

Dr. Bessels, again, remarks on the abundance of boulders on the shore of Smith's Sound in lat.  $81^{\circ} 30'$ , which are manifestly derived from known localities on the Greenland coast much further southward, and adds, "Drawing a conclusion from such observations, it becomes evident that the main line of the drift, indicating the direction of its motion, runs from south to north."<sup>1</sup>

It may further be mentioned that Dr. R. Bell, of the Canadian Geological Survey, has found evidence of a northward or north-eastward movement of glacier-ice in the northern part of Hudson Bay, with distinct indications of eastward glaciation in Hudson Strait.<sup>2</sup> For the Northern part of the Great Mackenzie Valley we are as yet without any very definite information, but Sir J. Richardson notes that Laurentian boulders are scattered westward over the nearly horizontal limestones of the district.

Taken in conjunction with the facts for the more southern portion of the Continent, already pretty well known, the observations here outlined would appear to indicate a general movement of ice outward, in all directions, from the great Laurentian axis or plateau which extends from Labrador round the southern extremity of Hudson Bay to the Arctic Sea; while a second, smaller, though still very important region of dispersion—the Cordilleran glacier-mass—occupied the Rocky Mountain region on the west, with the northern and southern limits before approximately stated.

I have refrained from entering into any detail at this time in respect to the glaciation of the northern part of the Cordillera belt, as it is probable that within the year we shall be more fully informed on the subject, as the result of observations to be expected from Mr. R. G. M'Connell of this Survey. Mr. M'Connell is now on the Mackenzie River, which, as well as the Porcupine branch of the Yukon, within the Arctic circle, it is intended that he shall examine during the summer.

#### IV.—NOTES ON THE SAUROPTERYGIA OF THE OXFORD AND KIMERIDGE CLAYS, MAINLY BASED ON THE COLLECTION OF MR. LEEDS AT EYEBURY.

By R. LYDEKKER, B.A., F.G.S., etc.

I PRESUME that most English students of Mesozoic Reptiles are acquainted, at least by report, with the magnificent collection of the remains of Sauropterygians and other Saurians from the Oxford Clay of Northamptonshire in the possession of Mr. A. N. Leeds, of Eyebury, near Peterborough. Those, however, who have not had the good fortune to see this unrivalled collection, can have no idea of its richness, or of the light it throws on the organization and affinities of the Sauropterygians of the later Jurassic seas. Till a few weeks ago I was among the number of those to whom this collection was known merely by report: but at the end of June I availed myself of Mr. Leeds' courteous invitation to see and study his

<sup>1</sup> Nature, vol. ix.

<sup>2</sup> Annual Report Geol. Surv. Canada, 1885, p. 14 D.D.; and Report of Progress, 1882-84, p. 36 D.D.

collection as fully as I might desire. On arrival, my astonishment was unfeigned to find that this collection comprised not, as I expected, only one or two imperfect skeletons of one or more species, but in some cases as many as five or six almost entire skeletons belonging to as many individuals of four well-defined species. The specimens are arranged on shelves and in trays in two rather small rooms, which they almost completely fill; and so perfect are many of them that there would be no great difficulty in mounting entire skeletons of these extinct Saurians in the same manner as those of existing Cetaceans are exhibited in our Museums. In many cases every process and spine of the vertebræ is absolutely perfect, owing to the careful and patient manner in which Mr. Leeds has personally extracted the skeletons from the soft clay in which they lay embedded. The paddles too, which have been such a stumbling-block to the palæontologist, have every bone in its natural position, so that there can no longer be any doubt as to their mode of arrangement.

Apart, however, from the intrinsic perfection of this collection, its great importance consists in the clearing up of the relations and affinities of the many so-called species of Sauropterygians which have been described upon more or less imperfect remains from the Oxford Clay. In order to avail myself of the full advantages to be gathered from a visit to this collection, I had carefully studied all the specimens previously described from this horizon; and, through the courtesy of Prof. A. H. Green, I had the further advantage of having the type vertebræ on which the late Professor Phillips founded his *Plesiosaurus Oxoniensis* and *P. plicatus* at the British Museum.

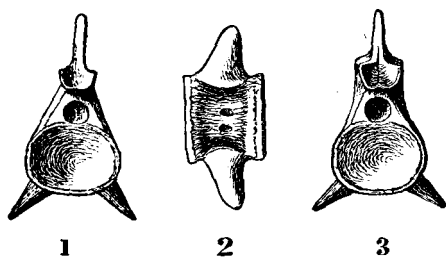


FIG. 1.—Posterior (1), hæmal (2), and anterior (3) aspects of a cervical vertebra of *Plesiosaurus plicatus*, from the Oxford Clay,  $\frac{1}{2}$ . (After Phillips.)

