III.—NOTES ON SOME FOSSIL ARTHROPODS FROM THE CARBONIFEROUS ROCKS OF CAPE BRETON, NOVA SCOTIA, RECEIVED FROM DR. H. M. AMI, M.A., F.G.S., F.R.S. (CAN.).

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

SOME years ago I published, with the late Professor T. Rupert Jones, F.R.S., a description of two small Limuloids referred to the genus *Bellinurus*, sent me by my friend Dr. H. M. Ami (then of the Canadian Geological Survey), who obtained them from the Lower Carboniferous Marine Series on the Intercolonial Railway of Canada, in Colchester County, Nova Scotia (GEOL. MAG., 1899, pp. 387–95, Pl. XV, Figs. 2 and 3), under the specific name of *B. grandævus*. Fig. 2 was collected from the sixth cutting east of Riversdale Station and Fig. 3 from the third cutting east of Colnary River.

Dr. Ami subsequently sent me a further collection of specimens made by him in 1907, from the Carboniferous Series, Glace Bay Mines, Cape Breton, Nova Scotia. Before describing these, however, I venture to give a few notes on the country whence they were obtained, taken chiefly from Dr. Ami's account of Nova Scotia.¹

Nova Scotia, New Brunswick, and Prince Edward Island form a group of provinces known as "the Maritime provinces", on the eastern flank of the Dominion, and with Newfoundland represent the most approximate land to our shores in North America.

The peninsula of Nova Scotia, 268 miles in length, varying from 60 to 100 miles in width, forms a part of the ancient Acadia, being connected by an isthmus with the Province of New Brunswick at the head of the Bay of Fundy (well known for its high tides), its main axis being from north-east to south-west, and its mountains, with its appendage Cape Breton Island being, geologically, outliers of the Appalachian system on the mainland to the south-west. The northern limit of the Carboniferous system touches the Gulf of St. Lawrence at Miscou Head, and extends in a broad band along all the inner coast of Nova Scotia and into Cape Breton, and comes out near Sydney upon the coast of the Atlantic, where the waves wash the coal-seams on the sea-shore. Carboniferous rocks also occur in the Magdalen Islands and at the south-western point of Newfoundland, where a seam of coal 3 feet thick crops out near the shore.

The Island of Cape Breton is really a continuation of Nova Scotia, from which it is only separated by the Strait of Canso; it is 108 miles long, and contains the important coal-field of Sydney, which extends along the Atlantic shore for 32 miles and covers an area of over 250 square miles. Thirty-four seams occur in this section, but only a few of them have been worked.

Pictou Coal-field, situated on Northumberland Strait, has the finest harbour on the whole north coast of the province. Here the

¹ *Stanford's Compendium of Geography and Travel* (new issue), 1915, North America, vol. i, Canada and Newfoundland; edited by Henry Ami, M.A., D.Sc., F.G.S., F.R.G.S. F.R.S. (Can.); 8vo, 2nd ed. revised, pp. xxviii + 1070.

largest vessels resort to ship coal from the adjacent mines. The field is 35 square miles in extent, and is remarkable for the great thickness of its seams. In one section the main seam is 34 ft. 7 in., and what is known as the deep seam is 22 ft. 11 in. thick. Other seams range from 12 feet, 11 feet, 10 feet, 5 ft. 7 in., 3 ft. 3 in.; in all 107 ft. 10 in. of coal have been recorded in this area.

The Carboniferous formation extends from the high land of Cape George westward along the whole coast of the peninsula bordering Northumberland Strait, and across the country to Chignecto Bay and the Minas Basin, at the head of the Bay of Fundy, occupying Cumberland County and the greater part of Pictou, Colchester, and King's Counties. This forms the Cumberland Coal-field and has an area of 430 square miles, worked chiefly at Springhill, where eight seams occur with an aggregate thickness of 52 ft. 7 in. of coal. Mines have, however, been opened at several other places, as at River Herbert, at Maccan, and at Joggins, whose port and rail-head is at Amherst.

