

cene. Others of similar character in South Carolina and Georgia, as at Orangeburg, Aikin, Stony Bluff, and Millhaven, belong to the burrstone formation, which is of the eocene period.

The species of eocene shells common to the United States and Europe appears to be very small. I have in my cabinet eighty-five species, in a good state of preservation, from Claiborne, Alabama, presented to me by Mr. Conrad; and I procured from the various localities already enumerated in this paper about forty species which I could not identify with the above, or with any which I have seen from Claiborne. Out of these 125 species I have been able to identify the following seven only with European eocene shells: namely, *Bonellia terebellata*, *Trochus agglutinans*, *Solarium canaliculatum*, *Infundibulum trochiforme*, *Cardita planicosta*, *Lithodomus dactylus*, *Ostrea bellovacina*. The proportion, therefore, of species common to Europe and the United States scarcely exceeds five per cent., and the proportion of species now living and identical with the American eocene shells appears to be still smaller. In regard to geographical representations, I found at least one fourth of the species to be very closely allied to European eocene fossils, while another fourth presented forms differing greatly from any species procured from the eocene strata of Europe, although belonging to genera which are abundantly represented in these formations.

March 12. 1845.

Sir Robert Burdett, Bart., of Ramsbury Park, Wilts, and Warrington W. Smith, Esq. M.A. of Trinity College, Cambridge, were elected Fellows of this Society.

The following communication was read:—

On the comparative Classification of the Fossiliferous Strata of NORTH WALES, with the corresponding deposits of CUMBERLAND, WESTMORELAND, and LANCASHIRE. By the Rev. ADAM SEDGWICK, M.A., F.R.S., Woodwardian Professor of Geology in the University of Cambridge.

THE author referring to his memoir on the structure of North Wales, published in the first number of this Journal, for an account of the sequence of the rocks in that district, states that his object now is to bring the successive groups of the Cumbrian mountains into comparison with the three primary divisions of the whole Welsh series.*

* These divisions are:—

3. The uppermost slate rocks of the Upper Silurian age, consisting of a series of beds called by the author the '*Creseis* flagstone,' from the abundance of that fossil, overlaid by the Denbigh flag, &c.

2. Roofing slate and greywacke of great thickness, with alternating beds of contemporaneous porphyry.

1. Chlorite and mica slate, &c. of Anglesea and the S. W. border of Caernarvonshire.

The whole series of the Cumbrian slates, like that of North Wales, has been considered to admit of three primary divisions, but hitherto the separation has been chiefly made from a consideration of physical characters and superposition, and without reference to fossils; the uppermost only of the three being supposed to contain them. In this state the author left his maps in 1824, and they show the superficial extent of the igneous and intrusive rocks, of the lowest or Skiddaw slate, of the great mountain masses of green roofing slate and porphyry, alternating in vast parallel bands, and lastly, of the fossiliferous slates extending from the Coniston limestone to the highest beds on the banks of the Lune, near Kirby Lonsdale.

Of these beds the author considers that the Skiddaw slate has, perhaps, no true equivalent in N. Wales, and that the green slates and porphyries are probably the exact representatives of a portion of the great system of Snowdonian slates. The Snowdonian slates, however, contain fossils, and the green slates and porphyries of Cumberland are without them; a difference accounted for as the consequence of the greater abundance of igneous rocks among the green Cumbrian slates. It remains then to find the equivalent of the fossiliferous rocks in the third and highest division of the Cumbrian slates, and for this purpose the author discusses in its most limited form the following questions, namely:—Into what groups may we subdivide the slates expanded between the Coniston limestone, and the highest beds of the series on the banks of the Lune, near Kirby Lonsdale? and what are their equivalents in North Wales? Professor Sedgwick considers that, with the exception of the Coniston limestone, and two or three hundred feet of slate and shales surmounting it, the whole of the upper series is *Upper Silurian*, and in the parallel of the Denbigh flagstone, using this latter term in its most extended sense.

