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UNIVERSITY OF MICHIGAN

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ARTHRODIRAN REMAINS FROM THE DEVONIAN OF MICHIGAN

BY
E. C. CASE

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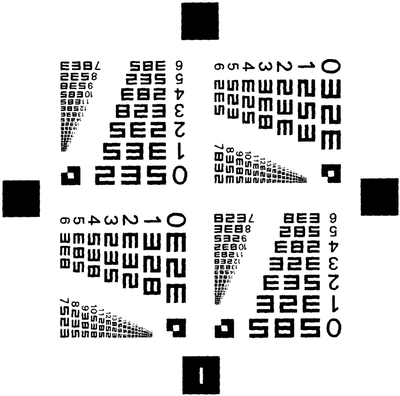

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CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

(*Continuation of Contributions from the Museum of Geology*)

UNIVERSITY OF MICHIGAN

Editor: EUGENE S. MCCARTNEY

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(*Continued on inside of back cover*)

VOL. III, No. 9, pp. 163–182 (5 pls., 13 text figs.) DECEMBER 18, 1931

ARTHRODIRAN REMAINS FROM THE DEVONIAN OF MICHIGAN

By E. C. CASE

THE quarry of the Kelly Island Limestone Company at Rockport in Alpena County, Michigan, has yielded fragmentary remains of Arthrodires for some years, but nothing that could be identified or described has previously been recovered. During the summer of 1930 Professor G. M. Ehlers and Mr. Charles Campbell made a small collection from a recently opened face in the quarry which was more than usually rich in fish remains. The specimens were of such interest that Professors Case, Ehlers and Hussey made a subsequent trip to the quarry, which resulted in the recovery of more material.

A party from the Geological Survey of Michigan made a section in this quarry in 1926. At a later date Case added to this section an upper bed revealed by an extension of the quarry face.

As now known the section is as follows:

	Feet
ZONE 6	
Layer 3. Yellow weathered limestone	2
Layer 2. Bluish white, plastic clay, when present; frequently absent. No fossils	2
Layer 1. Blue clay, fossiliferous. Shading into the yellow weathered limestone above. Sometimes separated from it by the layer of blue, plastic clay	8
ZONE 5. Limestone, gray, lithographic. Base becomes dark gray at contact with the black limestone	10
ZONE 4. Limestone, black, with many corals and stromatoporoids. Fish plates	10
ZONE 3. Black shale with many heads of *Acervularia*	1
ZONE 2. Limestone, black; similar to that of Zone 4 above	12
ZONE 1. Bell shale. Exposed	5

The limestone above the Bell shale is designated by the Geological Survey of Michigan as the Rockport limestone of the Long Lake

formation in the Traverse series of the Devonian. The fish remains occur in the black limestone of Zone 4 and in certain shaly and light-colored limestone phases of the same zone. The dark color is due to the infiltration of bituminous material and the stone will sometimes burn with a dark, smoky flame in the heat of a blast lamp. The bones are deep black in the rock, but weather to a light blue, having the characteristic appearance of the mineral vivianite into which they have been converted.

The most perfectly preserved Arthrodire remains are those of a small form approaching so closely one from the Columbus limestone near Delaware, Ohio, described by Eastman [1] as *Protitanichthys*, that it is placed in the same genus, but considered a new species, *Protitanichthys rockportensis*, with specimen number 12980 U.M., consisting of the complete impression of the cephalic shield and some portions of the shield itself, as the holotype, and specimen numbers 12976 U.M., 12978 U.M. and 12979 U.M., used in interpreting the holotype, as paratypes.

The specimen described by Clarke [2] as *Coccosteus (?) halmodeus* and regarded by Eastman and Hussakof as a *Dinichthys* is so similar to the specimens from Ohio and Michigan that it seems to the author of this paper that it should be included in the same genus. Both the New York and the Ohio specimens are from the Marcellus horizon in the Devonian.

