

ON THE SILURIAN DEPOSITS OF THE NORTH OF ENGLAND. 105

Thursday, 17th November 1870.

GEORGE LYON, Esq., Treasurer, in the Chair.

The following Gentlemen were elected Fellows of the Society:—

1. Rev. P. STEWART, M.A., Minister of Gilmerton.
2. EDWARD A. STURMAN, LL.D., M.A., Principal of Packington College, London.

The following Communication was read:—

On the Correlation of the Silurian Deposits of the North of England with those of the South of Scotland. By H. ALLEYNE NICHOLSON, M.D., D.Sc., M.A., F.R.S.E., &c., Lecturer on Natural History in the Medical School of Edinburgh, Vice-President.

The object of my communication to-night is simply to lay briefly before the Society the relationships which have been made out, or which we may hope to establish, between the Silurian rocks of the north of England and those which occupy the "Southern Highlands" of Scotland. And, in the first place, let me point out to you a fact which ought to be very cheering to all of us. The Silurian districts of the north of England and the south of Scotland, as you all know, may be very favourably compared with the classical Silurian regions first described by that eminent geologist, Sir Roderick Murchison, both in point of actual thickness and as regards the superficial area which they occupy. There was one point of view, however, in which "Siluria" might be said to stand unrivalled, in this country at any rate, and that was in the abundance and beautiful preservation of its organic remains. Now, I think I may safely say, there are few of us, however ardent geologists, who do not prefer to find our work in the field assisted by the occurrence of those "medals of creation" which we know as fossils; and there are many of us who in addition have an intelligent interest in these, as working palæontologists. There can, therefore, be very little doubt but that the investigation of the Silurian deposits of the north of England and the south of Scotland has suffered much retardation, and even in some cases has been erroneously carried out, in consequence of their supposed unfossiliferous nature. It is quite true that certain limited beds in both areas, such as the Coniston limestone of Cumberland and Westmorland and the anthracitic shales of Dumfriesshire, have long been known to yield organic remains in tolerable plenty. There is no doubt, however, that there was, and perhaps still is, a very prevalent idea that the great mass of the deposits of both areas were unfossiliferous, and there can be equally little doubt but that this

idea, as I said before, has materially interfered with the elucidation of the complicated rocks of these regions. And this is not to be wondered at, partly because fossiliferous rocks are certainly more attractive to the generality of geologists than strata devoid of life, and partly because the best of observers are sure to fall into errors when mapping and subdividing any extensive series of Silurian rocks by their lithological character alone. Things, however, I am happy to say, have considerably altered at the present day as regards both of the regions of which I am speaking. By the researches of Sedgwick, Ruthven, M'Coy, Salter, Harkness, Hughes, and myself, the Silurian rocks of the north of England have been shown to contain a very extensive series of organic remains, comparable in most respects to those of Siluria itself, and even sometimes supplying gaps in our knowledge. Similarly, by the investigations of Murchison, Nicol, Harkness, M'Coy, and Salter, and many other observers—amongst whom it is a gratifying fact to find many of the Fellows of our Society holding a prominent and honourable position—the Silurian series of the south of Scotland has been cleared from the stigma of barrenness, as far as fossils are concerned, and has been shown ready and willing to yield divers palæontological treasures to those who would take the trouble to look for them. It cannot be denied that the organic remains of the Silurian rocks of the north of England and the south of Scotland are decidedly inferior in most cases to those of Wales in point of beauty and in their state of preservation, and also that they are much more difficult, as a rule, to obtain, but the fact of their existence at all is the great point. It is, also, a very encouraging thing to remember that in both the regions in question the rocks have hitherto been very insufficiently examined, and that the happiest results may be hoped for from a full and careful examination, carried out by competent observers. I trust, therefore, that those of us whose opportunities allow them to prosecute this investigation, will not forget what a wide and inviting field lies open to them in this direction, and that they will not allow themselves to be deterred by the unquestionable difficulties and discouragements with which this field of research is unfortunately attended. In confirmation of this, I need only point to the very valuable and important results obtained within the last twelve months by Messrs Lapworth and Wilson in their energetic researches in the Silurian rocks of the south of Scotland—results which I shall have to speak of at greater length when I have spoken of the Silurian rock series of the north of England.