The author then enters into some detail with regard to the actual working out of the geology of this district, and his ultimate discovery that a great movement of the strata had brought up the Coniston limestone a second time, on the south side of the estuary of the Duddon, in a ridge called High Haulme, N. W. of Dalton in Furness. In this ridge the beds are nearly vertical, and are associated with trappean rocks and porphyries exactly like those under the Coniston limestone on the north side of the Duddon, which are several miles distant.

The calcareous bands of this ridge being nearly in the same line with a second or higher band of limestone, became confounded with it, and this has led to a wrong estimate of the geological equivalents of the second band of limestone. The mistake being corrected, it appears that the successive groups of strata will easily fall into their right places without the intervention of any great unconformable overlap. Thus the fossiliferous slates present—first, the Lower Silurian rocks in a very degenerate form; and secondly, the Upper Silurians in a noble series, more complete and far thicker than the Denbigh flagstones, and ending with the red flags or tile

stones of the Lune. The author then proceeds to describe some of the lower groups of these rocks and their fossils.

1. *The Coniston limestone.* Most of the points of interest with regard to this bed have been described by the author in a former paper, of which an abstract has been given in the Proceedings of the Geological Society.*

It is of a dark blue colour, traversed occasionally by contemporaneous white calcareous veins, and its colour appears to be derivable from metallic oxides and not from carbon, as it burns to a dark-coloured lime, which is used for agricultural purposes, and as a cement stone. This limestone sometimes immediately overlies felspar rock and porphyry, and the bottom beds, although generally impure and siliceous and occasionally slaty, contain in some places 20 or 30 feet of beds fit for use. In Long Sleddale, however, a singular trappean rock with great balls of agate underlies the limestone, and in Kentmere the lower beds contain masses of coarse conglomerate; and although this is rare, yet as a general rule these beds exhibit no marks of metamorphosis, and the green slates and bedded porphyries below are so parallel to the limestone, that all have evidently been disturbed together, while the passage from the lower beds to the upper is almost instantaneous.

The limestone bands are variable in their character, and not strictly continuous, and the best beds are generally only a few feet thick. On one side of Long Sleddale they are good, on the other very degenerate, and occasionally they only form irregular rognons in a dark fossiliferous slate. Above the limestones are shales and soft slates, pyritous at the division of the beds †, and generally of dark colour; in these the rognons disappear gradually, but the fossils ascend into them for some distance. At Sunny Brow the slates are harder but too much jointed to be worked: at Ash Gill, however, they are extensively quarried and contain many fossils, one or two of them new species, but of Lower Silurian types. The thickness of this group, which terminates the Lower Silurian series, is probably upwards of 300 feet.‡

* Proceedings, &c., vol. i. p. 249.

† In consequence of this appearance, unsuccessful attempts have been made to obtain copper from these beds, but small veins and strings of sulphuret of copper have been partially worked to the east of Coniston.

‡ The author appends the following observations concerning the fossils of the Coniston limestone.

The Coniston limestone seems to contain all the characteristic fossils of the Llansaintfraid section combined with many of the Bala species. The following is the list of species: —

Polyparia.

<i>Astrea</i> , one or two species	<i>Stromatopora concentrica</i>
<i>Favosites polymorpha</i>	<i>Turbinolopsis bina</i>
<i>F. spongites</i>	<i>Retepora</i> , scattered pores of a large species
<i>F. fibrosa</i>	<i>Catenipora escharoides</i>
<i>Porites pyriformis</i> , in abundance, and a nearly allied species of larger size	<i>Tentaculites annulatus</i>
<i>P. inordinata</i>	<i>Tentaculites</i> , a new species

2. *Coniston flagstone*. This group the author has formerly described as *Brathay flagstone*, but now proposes to change its name to *Coniston flagstone* for the sake of symmetry. No group is better defined than this in the Lake country, and although the Brathay and Coniston quarries are several hundred feet above the preceding group, the series may be completed, in consequence of the regularity of the dip, by connecting a succession of quarries, and in this way the whole is estimated to be not less than 1500 feet thick.

