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FISH-REMAINS FROM THE UPPER OLD RED  
SANDSTONE OF GRANITE HARBOUR,  
ANTARCTICA.

BY

ARTHUR SMITH WOODWARD, LL.D., F.R.S.

WITH ONE PLATE.



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# FISH-REMAINS FROM THE UPPER OLD RED SANDSTONE OF GRANITE HARBOUR, ANTARCTICA.

By ARTHUR SMITH WOODWARD, LL.D., F.R.S.

WITH ONE PLATE.

THE fish-remains discovered by Mr. Frank Debenham in the "Beacon Sandstone" of Granite Harbour, are merely dermal plates and scales. They are all isolated and scattered, showing that the fishes they represent were disintegrated before burial; but the fragments are beautifully preserved, and in transparent sections their histological structure is perfectly observable. They are very little mineralised, and the cavities, at least in weathered portions, are often empty. The specimens are usually conspicuous as whitish or bluish-grey patches on the grey or blackish rock, though a few are darkly stained.

## SUB-CLASS OSTRACODERMI.

### ORDER ANTIARCHI.

Numerous typical fragments of the dermal armour of Ostracoderms are easily recognisable, and all appear to belong to the Order Antiarchi. Some are not sufficiently characteristic or well-preserved for exact determination, but others may be referred at least to their respective genera without much hesitation.

Seven portions of keeled plates of uncertain outline, besides other fragments, exhibit the peculiar structure of Antiarchan armour—an outer dense tuberculated layer, a middle thick layer of cancellæ, and an inner thin layer of parallel laminae. One of these specimens, P. 12535\* (Fig. 1), which has lost much of its tissue both externally and internally, shows a thickening in the middle of the cancellated layer in the hollow of the keel and an arrangement of the cancellæ in roughly transverse lines, evidently to strengthen the plate at the bend. When viewed in cross-section (Fig. 1A) the cancellæ appear to be very variable and irregular in size, and as seen under the microscope the walls between

\* The numbers refer to the Register Pisces of the Department of Geology.

them are comparatively thin, consisting of a few delicate parallel laminae. In another specimen (P. 12536) the walls between the cancellae are relatively thicker, and there are traces of bone-cells between the laminae. In a third specimen (P. 12537) embedded in hard rock, the cavities are infiltrated with calcite and the bone is too darkly stained to be clear, but all the layers of the shield are distinctly recognisable (Fig. 2) in their characteristic arrangement. Below the thin dense outer layer, which rises at intervals into rounded tubercles, there is a zone of small cancellae with relatively thick walls; below this is a zone of larger cancellae with delicate walls; and finally there is a thin inner or basement layer of parallel laminae. Traces of bone-cells are seen between the laminae of the plate throughout. A similar arrangement of the successive layers of the shield is also well shown in the broken section of another fragmentary specimen (P. 12538).

*Bothriolepis antarctica*, sp. nov. Figs. 3-9.

The structure of the two Ostracoderm plates last described agrees most closely with that of *Bothriolepis*,\* and several fragments in the collection may certainly be referred to this genus.† They include both parts of the head and trunk and plates of the appendages.

A right *lateral occipital plate* (P. 12543) is nearly complete, and shown of twice the natural size in Fig. 3. The greater part of the corresponding plate of the opposite side is also preserved on another piece of rock (P. 12544). It is a little wider than long, the maximum width being about 11 mm., while its maximum length is 9.5 mm.; and its anterior margin is angulated somewhat nearer to the external than to the internal margin. Its outer face is completely covered with an ornament of coarse rounded tubercles, which are united into a network by lower rounded ridges; and the stronger of these ridges tend to form transverse lines on the antero-external part of the plate. A groove for a slime-canal (*l*), close to and nearly parallel with the external margin, is seen in the slightly broken postero-external part. As this groove does not run into a transverse groove, or commissure, but merely passes out at the posterior margin, the arrangement corresponds with that of *Bothriolepis* and differs from that observed both in *Asterolepis* and *Pterichthys*.