The Silurian rocks of the north of England occupy the whole of that picturesque region which is properly called the Lake District, extending to the south and east far beyond the limits of this area. The entire series attains the enormous thickness of

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certainly over 20,000 feet, and comprehends the following chief subdivisions:—

1. *The Skiddaw Slates*, a vast mass of dark-coloured earthy shales, often more or less cleaved, and having an aggregate thickness of about 7000 feet. Organic remains are rare in the Skiddaw slates, but a sufficient number has been found to demonstrate clearly the identity of the series with the so-called Quebec group of Canada. This is unequivocally shown by the graptolites, of which no less than thirty-three species are known at the present day. Of these, sixteen forms are specifically identical with species which occur in the Quebec group, whilst eleven are peculiar to the Skiddaw series, only one of these twenty-seven forms having been hitherto discovered in any other Silurian formation in any part of the world. Four of the genera, also (*viz.*, *Dichograpsus*, *Tetragrapsus*, *Trigonograpsus*, and *Phyllograpsus*), are exclusively confined to this horizon. There can, therefore, upon this evidence alone, be no hesitation in regarding the Skiddaw and Quebec group as a peculiar formation which has no exact parallel in the typical Silurian series of Wales. That the Skiddaw slates have, however, a close relationship with the lower portion of the Lower Llandeilo rocks cannot be doubted, and is clearly indicated by the few remaining fossils, especially by the two characteristically Lower Llandeilo graptolites, *Didymograpsus geminus* and *D. patulus*. The total absence, also, of "primordial" trilobites, taken along with the occurrence of the genera *Agnostus*, *Aeglina*, *Trinucleus*, and *Phacops*, affords very clear evidence of the correctness of referring the Skiddaw series to the base of the Lower Llandeilo, or to the Arenig group of Sedgwick.

2. The Skiddaw slates are surmounted by a series of rocks termed by Professor Sedgwick the "Green Slates and Porphyries," but which Professor Harkness and myself propose to call the "*Borrowdale series*." These consist almost entirely of cleaved felspathic ashes, breccias, amygdaloids, alternating with masses of felspathic trap. From its nature, the entire series, having an average thickness of perhaps 5000 feet, has naturally proved hitherto extremely unfossiliferous. Near its summit, however, there is in many localities a band of shales, which sometimes attains a considerable thickness, and which has yielded numerous organic remains. These fossils are exclusively referable to well-known Bala types, and there can, therefore, be no hesitation in referring the Borrowdale series, in its upper portion at any rate, to the Caradoc formation of Wales.

3. Succeeding to the Borrowdale rocks we have the well-known *Coniston limestone*, consisting of calcareous bands of varying thickness and number, intercalated with bands of cleaved shales. The average thickness of the Coniston limestone is about

300 feet, and it is richly fossiliferous ; but it is unnecessary for me to say anything further on this head, as the fossils are undoubted Bala forms, and the Coniston limestone is the unquestioned equivalent of the Bala limestone of Wales. I may notice, however, that in some localities some of the higher shale beds become enormously expanded in thickness, and they have been termed by Mr Hughes "Strophomena" and "Trinucleus" shales, from the abundance in them of these fossils.

4. Immediately above the Coniston limestone series, wherever a clear section is obtainable, is found a peculiar group of dark gray or black shales with intercalated grits, to which the name of "*Graptolitic mudstones*" was applied by Professor Harkness and myself. The propriety of this name will be evident when I say that this zone of rocks, though small in actual thickness, has yielded no less than twenty-seven species of graptolites. I am not going to enter here into the vexed question of the age of this horizon, and shall simply state my belief that it belongs to the Lower Silurian series. I think this is shown with tolerable certainty by the fact that thirteen of the known forms, or nearly 50 per cent., are specifically identical with well-known species in the anthracitic shales of Dumfriesshire, the age of which is generally admitted to be Upper Llandeilo. I am, further, bound to say that I now think that the identity of many of the species of our graptolitic mudstones with those of *étage E.* (Upper Silurian), of the Silurian basin of Bohemia, can be adequately explained by M. Barrande's admirable theory of "Colonies," as I shall endeavour to point out upon some future occasion.