The mineral character of the Coniston flags resembles that of the lower Denbigh flags, but is more altered by slaty cleavage *,

Mollusca.

- | | |
|--|---|
| Orthoceras, three smooth species, like those from the lower Bala limestone | Orthis vespertilio |
| Lituities cornu-arietis | O. virgata |
| Euomphalus? | O. actoniæ |
| Turritella, or Terebra | Orthis n. sp. (named in MS. <i>crucialis</i>), perhaps two species under the same name |
| Turbo? | O. radians |
| Leptæna depressa | Orthis n. sp. ? with fine simple ribs |
| L. n. sp., decussated | Orthis n. sp., same as from Dudley, a curious rough species |
| L. sericea | Atrypa (Spirifer), resembling S. acuminata |
| L. transversalis and another | A. (Spirifer), a smooth species, ? new |
| L. (Orthis) grandis, Sil. Syst. | Atrypa affinis |
| Orthis canalis | Spirifer n. sp. named in MS. |
| O. alternata? | S. n. sp. ? small variety of S. radiatus |
| O. testudinaria | |
| O. flabellulum β | |

Crustacea.

- | | |
|------------------------------|--|
| Cytherina lævigata | A. tyrannus |
| Paradoxides quadrimucronatus | Illænus (<i>Bowmanni</i> , MS.; called <i>Bumastus Barriensis</i> in a former list) |
| Calymene Blumenbachii | Brontes, undescribed species (<i>vide</i> Portlock's report). |
| Calymene n. sp. | |
| Asaphus Powisi | |

The corals, both as to species and numbers, are precisely similar to those north of the Berwyns.

In the abundance of *Leptæna depressa*, *L. transversalis*, *Orthis radians*, and above all, *O. inflata*, with spiral shells, and *Lituities cornu-arietis*, there is an analogy with the beds north of the Berwyns: but the presence of *Orthis Actoniæ* and *O. virgata*, with *Spirifer (crucialis)*, which are also plentiful, approximates the group to that from Bala and the Coniston limestone; it resembles also these latter beds in possessing the smooth *Orthoceras*, *Encrinites*, and *Illænus (Bowmanni)*, but it differs in the scarcity of *Orthis canalis*, *O. testudinaria*, and *O. vespertilio*, and the absence of *O. flabellulum*, *O. alternata*, *Spirifer radiatus*, *Agnostus pisi-formis*, *Trinucleus Caractaci*, and *Asaphus tyrannus* (one doubtful specimen of this latter having been found), fossils characteristic of the lower group in Wales.

An undescribed *Paradoxides*, a tail of a new *Brontes*, a curious undulated fossil (perhaps crustacean), a new *Tentaculites*, and abundance of *Cytherina* (a marine *Cypris*) seem peculiar to the Coniston limestone; and the last is a very interesting fossil, not having been known before in rocks of the Silurian series.

* The author observes, with reference to this condition, that he has observed in the flags in question distinct cases of a second cleavage plane entirely distinct both from joints and bedding.

and is chiefly made up of a dark coloured coarse slate or flagstone, through which are distributed rounded concretions, (sometimes spoiling the slate,) in which, as well as in the colour and bedding of the rock, in the presence of small calcareous veins, and the appearance of a great bedded mass of ripple marked flagstones without slaty cleavage at the top of the group, there is seen a near resemblance to the Denbigh flags. In the upper flags just alluded to, there are also (in the gill above Hawkshead Fould) calcareous masses and lenticular beds of limestone not fossiliferous, and probably not continuous, and therefore not considered by the author as forming a second band of limestone.

The Coniston flags thus characterised extend from the extremity of Shap Fell to the top of the Duddon Estuary, and might readily be laid down on a good map. It only remains, therefore, to determine their relative position from the included fossils.

