ORDINARY MEETING, JUNE 7TH, 1872.

The Rev. THOMAS WILTSHIRE, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Memoirs of the Geological Survey of England and Wales," vol. iv., "The Geology of the London Basin," by William Whittaker, B.A., F.G.S., from the Author.

"Thesaurus Siluricus, the Flora and Fauna of the Silurian Period," by J. J. Bigsby, M.D., F.G.S., from the Author.

"Sketch of the Geology of the Neighbourhood of Banbury," by Thomas Beesly, F.C.S., from the Author.

"Report for 1870 of the Geological Survey of Ohio," from the Ohio State Survey.

"Thirty-ninth Annual Report of the Royal Cornwall Polytechnic Society, 1871," from that Society.

"Quarterly Journal of the Geological Society," from that Society.

"Abstract of the Proceedings of the Geological Society," from that Society.

"Proceedings of the South Wales Institute of Engineers," from that Institute.

The following were elected Members of the Association:—

George Blumberg, Esq.; James Campbell, Esq.; William Chapple, Esq.; Edwin Litchfield, Esq.; Samuel Rowles Pattison, Esq., F.G.S.; Mrs. Robins; Miss Jane C. Seel; W. T. Stone, Esq.; Thomas Warburton, Esq.; and Cecil Ray, Esq.

The following Papers were read:—

1. ON THE CLASSIFICATION OF THE CAMBRIAN AND SILURIAN ROCKS.

By HENRY HICKS, Esq., M.R.C.S., F.G.S.

Geological science is so progressive, and new discoveries are so frequently made, that it can scarcely be expected that the classification of any portion of the series of stratified rocks can remain long without the necessity for considerable change and modification: the classifications, therefore, of the Cambrian and Silurian Rocks, by Professor Sedgwick and Sir R. Murchison, made many years ago, and sufficiently correct at that

time, are now in several respects unsatisfactory. Even at present, when so much still lies hidden from our view in unexplored regions, any attempt at a classification must be more or less imperfect, though it is satisfactory to find that fresh discoveries leading towards a natural arrangement are continually being made.

Systems of classification are necessary, if only for working purposes, and doubtless cannot be dispensed with on that account; still, it must not be forgotten that all lines of division, wherever placed, are more or less arbitrary, for we have only one great natural system to deal with, and, therefore, as Nature from time to time unfolds herself to us, so these lines have to yield and give way to others.

We know also that there are numerous breaks in the succession even at present, and we avail ourselves of these accidental circumstances frequently for purposes of classification; but as these have arisen chiefly from faults in the strata, denudation, and such causes, we must expect to be able to fill up many of these gaps as our knowledge of hitherto unexplored and imperfectly explored regions becomes more satisfactory.

It is important also to bear this fact in mind in examining the organic remains of succeeding groups; for, however dissimilar the forms in these groups may appear, this must not be looked upon as a want of accord in nature, but as evidence only of the absence, by some accidental cause, of deposits, which, had they been present, would have shown how unvaryingly true Nature has always been to her laws.

In the accompanying Table the groups of strata which are known, collectively, to form at present the Lower Palæozoic rocks of this country are placed in their natural order of succession; and side by side the classifications of these groups, as adopted by Professor Sedgwick, and by Sir R. Murchison, along with the one now proposed.

All rocks not newer than the Bala Limestone were placed by Professor Sedgwick in his *Cambrian*, which was divided by him into an *Upper*, *Middle*, and *Lower* portion; the *Upper* consisting of the Bala group, and the Arenig or Skiddaw group; the *Middle*, of the Tremadoc, and Ffestiniog groups; and the *Lower*, of the Harlech, and Longmynd or Bangor groups. His *Silurian* included the beds from the base of the May Hill group to the top of the Downton Sandstone, the Bone Bed, and Upper Ludlow.

By Sir R. Murchison, the *Cambrian* was made to include only

the beds contained in Professor Sedgwick's *Lower Cambrian*, viz., the Longmynd or Bangor group, and the Harlech group, the whole series above these being called *Silurian*, or rather, in his most recent work, *Primordial Silurian* and *Silurian*, the name *Primordial Silurian* being adopted by him after the publication of the researches by Mr. Salter and myself in the Menevian group in Wales.

Murchison's classification varied considerably from time to time (the last being that published in "Siluria," in 1868, and which corresponds with the one in the Table), and apparently not so much with a view to a more natural arrangement as to include all fossiliferous rocks of the early formations in his Silurian, leaving the term Cambrian only to what he in 1868 called the sterile bases of the fossiliferous rocks; these "sterile bases," however, even in that year proved to be themselves richly fossiliferous.

