JANUARY 6, 1847.

Charles Fraser, Esq. was elected a Fellow of the Society :—

The following communications were read :—

1. *On the Meaning originally attached to the term "CAMBRIAN SYSTEM," and on the evidences since obtained of its being geologically synonymous with the previously established term "LOWER SILURIAN."* By Sir RODERICK I. MURCHISON, G.C.St.S., V.P.G.S., F.R.S. &c.

[“ By such proofs (organic remains) we are enabled to distinguish the Silurian deposits from all others previously described, and through every lithological change we can thereby separate the System into Upper and Lower divisions.”—*Silurian Syst.*, p. 9.]

IN a communication upon the Silurian rocks of Sweden, published in the preceding number of the Quarterly Journal of the Geological Society, I stated my objections to some opinions of Professor Sedgwick contained in the previous volume, which suggested a re-arrangement of the recognised divisions of the Upper and Lower rocks of the Silurian system. I was then chiefly called upon to point out the inapplicability of the proposal to remove the Wenlock formation (or a great part of it) from the Upper to the Lower Silurian; for even down to last year Professor Sedgwick had invariably spoken of all the lower palæozoic fossils of North Wales and Cumberland as belonging to one or other of those natural divisions*. In a word, the Upper and Lower Silurian fossils published by me had been appealed to by him as the types by which he worked out their equivalents in the above slaty tracts; and even in his memoir published in 1846, he still divided the older palæozoic rocks of our island into Upper Silurian, Lower Silurian, and Cambrian†. In the memoir, however, which he read at the last meeting, Professor Sedgwick took a new course, for which I was unprepared by his previous publications‡. After indicating the order of the strata in and beneath the Bala limestone, he now puts forth what I can only understand as this general proposition, viz. that although the fossil type of such rocks is essentially what he and others had recognised as “Lower Silurian,” the term “Cambrian” ought in preference to be applied to them, because a succession of great physical masses exists in North and South Wales which is not developed in the tracts formerly described in the Silurian region. In this way, the term Lower Silurian would be suppressed, and the Silurian system, deprived of its lower half, would be split up into two systems of fossiliferous strata beneath

* See Quarterly Journal Geol. Soc., vol. i. p. 1; No. 4. p. 442; vol. ii. p. 106.

† Ibid., vol. ii. p. 130.

‡ Let no one suppose, that in consequence of the divergence of our present views on a point of geological nomenclature, there has been the slightest cessation of friendly intercourse between us. Professor Sedgwick wrote to me four months indeed before his memoir was read, and candidly explained his opinions.

the Devonian, instead of continuing to be one natural series divided into two groups, as first established in Britain and subsequently extended to other parts of Europe.

Painful as it is to me to oppose my distinguished associate,—the friend with whom I have so often cooperated, and to whom I dedicated the “Silurian System,” I am compelled to resist a proposition, the adoption of which would, I conceive, be productive of great disservice to the progress of geology; and he must therefore excuse me if I defend the ground of Caractacus, with a pertinacity approaching to that of the old Silurian chief.

I shall therefore treat this question under the following heads:—the origin of the terms “Silurian” and “Cambrian”—the nature and progress of the classification to which the term “Silurian” referred, whether in Great Britain or the continent—and the effects of the adoption of the proposed change upon geological science.

After labouring during four years in certain Welsh and English counties, in which I had traced out and defined a succession of fossiliferous deposits, from the base of the Old red sandstone down to certain older rocks then called “slaty greywacke,” I was urged by many geologists to designate such rocks by a distinct name. Accordingly in June 1835* I applied to them the term “Silurian System,” thereby to distinguish a series of strata several thousand feet thick, and having a general community of fossil characters within the ancient British kingdom of the Silures. These I divided into two groups, the Upper consisting of the Ludlow and Wenlock, the Lower of the Caradoc and Llandeilo formations; the chief or typical fossils of each, being identified or named by Mr. James Sowerby and myself, were then enumerated in tables†. To make this matter clear, I here reprint the very woodcut and lettering used twelve years ago.

At that time the word “Cambrian” was unknown, and it originated in the following manner‡. In the accompanying diagram of succession, the Upper and Lower Silurian rocks were represented as reposing on *unconformable* strata which were termed “slaty grey-

* Phil. Mag. June 1835, vol. vii. p. 50.