In the Brathay quarries were found *Graptolites ludensis* in considerable abundance, and at another locality, within a few hundred feet of the Coniston limestone, *Atrypa compressa* was also plentiful, and was accompanied by a *Creseis*. At Cold Well, considerably above the Brathay quarry, appeared *Asaphus caudatus*; and at Kentmere in the same group *Astrea ananas*, *Creseis* being distributed throughout. All these fossils occur in the Wenlock shale, or Lower Denbigh flag. The author therefore concludes that the series in question represents the Lower Denbigh flagstones, and is the equivalent of the Wenlock shale.

3. *Coniston or Furness Grits*. This name is given to a group of bluish grey grits of great thickness, and very highly inclined, overlying the Coniston flags. It is on the whole a well defined group; but at its N.E. end is broken up by the interpolation of slaty bands, and loses its well defined mineral type. It may, however, be distinctly traced, and laid down on a map, from Bannisdale Head to Broughton; occupying a zone, on the average, more than half a mile wide. No fossils have as yet been discovered in it, but the author brings it into comparison with some hard grits which alternate with the lower Denbigh flags, north of the Holyhead road; he does this however only for the purpose of exhibiting analogies of structure in rocks of nearly the same epoch.

4. *Ireleth Slates, &c.* This is described as a great group possessing a considerable unity of character, and characterised by rocks with a good slaty cleavage distinct from the bedding, the slates being sometimes good enough for quarrying, and alternating with gritty bands, some of them very coarse, and rarely passing into a conglomerate form. The beds of this group are greatly contorted through their whole range, and especially at their north-eastern and south-western ends, and the thickness of the whole is very difficult to determine justly. For convenience of description, the whole series is separated by the author into three divisions, namely:—

a. *The Lower Ireleth slates*, a band of considerable width, made up of beds dipping at high angles, and steadily to the S.E. Being

seldom contorted, these beds must be of great thickness. They produce workable slate, but no distinct fossil species have yet been found in them.

β. A thin zone of *calcareous slate with concretions of limestone*. This bed is only a few feet thick, and the *roggnons* of limestone are sometimes replaced by a singular cellular calcareous slate with obscure casts of fossil shells. It ranges on the south of the Duddon, and has been traced from point to point; and after an interruption of two or three miles it appears at Tottle Bank heights, from which it may be traced over the neighbouring hills to a spot below Low Hall farm on the east side of Coniston water. A third obscure band of limestone is stated by the author to exist in the hills north of Nibthwaite.

The fossils of these bands of limestone are Upper Silurian; but though numerous they are very obscure.* In his letters on the lake district, the author states that he has described these fossils as Lower Silurian; but the specimens alluded to were obtained from High Haulme, three quarters of a mile S.E. from Ireleth village. "The limestone there forms a ridge not exactly continuous with the other limestone, which I accounted for by the interposition of a fault. But there is no fault of the kind I supposed. The High Haulme limestone is an independent ridge, the limestones and the slates are vertical, and associated with great masses of felspar rock and porphyry, exactly like the older slates below the Coniston limestone, and when brought up against the newer series of slates, these latter are thrown into most extravagant contortions."†

γ. The third subdivision of the great complex slaty group here described is termed by the author the *Upper Ireleth slates*, and exhibits remarkable examples of structure. These beds contain round concretions, like those of the Coniston flags. They are of great thickness, and alternate with beds of grit passing into coarse sandstone, and, rarely, into a conglomerate. Following them from Ireleth, where they are largely worked, to the Leven sands, they gradually pass into a coarser deposit without any regular line of demarcation. These coarser beds also contain concretions, and, though unfit for use, they continue to show a striped surface and slaty structure.

* The author adds in a note, "The enormous dislocation which throws forward the Coniston limestone at the Water Head seems to affect the whole chain of hills to the bottom of the lake. The corresponding beds on the opposite sides of the lake are not in the prolongation of the lines of strike. The lake therefore occupies a line of fault, on the eastern side of which is an enormous upcast of the whole series of rocks."