Eastman notes three points in which his *Protitanicthys* differs from *Dinichthys* and approaches *Coccosteus:* "First of all, there is to be noted the small size, correlated with the finely tuberculate ornament of the external surface; secondly, the sinuous suture line between the pair of central plates; and thirdly, the exclusion of the pineal from contact with the latter pair." Eastman continues: "The form of the head shield, too, although this can be determined only approximately, appears to have been long and narrow, without much lateral expansion at the posterior border. One striking peculiarity, however, distinguishes it from the species

[1] Eastman, Charles R., *Devonian Fishes of the New York Formations, Memoir 10, New York State Museum*, pp. 144–149, pl. 10, fig. 30, 1907.

[2] Clarke, J. M., "New and Rare Species of Fossils from the Horizons of the Livonia Shaft," *Thirteenth Annual Report of the State Geologist (N.Y.) for 1893*, pp. 161–168, pl. 1 and figures, 1894.

of *Coccosteus* and *Dinichthys*, and points to the ancestral relationships with *Titanichthys*, in recognition of which we have given it the generic name. *** We refer to the large size and transverse elongation of the pineal plate, which, according to our view, indicates initial modification along the line of descent culminating in *Titanichthys*."

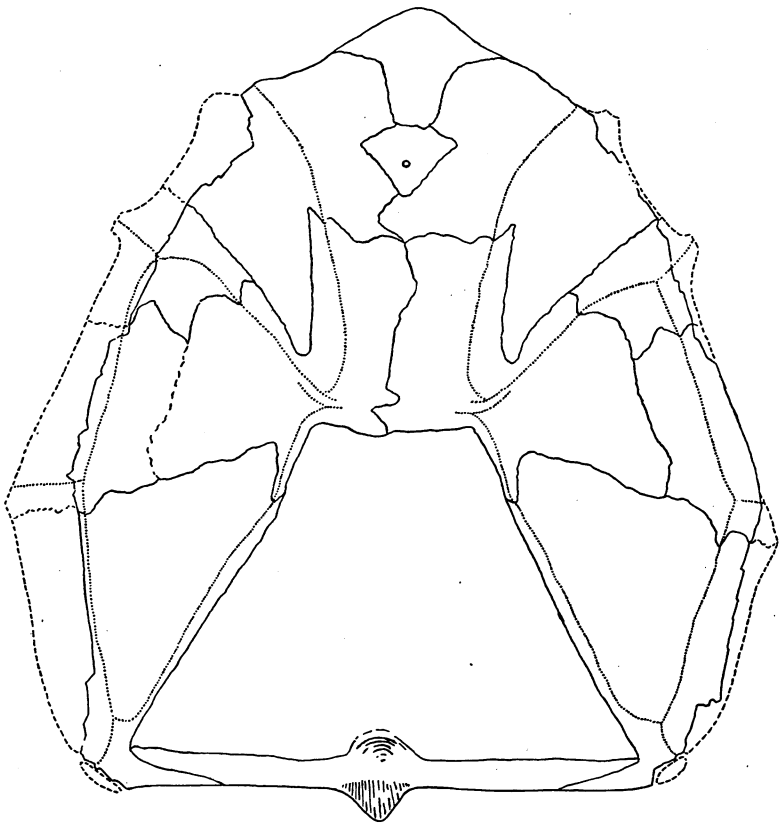

FIG. 1. Cephalic shield of *Protitanichthys rockportensis*. Number 12980 U.M. Restored portions in broken lines; sensory grooves dotted. × ½

Clarke's figure of *halmodeus* does not show the broad pineal plate, but the similarity in the rest of the cephalic shield of his

specimen to those from Ohio and Michigan suggests that there may have been a misinterpretation of the New York specimen in this region.

The description and illustrations of the cephalic shield of *P. rockportensis*, Figure 1, and Plate I, Figure 1, are based on the holotype checked by the paratypes and two less perfect specimens.