5. Above the graptolitic mudstones we have the well-known group of rocks, termed by Professor Sedgwick the "*Coniston flags*." These consist of from 2000 to 3000 feet of gray or black cleaved flags, with shaly or gritty beds intercalated amongst them. A noticeable point, too, is the very frequent occurrence of calcareous concretions. In this case, as in the preceding, I shall not touch here upon the question of *age*. Fossils are very few and mostly badly preserved, consisting almost of graptolites and orthoceratites. I would wish, however, specially to draw your attention to the fact that no double-celled graptolite except *Ratiolites* has hitherto been detected in this group of beds, the three common forms being *Retiolites Geinitzianus*, *Graptolites priodon*, and *G. colonus*. The other characteristic fossil is the well-known bivalve *Cardiola interrupta*.

6. The Coniston flags are succeeded by a great group of massive grits or greywacke, with sandy slates or shales, and sometimes with regularly slaty bands (Bannisdale slates). This group is known as the "*Coniston grits*," and its thickness is estimated by Mr Hughes as being about 4000 feet. Here we again reach firm ground, as far as the question of age is con-

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cerned, it having been conclusively established by the researches of Mr Hughes that the Coniston grits are referable to the Upper Silurian rocks. I was, I must admit, very reluctant to accept this conclusion at first, but the evidence is irresistible. In proof of this, I need only mention the occurrence of three fossils, namely, *Rhynchonella navicula*, *R. nucula*, and *Beyrichia Kloe-deni*. I may also draw your attention to the common occurrence in this series of both *Graptolites priodon* and *G. colonus*.

7. Lastly, the Coniston grits are overlaid by a great series of beds, for which the name of "*Kendal Rocks*" might be appropriately retained, of unquestionable Ludlow age. They consist of a series of grits and shales, attaining a thickness of certainly not less than several thousand feet, and charged with numerous fossils, almost all of which are found in the Ludlow rocks of Wales. I need not, therefore, dwell longer upon this group, since its position and age are unequivocal.

Let us turn now to the south of Scotland, and let me briefly run over the leading subdivisions which have been now established in this extensive and complicated area, comparing them where possible with the Silurian series of the north of England. And let me say, in the first place, that it is only recently that it has become possible to give anything like a connected view of the sequence of the Silurian rocks of the south of Scotland. In spite of the persevering labours of Sir Roderick Murchison, Harkness, Nicol, and others, many gaps, nevertheless, remained to be filled up in our knowledge.

By the researches of the Geological Survey and of the members of our own body, and by the admirable memoir of Mr Charles Lapworth, many of these gaps have been abolished. Still much remains to be done, and many of the points which I shall have to mention still offer an inviting field for further and more detailed examination. In some cases, also, you must understand that I am merely stating my own opinions, formed by an examination of some of the more typical sections.

The following, then, may be taken as a provisional view of the sequence of the Silurian rocks of the south of Scotland, so far as our present knowledge will permit us to arrive at any definite conclusion:—

1. The *Bottom* or *Axial rocks* of Hawick and Borthwick water. These are a series of schists and greywackes, supposed to form the base of the whole Silurian series of the south of Scotland. They have hitherto been but very imperfectly examined, either from a palæontological or a stratigraphical point of view, and they have not as yet yielded any fossils. In the absence of organic remains, it is wholly impossible to decide as to the exact position of these beds, which, in the meanwhile, certainly should not be called "*Bottom Rocks*." If these beds should

ultimately be shown to underlie the Moffat shales, then they may be regarded with considerable probability as representing the Lower Llandeilo of Wales or part of the Skiddaw series of the north of England; but it is just as likely that there is an unconformity, and they may be of Cambrian age.