The first skeleton to which I directed my attention was the somewhat imperfect one which Prof. H. G. Seeley described some years ago in vol. xxx. of the Geological Society's Journal, under the new generic and specific name of *Muranosaurus Leedsi*. Since that specimen was found Mr. Leeds has obtained several other much less imperfect skeletons of both immature and adult individuals, which he refers, and in my judgment quite correctly, to the same species. The immature skeletons show, however, that the cervical vertebræ are quite indistinguishable from those from the Oxford Clay near Oxford, to which Prof. Phillips applied the name *P. plicatus* (Fig. 1); and the specific name *Leedsi* must, therefore, yield place to this earlier one. The most important point, however, on which these new skeletons throw

light is the structure of the pectoral girdle. It will be remembered that the genus *Murænosaurus* was founded upon a supposed peculiarity of this part of the skeleton—to wit, that the preaxial border of the coracoids was not connected by a median bony bar with the pre-coracoids (using the terms employed by Mr. J. W. Hulke). Now the new specimens show that this restoration of the pectoral girdle is solely due to the imperfection of the type specimen; and, as Mr. Leeds at once pointed out to me, the portion of the scapulo-precoracoid regarded as the precoracoid in the figure given in the Q J.G.S. vol. xxx. p. 448, and made to meet its fellow in the middle line, is really the dorsal part of the scapula. The pectoral girdle is in fact of the same general structure as that figured by Prof. Seeley on p. 447 of the same volume as the type of the so-called *Colymbosaurus*; and there appears to be no distinction, so far as regards the pectoral girdle (on which the two were founded), of both *Murænosaurus* and *Colymbosaurus* from the earlier *Elasmosaurus* of Prof. Cope. If, however, we follow Mr. Hulke in retaining the Jurassic and Cretaceous Sauropterygians exhibiting this modification of the pectoral girdle in the original genus *Plesiosaurus*, of which they form a well-marked group, then we may continue to use the name *Plesiosaurus plicatus* for this species. An allied, and apparently unnamed species, represented in Mr. Leeds' collection, and distinguished by its shorter cervical vertebræ, which are also fewer in number, is also known to me by a considerable portion of a skeleton obtained from the Oxford Clay of Weymouth. This form I shall describe, and if necessary name on a future occasion; Mr. Leeds having kindly lent me one of the cervicals of his mature example.

The next species I have to mention is *P. Oxoniensis*, represented by several nearly entire skeletons in the Eyebury Collection. Of the specific identity of these examples I have satisfied myself by a comparison with the type cervical and dorsal vertebræ in the Oxford Museum. This species was referred by Prof. Seeley to a subgenus of *Murænosaurus*—I presume on the evidence of a pectoral girdle figured in Phillips's "Geology of Oxford" (p. 310), which is turned the wrong way upward and described as the pelvis. The coracoids (pubes) in that example are, however, I believe, referable to the so-called *Plesiosaurus philarchus*; and the Eyebury specimens show that the pectoral girdle was of the type of the so-called *Colymbosaurus*. These specimens show, moreover, that the remarkable pectoral limb from the Oxford Clay of Bedford, figured by Phillips on p. 315 as a pelvic limb, and made the type of *P. eurymerus*, is really referable to *P. Oxoniensis*; the limb figured on p. 312 of the "Geology of Oxford" under the latter name apparently belonging to *P. plicatus*.

A fourth species represented in Mr. Leeds' collection is the so-called *Plesiosaurus philarchus* of Prof. Seeley, characterized by its long mandibular symphysis. The examples of this species show that in the young there were two distinct costal facets in the cervical vertebræ; while the teeth, and pectoral and pelvic girdles, present a great resemblance to those of *Pliosaurus*. This species seems to

be closely allied to *Thaumatosauros oolithicus*, of the Lower Jurassic of Würtemberg, in which the teeth have the same structure and the cervical vertebræ are likewise furnished with two costal facets. The latter species, again, appears to come so close to the Upper Liassic *Plesiosaurus Cramptoni*—the type of Prof. Seeley's genus *Rhomaleosaurus*—that with our present material not even specific characters can be recognized. On these grounds I am inclined to include all these three species, together with the Lower Liassic *P. megacephalus*, in a single genus, for which the name *Thaumatosauros* should be adopted. This reference I shall again have occasion to mention in an addendum to a paper on the Oxfordian species in the "Geological Society's Journal"; the knowledge I have gained since that paper was read having induced me to remove that species from the genus *Plesiosaurus*. Mr. Leeds' examples show that a small omosternum was present.

Of the genus *Pliosaurus* Mr. Leeds possesses only a number of detached teeth, which differ from those of the Kimeridgian forms in the imperfect development of the "carinæ," and the absence of the distinct smooth and flat intercarinal space. These teeth appear indistinguishable from the one from the Oxfordian of Boulogne described and figured by M. Sauvage under the name of *Liopleurodon ferox*. I can see, however, no reason why this species should be separated from the Owenian genus, and it may accordingly be known as *Pliosaurus ferox*. The cervical vertebræ from the Oxford Clay in the Cambridge Museum to which Prof. Seeley has applied the name *P. pachydirus*, without, however, giving any specific diagnosis, are probably referable to the same species.