At the Joggins, on the shore of Chignecto Channel, at the head of the Bay of Fundy, is a unique natural exposure of a continuous section of Middle and Upper Carboniferous strata, which gave Sir William Logan an actual measurement of 14,570 feet. It is a classic region for geologists, and Sir Charles Lyell, who examined it in 1842, and in 1845, and lastly in 1852, pronounced it to be the finest example in the world of a natural exposure of uninterrupted coal-measures in a continuous section 10 miles long.

The beds, says Lyell,¹ are all seen dipping the same way, their average inclination being at an angle of 24° S.S.W., the vertical height of the cliffs being upwards of 300 feet. He observed seventeen trees in an upright position, or, to speak more correctly, at right angles to the planes of stratification; he counted nineteen seams of coal, varying in thickness from 2 inches to 4 feet. At low tide a fine horizontal section of the same beds is exposed to view on the beach. The thickness of the beds alluded to is about 2,500 feet, the erect trees consisting chiefly of large *Sigillariæ*, occurring at ten distinct levels, one above the other; but Sir William Logan, who afterwards made a more detailed survey of the same line of cliffs, found erect trees at seventeen levels, extending through a vertical thickness of 4,515 feet of strata, everywhere devoid of marine organic remains. The usual height of the buried trees seen by him was from 6 to 8 feet; but one trunk was about 25 feet high and 4 feet in diameter, with a considerable bulge at the base. In no instance could he detect any trunk intersecting a layer of coal, however thin; and most of the trees terminated downwards in seams of coal. Some few only were based in clay and shale; none of them, except Calamites, in sandstone. The erect trees, therefore, appeared in general to have grown on beds of coal. In the under-clays *Stigmaria* (the roots of the *Sigillariæ*) abound.

In 1852 Sir William Dawson and Lyell made a detailed examination of one portion of the strata, 1,400 feet thick, where the coal-seams are most frequent, and found evidence of root-bearing soils at

¹ *Elements of Geology*, 1865, 6th ed., p. 482.

sixty-eight different levels. Like the seams of coal which often cover them, these root-beds, or *old soils*, are at present the most destructible masses in the whole cliff, the sandstones and laminated shales being harder and more capable of resisting the action of the waves and the weather. Originally the reverse was doubtless true, for in the existing delta of the Mississippi those clays in which the innumerable roots of the deciduous cypress and other swamp-trees ramify in all directions are seen to withstand far more effectually the undermining power of the river, or of the sea at the base of the delta, than do beds of loose sand or layers of mud not supporting trees.

As regards the fossil plants (of which Sir William Dawson records over 150 species in the Coal-measures of the South Joggins),¹ they belong to the same genera, and most of them to the same species, as those met with in the distant coal-fields of Europe. Many of the still erect trunks of *Sigillaria* and *Lepidodendron* had their interiors filled up with layers of sandstone, in which Lyell frequently observed fern-leaves, and sometimes fragments of *Stigmaria*, which had evidently entered together with sediment after the trunk had decayed and become hollow, while still standing under water.

When the Carboniferous forests sank below high-water mark a species of *Spirorbis* or *Serpula* attached itself to the outside of the stumps and stems of the erect trees, adhering occasionally even to the interior of the bark—another proof that the process of envelopment was very gradual. These hollow upright trees, covered with innumerable marine annelids, resemble a “cane-brake”, as it is commonly called, consisting of tall reeds of *Arundinaria macrosperma*, which Lyell saw in 1846, at the Balize, or extremity of the delta of the Mississippi. Although these reeds are freshwater plants they were covered with *Balani*, having been killed by an incursion of salt water over an extent of many acres, where the sea had for a season usurped a space previously gained from it by the river. Yet the dead reeds, in spite of this change, remained standing in the soft mud, showing how easily the *Sigillariæ* and *Lepidodendron*, hollow as they were but supported by strong roots, may have resisted for some time an incursion of the sea.

The investigation of the organisms preserved in the interior of these hollow trunks of *Sigillariæ*, at the Joggins Coal-measures, by Sir William Dawson, during many years, has resulted in the further discovery of quite a number of new and very interesting forms of terrestrial animals belonging to the Coal period.