† The following is a list of the fossils collected at High Haulme from the dislocated Coniston limestone:—

Cyathophyllum
Catenipora escharoides
Favosites fibrosa, and other species
Retepora, very large
Porites pyriformis
Astrea

Turbinolopsis bina
Spirifer crucialis
Orthis Actoniae
—— canalis
—— inflata
Calymene Blumenbachii.

This group may be traced to Shap Fells and Bretherdale, parallel to the lower beds ; and in the hills composed of it on the sides of Kentmere, Long Sleddale, &c., several fossils were obtained, of which the following is a list : —

Leptæna lata.	North end of Potter's Fell, Helme Park, &c., Underbarrow.	
Orthis lunata.	Ditto	Ditto.
Spirifer ? (S. octoplicatus of Mr. Sharpe's paper.)		Ditto.
Terebratula navicula (plenty).	Ditto	ditto.
Avicula retroflexa.	Ditto	ditto.
Cornulites serpularius.	Ditto	ditto.
Turritella conica.	Underbarrow.	
Ophiura n. sp.	Potter's Fell.	
Orthoceras ibex.	Helme Park, &c., Howgill.	
	&c.	&c.

5. *Group of coarse Slates, Flags, Grits, &c.* — The author has already noticed this group as a coarse development of the Ireleth slates, and the beds have been named by Mr. Sharpe, *Windermere rocks*. They are so far important that they are of great thickness, and pass downwards into the Ireleth slates. Upwards, they blend themselves insensibly with the sixth group ; the singular slates, grits, and flagstones which commence a few miles north of Kendal, and continue southwards over the moors as far as Kirby Lonsdale, ending in red slaty beds like the tilestone of Shropshire, the geological place of which these slaty beds occupy.

The group now under consideration is greatly broken and shattered by faults, but no part of it can be considered non-fossiliferous, as the author found *Cardiola interrupta* in the very heart of it, and fragments of encrinites elsewhere.

The author is not aware of any evidence of want of conformity between the beds of this group and the other masses.

6th *Group, nearly on the parallel of the Upper Ludlow.*

The author is inclined to place the base of this group near Underbarrow, whence to the limestone of Kendal Fell there is a magnificent section. The fossils are very numerous, and some are peculiar to the neighbourhood. *Terebratula navicula* is only found in the lower part, but the whole upper part is full of fossils, the prevailing type being Upper Ludlow, although amongst these beds is a remarkable band with *Asterias*.

A great downcast fault in the valley of the Kent affects these beds, and on its south side is seen the "tilestone," separated from the other rocks by singular calcareous shales.

The siliceous, flaggy, and gritty beds of the Upper Ludlow are then carried with many breaks and undulations to the valley of the Lune, where they are overlaid by a thick mass of tilestone.

The uppermost beds of this tilestone are full of fossils, all of Upper Silurian species ; and there is, in the opinion of the author, no true passage from the tilestone to the overlying old red sandstone.*

* The author's opinion seems to be grounded on the three following facts : —

(1.) As a general rule the conglomerates of the old red sandstone are perfectly unconformable to the upper slates of Westmoreland : of this there are many undoubted examples,

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The author next alludes to the rocks of Howgill Fell and Ravenstonedale on the east side of the valley of the Lune; and he considers that these rocks, which offer considerable difficulties in their accurate determination, though separated by great faults from the higher parts of the Upper Ludlow series, are not to be considered as unconformable to that series, and probably contain a portion of it in their great folds and undulations. Through the eastern boundary of the district in which they occur, ranges the great Craven fault, described by the author in a former paper; and he has found, brought up apparently on one side of the fault, and appearing in the hills between Dent and Sedbergh and between Sedbergh and Ravenstonedale, a series of calcareous shales containing fossils, which mark the date of the series as not far from the parallel of the Coniston limestone; but he believes with Mr. Sharpe, that the greater part of Howgill Fells is made up of the coarse gritty Upper Silurian beds between the Ireth slates and the Upper Ludlow rocks.