Leaving now the Eyebury Collection with the expression of my thanks to its owner for his courtesy in placing it thus freely before me, our attention may be directed in the remaining part of this paper to certain large Plesiosaurian remains from the Kimeridge Clay, which are allied to *P. Oxoniensis*. In the first place I may mention that after leaving Peterborough I availed myself of the permission of Mr. Marshall Fisher, of Ely, to visit his collection, which contains the pectoral girdle figured by Prof. Seeley on p. 447 of the thirtieth volume of the "Geological Society's Journal," under the name of *Colymbosaurus*, and thence proceeded to the Woodwardian Museum at Cambridge to have one more look at the vertebral column to which the same authority has given the name of *Plesiosaurus megadirus*; both specimens being from the Kimeridge Clay of the Cambridge-shire district.

Before going further it is, however, necessary to recapitulate briefly the history of these large Kimeridgian Plesiosaurs. In the "British Association Report" for 1839, Sir R. Owen described a propodial bone (humerus or femur) of a large Plesiosaur from the Kimeridge Clay of Shotover in the collection of the late Lord Enniskillen, under the name of *Plesiosaurus trochanterius*; this specimen being now in the British Museum. Its structure is shown in the accompanying woodcut of another example. In the year 1841 this species, together with *P. grandis*, was referred to the genus *Pliosaurus*; of which the

type is *P. brachydirus*, described in the previous year in the same writer's "Odontography." In 1869 Prof. Seeley, in his "Index to the Woodwardian Museum," applied the name *Plesiosaurus megadirus* to the above-mentioned vertebral column in the Cambridge Museum; merely, however, mentioning its large size and the number of the cervical vertebræ, and the description being therefore insufficient to authenticate the name. A second imperfect skeleton, in the same collection (presented by Mr. Stead Jones), was referred to the same species; that specimen having a propodial of the peculiar type of *P. trochanterius*. In the following year Mr. Hulke described in the Q.J.G.S. vol. xxvi. the vertebral column, the pectoral and pelvic propodials, and the imperfect coracoids of a large Plesiosaur from the Kimeridge Clay of Dorsetshire under the name of *P. Manseli*; and also certain dorsal vertebræ remarkable for their very short centra, to which the name *P. brachistospondylus* was accordingly applied. In the course of the description of the former species the resemblance of the propodials to the type of *P. trochanterius* was pointed out, and no very good reasons were given why the specimen should not have been referred to that species, which was thus proved to be Plesiosaurian.

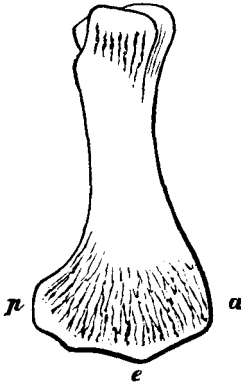


FIG. 2.—Dorsal aspect of the right humerus of *Plesiosaurus trochanterius*; from the Kimeridge Clay,  $\frac{1}{16}$ . *a*, preaxial, *p*, postaxial border; *e*, division between radial and ulnar facets. (After Phillips.)

Reference was also made to *P. megadirus*, which was considered to be closely allied, although it was stated that in the opinion of Mr. W. Davies it was not identical. It should be added that Mr. Hulke's types are preserved in the British Museum. The year 1871 saw the publication of Phillips's "Geology of Oxford," in which work vertebræ of large Plesiosaurs from the Kimeridgian of Oxfordshire were described under the names of *P. brachyspondylus* and *P. validus*; the former being wrongly identified with *P. brachyspondylus* of Owen, which is really a Pliosaur, and the latter being regarded as new. No reference (perhaps owing to the close sequence of the two works) was, however, made to Mr. Hulke's *P. Manseli*; and detached

propodials were described under the name of *P. trochanterius*. *P. brachyspondylus* was regarded as the Kimeridgian analogue of *P. Oxoniensis*; the vertebræ having the same short and distinctly cupped centra, which characterize both that species and *P. Manseli*. It should also be observed that Phillips described another large Kimeridgian Plesiosaur, which had flattened terminal faces to the centra, and is closely allied to *P. plicatus*, which belongs to a totally different subgroup. Thus matters stood till 1874, when in vol. xxx. of the Q.J.G.S., Professor Seeley figured on p. 447 the above-mentioned pectoral girdle from Ely, under the new generic title of *Colymbosaurus*; stating on p. 445 that the type species was to be *P. megadirus*, which, as already stated, had never been sufficiently described. It was also mentioned on p. 448 that *Plesiosaurus Manseli* was to be referred to a subgenus of *Muronosaurus*.