Of these we may mention the remains of some small Amphibian reptiles referred to *Dendroperpeton Acadianum* and *Hylonomus Lyelli*, Dawson. To these have been added *Baphetes planiceps*; numerous insect remains, and a Myriopod, *Xylobius sigillariæ*; an air-breathing snail, *Pupa vetusta*, etc.²

¹ *Acadian Geology: The Geological Structure, Organic Remains, and Mineral Resources of Nova Scotia, New Brunswick, and Prince Edward Island*, by Sir Wm. Dawson, 8vo, 1868, pp. 694.

² “Air-breathing Animals of the Palæozoic Rocks in Canada,” by Sir Wm. Dawson, C.M.G., F.R.S.: Trans. Roy. Soc. Canada, 1894.

Bivalve mollusca are extremely abundant in certain shale beds of the Coal-measures, and many have been described and figured by Sir Wm. Dawson, Dr. Wheelton Hind, and others.¹

FIG. 1.—*Anthracomya arenacea*, Dawson. $\times 1\frac{1}{2}$. Found on the same slab with *Euproops Amia*, H. Woodw. From Donkin Pit, No. 6. Coal-measures: Glace Bay Mines, Cape Breton, Nova Scotia.

The specimens of Limuloid Arthropods already described by me from Nova Scotia in this MAGAZINE (for September, 1899) were referred to the genus *Bellinurus*; those about to be noticed were also obtained by Dr. Ami, but from the northern extremity of the province at Glace Bay Mines in the Island of Cape Breton, and are referred to the genus *Euproops*. (See Text-figs. 2–4, pp. 466–7, *infra*.)

Order MEROSTOMATA, Dana, 1852.

Sub-order II. XIPHOSURA, Gronovan, 1764.

1. Genus *EUPROOPS*, Meek & Worthen, 1868, Geol. Surv. Illinois, vol. iii, 1868.

SYNONYMY.—*Prestwichia* (H. Woodward, 1867), having been preoccupied by Lubbock in 1863 for a genus of HYMENOPTERA, *Euproops* becomes the type for the following species:—

- Euproops Danae*, Meek & Worthen, Geol. Surv. Illinois, vol. iii, 1868.
- E. (Prestwichia) anthrax*, H. Woodw., Quart. Journ. Geol. Soc., vol. xxiii, p. 32, pl. i, fig. 2, 1867.
- E. (Bellinurus) anthrax*, Bailey, Ann. Mag. Nat. Hist., ser. III, vol. xi, p. 113, 1863.
- E. Colletti*, White, Fauna of Indiana Coal-measures, Geol. & Nat. Hist., pl. xxxix, fig. 2, 1883.
- E. longispina*, Packard, American Naturalist, vol. xix, p. 292 (not figured), 1885.
- E. (Limulus) anthrax*, Prestwich, Trans. Geol. Soc., ser. II, vol. v, pl. xii, figs. 1–4, 1840.
- E. (Prestwichia) anthrax*, Bolton, Trans. Manchester Geol. Soc., vol. xxxiv, fig. 120, p. ix, 1915.
- E. (Prestwichia) Birtwelli*, H. Woodw., GEOL. MAG., Vol. IX, p. 440, Pl. X, Figs. 9, 10, 1872.
- E. (Prestwichia) Birtwelli*, H. Woodw., Pal. Soc. Mon., Merostomata, pt. vi, p. 247, pl. xxxi, figs. 7a, b, 1878.
- E. (Prestwichia) anthrax*, H. Woodward, Pal. Soc. Mon., Merostomata, pt. v, p. 244, pl. xxxi, fig. 6, 1878.

Euproops Amia, H. Woodw., sp. nov. (Text-figs. 2–4, pp. 466–7.)

The specimens referred to this species consist of an almost complete example and two detached head-shields of a new species of “king-crab”, exposed on the surface of three slabs of black-grey shale, associated with specimens of a bivalve mollusc, *Anthracomya*

¹ See Quart. Journ. Geol. Soc., vol. i, pl. xx, fig. 4, 1894 (W. Hind).

arenacea, Dawson (Text-fig. 1), fragments of plant-remains, and some traces of fish-scales.

