

into vast clusters of several tons weight, resembling masses of stalactite, the component portions being nearly parallel to each other. Mr. Strickland supposes that currents of water (or possibly of wind, operating during ebb tide), flowing in a certain direction, may have disposed the sand in ridges parallel to that direction, and the carbonate of lime may have afterwards been attracted into these ridges in preference to the intermediate portions. This view is confirmed by the fact, that these concretions have frequently a pebble attached to the larger end, as though it had protected a portion of sand from the current, and caused it to accumulate in a ridge on the lee side, a circumstance which may frequently be observed where sand is drifted by the wind or water.

Nov. 30.—William Baker, Esq. of Bridgewater, Andrew Roos-malecoeg, Esq. of King's College, Dr. Lyon Playfair of Primrose, near Blackburn, Lancashire, and John Buckman, Esq. of Pittville Street, Cheltenham, were elected Fellows of this Society.

“On the Bala Limestone.” By Daniel Sharpe, F.G.S.

Before entering upon his own views, the author quotes the opinions published by others upon the age of the limestones of Bala and Coniston; previous to the labours of Professor Sedgwick and Mr. Murchison, these two calcareous bands were thought to be of the same age, and to be nearly the oldest fossiliferous beds in this country; but the first definite arrangement of them was made by Professor Sedgwick, whose views will be found in our Proceedings (vol. ii. p. 675), placing both these limestones in the Upper Cambrian system, which he stated to lie below the Silurian system of Mr. Murchison, and above the Lower Cambrian system, or old slate series of Carnarvonshire, Cumberland, &c., a view adopted by Mr. Murchison in his work upon the Silurian system, upon the authority of Professor Sedgwick.

In 1839 Mr. James Marshall classed the Coniston limestone with the Caradoc sandstone, upon the evidence of fossils examined by Mr. J. Sowerby, and pointed out that it rested upon the Lower Cambrian rocks; thus omitting the Upper Cambrian system in the North of England (Reports of the British Association, vol. viii. p. 67.)

The second edition of Mr. Greenough's Map adopts Mr. Marshall's view of the age of the Coniston limestone, and omits the Upper Cambrians in the district of the Lakes; but retains them in North Wales, under the name of Upper division of the lower Killas, in which is included the Bala limestone, thus placed in a different system from the limestone of Coniston.

Professor Sedgwick's memoir of November 1841 follows the same view (Proceedings, vol. iii. p. 545); and in a note, p. 551, that author removes all doubt as to his opinions by apologizing for having formerly placed the Bala and Coniston limestones on the same parallel.

Notwithstanding the agreement of our best geologists in placing the Bala limestone in the Upper Cambrian system, Mr. Sharpe was induced to doubt the accuracy of this classification, by observing that

everyone admitted that the Bala fossils agreed, as far as they had been examined, with those of the Lower Silurian beds, and that there was no clear line of separation between the Lower Silurian and Upper Cambrian groups: but his attention was particularly drawn to this district by Mr. Bowman's observations on Denbighshire, laid before the British Association in 1840 and 1841, and since published in the first volume of the Transactions of the Geological Society of Manchester, p. 194, which Mr. Sharpe regards as the first indication of the true structure of this part of North Wales; Mr. Bowman classes as Upper and Lower Silurian many beds before mapped as Upper Cambrian, showing that the previous classification of the rocks of North Wales could not be relied upon.

Mr. Sharpe quotes largely from Mr. Murchison's Address from the Chair in February 1842, to show that the Upper Cambrian cannot be separated from the Lower Silurian beds by the help of organic remains, as "Lower Silurian species range through the Upper Cambrian rocks, and throughout the whole of North Wales," and "prevailed during that vast succession of time which was occupied in the accumulation of all the older slaty rocks previous to the Upper Silurian period."

Mr. Sharpe points out, that up to the moment of his taking up the subject no one of the authors quoted had expressed a doubt of the existence of a great thickness of fossiliferous beds below the Caradoc sandstone and Llandeilo flags, although it was admitted that these supposed beds could not be distinguished by their fossils from the Lower Silurian; and he states that the object of his communication is to show the error of this view as relates to the Bala rocks, which he proposes to prove to be the equivalent of the Lower Silurian beds described by Mr. Murchison, and not part of an older series; and he infers from analogy that the same will be found to be the case in other parts of North Wales which he has not visited, where he conjectures that all the rocks containing shells of Lower Silurian species will also prove equivalents of the Lower Silurian beds. Instead of continuing the Silurian system downwards through a vast thickness of slate rocks, Mr. Sharpe proposes to strike out one of its original members, regarding the Caradoc sandstone and Llandeilo flags as one and the same formation which has received different names according to its mineral character; he observes, in confirmation of this view, that both formations are never equally developed in the same district, and that the fossils found throughout are too nearly the same to warrant the separation of the lower beds under a separate name. Still Mr. Sharpe believes that there are in Wales, as in Westmoreland and Cumberland, vast accumulations of slaty rocks below the Silurian system, in which no fossils have been found, and which must retain the appropriate name of Cambrian rocks.