An impression of the outer face of a left *anterior ventro-lateral plate* of the trunk (Fig. 4) is only imperfect near the median border and just above the articulation for the appendage (P. 12545). Its maximum length is 18 mm., the maximum width of the horizontal lamina is 8 mm., and the maximum depth of the ascending lamina is 4 mm. The plate is shown to have been completely covered with reticulated ridges, producing a coarse ornament of pits, which only exhibit a tendency to arrangement in lines close to and concentric with the anterior margin. The low lateral ascending lamina is inclined

\* For the most exhaustive account of *Bothriolepis*, see R. H. Traquair, "Fishes Old Red Sandst. Britain" (Pal. Soc. 1904, 1906), pp. 107-131, with plates.

† E. S. Goodrich, in Lankester's "Treatise on Zoology," Part IX (1909), p. 206, fig. 180.

outwards, making an angle greater than a right-angle with the horizontal lamina; and its upper border bears the mark of the narrow overlap of the anterior dorso-lateral plate. The articulation for the appendage, seen in cross-section (*ar*), is within the anterior third of the plate. The anterior margin of the horizontal lamina has a forwardly convex curvature, and the antero-median angle of the plate is sharply truncated where it adjoins the *semilunar*. The upper margin of the ascending lamina curves downwards to meet the posterior margin of the horizontal lamina in an obtuse angle.

The outward inclination of the ascending lamina of the plate just described, and the inferred shape of the *semilunar*, are distinctive characters of *Bothriolepis*; while the external ornament is that usual in this genus.

Remains of the articular portion of a larger right *anterior ventro-lateral plate* (P. 12546) also show a characteristic feature of *Bothriolepis*. The specimen (Fig. 5) is so much fractured that it is not easily interpreted, but by direct comparison with the front half of a right anterior ventro-lateral plate of *Bothriolepis major* in the British Museum (No. P. 8282a) the parts can be recognised. The wide rounded groove (*g*) to accommodate the dorsal articular plate of the appendage, is overhung by a mass of cancellated tissue (*t*) in which the rather large chambers are elongated and arranged in lines at right-angles to the articular face. This mass is exposed in a transverse section, which also cuts across the inner continuation of the canal (*c*) penetrating the articular prominence. Round, below, and internal to the canal, the tissue becomes very finely cancellous, and some of it is darkly stained in the fossil. So far as preserved, the coarsely cancellated mass of tissue above the articulation is exactly similar to that of *Bothriolepis*, while differing from the denser and smaller mass in *Pterichthys* and *Asterolepis*.

A left *posterior ventro-lateral plate* (P. 12547), with a maximum width of 21 mm. and a total length of not less than 50 mm., is preserved in counterpart and variously fractured to expose the different layers of which it consists (Figs. 6, 6A). Part of the outer face shows the reticulate ridges producing the characteristic coarse pitted ornament. Below this are traces of the layer of polygonal chambers, resting on the very thin layer of fine parallel calcified ridges which run obliquely backwards from the internal or median margin to the external or lateral margin of the plate. Below this again the inner face is formed by the laminated nacreous layer. As in the typical *Bothriolepis*, the ascending lateral lamina is inclined at slightly more than a right-angle to the horizontal lamina. The truncation of the antero-internal angle of the horizontal lamina indicates the presence of a large diamond-shaped *median ventral plate*; but the margins are imperfect.

Part of another left *posterior ventro-lateral plate* (P. 12548) also shows the ascending lateral lamina inclined as in *Bothriolepis*. The broken sections of the specimen exhibit all the characteristic features of Antiarchan armour.

A crushed left *ventral articular plate* of an appendage (P. 12549) is exposed from the inner face and displays the characteristic shape and texture of the proximal end, which measures about 10 mm. across (Fig. 7). This rounded end consists, as usual, of a close series of fine laminae nearly parallel with the long axis of the bone and united by cross-

structures. Below this articular portion the inner margin is sharply notched. The other margins are incomplete.