† Even at that early period I guarded against the possible inference that the mineral masses so defined were to be viewed as persistent. I showed, for example, that in some tracts the lower division exhibited great thickness of sandstone beneath flags and limestone; in others *vice versa*. The same was explained at greater length in the work subsequently published (1839), wherein the evanescence of mineral types being indicated, it was maintained, that the fossils alone could truly indicate the age of the strata. This fact is now mentioned, because notwithstanding all my caution, it has recently been stated that flagstone beds with *Asaphus Buchii* occasionally lie above sandstone to which the word “Caradoc” may be applied. My classification, I repeat, was never based on such mineral succession; for whether the lower rocks were flaglike and calcareous, sandy or quartzose, schistose or slaty; whether the uppermost bed was sandstone and the lowest schist, or the reverse, their age was alone to be determined by *their imbedded fossils*. And as to the mineral base, I will cite my own words:—“Although the calcareous flags of Llandeilo with their accompanying schists are considered to form the base of the Silurian system, their place is sometimes taken, *often indeed they are underlain* by sandstones of considerable thickness.” (Sil. System, p. 8.)

‡ See also Sil. Syst. p. 8.

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wacke," which was meant to represent certain inferior unfossiliferous rocks (like those of the Longmynd range of Shropshire). Now on sending a copy of my new classification to M. Elie de Beaumont, that eminent geologist, wishing to mark strata separated by lines of dislocation by separate names, suggested the propriety of further distinguishing those last-mentioned unconformable and inferior rocks by the term "Hercynian," as taken from the Hartz mountain in Germany, where, as he then believed, the oldest slaty group would prove to be of higher antiquity than the strata to which I had applied the word "Silurian." Unwilling that the name for these infra-Silurian rocks should be taken from a foreign country, in which no precise palæozoic horizon had then been fixed, I at once urged Professor Sedgwick to apply to his slaty rocks, which were confidently believed to be inferior to my own, some term, on the same geographical principle by which I had been governed in proposing "Silurian." I even ventured to suggest the word "Snowdonian," because I knew that my friend then considered the N.W. portion of the Welsh chain to be made up of the oldest fossiliferous masses; but preferring a more comprehensive geographical name, he took that of "Cambrian." With this arrangement we both felt certain, that no anomaly could be introduced into the lower palæozoic classification, as the relations and fossil contents of mineral masses which were contiguous, must be eventually cleared up without fear of error or the introduction of theoretical views.

The word "Cambrian" (as far as I know) was first used in print by myself in the year 1836, in describing the structure of Pembroke-shire. But whilst I then spoke generally of such Cambrian rocks, and afterwards at greater length in my large volume, their analysis and examination formed no part of my scope; that task having been specially undertaken by Professor Sedgwick, at a time when I really believed, that from their great thickness, apparent inferiority and different lithological structure, they would be found to contain a suite of orga-

nic remains distinct from those I had called "Lower Silurian." Improving in the following years the description of the Silurian region, and having completed as well as I could by my own labours (aided by a few kind friends resident in the country) the collection of its typical fossils, I published in 1839 the "Silurian System," as founded on my own researches. This work was accompanied by a map, which as far as the parts coloured Silurian are concerned, has, I believe, been found little fault with; the distinctions of the Upper and Lower Silurian rocks with their subordinate formations (all perfectly conformable, be it observed, to each other) being accurately laid down in reference to other overlying deposits. But notwithstanding the labour bestowed upon it, this map was necessarily very defective in the boundary-line between the typified Lower Silurian and the *untypified* Cambrian rocks. In the northern part of the map that line was, indeed, for the most part inserted, at my request, by Professor Sedgwick himself*; and in Central and South Wales it indicated, according to my view, little more than that to the west of it, the so-called Cambrian rocks were then neither zoologically nor physically explored—a task which, as repeatedly announced to the Geological Society and expressly declared in my work, was left exclusively to Professor Sedgwick. But although it was, so to speak, a point of honour with me not to trench upon the privileges of the eminent geologist who had engaged to describe the Cambrian region, I can truly say, that I repeatedly urged him to determine the organic remains of those slaty rocks; for I then thought, I repeat, that they would be found to be in that manner essentially distinguished from my Silurian types. Years however rolled on and this desirable end was not accomplished; and no peculiar fossils having to this day been published, the Cambrian system consequently remained without organic characters of its own. It was, in fact, a great physical mass without the vitality of a system.

All that I knew of the fossils of the so-called Cambrian rocks, at the period of the publication of my work, was, that the chief forms which occurred in their Eastern or upper division, as at Bala, were specifically the same as my Lower Silurian types,—a strong proof that there was a gradual transition from the one to the other, and that the boundary-line drawn upon my map between the tracts named Siluria and Cambria was merely provisional, and had been laid down on no fixed geological principle. Thus in speaking of some of these Bala fossils my words were—"As these shells abound also in the Lower Silurian rocks, it would seem that as yet no defined line of zoological division occurs between the Lower Silurian and Upper Cambrian group; and that as our knowledge extends, we may probably fix the lowest limit of the Silurian beneath the line of demarcation which has for the present been assumed †." Surely words could not more explicitly show, both that the boundary-line marked in the map was not a natural limit, but simply a geographical (not a true

* See description of the map, Sil. Syst. p. xxix.