Returning then to the comparison which was the great object of his communication, the author states as his general result, —

1st. That the chlorite and mica slates of Caernarvon and Anglesea have no parallel in Cumberland, being of a distinct epoch from the other rocks in the district, and evidently older. The same cannot be said of the metamorphic and crystalline rocks of Skiddaw forest, which rest on the granite, and pass gradually into the coarse Skiddaw slate. These may have assumed their present structure after the epoch of the Skiddaw slates.

Of the Skiddaw slate also, the author finds no exact representative in North Wales. It is not traversed by contemporaneous beds of porphyry, &c. Though composed of a fine, dark, glossy clay slate alternating with coarse bands, (sometimes, though rarely, passing into very coarse grit,) and though containing in one or two places a quantity of carbonaceous matter, it does not effervesce with acids, and no fossils have yet been obtained from it. Should fossils be discovered in it, they must belong to some of the oldest Protozoic types of our island.

2. That the green slates and porphyries of Cumberland cannot be separated from the rocks of the same mineral structure in Snowdonia. One, however, contains bands of fossils, and the other does not. The porphyries abound so much in Cumbria, that organic beings were unable to exist among them, or their remains have become obliterated.

3. The Coniston limestone represents the top of a series which passes into the *Creseis* and *Graptolite* flagstone; and so also does the Llansaintffraid limestone. The list of fossils from these two groups is also nearly identical, and they both contain some Wen-

(2.) The beds of old red conglomerate on the Lune are not exactly parallel to the beds of "tilestone."

(3.) The conglomerates contain many fragments of the "tilestone," which must have been solid before the conglomerates were formed.

lock fossils and shells. Hence the Coniston limestone does not represent the great limestone east of Bala Lake.

4. The Upper Silurian beds form a very distinct system or group of formations, and the lowest division of the system seems to coincide exactly with the lower Denbigh flags. In all other parts of the upper series there are only analogies of structure, and the groups do not physically represent the groups of the same system in Siluria proper. The upper groups in Westmoreland are more largely developed in North Wales, and contain a fine tilestone, and so far they conform to Mr. Murchison's types.

5. The list of fossils taken as a whole conforms also very exactly to the Upper Silurian lists of Mr. Murchison, but the distribution of the species is very different, because the physical conditions of the deposit were different.

Between the distribution of the species in the upper system of Wales and Cumberland there is a close analogy, because the conditions of deposit were, especially in the lower part, very analogous.

6. The fossils of the lower or Protozoic system form but one group, although some species are found in the Coniston and Llansaintffraid bands which do not appear in the lower beds, and *vice versa*, and the fossils disappear altogether in descending order.

The author promises to resume the subject, and to give fuller details, and a more copious list of fossils, in a future communication.

April 2. 1845.

The following gentlemen were elected Fellows of this Society :—
Waller A. Lewis, Esq., B.A., Capt. Washington, R.N., Albenmarle Bettington, Esq., Robert Stephenson, Esq., George Stephenson, Esq., Lieut. Baird Smith of the Engineers, Capt. Thomas Hutton of the Bengal Army, John McClelland, Esq., of the Bengal Medical Service, and the Earl of Auckland.

The following communications were read :—

1. *On a supposed AEROLITE, said to have fallen near LYMINGTON, HERTS.* By R. A. C. AUSTEN, Esq., F.G.S.

In this communication the author described a fragment of stone supposed to have fallen from the air, and stated the evidence on which the supposed fact of its being an *Aerolite* was founded.

2. *On the Junction of the Transition and Primary Rocks of CANADA and LABRADOR.* By Capt. BAYFIELD, R.N., F.G.S.

THE country to the northward of Lakes Superior and Huron, and of the St. Lawrence River and Gulf, is for the most part a wilder-