With these facts we may proceed to criticism. In the first place I cannot find any characters by which *P. Manseli* can be distinguished from *P. trochanterius*, and since the description of the latter is sufficient, I consider that we should adopt the earlier name. *P. brachyspondylus* appears, moreover, to be founded upon dorsal vertebræ of the same species which have been subjected to a strong crush in the axial direction. I have compared the vertebræ figured by Phillips under the name of *P. brachyspondylus*, and also the types of his *P. validus*, with the corresponding vertebræ of the column described by Mr. Hulke, and find an absolute identity between the two; the difference on which Phillips separated *P. validus* from *P. brachyspondylus* being merely due to the different serial position of the vertebræ, and to an erroneous restoration of the neural arch. With regard to the type skeleton of *P. megadirus*, Prof. Hughes has been good enough to send some of the cervical vertebræ to London, and from comparing these, and from a personal examination of the rest of the skeleton two days after having carefully examined that of the so-called *P. Manseli*, I am fully and absolutely convinced of the specific identity of the two. This is also borne out by all the detached vertebræ of this type from the Cambridgeshire district in the British Museum, which cannot be distinguished from those of the latter. Further evidence is afforded by the above-mentioned paddle in the Cambridge Museum, and by another in the collection of Mr. Fisher, in both of which the propodial is of the *P. trochanterius* type.

Now comes the question of the pectoral girdle on which *Colymbosaurus* was founded. As this was referred definitely by its describer to the so-called *P. megadirus*, I had imagined that it was associated with vertebræ of the same type as those of the latter; but my astonishment on arriving at Ely was considerable on hearing from Mr. Fisher that it was an entirely isolated specimen. Although I think it most probable that this specimen is referable to the present form—that is, *P. trochanterius*—yet Prof. Seeley, on the supposition that these two forms were distinct, had no more grounds for referring it to *P. megadirus* rather than to *P. Manseli*, unless he assumed that all the Cambridgeshire specimens belonged to the former and all the Dorsetshire to the latter. Even then, however, there was also the

possibility of this specimen belonging to the large form allied to *P. plicatus* (for which I propose to adopt Owen's name *P. truncatus*), of which there are vertebræ from Ely in the British Museum.

So far, therefore, as I can see, the forms described under the names of *P. trochanterius*, *P. megadirus*, *P. brachistospondylus*, *P. Manseli*, *P. brachyspondylus* (Phillips), and *P. validus*, belong to one and the same species. On the evidence of a detached pectoral girdle Prof. Seeley has, however, made *P. megadirus* the type of the genus *Colymbosaurus*, while *P. Manseli* is referred to a second genus, *Murænosaurus*, apparently on the evidence of the broken coracoids of the type specimen. I think it very probable, as already said, that the pectoral girdle in question does belong to the present species; and I believe, moreover, that the pectoral girdle of the type specimen of *P. Manseli* when complete was (as Mr. Hulke states on p. 59 of the "Proc. Geol. Soc." for 1883) of precisely the same general form; this form having apparently obtained in all the Upper and Middle Jurassic Plesiosaurs.

As a climax to the treatment to which Plesiosaurs have been subjected we may notice Prof. Cope's restoration of the so-called *Elasmosaurus platyurus*, given in the "Trans. Amer. Phil. Soc." vol. xiv. pt. i. pl. ii. In this instance the head has been placed at the extremity of the tail; and the Professor is consequently led to remark in his description that in the vertebræ the prezygapophyses present the unheard-of peculiarity of looking downwards instead of upwards, while the so-called cervicals are indistinguishable from the caudals of other forms.

Finally, after long consideration I have come to the conclusion that it will be convenient to separate from *Plesiosaurus* all those supra-Liassic species having single costal facets and a pectoral girdle without omosternum and the coracoids united by a median bar with the precoracoids. For these forms I propose to adopt the name *Cimoliosaurus*, Leidy, as being the earliest of the numerous terms which have been applied to this group. The typical forms have flattened terminal faces to the vertebræ; but I do not propose to generically separate these forms like *Plesiosaurus trochanterius* and *P. Ozoniensis* in which these faces are cupped; although if such separation should be found advisable, I believe the term *Polycotylus* of Cope is the one which should be adopted. I shall show on another occasion that *Elasmosaurus* of Cope is not separable from *Cimoliosaurus*.

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#### V.—OUTCROPS.

By W. W. WATTS, M.A., F.G.S.,

Fellow of Sidney College, Cambridge, and sometime Deputy-Professor of Geology at Oxford.

**N**OW that mapping constitutes such an essential part of field-work, it may be of use to some of your readers to connect together a few rules which have occurred to me on this subject.

*Valley-Outcrops*.—Professor Green has devised an admirably common sense method by which the outcrop of a flat rock-bed can be