† Sil. Syst. vol. i. p. 308.

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geological) line which ran between my working-ground and that of Professor Sedgwick; whilst they clearly indicated my belief, that the Silurian system, as distinguished by its fossils, would probably be carried further downwards when the region should have been thoroughly explored.

In fact, the problem to be then solved was—whether the enormous masses of rock which seemed to rise out from *beneath* the Bala beds would be found to contain a distinct group of organic life? If not, I for one should never have thought of considering them as constituting a system equivalent to the Silurian.

In the meantime other geologists began to occupy themselves in North and South Wales. Mr. Bowman made an excellent addition to our acquaintance with the former, by showing the exact equivalents of some of my Upper Silurian strata in Denbighshire; and whilst Professor Sedgwick was renewing his labours, Mr. Sharpe also entered the Welsh arena, and contributed, as the Society knows, many new and valuable data. But whoever was the inquirer, no fossils were reported or heard of but “Silurian.” In South Wales Sir H. de la Beche and the Government Surveyors showed, that the rocks of certain quartzose and slaty tracts which had been loosely mapped as Cambrian by myself, were, in truth, physically as well as zoologically, the same Lower Silurian strata I had described on their eastern and southern frontier, and that thus, with the exception of certain limited districts occupied by very ancient unconformable greywacke void of fossils, as at St. David’s, &c. (like that of the Longmynd in Shropshire, represented in the woodcut p. 167), the lowest fossiliferous strata in South Wales were all conformable and connected masses. Even in a geographical sense therefore, the question whether the so-called Cambrian rocks could be characterized by peculiar fossils, seemed to be thus narrowed to the space included between Cader Idris, the Menai Straits and Bala.

Having satisfied myself in 1842, in company with Count Keyserling, that the prominent fossils in the rocks of Snowdon were nothing but published species of Lower Silurian *Orthidæ* with simple plaits, I next learnt from Professor Sedgwick himself, that he could discover no types differing from the Lower Silurian in any tracts of North Wales or Cumberland. Referring, indeed, to his works as well as to those of Mr. D. Sharpe, it was evident that whatever differences of opinion might exist between those authors concerning points of structure, the arrangement of the masses or their geographical boundaries, they both agreed as to the persistence of known and published Silurian types through many of the lower slaty strata of North Wales and the Lake Country. Thus fortified by the assurances of my contemporaries, including the Surveyors of the Government, and by personal visits to North Wales, Westmoreland and Cumberland, I ventured to comment on the facts in my Address to the Geological Society in 1843, broadly stating, that as the whole of the *fossiliferous* series of North Wales seemed to exhibit no vestiges of animal life different from those of the Lower Silurian group, the tract must henceforward be considered of that age. It was on

this principle that I then coloured a geological map of England at the request of the Society for the Diffusion of Useful Knowledge.

In the meantime, however, though, for the reason before assigned, I had taken little part in the local question of what might be termed Cambrian *as distinguished* from Lower Silurian, (leaving that point to be finally settled by the Government geological surveyors,) I had, by more extensive surveys in other parts of Europe, gathered positive evidences for coming to a definite conclusion respecting the base of the Lower Silurian rocks. Finding that in Russia the lowest fossiliferous band was unquestionably my Lower Silurian group* (a view which was unanswerably sustained by the inquiries of my associates De Verneuil and Von Keyserling), I further saw this group in Scandinavia (with nothing but fucoids in its lowest beds) resting at once on pre-existing slaty and crystalline rocks. Northern Europe was first distinctly appealed to as exhibiting the base of the series of animal life, and the Lower Silurian was, by observations in Scandinavia, thus shown to be the protozoic group. Then came the comparison of the lowest fossiliferous strata of North America, by American authors and Mr. Lyell, with a Lower Silurian type similarly related to pre-existing rocks; and lastly in the first chapters on the geology of Russia in Europe and the Ural Mountains, the grounds were fully explained (1845) on which the conclusion had been generally arrived at, that the Lower Silurian was the protozoic or oldest type of animal life yet discovered.

None of my opinions successively put forth from the year 1843 to the present time were objected to, and I naturally therefore believed, judging indeed also from Professor Sedgwick's new map of North Wales†, that the question of palæozoic nomenclature was settled. I firmly thought, that however thick, however diversified in mineral characters, all Welsh and British as well as all foreign strata, in which certain typical forms prevailed, would be included in the Lower Silurian group. For what, I inferred, could it import in a nomenclature founded on the principle of "strata identified by their fossils," whether the rocks termed Lower Silurian were two or three thousand feet thick in the region where they were first described, or many times as thick in the western parts of North Wales, provided they were in both tracts characterized by the same groups of fossils? I knew for example, that in the very thin but undisturbed bands of Russia, a greater number of species of animals had been found than had then been detected on the same parallel in the greatly expanded North Welsh rocks. It therefore seemed to me to matter little to the geologist occupied with the history of successive races and their apparition on and disappearance from the surface, that he should be told of a tract, in which there was a much grander and more diversified mineral character (with enormous porphyritic masses) than in the region wherein he had previously described similar *zoological* types.