Like the type of the genus (see *supra*, p. 465) in *Euproops Amia*, the head-shield is remarkable by reason of its narrowness from back to front, and the extreme lateral expansion of its cheek-spines, which curve upwards and outwards from the posterior border of the head-shield towards the middle of the cheek before curving downwards to their slender extremities, forming an arc of about 55 mm. measured around the front border of the shield, and 36 mm. along the chord from the extreme points of the cheek-spines, or more than three times as wide as the head-shield is long. The frontal border is narrow and slightly flattened, and the frontal doublure is less strongly marked.

FIG. 2.—*Euproops Amia*, H. Woodw., sp. nov. $\times 1\frac{1}{2}$. (The telson is restored.) Donkin Pit, No. 6. Coal-measures: Glace Bay Mines, Cape Breton, Nova Scotia.

The posterior border of the head where it unites with the thoracetreron is 14 mm. broad, but it widens to 29 mm. (including the genal border). The glabella, which is slightly raised, is 10 mm. wide at the cervical border, but slightly widens across the line of the orbits, which are only obscurely to be determined, and is faintly circumscribed by a roundly protuberant rim, within which the glabella forms into a double arch in front, the two arches uniting in a V-shaped backwardly directed ridge in the central line, behind which are three small median lobes marked off by transverse furrows, the hindmost resting on the cervical furrow and the front one extending up to the V-shaped point of the axial ridge. The basis of the glabella ridges gives rise to two backwardly directed slender spines, each 9 mm. in length (these are broken off in Fig. 2, otherwise the most complete specimen, but are seen in the detached head-shields, Figs. 3 and 4). The thoracetreron articulates along its anterior border with the posterior margin of the head-shield, which is roundly elevated and cordiform in outline, being 11 mm. broad anteriorly, 16 mm. across at its widest part, and about 25 mm. to the extremity of its lateral marginal spines. The axial division of the cephalon, 5 mm. in width, is continued down the centre of the thoracetreron, diminishing gradually to about half that width posteriorly.

The longitudinal furrows of the axis serve to maintain the trilobed character of the whole body. The thoracetreron consists of six nearly equal, coalesced segments (the ridge and furrow of each are marked on the central lobe) curving backwards to the margin, and bordered by a stout ridge, which in each segment terminates in a prominent marginal spine (of which there are seven, the seventh forming a part of the rudimentary abdomen); the spines are united to each other by a flat narrow-scalloped border of the shield. The extremity of the axis, composed of two or more coalesced segments and together with the telson or caudal spine (wanting in this specimen), form the rudimentary abdomen: (the telson or tail-spine being absent can only be vaguely estimated from other specimens). There are indications of tubercles along the axial lobe, the base of the largest of which is seen near the termination of the axis over the articulation for the telson.

FIG. 3. $\times 1\frac{1}{2}$. FIG. 4. $\times 1\frac{1}{2}$.

FIGS. 3 and 4.—Two detached head-shields of *Euproops Amia*, H. Woodw., showing long post-cephalic spines from the genal border of the head-shield. From Caledonia Pit, No. 4: Glace Bay Mines, Cape Breton (H. M. Ami, 1907).

Compared with the type of *Euproops* (*E. Danae*, Meek & Worthen) the head-shield of *E. Amia* is deeper from back to front, the free-cheek spines are more laterally divergent and more hollowed out upon their inner posterior border; the axis is broader than in the type, in which the margin of the glabella is somewhat narrower and the eyes are said to be more anteriorly placed; in *E. Amia* the posterior border of the glabella, which is rounded, terminates in a pair of slender spines three times as long as those of the type (*E. Danae*). The thoracetreron in *E. Amia* is roundly cordiform, and the scalloped marginal border is more definitely separated from it. [As Dr. Meek's specimen is mainly known by his admirable restoration a strict comparison with less perfect materials leaves some points rather doubtful.]

I dedicate this species to its discoverer, my friend Dr. Henry M. Ami, who has devoted many years to the study of Acadian geology.