2. The *Moffat series* or *Anthracitic series*, which succeeds, consists of a great group of shales of various colours with intercalated beds of massive grit, the prominent feature in the group being the occurrence of a band or bands of black anthracitic shale, containing numerous graptolites. The organic remains of the Moffat group are now sufficiently well known to allow of a definite determination of the age of the series, and there can be little hesitation in believing that the Moffat series corresponds most closely with the Upper Llandeilo of Wales. Leaving the graptolites out of consideration, this conclusion would appear to be warranted by the occurrence of *Siphonotreta micula*, *Lingula brevis*, and *Acroteta Nicholsoni*; and the evidence afforded by the graptolites points, upon the whole, in the same direction. Thus, the four predominant genera are *Diplograpsus*, *Didymograpsus*, *Climacograpsus* and *Dicranograpsus*, all of which are pre-eminently if not exclusively Lower Silurian, and are more especially characteristic of the inferior portions of the Lower Silurian series. Taken by themselves, however, the graptolites would not afford completely satisfactory proof of the Upper Llandeilo age of the Moffat beds; since most of the Moffat species reappear in the Coniston mudstones, which are undoubtedly of Caradoc age, and the leading point of difference, as far as the graptolites are concerned, is simply the absence of the genera *Didymograpsus* and *Dicranograpsus* in the latter deposit. In this question, as in many others, it is greatly to be regretted that we have so little stratigraphical evidence to go upon, and that the age of the beds must be determined almost altogether from the affinities of the fossils. Upon the whole, however, taking the graptolites along with the brachiopods, there need not be much hesitation in arriving at the conclusion that the Moffat beds are truly of Upper Llandeilo age. In this case they have no equivalent in the Silurian series of the north of England, unless, indeed, the igneous series of the green slates and porphyries is to be regarded as belonging in its lower portion to the Upper Llandeilo.

3. The Moffat series is in all probability succeeded upwards by rocks of Caradoc or Bala age, but the district has not yet been sufficiently explored to allow of any positive assertion on this point. On the Ayrshire coast, however, in the neighbourhood of Girvan, there is a limestone, which was originally described by Sir Roderick Murchison, and which is shown by its organic remains to be the undoubted representative of the Bala limestone of Wales and the Coniston limestone of the north of Eng-

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land. Here, therefore, we for the first time meet with a definite horizon—the *Girvan limestone*—from which it would be possible to work either upwards or downwards.

In Peeblesshire, again, we meet with the well-known *Wrae limestone*, which has usually been more or less doubtfully referred to the Llandeilo series, and has been regarded as the equivalent of the Llandeilo limestone. The few fossils which have hitherto been discovered would, however, undoubtedly go to prove that the Wrae limestone is of Caradoc age, and is the representative of the Bala or Coniston limestone. This, however, is a point well worthy of the attention of the Society, and one which would undoubtedly richly repay careful investigation. Elsewhere, as between the Moffat and Abingdon, and in Leadhills, the Wrae limestone appears to be represented by a conglomerate; and I entertain no doubt that a similar change occurs in the Gala-shiels district, where Mr Lapworth has described the occurrence of a conglomerate or a breccia surmounting the rocks of the Moffat series.

4. That the Bala beds of Girvan are succeeded upwards by rocks of Llandovery age is now pretty generally admitted; but I need not dwell upon these, as no rocks of undoubted Llandovery age have hitherto been made out in the north of England. I would, however, point out here that at this horizon we have a decided difference between the Silurian series of the north of England and that of the south of Scotland. The Coniston limestone of the north of England, as I have before said, is everywhere surmounted by the small but curious group of the Coniston mudstones, charged with numerous graptolites, most of which have a Lower Silurian *facies*, and many of which are specifically identical with the graptolites of the Moffat series. The Girvan limestone, on the other hand, though certainly representing the Coniston limestone, does not appear to be followed by any beds comparable to the Coniston mudstones, and the same would seem to be the case with the Wrae limestone; so that we must conclude that the Coniston mudstones are not represented at all in the south of Scotland. If time permitted, I think this could easily be shown to be an instance of the "Colonies" of M. Barrande, but I must reserve this for a future occasion.