Mr. Sharpe did not map the district in detail, but he traced two sections to show the position of the Bala beds with regard to the Berwyns, as he considered the question to turn upon the accuracy or error of the statement of Mr. Murchison, p. 308, "that the Bala limestone dips under the chief mass of the Berwyns."

The first section begins westward, at the igneous chain of Arenig Mawr, the natural boundary to the district; it crosses the town of Bala, and ends eastward at the Calettwr, where a dark slate, the upper bed of the Bala series, abuts unconformably against the clay-slate of Moel-halog, which is referred to the Cambrian system. This section places the Bala beds in a detached trough, and shows that they do not dip under the Berwyns: but their succession is not well shown, owing to the disturbed state of the surface.

The other section is in two parts; from the head of the lake of Bala up the Twrch to Bwlch y Groes, and across the Dyfi by Dinas Mowddy and Mallwyd, which line the author recommends to those who wish to study this series, as the rocks are well exposed in the upper part of the valleys of the Twrch and Dyfi: on the west it begins at the northern prolongation of the igneous chain of Arran Mowddy, and continues eastward through a conformable succession of beds up to the Upper Silurian; each section shows the whole of the Bala series, the upper bed of blue slate, which on the Calettwr rests unconformably against the Cambrian clay-slate, being the same which is overlaid conformably beyond Mallwyd by an Upper Silurian series of soft blue or liver-coloured shales alternating with hard, grey grits, without cleavage or fossils, dipping east-south-east, which Mr. Sharpe identifies with the No. 2. of Mr. Bowman's lower division of the Upper Silurians, the probable equivalents of the Wenlock shale.

Mr. Sharpe then describes the Bala series of rocks, beginning with the uppermost beds.

1. *Dark blue slate*.—Worked at Craig Calettwr for good roofing-slates and flags; in one quarry the beds dip W.N.W 35° , and the cleavage planes dip W.N.W 65° ; in another the beds dip W. 70° and the cleavage W. 80° . Between Dinas Mowddy and Mallwyd it is largely quarried for good slate and flags; the beds dip S.E. or E.S.E. about 30° ; the cleavage is perpendicular, and strikes S.S.W. The lower beds pass into a soft argillaceous slate of no value. The whole is not less than 300 or 400 feet in thickness.

2. *Upper Bala limestone*.—A dark blue bed ten feet thick, accompanied by calcareous slates and soft brown shales, with many fossils, among which are *Orthis canalis* and *O. compressa*, and several new species. Mr. Edward Davis, who accompanied the author, discovered this bed at Pen-y Dall Gwm, four miles south-east of Bala, dipping W. $\frac{1}{2}$ S. 70° : it is supposed to follow a line bearing N.N.E., much broken up by faults*.

3. *Rotten argillaceous schist and indurated shale*.—Light grey, weathering to brown, with many joints and few fossils; well exposed in the valley of the Dwm-lach, above its junction with the Dyfi: 400 feet thick.

4. *Bala limestone*.—A dark blue rock similar to No. 2, thirty or forty feet thick, with calcareous shales and grits full of organic remains, among which are *Orthis pecten*, *anomala*, *vespertilio* and *bi-*

* Mr. J. B. Morris has since met with the same bed in the valley of the Dyfi at Blaen-y-Pennant.

lobata, *Leptæna sericea*, *duplicata* and *depressa*, and *Spirifer radiatus*. This bed is much broken, and difficult to trace, but its general direction from Y-Garnedd, $1\frac{1}{2}$ mile east of Bala, to the upper valley of the Cowarch, is nearly N.N.E. The line of limestone laid down, both in Mr. Murchison's and Mr. Greenough's Maps, is compounded of the beds No. 2. and No. 4.

5. *Grey slaty grits*.—Occasionally streaked or passing into brown, very hard; well seen on both sides of the lake of Bala and in the upper part of the valley of the Twrch; usual dip E.S.E. 45° , but much disturbed about the foot of the lake; the upper bed contains *Orthis canalis*, *anomala* and *vespertilio*. In the lower part is a bed thirty or forty feet thick of impure grey limestone with many fragments of *Trilobites* and other organic remains, among which Mr. Sharpe recognised *Bumastus Barriensis*, *Trinucleus Caractaci*, *Illænus crassicauda*, *Orthoceras approximatum*, and *Lituites cornu-arietis*. This bed was only seen near Rhiwlas and Llan-y-ci, on the north-west of Bala. The grits below the limestone are similar to those above, and contain *Orthis canalis* and *vespertilio*, *Leptæna sericea* and *Asaphus tyrannus*. The whole exceeds 500 feet in thickness.