2. NOTE ON EUPROOPS (PRESTWICHIA) BIRTWELLI, H. Woodw.

Prestwichia Birtwelli, H. Woodward, GEOL. MAG., Vol. IX, p. 440, Pl. X, Figs. 9, 10, 1872.

P. Birtwelli, H. Woodward, Pal. Soc. Mon., *Merostomata*, pt. v, pl. xxxi, figs. 7a, b, c, p. 247, 1878.

After careful reconsideration of this species I have come to the conclusion that the nodules in which these two specimens were enclosed contained only the *central portion* of the body-shields, and that the flat marginal scalloped borders, with their spines, and telson were not preserved as they extended beyond the hard central concretion into the softer external concentric layers of clay (as frequently observed by Dr. Moysey and myself in the clay-ironstone nodules at Shipley, near Ilkeston, Derby, and those also of Rochdale, Lancashire, and Coalbrookdale, Shropshire), and so were not preserved.

The general form of the raised rounded central portion of the body-shield resembles more that of *Euproops* than it does *Prestwichiarella*. Assuming the margin to have been furnished with a scalloped border and the segments to have terminated in marginal spines upon the border of the thoracetrone, the resemblance to *Euproops Danae*, *E. anthrax*, and *E. Amie* would have been complete.

Formation and Locality.—Coal-measures: Cornfield Pit, south bank of the River Calder, Padiham, Lancashire.

3. NOTE ON THE GENUS PRESTWICHIA, H. Woodw., 1866.

In reference to the genus *Prestwichia* I had for some time been doubtful as to the advisability of retaining the species named *P. anthrax* and *P. rotundata* under the same genus. The investigation of this matter led to the discovery [to which my attention was obligingly drawn by my friend Mr. Charles Davies Sherborn, of the British Museum (Natural History)] of a note which had appeared in the *American Geologist* for 1905, p. 330, by Mr. T. D. A. Cockerell, of the University of Colorado, U.S., that the name *Prestwichia* had been *preoccupied* for a genus of HYMENOPTERA by Lubbock in 1863, and suggesting the propriety of transferring the species so named to Messrs. Meek & Worthen's genus *Euproops*, 1868. The specimen here referred to was first described in 1865 by Meek & Worthen under the name of *Belinurus Danae*; later on Mr. Meek assigned his specimen to a new genus between *Belinurus* and *Prestwichia*, for which he proposed the name *Euproops*, in allusion to the anterior position of its eyes.¹

But although this form, like *Prestwichia*, has the segments of the *thoracetrone* anchylosed, *Euproops* differs from it in the quadrangular form of the glabella, and the eyes being situated forward on its anterior lateral angles, while in *Prestwichia* they are borne upon the lateral margins; the genal border must therefore be considered equivalent to the orbital suture, or (most probably) coalesced with it.²

¹ F. B. Meek, Amer. Journ. Sci. & Arts, May, 1867. See also GEOL. MAG., July, 1867, p. 320, and Geol. Rept. by Meek & Worthen, Survey of Illinois (Palæontology), vol. iii, 1868.

² In many of the Trilobita the eye-suture and the axial line of the glabella are close together; in young stages of the living American *Limulus* the axial

4. PRESTWICHIANELLA, gen. nov., 1918.

Prestwichia, H. Woodw., November 21, 1866.

P. rotundata, H. Woodw., Quart. Journ. Geol. Soc., vol. xxiii, p. 32, pl. i, fig. 2, 1866.

Limulus rotundus, Prestwich, Trans. Geol. Soc., ser. II, vol. v, pl. xli, fig. 5, 1840.

Seeing that the name of *Prestwichia*, H. Woodw., was preoccupied by Lubbock in 1863, I now propose to substitute, for the species *P. rotundata*, the new generic name of

Prestwichianella, H. Woodw., gen. nov.¹

Character amended.²—Head-shield semicircular. The genal borders and frontal margin are broad and smooth, and curved roundly on each side towards the thoracetron and ending in moderately broad lateral genal spines; the glabella is divided along the centre by the axial furrow, and by two other slightly diverging parallel lines on either of the axes, reaching nearly half-way to the frontal border, where they are arcaded, forming a rounded raised confluent line in front of the glabella. The circular line seen outside the border of the glabella may indicate the impression of the line of the broad incurved under-margin of the head-shield.

