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ORIGINAL ARTICLES.

I.—NOTES ON THE GENUS *PHANEROPLEURON* (HUXLEY), WITH A DESCRIPTION OF A NEW SPECIES FROM THE CARBONIFEROUS FORMATION.

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(PLATE XIV.)

THE genus *Phaneropleuron* was instituted by Professor Huxley, in 1859,¹ for the reception of that singular fish *P. Andersoni*, from the Upper Devonian Yellow Sandstone of Dura Den, in Fifeshire, which species was also subsequently described by him in the tenth Decade of the Geological Survey, published in 1861. In the present communication I have to add a second species, from the Lower Carboniferous strata (Burdiehouse Limestone) of Edinburghshire, by which our knowledge of the genus is thus certainly carried a stage further upwards in the geological series.

Before, however, proceeding to the special description of the Carboniferous form, I have a few notes to contribute regarding the general characters of *Phaneropleuron*, as shown in the first described species, the results of a careful examination of the specimens in the St. Andrew's Museum, obtained subsequently to the publication of Professor Huxley's descriptions. I have also enjoyed the opportunity of comparing these results with the appearances exhibited in the suite of specimens in the British Museum, and in the Museum of Practical Geology in Jermyn Street.

As Professor Huxley has pointed out, in his excellent and concise descriptions above referred to, *Phaneropleuron Andersoni* is remarkable for its thin circular overlapping scales, for its persistent notochord, but well ossified neural and hæmal arches, spines, and median fin-supports, and for the great length and prominence of the ribs, which shine so conspicuously through the thin external covering of scales. The ventral, and most probably also the pectoral fins, are acutely lobate, with a central scaly axis fringed with rays on both sides, as in the recent *Ceratodus Forsteri*, the extinct *Holoptychius*, etc., and there is a distinct narrow anal fin in front of the lower lobe

¹ In Anderson's "Dura Den, a Monograph of the Yellow Sandstone." Edinburgh, 1859.

of the caudal. The dorsal fin commences low in front, but becomes deep and broad, as the form of the body narrows towards the tail. As regards the form of the tail, and the relations and configuration of the dorsal fin behind, Professor Huxley's views, at the time he wrote his descriptions, were, that the dorsal terminated posteriorly in an almost vertically truncated extremity, beyond which the notochord was continued for some distance. The upper lobe of the caudal seemed to be obsolete, while, on the other hand, he could trace the lower lobe, commencing immediately behind the anal, to near the extreme end of the body.¹ Subsequently obtained material, however, shows that the appearances which justified so eminent a palaeontologist in adopting the above-mentioned views were due to defective preservation of the specimens at his disposal, and that the dorsal fin was, as in the recent *Lepidosiren* and *Ceratodus*, continued, as a *dorso-caudal*, to the very extremity of the body, which condition I have endeavoured to express in the subjoined woodcut, representing a restored outline of the fish. I may mention that Prof.

Restored outline of *Phaneropleuron Andersoni*.

Huxley has expressed to me his entire concurrence in this view. The tail of *Phaneropleuron* is, then, beautifully diphycercal, a slight tendency to the heterocercal form being, however, shown by a very constant, though slight, upward curvature of the caudal extremity of the body.

I am also in a position to give a few additional details regarding the structure of the head, though unfortunately our knowledge on this point still remains very imperfect. In general configuration the head must have resembled much that of *Ceratodus Forsteri*, being considerably flattened above, while the high occipital region slopes off downwards and forwards to the bluntly-pointed muzzle. Internally, the cranium seems to have been very extensively cartilaginous, as I have seen no trace of any ossifications of its base or side-walls, but above it was protected by a buckler formed of a great many osseous plates firmly articulated together by suture, though none of the specimens I have seen are sufficiently perfect to enable one to map out completely their number and arrangement. However, in two of the specimens in the St. Andrew's Museum, three plates, one median and two lateral, may be very distinctly made out, forming the posterior or nuchal margin of the cranial shield, and corresponding to the three similar plates in *Glyptolemus*. In front of the median plate are two elongated *parietals*, while on each side of it, and articulating also with the posterior external

¹ Mem. Geol. Survey, Decade X., p. 49. Also in Anderson's "Dura Den," p. 67.