An impression of the inner face of another articular plate of an appendage, of about the same size, exhibits two strongly marked ridges, one extending transversely below the rounded head, the other passing downwards from this along the vertical median line. This specimen (P. 12550) may represent the *dorsal articular plate*, but the determination is uncertain.

The distal portion of a left *ventral anconeal plate* of an appendage (P. 12551) is shown from within in direct articulation with the adjoining part of the *external marginal* (Fig. 8). An impression of the outer face of the anconeal plate (*a*) proximal to the piece preserved, proves that it was ornamented externally by coarse longitudinal ridges, with a few irregular cross-ridges, producing a reticulated ornament. The large rounded distal end, which formed the movable articulation for the terminal segment of the appendage, consists of fine parallel plates or fibres which run obliquely backwards and outwards. It measures 6 mm. in extreme width. The external marginal (*m*) is fringed along the outer border with a row of large tubercles, which are apparently uniform in size and spacing. Its width at the distal end is 3.5 mm. The external ornament appears sufficient to justify the reference of this specimen to *Bothriolepis*.

A *proximal external marginal* of the distal segment of an appendage (P. 12552) lacks only its distal end (Fig. 9). Its maximum width at the proximal end is 5.5 mm., and its total length would be about 17 mm. At the obliquely truncated proximal end of the plate the finely cancellated tissue of the overlapped portion is preserved, but the other portion is shown only in impression. The outer face is clearly marked by a few irregular longitudinal ridges, while the externo-lateral border bears a row of large blunt tubercles. The ridged ornament is characteristic of *Bothriolepis*, the corresponding part in *Pterichthys* and *Asterolepis* being tuberculated.

The plates of *Bothriolepis* thus described obviously belong to specimens of various sizes. The anterior ventro-lateral plate (Fig. 4), for example, is too small to belong to the same individual as the posterior ventro-lateral plate (Fig. 6). There is, however, no reason why they should not all belong to one species, and they may be provisionally so regarded. The shape of the lateral occipital plate (Fig. 3), with its sharply angulated anterior margin, is a little different from that in the head of any species of *Bothriolepis* hitherto known. It therefore probably represents a new species, which may be named *B. antarctica*.

*Byssacanthoides debenhamsi*, gen. et sp. nov. Figs. 10, 11.

Some fragments of a ribbed spine exhibit much superficial resemblance to *Onchus*, but are readily distinguished by their microscopical structure. They are, indeed, most nearly similar to the spine on the posterior dorsal plate of the Antiarchan Ostracoderm, *Byssacanthus*.\*

\* A. S. Woodward, Ann. Mag. Nat. Hist. [6], Vol. XV (1895), p. 142, with text-fig.

The largest specimen (P. 12553), which is sharply broken at each end, measures 1 cm. in length and maintains an approximately uniform diameter of 2 mm. It is round in cross-section, and the irregular longitudinal fracture of the specimen exposes a large internal cavity filled with matrix (Fig. 10). The outer face is marked with fine, smooth, straight, longitudinal ribs, which are closely arranged and parallel, rarely intercalated.

The superficial longitudinal ribs appear to be the outer edges of thin wedge-shaped radiating plates of which the tissue of the spine is composed. These are still better seen in another fragment (P. 12555), which is weathered; and their structure is perfectly preserved in a third specimen (P. 12554), which is sufficiently hard to be studied in microscopical section (Fig. 11).