5. We next come to the series of rocks described by Mr Lapworth, under the name of the *Gala group*, comprising the Abbotsford flags, the Gala grits, the Buckholm sandstones, and the Thornilee and Grieston slates. These have been so recently described to us by Mr Lapworth, that I need do no more here than merely point out their palæontological relations with the Coniston flags of the north of England. The predominant fossils of the Gala group are graptolites, which are found in great abundance; but they present a great difference as compared with

the graptolites of the Moffat series. The genera *Didymograpsus*, *Climacograpsus*, and *Dicranograpsus*, so characteristic of the Moffat beds, are now wholly wanting, and the genus *Diplograpsus*, if present at all, is only represented by one or two diminutive forms. Not only is this the case, but we now for the first time meet with *Graptolites priodon* and *G. colonus*, both wanting in the Moffat series, but highly characteristic of the Coniston flags and grits. Another form, also met with now for the first time, is the singular *Retiolites Geinitzianus*, which is common to both the Gala group and the Coniston flags. A decided connection, however, between the Gala group and the Coniston mudstones is established by the presence in the former of *Graptolites turriculatus*, a beautiful and well-known Bohemian fossil, in addition to the species already mentioned.

Upon the whole, therefore, as far as the evidence already discovered goes, there is much reason to believe that the Gala group of the south of Scotland is the representative of the Coniston flags, and perhaps the lower portion of the Coniston grits of the north of England.

6. The occurrence in Kirkcudbrightshire of beds of Upper Silurian age has long been known. These, the so-called *Balmoe beds*, have been paralleled with the Wenlock shale of Wales, partly on account of their lithological characters; and partly from their organic remains. In a paper read before the British Association at Liverpool, Mr Lapworth showed that similar beds extend from Kirkcudbrightshire to the vicinity of Hawick, succeeding the beds of the Moffat series to the south, either by an unconformable junction, or by the intervention of a powerful dislocation. The reference of these beds to the Upper Silurian series appears to be indisputable, and there can be equally little doubt that they represent a portion of the Wenlock series of Wales. To the north of the area of the Moffat beds the occurrence of strata of Wenlock age has likewise been shown by the researches of Messrs Brown and Henderson in the Pentland Hills; but it is probable that here we have only the summit-beds of the Wenlock group.

As I before remarked, there is no doubt but that the Coniston grits of the north of England are of Upper Silurian age, and as they are succeeded by a great series of undoubted Ludlow rocks, there can be little hesitation in regarding them as part of the Wenlock series. We may, therefore, fairly assume that the Balmoe beds of the south of Scotland may be compared without violence to the Coniston grits of the north of England; a strong lithological similarity, indeed, subsisting between the two. Much more work, however, must be done before we can speak positively either as to the exact relation between the two groups, or as to the exact place held by either in the Silurian series of Siluria itself.

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7. In conclusion, the Ludlow rocks alone remain to be considered, and on this point very little indeed need be said. The only locality in Scotland in which rocks of undoubted Ludlow age are known is in the Pentland Hills, but they here present the satisfactory feature of being highly fossiliferous, so that there cannot be the remotest doubt as to their true position and age. You are so well acquainted with these beds, both as regards their lithology and palæontology, that it is wholly unnecessary for me to make any further remarks about them. I will only add, that they are the undoubted equivalent of the Ludlow rocks of Kendal, which attain in the north of England a thickness of several thousand feet, and are charged with the characteristic fossils of the Ludlow formation.

Thursday, 19th January 1871.

JAMES H. SANDERSON, Esq., Councillor, in the Chair.

The following Communication was read:—

On the Origin of Cabook, or the Laterite of Ceylon. By H. F.
ALEXANDER, late of Colombo, Ceylon.

(*Abstract.*)

The views embodied in this paper were the results of the actual observation of cabook, in its native beds in the vicinity of Colombo; and they were illustrated by specimens, by photographs, and by a map of the district, illustrative of the principal geological features.

Cabook appears to be a formation peculiar to the east. It is found in India, in Ceylon, and, it is believed, in the Malayan archipelago. Cabook is the name by which it is familiarly known to the natives of Ceylon. All the hills in the immediate vicinity of Colombo are composed of it. It forms the great building material of the district; and is largely used in the formation of the roads: it therefore meets the observer at every turn. Its colour may be said to be a brick red.

The received opinion is, that it is simply disintegrated gneiss; but, undoubtedly, there are strong reasons for believing that this view of it will be found to be wrong, and that further investigation will prove it to be of volcanic origin: a clay lava, if it may be so expressed. Tennent, in his work on Ceylon, styles it "a product of disintegrated gneiss," and refers, as authorities, to Drs Macvicar, Gardner, and Davy. In conversation with the writer, he stated that his views (though he had