As shown in the section of the quarry, Zone 4, in which the

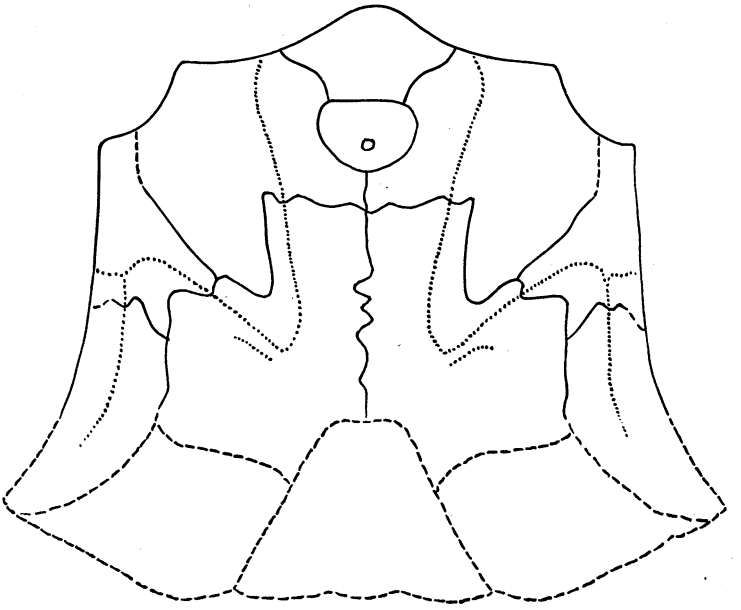

FIG. 2. Restoration of the cephalic shield of *Protitanichthys fossatus* Eastman, from Eastman

Arthrodire remains occur, carries numerous large stromatoporoid and coral heads. The cadavers came to rest upon a very irregular bottom and the cephalic shields and separate bones were somewhat distorted by being pressed down upon and between the resistant heads. This has rendered it necessary to make some readjustment in the drawings of the shield, which is represented as flat instead of convex and irregular. The obvious asymmetry of the two sides has been preserved.

The outline of the cephalic shield is oval. The exact periphery is not preserved in the holotype, but has been restored in broken line from the paratypes. This is not the shape suggested by Eastman for the genotype (see Fig. 2), but it will be noted that the whole posterior portion of his figure is restored and does not recognize the reëntrant posterior portion of the border. His restoration was evidently influenced by Clarke's restoration of *halmodeus* (see Fig. 3.)

The greatest differences between *rockportensis* and the two

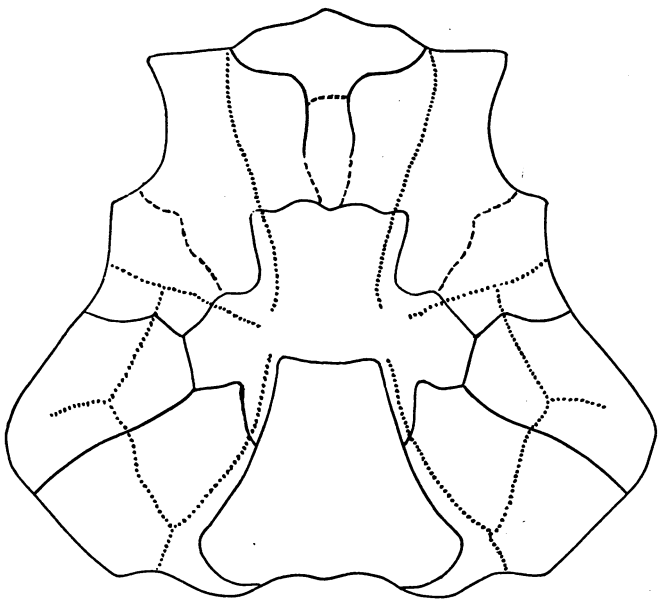

FIG. 3. Restoration of cephalic shield of *Protitanichthys* (*Coccosteus*) *halmodeus* (Clarke), from Clarke

other species, which are the definitive characters of the species, are the larger size of the lateral wings of the central plates, the correlative narrowing of the marginals, and the larger size of the median occipital plate. The latter point is somewhat conjectural in Eastman's *P. fossatus*, as the whole plate is restored in his figure.