* See announcement to the York Meeting of the British Association, 1844.

† See Geological Journal, vol. i. p. 1 and map.

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The names of William Smith remained unchanged, although his original mineral types were in after-times found to be often of very small persistence. It was not proposed to change the name of Lias, when that formation was found to be three times as thick at Whitby (with numberless new inferior strata and many new fossils) as in the South of England where it was first named. Modern geology will stand on an insecure basis, if the principle of identifying strata by their fossils be abandoned. But it is now proposed to abrogate the established name of the type, and substitute for it that of a tract the fossils of which have never been published, long after the Lower Silurian rocks were first named and distinguished by peculiar forms —when the fossils of that age have been so labelled in numerous museums on both sides of the Atlantic, and when geologists and palæontologists of all countries have adopted the term, and already know (through the previous admissions indeed of Professor Sedgwick himself) that the greatest portion of the Cambrian is zoologically nothing more than a downward extension of the Lower Silurian group.

Let me then ask my brother-labourers to adhere to the use of a name which has been so long current, and which for some years has had a definite meaning attached to it both by its fossils and position in various parts of the world. Geologists have already honoured me with their approbation for having worked out certain phænomena, which explained the first clear succession downwards from the base of the Old red sandstone. They will not, I trust, forget the toil by which these results were obtained, nor cease to be alive to the fact, that by the forms which I described, order was at length elaborated amidst various slaty tracts, often highly dislocated and in parts metamorphosed, over which such Silurian types are *now* found to spread. For, even in reference to Britain, the succession of the broken and porphyritic region of North Wales, Westmoreland and Cumberland, might, I apprehend, have long remained undeciphered, if it had not been for the constant appeals which the geologists who have explored those tracts have made to the established Silurian strata. Is then the key which has served to open out such regions to be now thrown away?

But passing for a moment to some of its leading details, let us now see if the memoir recently read by Professor Sedgwick contains anything new to lead us to change the previous arrangements. Enlarging the discovery of Mr. Davis announced to us in 1845*, of the existence of a species of *Lingula* in the rocks near Tremadoc in Carnarvonshire, Professor Sedgwick tells us, that this band lies many thousand feet beneath the Bala limestone, including however, it will be observed, enormous interpolations of stratified igneous rocks.

I grant that his sections (obscure as he admits some of them to be) afford proofs of an enormously thick succession of “great physical masses.” They clearly indicate that in the early days of submarine life, the area of the earth’s surface now constituting Merioneth- and Carnarvonshire was much agitated by plutonic eruptions

* Quart. Journ. Geol. Soc. vol. ii. p. 70.

which threw down thick sheets of porphyry, trappean ashes and other igneously formed matter on the bottom of the then sea, and that in relation to them, the quiet sedimentary deposits containing animal life were small. By such operations and by the subsequent eruption of other igneous rocks, the whole series was, in these tracts, greatly expanded and diversified, whilst by other events the masses were thrown up into lofty mountains and underwent much crystallization. But then comes the question, what are the animals which lived during the accumulation of this extravasated and troubled marine series?

Assuming that Professor Sedgwick be perfectly correct in his interpretation of what are really the lowest strata (though as yet we have no proofs like those derived from Scandinavia, that the *hypozoic* rocks of Anglesea are inferior to the lowest fossiliferous beds), we are informed by him, that in passing from W. to E. on several parallels, whether near Tremadoc, near Penrhyn, or again near Cader Idris, there exists an ascending series from lower slaty and quartzose strata through igneous rocks in which no fossils have been observed, and thence into beds charged with a *Lingula* and fucoids; and that after passing through other alternations of slaty and igneous rocks, the geologist reaches the chief fossiliferous zone of the north-western portion of Wales, as exhibited in the range of Snowdon.