The outer layer of the spine (*o*), when viewed in transverse section, is seen to be denser than the rest of the tissue, but it appears to be partly removed in the specimen figured. It contains irregular vascular spaces, and the tissue itself is traversed by a network of extremely fine irregular tubules, occasionally expanded into spaces which may have been occupied by bone-cells. The zone of wedge-shaped plates (*w*) is sharply marked off from this outer layer, and forms the greater part of the thickness of the side of the spine, but is much reduced in the anterior middle portion. Each wedge is separated from its fellow by extensive but irregular vascular spaces, and its tissue in transverse section is seen to be not only traversed by the network of very fine tubules already noted in the outer layer, but is also marked by a few dark transverse bands which are nearly parallel with the outer face. The zone of wedge-shaped plates is also sharply marked off by a dark line from the inner layer (*i*), which is thickest in the middle part of the spine and is traversed by very large and irregular vascular spaces, which are seen to communicate with the pulp-cavity (*p*). The tissue of this layer again is traversed by a network of extremely fine tubuli, and each wall between the vascular spaces is darkest or densest in its middle portion.

In the fragment from which the microscope-section has been prepared, the pulp-cavity is widely open behind, and the spine does not appear to have been bilaterally symmetrical. It is therefore presumably from the base of a spine which differs considerably from that of *Byssacanthus*, where the lower end is completely closed. In transverse section, however, the new specimen agrees remarkably well with the spine of *Byssacanthus* in the appearance of the three layers of which it is composed; and it differs completely from that of *Ouchus*, in which there are no wedge-shaped plates, while the inner layer is dense and to some extent finely laminated.\* *Ouchus*, it may be added, is also typically Elasmobranch in exhibiting no trace of bone-cells. The spine which is so imperfectly known, therefore, probably represents a new Antiarchan genus, *Byssacanthoides*, and the species may be named *debenhami*, in honour of its discoverer.

\* J. V. Rohon, Mém. Acad. Imp. Sci. St. Pétersb. [7], Vol. XLI, No. 5 (1893), p. 42, fig. 9.

## SUB-CLASS ELASMOBRANCHII.

## ORDER ACANTHODII.

*Cheiracanthus*, sp. Fig. 12.

Two isolated scales are evidently Acanthodian, and so closely similar to those of the typical *Cheiracanthus murchisoni* from the Middle Old Red Sandstone of Scotland, that they may be provisionally referred to the same genus. The best-preserved specimen (P. 12576) is shown to be square and slightly more than a millimetre in diameter (Fig. 12). Its outer face is shiny, and a close series of fine, regular, nearly parallel grooves extends diagonally across two-thirds of this face from the two posteriorly directed borders, which are distinctly bevelled, but not crimped or serrated. The second specimen, though more imperfect, is evidently similar.

Acanthodian scales\* are also recognisable in microscope-slides of the rock, and a characteristic specimen in transverse section (P. 12559) is shown in Fig. 13. The outer face of this scale is flat, and one end is produced considerably beyond the supporting base. The deep exerted portion exhibits well its concentric laminated structure, traversed in places by a few irregular branching canaliculi. The shape of the comparatively small rounded base, which was originally inserted in the skin, is also distinct; but its structure is obscured by a dense stain of mineral matter. As usual, there is no pulp-cavity.

## ORDER SELACHII (?).

*Dermal tubercles*. Figs. 14-22.

Minute fragments of dermal armour are scattered abundantly through various specimens of the rock, but most of them are shown only in broken section and so cannot easily be identified. Some are evidently fragments of dermal plates or scales, but the majority seem to be shagreen-granules referable either to primitive Ostracoderms or to Elasmobranchs.

Some granules of various shapes exhibit a relatively large pulp-cavity. The broken transverse section of an oval specimen (Fig. 14) bears a trace of three prominences or flutings on one side (P. 12589). A similar section of a smaller rhombic specimen (Fig. 15) exhibits a fluting or sinuosity on two contiguous sides (P. 12561). Another specimen appears in transverse section (Fig. 16) as an irregular elongated rhomb (P. 12590). A fourth specimen, apparently in vertical section (Fig. 17), rises to an acute apex, which is nearer to one margin than to the other (P. 12563). Another specimen which seems to be similarly displayed (Fig. 18) is low and flattened.