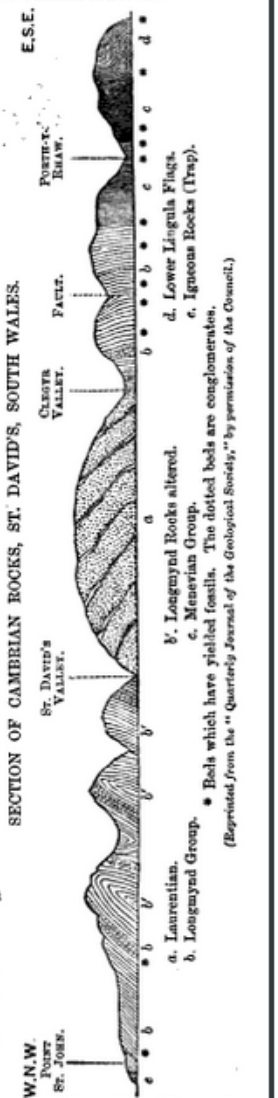
The divisions now proposed differ in several particulars from those of Professor Sedgwick, and Sir R. Murchison, and are an attempt at a more natural arrangement in accordance with Palæontological evidence. This arrangement has already been adopted to a great extent by Sir Charles Lyell, in his "Student's Manual of Geology," 1871, and by Mr. Salter and myself in several papers.

I have left out from the Table the rocks which of late years have become known to us under the names *pre*-Cambrian or Laurentian, as they have yielded no organic remains at present in this country. Moreover, their position is easily recognised, and no difficulty is likely to occur with them. They appear generally as quartziferous or granitic rocks, with a strike from N.W. to S.E., and, hence, discordant to that of the overlying Cambrian strata, which invariably in this country has a strike from about N.E. to S.W. These *pre*-Cambrian rocks occur as ridges in the strata in the neighbourhoods of St. David's, and Malvern, Charnwood Forest, the Hebrides, and western parts of Scotland.

In the Table the lowest group is the Longmynd, so named from the Longmynd hills of Shropshire. This group is usually divided into an upper and a lower portion, the former supposed to be equivalent to the Harlech Grits, and the latter to the Llanberis Slates. There is no evidence, however, at present to show that the Llanberis Slates are older than the Harlech Grits, for the difference in their lithological characters may easily

be explained, as stated by Sir C. Lyell, by looking upon them as deposits of fine mud thrown down in the same sea, on the borders of which the sands of the Harlech Grits were accumulating. The great thickness of the strata in the Longmynd hills has naturally led authors to believe in the probability of a more ancient series occurring there than is present in the Harlech district, but this view seems not borne out by actual facts, since there is every probability of repetitions of the strata in the Longmynd district, as is the case at St. David's; moreover, after an examination of the beds at these places, I am inclined to believe that in no case does the actual thickness of the series, without repetitions, attain to nearly what has been usually given to it in the Longmynd hills. The series so well exposed in coast sections at St. David's is evidently identical with that in North Wales, and Shropshire; the lithological characters and the order of succession being strangely alike, and even the thickness, when any particular series is exposed to view, shows only a very slight difference. The lowest beds at St. David's, in my opinion, are certainly of equal antiquity to any in the Longmynd hills, and have the advantage of showing a base resting on a *pre*-Cambrian ridge, such as is nowhere shown in the Longmynds, or in North Wales. The accompanying section explains the relation of these beds to the *pre*-Cambrian islands at St. David's.

The life of this period, so far as we at present know, consisted of annelids, crustaceans, brachiopods, pteropods, and sponges. From 3000 to 4000 feet of these beds, in natural succession, have



yielded fossils at St. David's, where as yet they have been chiefly examined. The Longmynd beds in Shropshire, in North Wales, and also in Ireland, have also yielded a few indications of life, but these districts need further exploration. Resting on these rocks at St. David's and in the Harlech district, we have a series of grey and blue flags and slates, with some sandstones at the upper part; and designated by Mr. Salter and myself the "Menevian Group." These beds are richly fossiliferous, and contain genera like those in the Longmynd Group below; several species are also common to the two groups. Between these two groups the boundary line separating Cambrian from Silurian was placed by Sir Roderick Murchison, and it is still retained here by the members of the Geological Survey. Lithologically there is a good deal of difference in these two groups, for the lower or Longmynd is almost invariably made up of green, purple, red, and grey rocks, and conglomerates; but palæontologically they are very nearly allied, and it would be in every respect wrong to place so strongly marked a divisional line between two groups so intimately connected by their organic contents. Sedgwick's line of division between the Middle and Lower Cambrian also comes in here, and from following lithological characters only. It may be granted, however, that there was some excuse for this boundary line, for at the time it was made no fossils had been found in the Longmynd Group. Henceforth, however, it will be impossible to retain this line, and I have therefore suggested that these two groups should go together to form Lower Cambrian, and that the line of division should be above instead of being below the Menevian Group. The genera and species of the Menevian group, also, are so thoroughly distinct from the immediately overlying rocks of the Lingula Flag group that the boundary seems to fall naturally at this spot.