He also points out that the same beds with *Lingula* occur along the Merioneth anticlinal in the valley of Festiniog, and that in proceeding westwards therefrom, a grand succession is seen up to the well-known horizon of Bala. Admitting that the *Lingula* of these low beds in North Wales is a new species, that single circumstance cannot surely be of much value in a discussion like this. *Lingulae* occur in nearly all the formations or subdivisions of the Silurian system of Britain from the Ludlow rocks to the Llandeilo flags, whilst in North America, as in North Wales, they are found at the base of the whole of the same series of animal life. Again in Russia, where fucoids only have been detected in the lowest strata, the shells immediately above them are *Orbiculae* and *Ungulites* (*Obolus*), both of them, like the *Lingula*, small horuy bivalves suited to a sandy or muddy sea-bottom in which there had been little calcareous matter. In North Wales, as in other palæozoic countries, the true test of the age of the rocks lies in the lowest zones in which the common and characteristic fossils are found. Now among the lowest of these North Welsh beds Professor Sedgwick mentions the *Asaphus Powisii*, a crustacean first described by myself from the very uppermost beds of the Caradoc sandstone of Shropshire, or rather from the Horderley limestone at the base of the Wenlock shale, its associated fossils near Tremadoc being *Graptolites Murchisonæ* and *G. foliaceus*, both common Silurian forms. A *Homalonotus* is next cited as pertaining to still higher beds, and is identified with a species from the Lower Silurian beds of Witting-slow in Shropshire.

The *Leptæna sericea*, a species frequent in the Wenlock shale, and which also ranges, as I have shown, throughout the Lower Silurian rocks, is said by Professor Sedgwick to run low down into the Snowdonian group together with the *Trinucleus Caractaci*, the most typical

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perhaps of all the Caradoc fossils; whilst the associated Orthidæ are nearly all the very same simple-plaited species figured in my work, and on which I have always dwelt as the best and surest types of the Lower Silurian strata; viz. *Orthis calligramma*, *O. vespertilio*, *O. flabellulum*, *O. Actonia*, *O. expansa*, *O. elegantula*, *O. Pecten*, &c.

Let these species be found in any part of the world, and I ask if their discoverer can possibly assign to them any other geological name than Lower Silurian fossils?

And here I would say a few words on one of the propositions of my friend Professor Sedgwick. Changing the old name "Lower Silurian" into the new one of "Cambro-Silurian," and showing that there is a considerable intermixture of Upper and Lower Silurian forms in this group, he states with justice that it should never have been cut off from the Cambrian. But why was it so cut off?—simply, I repeat, because the zoological contents of the great mass of the Cambrian rocks were unknown at the period when the original classification was proposed. As soon as this point was cleared up, I hold that the conduct I pursued, so far from being in antagonism with the rules and analogies which have hitherto guided geologists, was in direct obedience to the only canon on which their nomenclature has been based—viz. conformity of succession and similar organic remains. The only error committed was the original one of giving a systematic name to a mass of rocks before its fossils were known; and I venture to declare it to have been not merely my opinion, but that of every geologist who considered the subject, that the continuance of 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.

In respect to the geographical propriety of language on which my friend insists, I have already said that I was not responsible for the outlines and contents of his Cambrian region; and as to the observation about the Silurian system being now brought by increase of knowledge to mean nothing but "fossiliferous greywacke," I have simply to remind him, that until the Silurian system was fixed, and was followed by tracing the ascending succession of palæozoic life through the Devonian into the Carboniferous and Permian deposits, foreign geologists had indiscriminately applied the word "greywacke" to different members of this great palæozoic series. But I need not dwell on the advantages which followed from that first step in the palæozoic classification, as they have been kindly admitted by my contemporaries, including Professor Sedgwick himself.

Although it is unnecessary that I should deny, what I apprehend no modern geologist can sustain, that peculiar lithological features or extraordinary thickness can constitute any claim for the establishment of a new nomenclature, I may be excused for requesting that reference be now made to my former descriptions of such Lower Silurian strata when I found them intermingled with rocks of igneous origin in the Silurian region. I then specially described districts in the higher and western parts of Shropshire and in Radnorshire, in which

contemporaneous submarine volcanic rocks alternated frequently with beds containing Lower Silurian fossils; such masses having been subsequently penetrated by other eruptive matter. Those contemporaneous trap rocks were stated to be made up of many varieties, including felspathic grits, sandstones, conglomerates and breccias, greenstone and hornblendic rocks of many shades, with porphyries, &c. Now, although these rocks had a very different mineral aspect from that with which I was familiar in districts removed from such disturbing causes, I never thought of applying a separate name to them. They had, it is true, a peculiar aspect. They were often much swelled out by the interlacement of porphyries, greenstones, and "volcanic grit," and owing to these conditions, fossils were comparatively rare; but in deciding their age I appealed to the fossils only, and wherever I found certain forms, of *Orthidæ*, *Trilobites*, *Graptolites*, &c., I at once mapped in such masses as "Lower Silurian." As no one has ever doubted that the name was there rightly applied, I request geologists to read the chapters descriptive of these rocks*, and then to tell me if I have not in them given a fair illustration (though on a smaller scale) of the leading features which are said to characterize the infinitely grander masses of North Wales. With the exception of beds charged with *Lingulæ* and pisolitic iron ore, and marked by a perfect slaty cleavage, there is, I assert, no essential difference, whether mineral or zoological, between the above tracts of Shropshire and Radnorshire and the rocks of Carnarvon and Merioneth; and if the hundreds of feet of the one be expanded into the thousands of feet of the other, and the undulating hills ranging from 1200 to 1800 feet high be raised into rocky ridges from 2000 to 3000 feet high, geologists will have before them, in my opinion, the Cambrian system as now characterized by Professor Sedgwick.