The majority of the shagreen-granules are solid, and in section exhibit only a slight trace of the obliterated pulp-cavity. Several occurring in a group on one piece of rock

\* See O. M. Reis, "Ueber *Acanthodes Bronni* Agassiz," Schwalbe's *Morphol. Arbeiten*, Vol. VI (1896), p. 184, Pl. VII, fig. 2; also E. S. Goodrich, in Lankester's "Treatise on Zoology," Part IX (1909), p. 188, fig. 157.

(P. 12561) are shown enlarged in Fig. 19. Though irregular in shape, most of them approach a quadrangular form with variously indented sides. The last trace of the pulp-cavity is sometimes observable, sometimes it is marked by a slight stain.

In the same group is the only specimen which appears to exhibit the external face. It is smooth and crossed by two shallow parallel grooves which divide it into a large median lobe and two comparatively small lateral lobes (Fig. 20). This suggests a compound granule, such as occurs in the Upper Devonian *Cladoselache*\* and in many of the early Selachians.

It is difficult to prepare sections of these fossils, but in one microscope-slide (P. 12562) there are two granules evidently produced by the fusion of cusps. The best of these (Fig. 21) shows a small expanded base surmounted by two cusps, which are fused together for some distance, and then diverge in two planes at the apex so that the section is incomplete. A third and smaller cusp, doubtless fixed to the same base, is seen at one side. The microscopic structure is typically Elasmobranch, each large cusp showing a trace of an original pulp-cavity from which fine calcigerous tubes radiate to the periphery, while coarser tubes diverge into the upper part of the base, and the lower part of the base exhibits only a concentric structure. The second specimen (Fig. 22) seems to be cut in more oblique section, so that the expanded base is relatively large and the four constituent cusps are less well separated. The structure is again seen to be typically Elasmobranch, but that of the base is somewhat obscured by a dark mineral stain.

SUB-CLASS DIPNOI.  
ORDER ARTHRODIRA.

*Undetermined Coccostean.* Figs. 23, 24.

Remains of Coccostean dermal plates occur, but all are too fragmentary for generic determination. The largest specimen (P. 12563) is shown, slightly enlarged, in Fig. 23, with part of the ornament further enlarged in Fig. 23A. It is a thin flat plate embedded in hard dark shale, but its shape is uncertain, only part of one margin being clearly distinguishable. This margin seems to have been thickened throughout its extent by a broad rounded ridge, of which a fragment remains at its convex bend (*r*). The outer face of the plate is closely ornamented with stellate tubercles, which are nearly uniform in size but somewhat variable in shape, though all tending to be bluntly pointed. They are continued over the rounded marginal ridge, where their broken transverse sections exhibit a very small pulp-cavity.

A second fragment in black shale (P. 12564) is of a bent or ridged plate, also closely and coarsely ornamented with stellate tubercles (Fig. 24). It is exposed from within,

\* B. Dean, Mem. Amer. Mus. Nat. Hist., Vol. IX (1909), p. 214, figs. 1-3.

and so broken as to display the main trabeculae of the middle layer of the plate extending at right-angles across the angulation.

A smaller plate (P. 12565) in the grey sandstone, also ornamented with large bluntly-pointed tubercles, has a gently convex outer border and an obtusely angulated inner border, suggestive of one of the paired ventral plates of the trunk. Where the outer surface is broken away, the fine longitudinal trabeculae of the inner tissue are exposed.

Another fragmentary mass of coarsely fibrous tissue (P. 12566) in the grey sandstone, is also almost certainly Coccocean, and indicates a thicker plate than the specimens previously described.

#### SUB-CLASS TELEOSTOMI.

#### ORDER CROSSOPTERYGII.

*Holoptychius antarcticus*, sp. nov. Figs. 25, 26.