angle of the corresponding parietal, is another pretty large bony piece (*squamosal*?). Between the latter and the external margin of the buckler is a row of smaller plates, of which three are evident enough; but in no specimen I have seen, can the arrangement of the plates in front of those described be definitely made out, nor can I settle the question as to the position of the nasal openings. I have seen no hyomandibular; but in two specimens, one in St. Andrews, the other in the British Museum, a stout *palato-ptyergoid* may be seen to extend from near the articular extremity of the lower jaw forwards towards the snout: posteriorly, the surface of this bony lamina slopes upwards and inwards, but in front it becomes nearly horizontal, and there it is seen to be armed on its oral surface with numerous conical teeth. The form of the *maxillary* and *premaxillary* bones is not determinable, but the upper margin of the mouth was evidently bordered by dentigerous bones, the teeth being as described by Professor Huxley, in one row, short, conical, and pointed. The lower jaw is stout, composed evidently of several pieces, and close to the symphysis the ramus makes a pretty sharp bend horizontally inwards to meet its fellow. It is armed also with pointed teeth, an especially large one being seen at the symphyseal angle referred to. The *operculum* is very large, rounded posteriorly and inferiorly, but with nearly straight superior and anterior margins; below it overlaps an antero-posteriorly elongated, somewhat ovate *suboperculum*, not before noticed. There is no trace of any *preoperculum*. The orbit seems to have been situated rather far back; a curved bony plate is seen on the cheek, separating it from the operculum, and bounding it below and behind. Regarding the under surface of the head, I have nothing to add to Professor Huxley's description, not having seen any better specimen than that in the British Museum, to which he refers, and which certainly shows that the space between the rami of the lower jaw was occupied by bony plates, whatever their number might have been. Of the bones of the shoulder-girdle I have only seen two, viz., a well-marked *clavicle*, and at least one *supra-clavicular* proceeding from it towards the occipital region of the skull.

Phaneropleuron Andersoni (Huxley), towards the knowledge of whose structure I have contributed the above unfortunately only too imperfect notes, was hitherto the only species of the genus described, and the genus was known only from the Devonian beds of Dura Den. Some time ago, however, while looking through the Carboniferous fishes in the collection of the late Mr. Hugh Miller, my attention was directed by Mr. C. W. Peach, who was with me on that occasion, to certain un-named specimens, which he had already recognized as belonging to the genus in question, and which now gave undoubted evidence of its continuation upwards into, at least, the lower portion of the Carboniferous series. No locality was affixed to those fossils, but the stone in which they are imbedded is so identical in mineral character with the well-known Lower Carboniferous Limestone of Burdiehouse, near Edinburgh, that there can be no doubt but that they were derived from that locality. Moreover, I think that

sufficient justification for recording them as Burdiehouse fossils may be found in the fact, that two additional specimens of the same fish have been also found by that most indefatigable and successful collector, Mr. Peach, in the quarries of the very place in question.¹

Enumeration of Specimens.—For purposes of reference in the following description, the specimens before me may be numbered and characterized as follows:—

No. 1. Specimen (Fig. 1, Pl. XIV). measuring $5\frac{3}{4}$ inches in length, and showing the head, body, and caudal region, except the extreme termination of the tail. In the Miller Collection, Edinburgh Museum of Science and Art.

No. 2. Specimen (Fig. 2, Pl. XIV.) $4\frac{1}{2}$ inches in length, without head, but showing the greater part of the abdominal region, with the tail up to its very termination. Miller Collection.

No. 3. Portion of a fish, evidently originally a larger specimen than either of the two preceding. It shows a large portion both of the abdominal and caudal regions, but without either the head or the point of the tail. Length, $4\frac{1}{2}$ inches. Miller Collection.

No. 4. A nearly entire specimen, $5\frac{1}{4}$ inches long, somewhat distorted, showing a portion of the head and also the extreme termination of the tail, as in No. 2. In the collection of Mr. Peach.

No. 5. Portion of the caudal region, but without its extreme termination. Length, $3\frac{7}{16}$ inches. In Mr. Peach's collection.

Scales.—The body was evidently covered, as in the case of *P. Andersoni*, with thin and feebly ossified scales, which do not in any case conceal the bones of the prominent internal skeleton. Their exact size and configuration can hardly be accurately distinguished, owing to the state of preservation of the fossils, in which the scales are squeezed together into almost an homogeneous-looking film. As far as I can make out, they seem to have been of moderate size, cycloid or somewhat rhombo-cycloid in shape, imbricating in arrangement, and marked with concentric lines, but more especially with fine thread-like longitudinal or slightly radiating striae.