The thoracico-abdominal series of segments are apparently united together into one buckler, as seen in the larval stages of living *Limulus* (see H. Woodward, Mon. Pal. Soc., *Merostomata*, pt. v, pl. xxxiii, figs. 10–12, 1878). Central axis of body-segments narrow; abdomen rudimentary and coalesced with the hindmost thoracic segment, most probably bearing a short telson or tail spine. The broad membranous margin of the thoracetron extends nearly to the extremities of the seven strongly marked spines. Five short spines mark the posterior margin of the head-shield, and some small tubercles along the centre of the posterior axis with a more prominent spine near the base of the telson.

5. NOTE ON *BELLINURUS TRECHMANNI*, A NEW SPECIES OF LIMULOID ARTHROPOD FROM THE DURHAM COAL-FIELD.

I have been favoured by Mr. C. T. Trechmann, of Castle Eden, Durham, with the loan of a small specimen of a fossil “king-crab”, which he lately collected in the highest Coal-measures of the Durham Coal-field at Claxheugh on the Wear, near Sunderland. The beds are in the zone of *Anthracomya Phillipsii*, not generally known to occur in the Durham area, and as they will be shortly described by Dr. Trechmann he kindly permits me to notice this find in advance.

In 1866 I communicated a paper to the Geological Society, “On some points in the Structure of the Xiphosura, having reference to

line and the orbital suture are quite distinct and apart from each other (see Mon. *Merostomata*, pt. v, pl. xxxiii, fig. 10, after Packard; fig. 12, after Dohrn’s “*Trilobitenstadium*”). In the adult living *Limulus* the compound eyes occupy the lateral border of the glabella.

¹ *P. anthrax* and *P. Birtwelli* are now referred to *Euproops*.

² See description in H. Woodward’s Monograph on the *Merostomata*, Pal. Soc. vol., 1878, pt. v, pp. 244–7, pl. xxxi, fig. 5.

their relationship with the Eurypteridæ": Quart. Journ. Geol. Soc., vol. xxiii, pls. i and ii, p. 32, 1867; and again, in my Monograph on the Order Merostomata, Pal. Soc., pt. v, 1878, sub-order Xiphosura, pp. 236–48, I discussed the arrangement of the several genera of these Palæozoic forms of Arthropoda and proposed to divide the Coal-measure species into two genera:—

(A) Those having movable thoracic segments and anchylosed abdominal ones, under the genus *Bellinurus* (with 8 species, 1918).

(B) Those in which all the post-cephalic segments are coalesced under the genus *Prestwichia*. The name being *preoccupied*, it has now been found necessary to subdivide this latter group into two genera, namely: (1) *Prestwichianella*, with 1 species; (2) *Euproopa*, with 6 species.

In Section A, *Bellinurus*, König, the earliest records of this genus in which intelligible figures are given are: by Mr. Charles König, Keeper of Geology and Minerals in the British Museum in 1820 (*Icones Foss. Sect.*, pl. xviii, fig. 230), and later, in 1836, by Buckland, in his *Bridgewater Treatise*, i, p. 396; ii, p. 77, pl. xlv, fig. 3; Mr. Prestwich, in 1840, *Trans. Geol. Soc.*, ser. II, vol. v, p. 491, pl. xli, fig. 8; H. Woodward, 1866, *Trans. Glasgow Geol. Soc.*, p. 247, pl. iii, fig. 10, and *Pal. Soc. Mon., Merostomata* (Xiphosura), pt. v, 1878, p. 236, pl. xxxi, figs. 3a, b, c, and 4.

Genus *BELLINURUS*, König, 1820.