A small Holoptychian fish is represented by a few imperfect scales, which exhibit their characteristic microscopical structure. The best specimen (P. 12573) is shown of twice the natural size in Fig. 25. This scale is much longer than deep, ovoid in shape, and gently concave on its inner or attached face. It is widest in its overlapped portion, which is much larger than the exposed portion, and the division between these two portions is marked by a slight notch in one margin. The tissue when broken as in the fossil displays the concentric lines of growth; and the dense inner layer, of which merely a fragment remains at the anterior end of the specimen, has a smooth face marked only with a few fine vascular perforations. The outer layer of the scale, of which the greater part is preserved, is highly vascular, and at the anterior margin it shows its delicate radiating trabeculae. Most of the hinder exposed portion of the scale is exhibited as an impression on the rock, indicating an ornament of numerous small rounded ridges directed mainly antero-posteriorly but partly reticulated near the lateral margin.

One good transverse section of a scale (P. 12574) has been made to show its microscopical structure (Fig. 26). The highly vascular outer layer is about as thick as the dense inner layer, and its chambers are very irregular in size and shape, though all rounded in section. The inner layer is laminated as usual, with nearly straight canaliculi crossing the laminae, those of each lamina approximately parallel, but meeting at an angle the corresponding canaliculi of the lamina above and below—a feature specially characteristic of the Holoptychian scale.\* Near one edge of the transverse section the inner layer is thickened into a low boss, which seems to have been formed round the canal of the lateral line.

On the same piece of rock as the scale shown in Fig. 25, there is a small fragment

\* M. Lohest, Ann. Soc. Géol. Belg., Vol. XV (1888), Mém., p. 128, Pl. II, fig. 4; J. V. Rohon, Bull. Acad. Imp. Sci. St. Pétersb., n.s., Vol. II (1890), p. 1, pl. I.

of bone marked with a delicate reticulate ornament suggesting that of the clavicle of *Holoptychius*.

The form of scale now described differs considerably from any Holoptychian scale hitherto known, and may be named *Holoptychius antarcticus*. In its shape and the extent of its overlapped portion, it agrees best with the scales of the species commonly referred to *Glyptolepis*; but its exposed portion is more coarsely ornamented than in any of these species, and the tissue of the scale is apparently thicker.

*Osteolepid*. Figs. 27-29.

Some typically *Osteolepid* scales, showing their microscopical structure,\* are not generically determinable, and an imperfect operculum or cheek-plate, evidently of the same fish, is equally unsatisfactory. The smooth, shining outer surface of these fossils is very finely and regularly punctate, as in the Middle Devonian *Osteolepis*, *Diplopterus*, and *Thursius*; but most of the scales are larger than those of the known species of these genera, and are at least equal in size to those of the Lower Carboniferous *Megalichthys laticeps*.

Two of the largest scales (P. 12576) in the hard black shale from Granite Harbour belong to the lateral line, and are shown enlarged in Figs. 27, 28. In both, the margin of the anterior overlapped portion is preserved, displaying the acute antero-superior angle, the convex edge of the upper overlapped margin, and the rounding of the antero-inferior angle, giving the complete scale an irregularly ovoid shape. By the splitting of the rock the greater part of each scale shows only the middle layer of its tissue, which is traversed in part by the canal for the lateral line obliquely inclined downwards and backwards; but there are distinct traces of the rhombic exposed area, smooth and finely punctate. Another broken scale on the same slab shows that the wide overlapped portion is smooth and not impressed by any groove parallel with the edge of the exposed area. An isolated part of a scale (P. 12579) seems to confirm this observation. The quadrangular shape of the exposed area is well seen in a smaller specimen (P. 12581) in grey sandstone represented in Fig. 29. The margins are very slightly and irregularly sinuous.

A transverse section of a scale (P. 12583) under the microscope shows the vermiculating chambers in the highly vascular middle layer; the wedge-shaped pieces traversed by radiating canaliculi forming an upper layer, capped by a thin zone of translucent ganodentine; and the dense basement-layer with very few vascular canals.

The *Osteolepid* operculum or cheek-plate (P. 12588) is longer than deep, with its upper portion gently curved inwards. It is much broken, but there are remains of all three layers of its tissue, including the finely punctate shining surface.