Head.—In specimen No. 1 the head measures $1\frac{1}{2}$ inch in length, and is contained $5\frac{3}{4}$ times in the length of the whole specimen as preserved, but the end of the tail being lost, the original proportion would probably be, at least, as 1 to $6\frac{1}{2}$. In front a portion of bone is seen bearing a smooth, conical, sharp, tooth-like projection, $\frac{3}{8}$ of an inch long. In No. 3 the impression of a large broad operculum is distinctly visible, but in neither of the specimens can the contour of any other of the bones of the head be distinguished, though in places it may be seen that their free surfaces were ornamented with fine ridges.

Body.—In general form the body must have considerably resembled that of *Protopterus*, being moderately broad in the abdominal

¹ The following description of the new Carboniferous species formed part of a paper, entitled, "Additions to the Fossil Vertebrate Fauna of Burdiehouse, near Edinburgh," read before Section C of the British Association, at Edinburgh, August, 1871.

region, and becoming gradually attenuated to a fine point in the caudal, but in specimens free from distortion a very distinct upward curvature of the axis of the body is seen near the tail. There being no traces of vertebral bodies visible, the notochord must have been persistent, and the empty space which it occupied is well seen, especially in the caudal region. The neural arches and spines are well ossified; the latter are slender in form, and are long in front, getting gradually shorter as we proceed backwards. The form of the neural spines is most distinctly seen in the caudal region, where each, springing from a slightly expanded neural arch, passes very obliquely upwards and backwards, and becoming thin in the middle, ends in a laterally-flattened, expanded termination, to which one of the next set of elements, the dorsal fin-supports, may in many instances be clearly seen to have been articulated: indeed, I believe that this must always have been the case, though in the present fossils these elements are often displaced from each other, as in Fig. 2, Pl. XIV. These succeeding elements, the dorsal "inter-spinous bones," or fin-supports, well shown both in Figs. 1 and 2 of the plate, are likewise slender in form, expanded at both ends, and pass, like the neural spines which support them, obliquely upwards and backwards. They are frequently slightly curved, with a forwardly directed concavity. They are rather short and delicate in front, attaining their greatest length and stoutness opposite the beginning of the caudal region, whence backwards they again become smaller, till towards the end of the tail they can no longer be distinguished from the neural spines. The ribs are, as in *Ph. Andersoni*, very long and prominent, and are well seen in Fig. 1. The hæmal spines follow on the ribs as we pass from the abdominal to the caudal region, and with the appended supporting bones of the anal and inferior lobe of the caudal fins, agree essentially with the corresponding elements on the neural side of the notochord. The ribs, neural and hæmal spines, and median fin-supports seem to have been hollow, the central cavities, originally occupied by cartilage, being now filled with carbonate of lime.

Fins.—A comparison of the five specimens under examination shows that the dorsal fin was, as in *Ph. Andersoni* and in the recent *Lepidosiren*, perfectly continuous with the upper lobe of the caudal. In specimen No. 1 (Fig. 1, Pl. XIV.) the dorsal is seen distinctly to commence only three-quarters of an inch behind the head. This dorso-caudal fin is low at its commencement, but gets broader posteriorly, attaining its greatest breadth opposite the beginning of the caudal region, after which it becomes rapidly attenuated as it proceeds to the tip of the tail. On the hæmal aspect of the body there is some evidence in nearly all the specimens, but especially in No. 4, of a small, narrow, separate anal fin in front of the lower lobe of the caudal. This lower lobe of the caudal is not so broad as the upper lobe, and, proportionally, is considerably less deep than the corresponding part in *Ph. Andersoni*; like the upper lobe, it becomes finely attenuated posteriorly. The tail thus formed is beautifully diphyccercal, as seen in Fig. 2; there being, however, as above

remarked, a slight upward curvature of the axis of the body at its caudal extremity. This curvature is not seen in Fig. 2, as the specimen has undergone a slight distortion, but it may be observed in Fig. 1, and is still better seen in specimen No. 5, not figured.

The rays of the median fins are very fine, frequently bifurcating near their tips, and spring in bundles, which may be best studied in the dorso-caudal. They have, in fact, the same structure as in *Ph. Andersoni*. Each bundle results from the division, into numerous raylets, of the distally-directed apex of a small triangular basal piece, which, proximally, may frequently be seen to be articulated to the subjacent extremity of an interspinous bone or fin-support. A few of these triangular bases of the dorso-caudal fin-rays may be seen both in Figs. 1 and 2, though they are considerably more distinct in specimens Nos. 3 and 5, not figured.

In specimen No. 1 (Fig. 1), a bone of the shoulder girdle, probably the clavicle of the right side, is seen, but no undoubted trace of either pectoral or ventral fins can be detected in any of the fossils.