Nature's legends are, in a word, found to be composed of the same fossil types in the western parts of Wales as in the western limits of the Silurian region; the only difference being, that in the former the spaces between the letters are vastly more expanded, and that the whole region is more slaty, igneous and crystalline.

I say it advisedly, and after consultation with good palæontologists, who have examined the North Welsh fossils, that there is no essential difference between them and those of my Lower Silurian tracts. On the other hand, there are considerable variations in the distribution of the Upper Silurian species of the region I first described and those of parts of Wales, Cumberland and Westmoreland which have been recognised by geologists, including Professor Sedgwick himself, as Upper Silurian. Why then does he speak of and apply my Upper Silurian types only throughout his last memoir, and not equally depend on those styled Lower Silurian? Why, indeed, is the term "Lower Silurian" not once employed in his last memoir, though abundantly referred to in all his previous communications, when my types were appealed to? The only answer, it seems to me, which can be given, is that, as the word Cambrian is now de-

* See Silurian System, chapters 22 and 26.

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monstrated to be zoologically synonymous with Lower Silurian, Professor Sedgwick will not abandon the name he formerly applied to his great physical group, though such name was used before its fossil contents were known.

The question then is simply: Will geologists find it possible to use two terms to designate the very same succession of animal life upon the surface of the globe?—such terms being relatively made to depend upon the greater or less thickness of the strata and their diversity of lithological structure?

If then greater thickness of the masses be abandoned as a reason for a separate name, some geologists might contend that a physical separation of the upper and lower groups, or the unconformability of the one to the other, would afford grounds for such a distinction. But even this feature is wanting, in reference to the two groups characterized respectively by Upper and Lower Silurian fossils. There are, indeed, districts in which one portion of the Upper Silurian group is unconformable to another; and again, lines of dislocation producing unconformity occasionally affect the subordinate members of the lowest group itself, which Professor Sedgwick recognises as one natural whole. But we already know from the survey of the Government geologists, that all the Silurian strata roll over in conformable folds throughout South Wales, and that there is no general break between the masses occupied by Upper and Lower Silurian fossils in Wales, any more than within the limits of the Silurian region first chosen as a pattern. Indeed, I have strong grounds for believing, that the very rocks of Bala, about which so much discussion has taken place, will prove to be the physical equivalents of the schists, flags, limestones and sandstones which in South Wales have been described by me as Llandeilo flags.

There being, then, no unconformity between my Silurian and the Cambrian of Professor Sedgwick, the only remaining ground for changing the name, is the opinion which he seems to entertain, that the Silurian system, as originally described, is in reality made up of two natural-history groups, and ought therefore to have two names. On this point also it is scarcely necessary that I should go beyond the clear evidences recently afforded by the Professor himself, of the great interchange of fossils between the Upper and Lower Silurian groups*, to convince every one that they are so knit together in Britain as to be geologically inseparable†. When I published the 'Silurian System,' I then knew that a limited number of species only passed from the upper to the lower group, but in succeeding years I learnt, that many more were common to the two groups both in Great Britain and in other countries. My last memoir on Gothland has shown that out of 74 species of shells and crustacea in the Upper Silurian rocks of that island (46 of which are British Upper

* See also Quarterly Journal Geol. Soc., *antè*, vol. ii.

† The researches of the Government Geological Surveyors will presently bring to light facts which will place beyond all doubt, that even in North Wales or Cambria itself, many Upper Silurian forms are intermixed with those of Lower Silurian age; in short, Professor Edward Forbes has assured me, that in North Wales there is but one natural-history system only.

Silurian forms), 9 at least range into the Lower Silurian rocks of Britain, whilst 14 is the number, if the Lower Silurian type of Northern Europe be included. On the plain fact therefore, that there are many species of Trilobites, Orthidæ, and other shells which unite the two groups, I maintain that the Lower Silurian cannot be viewed as a system independent of the Upper.