The species included under this genus are:—

- Bellinurus bellulus*, König, 1820, *Icones Foss. Sect.*
- B. arcuatus*, Baily, *Ann. Mag. Nat. Hist.*, ser. III, vol. xi, p. 112, 1863.
- B. reginæ*, Baily, *Ann. Mag. Nat. Hist.*, ser. III, vol. xi, p. 107, pl. v, 1863.
- B. killorkensis*, Baily, *Brit. Assoc. Rep.*, p. 75, 1869.
- B. Kenigianus*, H. Woodw., *GEOL. MAG.*, p. 439, Pl. X, Fig. 8, 1872.
- B. grandævus*, Jones & Woodw., *GEOL. MAG.*, 1899.
- B. lunatus*, Parker, *Lancashire Naturalist*, 1907, p. 44.
- B. Baldwinii*, H. Woodw., *GEOL. MAG.*, 1907, p. 540, Fig. 1.
- B. longicaudatus*, H. Woodw., *GEOL. MAG.*, 1907, p. 541, Fig. 2.

BELLINURUS TRECHMANNI, H. Woodw., sp. nov.

Specific Characters.—Head-shield semicircular, being 9 mm. in breadth and 4 mm. in length, the genal spines moderately long, $2\frac{1}{2}$ mm. in length, directed outwards (the extremity is only preserved on one side); breadth of glabella $2\frac{1}{2}$ mm., the length is not easily determined but probably about two-thirds that of the head-shield, and there is a faint trace of the arched axis. The frontal border of the head-shield is distinctly marked and the centre is roundly elevated; the eyes are not distinct; the posterior border between the spines is fairly straight and measures $7\frac{1}{2}$ mm. The axis of the thoracitron agrees with that of the glabella in breadth (viz. $2\frac{1}{2}$ mm.), only very slightly diminishing towards the telson; its length is 4 mm. There are six free post-cephalic segments, which are markedly trilobed, directed slightly backwards, ending along the lateral margin in stout recurved spines; the pleuræ of these free segments diminish rapidly towards the extremity of the thoracitron. There is a small coalesced abdominal portion bearing a tubercle above the insertion

of the stout tail-spine, which is 1 mm. in breadth, but is only imperfectly preserved (length unknown).

There seems to be good evidence that the division (A) of Palæozoic "king-crabs" represented in the Coal-measures by the genus *Bellinurus* contains the oldest form of the Xiphosura, which take precedence, in time, over those with anchylosed segments referred to the division (B) represented by the genera *Prestwichianella* and *Euproops*, as evidenced by their precursor, *Neolimulus falcatus*, H. Woodward,¹ 1868.

This earliest known form from the Upper Silurian appears to have had all its segments free and unanchylosed, and the later form *Bellinurus kiltorkensis*, Baile, from the Old Red Sandstone, probably represents the same genus as is met with in the Coal-measures with free thoracic, and most of them had anchylosed post-thoracic somites.

FIG. 5.—*Bellinurus Trechmanni*, H. Woodw., sp. nov. $\times 4$. Upper Coal-measures: Claxheugh on the Wear, Sunderland.

The entire series of species of *Bellinurus* vary little in their general characters. They are all of small size and possessed a long caudal spine and rather marked triangular thoracetrone.

The specific characters of the Durham specimen are the obviously shorter and outwardly directed cheek-spines, and the broader and more parallel-sided axis of the thoracetrone, which is proportionately larger than in the other species of this genus.

I dedicate this species, which is the first that has been discovered in this great coal-field, to Mr. C. T. Trechmann, whose admirable contributions to the palæontology of New Zealand have already appeared in the pages of the GEOLOGICAL MAGAZINE and elsewhere.

IV.—ON THE OCCURRENCE OF "COAL-BALLS" NEAR AMBERGATE, DERBYSHIRE.

By W. D. VARNEY, B.Sc., University College, Nottingham.

IN the brick-pit cut into the Lower Coal-measures at Bullbridge, near Ambergate, the Alton Coal is exposed, immediately overlain by a marine shale roof, containing large nodules (bullions) and marine fossils.

¹ See GEOL. MAG., Pl. I, Fig. 1, and Mon. Pal. Soc., 1878, pt. v, *Xiphosura*, pp. 233-5, woodcut, and pl. xxxi, fig. 8.

This succession is similar to that occurring at Shore and other well-known localities in Lancashire, where the Bullion or Upper-Foot Mine contains numerous "coal-balls".