6. *Rotten grey clay-slate*, weathering to brown, forming the moor between Bala and Arenig, and exposed where Cwm Croes joins the valley of the Twrch: supposed to be 500 feet thick.

7. *Dark blue slate*, of poor quality, covers the eastern flanks of Arenig and Arran Mowddy, quarried at Blaen-y-cwm, where the beds dip N.E. 35° , and the cleavage dips E.N.E. 55° : the lowest bed of the series.

As the Bala beds are quite unconnected with the Cambrian rocks of the Berwyns, and are only overlaid by Upper Silurian deposits; as most of their organic remains are known Lower Silurian species, and as the total thickness of the whole series is about the same as has been assigned by Mr. Murchison to the Lower Silurians, Mr. Sharpe concludes that they are the exact equivalents of the Lower Silurian formation, and do not carry the series down below the beds described by Mr. Murchison. Mr. Sharpe considers it as easy to prove their identity with the Caradoc sandstone as with the Llandeilo flags, and again endeavours to show that these must be regarded as the same formation under different names. This classification replaces the dark blue limestones of Bala and Coniston, on the same parallel from which they were separated when Professor Sedgwick adopted Mr. Marshall's view of the Silurian age of the Coniston limestone, but left the Bala limestone in its erroneous position as part of the Upper Cambrians.

Mr. Sharpe adds comparative tables of the Silurian system as exhibited in three different districts:—in Westmoreland, as observed by himself; in Denbighshire and Merionethshire, the upper part taken from Mr. Bowman's memoirs, the lower added by himself; and in Shropshire, &c., as described by Mr. Murchison; but he defers the full comparison of these till he lays before the Society the conclusion of his remarks on Westmoreland.

Mr. Sharpe hopes that he has done away with an objection often

made to the Silurian system, that it wanted a definite base, and was not distinctly separated from the Cambrian system; this was not overlooked by Mr. Murchison, who states that the line drawn between the two systems was provisional. The difficulty arose from classing with the Cambrian system many beds belonging both to the Upper and the Lower Silurians, and it will vanish when this is corrected; the lower boundary of the Silurian system will then prove as distinct in North Wales as in Westmoreland and Cumberland; but to produce this result, the country west of Llangollen and Welsh Pool must be remapped. Of the district now coloured as Upper Cambrian a small share will be given to the Ludlow and Wenlock formations, a larger portion to the Lower Silurians, and certain central bosses of older rocks will remain for the Cambrian system: but the Upper Cambrian of Professor Sedgwick, and its representative in Mr. Greenough's nomenclature, the upper division of the Lower Killas, must be struck out of our tables, and the Lower Silurians made to rest on the true Cambrian rocks.

The igneous rocks of Arenig and Arran Mowddy are described as varying compounds of felspar and quartz. The two chains bear nearly north, and their eruption is supposed by the author to have modified the face of the country, and to have caused much of its present complication, the prevailing strike previously having been N.N.E. In the absence of direct evidence on the subject, Mr. Sharpe endeavours to prove that Arenig and Arran Mowddy are at least as modern as the Ludlow rocks, by showing that the upheaving of these chains has broken up the parallelism of the cleavage planes of the slaty rocks resting on them: assuming that these planes had originally a constant direction in each district, their dislocation at any spot would show that it had been disturbed subsequently to the cessation of the cleavage process, and we may thus class igneous eruptions as prior to, or posterior to, the cleavage; and may then connect them with the deposition of the formations, by observing at what epoch the cleavage ceased in the district. In North Wales and in Westmoreland, the cleavage only reaches into the Lower Ludlow formation; in Devonshire and Cornwall it continued later; therefore Arenig and Arran Mowddy must have been upheaved after the epoch of the Lower Ludlow shale.

The memoir concludes with a general list of the species of fossils found near Bala.

“Notice on the discovery of the Remains of Insects in the Lias of Gloucestershire, with some remarks on the Lower Members of this Formation.” By the Rev. P. B. Brodie, F.G.S.

The lower beds of the lias, in which these organic remains occur, are extensively developed in the neighbourhood of Gloucester and Cheltenham, and occupy the greater part of the vale. In the upper part of the lower beds, in a hard blue limestone, was found the elytron of a coleopterous insect of the family *Buprestidæ*, apparently a species of *Ancylocheira* of Escholtz. This was the only fossil of the kind met with by Mr. Brodie in this portion of the lias. With this