But it is not on the duration or passage of species from the one group to the other, that I alone depend for the conservation of the zoological unity of my system. The qualifications and character of what I term a system are chiefly based on the assemblage of its classes of animals. Thus, the Silurian was typified as the great system of Trilobites, which crustaceans rapidly dwindle away in the overlying Devonian, and expire in the Carboniferous system. Again, the Silurian system was represented as being the chief centre of Orthidæ, its lower half being specially marked by small species of that genus with simple plaits. It was further spoken of as charged with Graptolites, and also as being the horizon in which certain very peculiar chambered shells are most rife. Of late years its lower strata have been shown to abound in Cystidea, those simple forms which, chiefly by the labours of Von Buch, have been shown to be the earliest created forms of the great family of Crinoids. And here I would beg British geologists to attend to the importance of foreign comparisons, if they wish to see rock systems founded on laws of general distribution of animals. Abounding in the Lower Silurian rocks of Scandinavia and Russia, these Cystidea had not been found by myself in the Lower Silurian rocks of Britain, but the researches of the Government Geological Surveyors detected the common species of Northern Europe (*Echino-sphaerites aurantium*) in strata actually described and coloured in the map of the Silurian region by myself as Llandeilo flags, whilst the same observers are now detecting the same in greater quantity in the rocks of Bala and in Ireland.

Even whilst I write, I learn that the only strong distinction which was thought to exist between the Upper and Lower Silurian rocks has vanished by the discovery of the defences of cartilaginous fishes of the genus *Onchus* in the latter, as just announced by Professor Sedgwick; and thus, whilst my view of a period void of vertebrata, founded though it was on very general observation, must be abandoned*, I naturally rejoice in this unexpected additional evidence, whereby the Upper and Lower Silurian rocks are still more firmly united in one system †.

Whilst we are considering what are the natural distinctions of a system, or "terrain" in the sense in which I used the word, I

* See Russia in Europe and the Ural Mountains.

† I also learn from Professor E. Forbes and the geologists of the Government Survey, that they have detected the defence of an *Onchus* in the limestone near Bala. Professor Sedgwick states that the species he mentions were found in the Upper Llandeilo flags. Professor Phillips has detected fish-remains in the Wenlock shale, and they had been previously observed by the Rev. C. Brodie in the Wenlock limestone. Although the species of North Wales are not yet described, it is rather remarkable that the *Onchus* of these Lower Silurian rocks is said to resemble, to a great extent, the *O. Murchisoni*, Agassiz, of my Ludlow rocks.

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beg to be permitted, without further reference to Russia and Scandinavia, to show how in another portion of the continent, the Silurian system has recently been applied by a French geologist, M. Barrande, to Bohemia, the country of his adopted residence. The slaty fossiliferous rocks of Germany, like those of Devon and Cornwall, are, it is now well known, for the most part of Devonian age; but in Bohemia a long and wide tract consists of a basin of Silurian rocks, the lowest strata of which repose on sedimentary rocks void of fossils, and these again on crystalline schists. With no other guide than my original work, the 'Silurian System,' M. Barrande, after collecting 600 species of Bohemian fossils, 129 of which species are Trilobites, has, of his own accord, come to the conclusion, that the whole clearly indicate a true Silurian series. The lower half of this series is composed of two stages of quartzose and argillaceous strata, which are not merely referred to the Lower Silurian as a whole, but through their mineral characters and their Trilobites, and other organic forms, are even severally compared with the Llandeilo flags and Caradoc sandstone. The upper group, eminently calcareous, presents itself in three stages, the lowest of which M. Barrande (after most assiduous examination of the fossils) compares with the Wenlock limestone and shale, the middle with the Lower Ludlow rock (the chambered shells of which strikingly resemble those of the same formation in England), and the third or upper division with the Aymestry limestone and Upper Ludlow rock. I advert, therefore, with pleasure to such labours, because they prove that the detailed descriptions of certain typical Silurian tracts in England have not been unfruitful, even in reference to other and distant European tracts. I further trust that geologists may regard my late memoir on Gothland as a corroboration quite as striking, of the value of the detailed original description of the types of my own country*. On the other hand, I well know that there are Silurian tracts in the British Isles, which under different conditions of mineral origin present much fewer points of resemblance to the types of the Silurian region than the above-mentioned distant foreign regions†.

But rock systems must not be so formed as to suit one country only. For if it be granted that in Britain the Lower can generally be so separated from the Upper Silurian as to be capable of demarcation on a map, how could the geologist succeed in separating the Upper and Lower Silurian of Christiania in Norway, where these groups, each equally well characterized by fossils as in our own country, fold over together in such small united masses‡?

* See Quarterly Journal Geol. Soc. vol. iii. p. 1.

† Whilst these pages are passing through the press, I have learnt from Mr. M'Coy, that several of the Upper and Lower Silurian species of Ireland which he has described and named, are identical with specimens from Bohemia now in the collection of the University of Cambridge; and together with this fact it is curious to remark, that the mineral characters of the rock masses in the two countries coincide, and that in Ireland as in Bohemia, the Upper Silurian is eminently calcareous, the Lower Silurian sandy, quartzose and slaty. (See the Silurian fossils of Ireland 4to., as published by Mr. Griffith and Mr. M'Coy.)—9 April 1847.