No such concretions have been found and recorded from Derbyshire, but the Alton Coal in the above-named exposure was found to contain large nodules of iron pyrites. Some of these have centres composed of calcite or calcareous material, suggesting that these nodules were originally wholly calcareous.

One of these specimens, on being sectioned, was found to have a centre of calcite containing a Stigmarian rootlet, with the xylem (*a*) fairly well preserved surrounded by the cortex (*b*), which, though in a poor state of preservation, is still quite recognizable. Other parts of the section contained plant tissue badly preserved, and partly obscured by pyrites. Pyritization seems to have taken place along lines of tissue running through the calcite groundmass as seen at (*d*) and (*e*) in the diagram and in other parts of the slide.

Section of nodule showing plant-tissues (somewhat diagrammatic). *a*, xylem of Stigmarian rootlet; *b*, cortex; *c*, *d*, other tissue, partly hidden by pyrites (*e*).

At Bullbridge the Alton Coal is streaked with pyrites, which fills cracks and joints, and the thin veins often join on to the nodules of the same material. Hence the pyrites was deposited after the formation of the seam and its nodules. This fact, and the features of the nodule section described, show that the pyrites is secondary, and that the calcite and its petrified plant tissue were deposited before the pyrites, which has replaced the former and largely obliterated the vegetable tissue in so doing. In other words the nodules were true "coal-balls", now partly or wholly replaced by iron pyrites.

Hence the Alton Coal of Derbyshire contains nodules with petrifications, though they are mostly altered to iron pyrites. Thus the seam shows a striking resemblance to the Bullion Seam of Lancashire, as described by Miss Stopes and D. M. S. Watson.¹

¹ "On the Present Distribution and Origin of Coal-balls": *Proc. Roy. Soc.*, vol. cc, p. 173.

A rough analysis of the specimen sectioned showed that it contained, in addition to iron pyrites, calcium and magnesium carbonates and calcium sulphate, the last-named being present in sufficient quantity to form a thick efflorescence when the nodule had been kept for some time. This calcium sulphate is confined to the coal and its marine roof, where it is also abundant,¹ and to these two beds only, so that its occurrence seems intimately connected with the latter bed.

A new locality, therefore, can be cited for the occurrence of "coal-balls" or their equivalents, namely, the Alton Coal of Derbyshire, particularly near Ambergate, under conditions which help to confirm the theories enunciated by Professor Stopes and D. M. S. Watson,² namely, that in whatever coal tissue-bearing nodules occur, that coal is overlain by a roof of marine origin, and that the formation of these nodules was contemporaneous with that of the surrounding coal.

REVIEWS.

I.—SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN FOR 1917. 55 pp. London, 1918. Price 2s.

IT is a noteworthy sign of the times that this summary of the year's work of the Geological Survey deals almost exclusively with matters of practical and economic interest. The depleted staff has given evidence of great activity, and an immense amount of useful information has been collected, with the assistance of certain specialists who were temporarily attached to the Survey. The most important work carried out was an investigation into the reserves of iron-ore still existing in Great Britain. Every possible iron-field seems to have been very thoroughly examined, and it is estimated that the grand total of ores of all kinds amounts to no less than 11,311,000,000 tons. However, much of this is of very low grade and unlikely to be worked for some time to come.

The subject of refractories has also engaged much attention and a comprehensive memoir on the subject is in course of publication. The increased demand for tungsten ores has brought about important developments in Cornwall and Devon and new lodes have been reported on. A special examination was also made of Scottish pegmatite dykes as possible sources of potash felspar for pottery, enamel, and other purposes. A magnetic survey of certain parts of England was undertaken with the object of ascertaining whether certain observed disturbances of the magnetic needle were due to concealed masses of iron-ore; a report on the subject is in preparation. The proposal to construct a ship-canal across Scotland has necessitated investigation of the depth of drift and other superficial deposits along the proposed lines, with interesting results. Good progress has also been made with the publication of memoirs on the Scottish coal-fields.

¹ R. D. Vernon, *GEOL. MAG.*, 1909, p. 289.

² *Ibid.*, p. 181.