc group is historically unjust. I claim this great series as my own by the undoubted right of conquest; and I continue to give to it the name "Cambrian" on the right of priority, and, moreover, as the only name yet given to the series that does not involve a geographical contradiction. The name "Silurian" not merely involves a principle of nomenclature that is at war with the rational logic through which every other palæozoic group of England has gained a permanent name, but it also confers the presumed honour of a conquest over the older rocks of Wales on the part of one who barely touched their outskirts and mistook his way so soon as he had passed within them.

I claim the right of naming the Cambrian groups, because I flinched not from their difficulties, made out their general structure, collected their fossils, and first comprehended their respective relations to the groups above them and below them, in the great and complicated palæozoic sections of North Wales. Nor is this all,—I claim the name "Cambrian," in the sense in which I have used it, as a means of establishing a congruous nomenclature between the Welsh and the Cumbrian mountains, and bringing their respective groups into a rigid geological comparison; for the system on which I have, for many past years, been labouring is not partial and one-sided, but general and for all England.