‡ See woodcut, Russia in Europe, &c. vol. i. p. 17, and Quarterly Journal Geol. Society, vol. ii. part 2 (Miscell.), p. 71.

Having stated that the Upper and Lower Silurian rocks of Europe, including all the fossiliferous strata of Wales, are so knit together by fossils and the transitions of the masses, that they must be viewed as one natural-history series, I will now conclude by simply indicating the small area in various countries to which the Silurian system would be reduced, if the meaning of that term were to be changed and restricted to the upper half of the original system.

In England, though prominent in the typical districts of Shropshire and Herefordshire, the Silurian rocks, so dismembered, would occupy a mere band (scarcely to be defined on a general map) in Brecknockshire, Carmarthenshire and Pembrokeshire; whilst all the broad and specially typical Lower Silurian tracts laid down by me in Salop, Montgomery, Radnor and South Wales must be erased, since it is impossible to distinguish them by their organic remains from the groups of Snowdon. In Ireland, from what we already know, whether through the works of Mr. Griffith, Capt. Portlock, or the labours of the Government Surveyors, the system would pretty nearly disappear, as the great mass of the Irish lower palæozoic fossils are found to be Lower Silurian.

In Russia in Europe and in nearly all Scandinavia, Lower Silurian rocks and fossils only prevailing, the very name Silurian would be swept from the map, and the system so attenuated would there be confined to Gothland and some small Baltic isles!

Now, it must be borne in mind, that even when the lower and upper groups are united in one system as at present, the Silurian rocks of Russia do not occupy one-fifth part of the area of either the Devonian or Carboniferous systems of those regions*, whilst in Germany, the whole system, as at present united, bears an infinitely small proportion to the overlying Devonian group. A glance at the Geological Map of America in Mr. Lyell's work, shows to what a small area, in relation to the other palæozoic rock systems, the Silurian would be reduced, if its lower half were abstracted.

Independent, therefore, of the impropriety of mutilating a system established on the community of its zoological contents, the results of such an arrangement would be a violation of the meaning which ought in fairness to be attached to a great natural-history period, which was typified as such before the Devonian system was thought of. There are indeed authors who think, that the Upper Silurian is so linked on to the Devonian, that the former, or a large portion of it, might advantageously be merged in the latter; and if their views prevailed, the only portion of my system or terrain which Professor Sedgwick's proposition leaves to me would also be swallowed up, and thus, by invasions on both sides, the poor Silurian system would be obliterated.

On the principle however of *strata identified by their fossils*, geologists I hope agree with me in the conviction in which I abide, that in whatever rocks and to whatever depths the Lower Silurian types extend, the tracts so characterized must be considered to belong to the "Silurian System."

* See General Map, Russia in Europe and the Ural Mountains.

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In contending for the preservation of that system in its unity, I in no way detract from the very great merit of the researches of my friend Professor Sedgwick in developing the physical structure, dislocations, slaty impress, fossil characters and other phænomena of the rocks of North Wales, Cumberland and Westmoreland.

As already stated, I formerly hoped he would also point out in their lowest division the existence of a distinct zoological type which would have entitled those rocks to a separate name; but having failed to do so, it seems to me manifest, that his "Cambrian" cannot now be sustained by dismembering a fossiliferous system which has been so long established, so largely developed, and so widely applied over the world as the Silurian. Whether geologists will use the word "Cambrian" in reference to still older and often unconformable greywacke lying beneath all the beds with Silurian fossils, it is not for me to determine. My chief object in this communication is to explain how, by the progress of research, the protozoic types of various parts of northern Europe, including North Wales, have been shown to be true equivalents of the lower part of a natural system which I proposed twelve years ago, and which geologists of various countries adopted after a careful scrutiny of the evidences on which it was established.

2. *On the Geology of the CALF OF MAN.* By the Rev. J.G. CUMMING, M.A., F.G.S., Vice-Principal of King William's College, Isle of Man.

THE Calf of Man is an islet of about 800 acres in superficial extent, situated at the south-western extremity of the Isle of Man, and separated from it by a narrow channel, in breadth not more than 500 yards, called "the Race" or "Sound" of the Calf. Nearly in the centre of this channel, but rather towards its northern side, lies the small rocky islet of Kitterland, between which and the Isle of Man the channel is fordable at low water, and between it and the Calf islet the passage is rendered dangerous by several sunken rocks, the tide rushing through the channel at certain periods of ebb and flow at the rate of nine miles per hour.

Section (1.)