\* C. H. Pander, "Die Saurodipterinen, etc., Devon, Syst." (1860), p. 19, Pl. V, fig. 8; E. S. Goodrich, in Lankester's "Treatise on Zoology," Part IX (1909), p. 217, fig. 190.

## ORDER ACTINOPTERYGII.

*Palaeoniscid.* Figs. 30-34.

A few very small Palaeoniscid scales, scattered among the other fish-remains, closely resemble scales from the Upper Devonian of North America, which have been referred provisionally to *Rhadinichthys*.<sup>\*</sup> They are all wider than deep and only slightly ornamented with oblique lines of pittings which sometimes pass into grooves at the margin. All except one (P. 12570) are without the peg-and-socket articulation, and so are probably ventral, dorsal, or caudal scales.

One scale (P. 12589), twice as wide as deep, is produced a little upwards at its antero-superior angle, and seems to show four irregular and unequal serrations at its hinder border (Fig. 30). The pittings on its smooth outer face are few and inconspicuous. A deeper rhombic scale (P. 12563), which also seems to be serrated, has a few superficial pittings tending to fuse into grooves, and apparently a very fine oblique striation of the anterior margin (Fig. 31). An elongated irregularly pentagonal scale (P. 12576), which tapers behind, is ornamented with a few rows of pittings (Fig. 32). Portions of other scales with a similar ornament occur near it.

One imperfect ridge-scale of the tail (P. 12590) is comparatively large, but is marked only by a few minute pittings, and doubtless belongs to the same type of fish (Fig. 33). The two rami of the scale are fused at their pointed upper end, where a row of pits alone divides them.

A fragment of ornamented bone (P. 12591) may also perhaps be the dentary of the same Palaeoniscid fish (Fig. 34). At its presumed lower margin there is a narrow smooth area, but above this the whole outer face of the bone is covered with thick ridges of enamel which are nearly parallel, though sometimes branching, and are inclined downwards and backwards from the presumed tooth-bearing border. A dentary thus ornamented is already known in *Rhadinichthys*,<sup>†</sup> and a nearly similar bone has been found with the remains of the so-called *Rhadinichthys devonicus*.<sup>‡</sup>

Although the fish-remains now described are so fragmentary that few of them can be definitely named, they are sufficient to prove that the formation in which they were found is of Upper Devonian age. *Bothriolepis* is a common Upper Devonian fossil both in Europe and North America. The Asterolepids with spines and crests seem to have arisen in the Middle Devonian, but *Byssacanthus* is typically Upper Devonian, and *Byssacanthoides* is evidently related to it. The fluted Acanthodian scales from Antarctica provisionally referred to *Cheiracanthus*, may belong to any part of the Devonian series,

<sup>\*</sup> *Rhadinichthys devonicus*, L. Hussakof and W. L. Bryant, Bull. Buffalo Soc. Nat. Sci., Vol. XII (1918), p. 182, Pls. LIX-LXII, Pl. LXIII, figs. 1, 2, Pl. LXV and text-figs. 60, 61.

<sup>†</sup> R. H. Traquair, "Ganoid Fishes Brit. Carb. Form.—Palaeoniscidæ" (Mon. Pal. Soc., 1909), Pl. XXX, figs. 8, 13.

<sup>‡</sup> L. Hussakof and W. L. Bryant, *loc. cit.*, 1918, Pl. LXV, fig. 3.

and so are not distinctive; but the Selachian dermal tubercles are most closely similar to those of *Cladoselache* from the Upper Devonian (Cleveland Shale) of Ohio, U.S.A. The fragments of a CoccoSTEAN and the scales of *Holoptychius* may be either Middle or Upper Devonian, but some of the Osteolepid scales are rather large for a Middle Devonian species and are probably of later date. The Palæoniscid scales, as already remarked, closely resemble some from the Upper Devonian of North America. These are the earliest known remains of Palæoniscidæ, though their wide geographical distribution (in North America and Shetland as well as in Antarctica) suggests that still earlier forms will yet be discovered.