17 genera and 25 species have been found in the Longmynd Group, and 23 genera and 52 species in the Menevian Group. Twelve genera and eight species are common to both groups, and such genera as *Paradoxides*, *Conocoryphe*, and *Microdiscus* are amongst them. This proportion is far greater than we usually find between two groups so dissimilar in lithological characters, and comprising so great a thickness of strata.

The next group we come to consists of what has usually been called the Lingula Flags, and so named from the abundance of

Lingulella Davisii found in some of the beds, chiefly the middle ones. This group has been divided into an *Upper*, *Middle*, and *Lower* series, each characterised by genera and species peculiar to that zone. On the whole, considering the thickness of the strata, which must be over 5000 feet, this group is exceedingly barren of organic remains. The Lower or Maentwrog beds contain only four genera and eight species; the Middle or Ffestiniog beds six genera and six species; and the Upper, Dolgelly or Malvern Shales, ten genera and eighteen species. The lithological characters are bluish or grey arenaceous slates for the Lower, grey arenaceous and micaceous flags for the Middle, and soft black and bluish slates for the Upper. The genera and species increase greatly in these Upper beds, as is usual with fine muddy deep sea deposits, though the thickness of the Upper beds is not more than 600 feet. We have in these last a return to conditions similar to those which followed the shore and shallow water deposits of the Longmynds during the depositions of the Menevian Group; but sufficient time had elapsed to change the prevailing forms of life, and yet not to an extent that they did not retain some resemblance to their ancient ancestors. All the trilobites of the Lingula Flags are allied to *Olenus*, and there are none in any way Silurian in character.

Following the Lingula Flags are the Tremadoc rocks. These occur chiefly in the neighbourhoods of Portmadoc, in North Wales, and of St. David's, in South Wales. They rest conformably on the Lingula Flags, and usually graduate by insensible degrees from them. They are more than 1,000 feet in thickness, and consist of dark earthy slates and flaggy sandstones. In the table they form the upper group of the Cambrian, a position given to them by the late Mr. Salter, and afterwards by Sir C. Lyell, and others. Mr. Salter, along with Messrs. Homfray and Ash, of Portmadoc, examined these rocks very carefully in North Wales, and proved that they formed an intermediate series in which Cambrian genera seemed to commingle in about an equal degree with Silurian genera. This has been borne out since by the researches conducted in the neighbourhood of St. David's, in South Wales, where a considerable addition to the fauna has been made; but here the trilobites, which in these early rocks are the surest indices of the age of the strata, are more strongly primordial in type, and tend to connect the group still more closely to the underlying series.

The Arenig Group, which comes in next in the Table, is divided into an *Upper* and a *Lower* series, both characterised by a distinct assemblage of fossils. The Lower series occurs chiefly in the neighbourhood of St. David's, and is of about 1,000 feet in thickness. The fossils consist of numerous graptolites, especially dendroid forms, and trilobites of the genera *Oggygia*, *Trinucleus*, and *Æglina*. All the forms are thoroughly Silurian in character, and the series marks a definite line for the base of the Silurian groups. The Upper series comprise the well known Skiddaw Slates. Upon the Arenig comes the Llandeilo Group, the lowest rocks recognised by Sir R. Murchison in the typical Llandeilo district. This group in the Table is divided also into an *Upper* and *Lower* series, marked out by distinct faunas.

The Bala or Caradoc Group now comes in with its exceedingly rich fauna, and it forms in the Table the upper member of our Lower Silurian, and also of Professor Sedgwick's Upper Cambrian. Sir R. Murchison added to the Lower Silurian the Lower Llandovery rocks, but Sir Charles Lyell in his "Student's Manual of Geology," 1871, preferred "to regard them as the base of the Upper Silurian, to which group they are linked by more than twice as many species as to the Lower Silurian." The evidence of Professor Hall and others, in America, tends to prove, however, that ultimately it will be necessary to make a Middle Silurian division, and though the group is scarcely important enough, as hitherto known in this country, to warrant such a division, yet should a spot be found where the present unconformity is filled up, a series may be discovered, like that in the American continent, sufficiently large to enable it to be done.

The higher groups, *Wenlock* and *Ludlow*, which complete the Table, are each capable of being divided into at least two groups, with a considerable thickness of strata and well defined faunas.

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2. On the Silurian Rocks of the English Lake District.

By H. Alleyne Nicholson, Esq., M.D., D.Sc., M.A., F.R.S.E., Professor of Natural History and Botany in University College, Toronto.

Considering the extent to which the Silurian series of the English Lake District has been studied, it is somewhat remarkable that there should still be considerable difference of opinion as to the