Conclusion.—In the Carboniferous specimens before us, we have a fish very closely resembling the *Phaneropleuron Andersoni* of Huxley, but differing from it in its smaller size, in its somewhat more slender form posteriorly, in the smaller depth of the lower lobe of the caudal fin, and apparently also in the greater extension forwards of the dorsal fin. As it is evidently at least specifically distinct, I propose to bestow on it the title of *Phaneropleuron elegans*.

The genus *Phaneropleuron* is thus common to the Upper Devonian and Lower Carboniferous formations. It is one of the most interesting of the Palæozoic Ganoids, as showing the intimate relations subsisting between the ancient Crossopterygians with acutely lobate pectorals and ventrals, and the remarkable recent types, *Lepidosiren*, *Protopterus*, and *Ceratodus*. One cannot fail to be struck, as Prof. Huxley has already indicated,¹ with the many points of resemblance which this genus bears to *Lepidosiren*, in the general form of the fish, in its thin circular scales, and in many points in the structure of its internal skeleton. But from the true *Dipnoi*, with which Dr. Günther now unites the Devonian *Dipterus*, and the Carboniferous *Ctenodus*,² it differs, as is well known, materially in its dentition; and the position of the nasal openings, so peculiar a character in the recent *Dipnoi*, and in the fossil *Dipterus*, as Günther has pointed out, remains yet to be definitely settled. *Phaneropleuron* must therefore remain, as Prof. Huxley has placed it, the type of a distinct subfamily of Crossopterygidæ, viz., *Phaneropleurini*, and not very far removed from *Holoptychius*, and other acutely lobate-membered cycloferous Ganoids of Palæozoic times.

My best thanks are due to Mr. Archer, the able and liberal-minded Director of the Edinburgh Museum of Science and Art, for permission to figure and describe the Carboniferous specimens in the Miller Collection; to my genial friend Mr. Peach, for the loan of the two specimens in his private cabinet, and for having originally

¹ Dec. Geol. Surv. X. p. 26.

² Proc. Royal Soc. March 16, 1871, p. 379.

directed my attention to the subject; and also to the Literary and Philosophical Society of St. Andrews, for the free permission which they accorded to me to examine and make notes of the beautiful specimens from Dura Den, in the Geological collection of their Museum.

EXPLANATION OF PLATE XIV.

FIG. 1. *Phaneropleuron elegans*, natural size, from the Lower Carboniferous Limestone of Burdiehouse.

FIG. 2. Another specimen, natural size, without the head, but showing the extreme tip of the tail. The dorso-caudal fin is injured in front, and the direction of the caudal axis slightly distorted, so as to spoil the beautiful, though gentle, upward curvature which in the other specimens it is seen to have towards its termination.

II.—ON A CIRQUE IN THE SYENITE HILLS OF SKYE.

By T. G. BONNEY, M.A., F.G.S.

(Read before the Cambridge Philosophical Society, October 30, 1871.)

IN a communication to the Geological Society,¹ "On the formation of Cirques, and their bearing upon theories attributing the excavation of Alpine valleys mainly to the action of Glaciers," I confined myself to the examination of Cirques in sedimentary strata, and these to a large extent calcareous. I observed this restriction because the most typical examples, so far as I could ascertain, lay in non-crystalline districts, and because my own experience had not presented to me any very striking instances in other districts. The present brief paper is an attempt to show that, under favourable circumstances, the principles there laid down may also be applied to regions wherein crystalline rock exists.

A Cirque may be defined as a variety of what in Scotland is called "a corrie," viz., a more or less semicircular recess in the heart of a mountain region, and at or near the head of a valley, inclosed by a high wall of approximately vertical cliffs.

In the above-named paper I attempted to show that these Cirques could not be explained by: (α) what earlier geologists termed a crater of elevation; (β) or by any kind of marine action, such as has excavated some of the coves which may be seen among coast cliffs; (γ) or by the action of a glacier ploughing up the ground; and that the only explanation, consistent with the phenomena which they presented, was to attribute them to the erosive action of several small streams of water, derived from sources higher up, which, aided by atmospheric denudation,—rain, heat, frost,—cut their way gradually backward into the mountain side.

At that time I put aside the question of how far a favourable configuration of the surface was needed before these agents could act, and by what physical causes it had been produced; all I attempted to establish was, that Cirques in their present condition are the result of the joint action of running water and meteoric agents; and the same limitation must be supposed to hold in the present paper.

¹ Quart. Journ. Geol. Soc., vol. xxvii. p. 312.