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Fish-Remains from the Upper Old Red  
Sandstone of Granite Harbour, Antarctica.

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- FIG. 3.—*Bothriolepis antarctica*, sp. nov.; right lateral occipital, outer face, enlarged twice. *l.* slime-groove. (P. 12543.)
- FIG. 4.—Ditto; left anterior ventro-lateral plate, outer face, enlarged twice. *ar.* articulation for appendage in cross-section. (P. 12545.)
- FIG. 5.—Ditto; broken section of articulation for appendage, enlarged three times. *c.* canal in articular prominence; *g.* groove for dorsal articular plate of appendage; *t.* cancellated tissue above articulation. (P. 12546.)
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- FIG. 7.—Ditto; left ventral articular plate of appendage, imperfect inner face, enlarged twice. (P. 12549.)
- FIG. 8.—Ditto; portions of left ventral anconeal (*a*) and external marginal (*m*) plates of appendage, inner face, enlarged three times. (P. 12551.)
- FIG. 9.—Ditto; proximal external marginal of distal segment of appendage, showing ornament, enlarged three times. (P. 12552.)
- FIG. 10.—*Byssacanthoides debenhani*, gen. & sp. nov.; portion of broken spine, outer view, enlarged three times. (P. 12553.)
- FIG. 11.—Ditto; outer view of portion of spine, enlarged nine times, and transverse section of spine, same enlargement. *i.* inner layer; *o.* outer layer; *p.* pulp-cavity; *w.* layer of wedge-shaped plates. (P. 12554.)
- FIG. 12.—*Cheiracanthus*, sp.; scale, enlarged twelve times. (P. 12576.)
- FIG. 13.—Microscope-section of Acanthodian scale, enlarged thirty times. (P. 12559.)
- FIG. 14.—Section of ovoid Selachian dermal tubercle, enlarged six times. (P. 12589.)
- FIG. 15.— " " rhomboid " " " " fourteen times. (P. 12561.)
- FIG. 16.— " " " " " " " " twelve times. (P. 12590.)
- FIG. 17.—Vertical section of Selachian " " " " fifteen times. (P. 12563.)
- FIG. 18.— " " " " " " " " fifteen times. (P. 12561.)
- FIG. 19.—Group of Selachian dermal tubercles, chiefly in horizontal section, enlarged six times. (P. 12561.)
- FIG. 20.—Outer view of Selachian dermal tubercle, enlarged fifteen times. (P. 12561.)
- FIG. 21.—Microscope-section of Selachian dermal tubercle, enlarged fourteen times. (P. 12562.)
- FIG. 22.—Ditto. (P. 12562.)
- FIG. 23.—Coccostean plate, outer face, enlarged one-and-a-half times, with (23A) ornament enlarged four times. *r.* thickened margin. (P. 12563.)
- FIG. 24.—Portion of bend of Coccostean plate, inner view, enlarged three times. (P. 12564.)
- FIG. 25.—*Holoptychius antarcticus*, sp. nov.; scale, enlarged twice. (P. 12573.)
- FIG. 26.—Ditto; microscope-section of scale, enlarged six times. (P. 12574.)
- FIG. 27.—Osteolepid scale, enlarged twice. (P. 12576.)
- FIG. 28.—Ditto. (P. 12576.)
- FIG. 29.—Ditto, exposed face, enlarged twice. (P. 12581.)
- FIG. 30.—Palæoniscid scale, exposed face, enlarged eight times. (P. 12589.)
- FIG. 31.— " " " " " " " " fourteen times. (P. 12563.)
- FIG. 32.— " " " " " " " " eight times. (P. 12576.)
- FIG. 33.— " caudal ridge-scale, " " four times. (P. 12590.)
- FIG. 34.— " dentary, outer face, " " three times. (P. 12591.)