A detailed description of the plates is unnecessary; their out-

line and position are shown in Figures 1 and 4. It will be noticed that the outline of the plates does not correspond exactly with that of either of the other described species, but the difference is not greater than that between the outlines in the five specimens of *P. rockportensis.* The course of the sutures is notably irregular

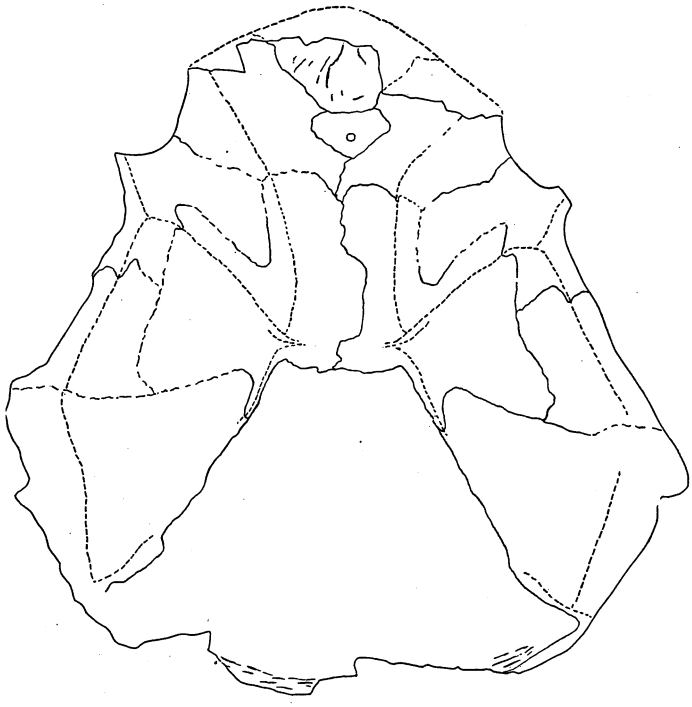

FIG. 4. Restoration of cephalic shield of *Protitanichthys rockportensis.* Number 12976 U.M., paratype. Restored portions shown in broken wavy lines. × ½

and the exact form of the plates was a matter of considerable individual variation. Much of the difference between Clarke's figure of *halmodeus* and the figures of the other species is due to the fact that he did not recognize the constant presence of the sharp reëntrant angle in the sutures wherever they are crossed by one of the sensory grooves.

The ornamentation is closely similar to that of *Coccosteus*. The tubercles are all small and frequently show a radiating, asteroid structure at the base. They are very uniformly distributed and become slightly smaller near the periphery of the shield. There is a decided lack of the tubercles near the center of the shield in the holotype, where the median occipital and the paired central plates meet, but in another specimen of the collection, number 13052 U.M., they are as abundant here as elsewhere. In the last specimen the sensory grooves are not so well marked as in the holotype, suggesting that with age the shield may have become thicker and more strongly marked with partial obliteration of the sutures and grooves. The median portion of the posterior edge of the median occipital is thickened and elevated and has very few and very small tubercles; the whole posterior border has a similar lack of tubercles and is marked by a series of fine transverse striations.

The system of sensory grooves is very clearly marked on the specimens and is shown in dotted lines in Figures 1 and 4. Certain additions and corrections may be made in completion of previous descriptions. The distal extremities of the prominent V-shaped grooves which cross the preorbital and postorbital plates and unite on the centrals clearly reach the edge of the shield just anterior and posterior to the orbits, forming valuable topographic marks in the pattern. Two short extensions from the apices of the V-shaped grooves turn in toward the center of the shield and terminate abruptly. The lower arms extend posteriorly parallel to the outer edges of the median occipital plate and continue to the posterior edge of the shield. These arms are obscurely marked in some of the specimens, and in one, number 12976, were at first thought to cross over to the median occipital plate and recross over to the external occipitals posteriorly, but this is probably not correct. The passage of the grooves from the central to the external occipital is marked by a sharp posterior deflection of the suture between the two plates, a topographic point noticeable in all the cephalic shields of the Arthrodires.

The sensory grooves form a continuous system near the periphery of the shield on the postorbitals, the marginals and the external

occipitals. From this system a branch runs out to the edge on the marginal, slightly anterior to its posterior end, and a second branch runs to the edge near the posterior end of the external occipital and is probably extended across to the anterior dorso-lateral plate.

In Figure 5 and Plate I, Figure 2, there is shown the under surface of the shield as exposed in specimen 12979. This illus-

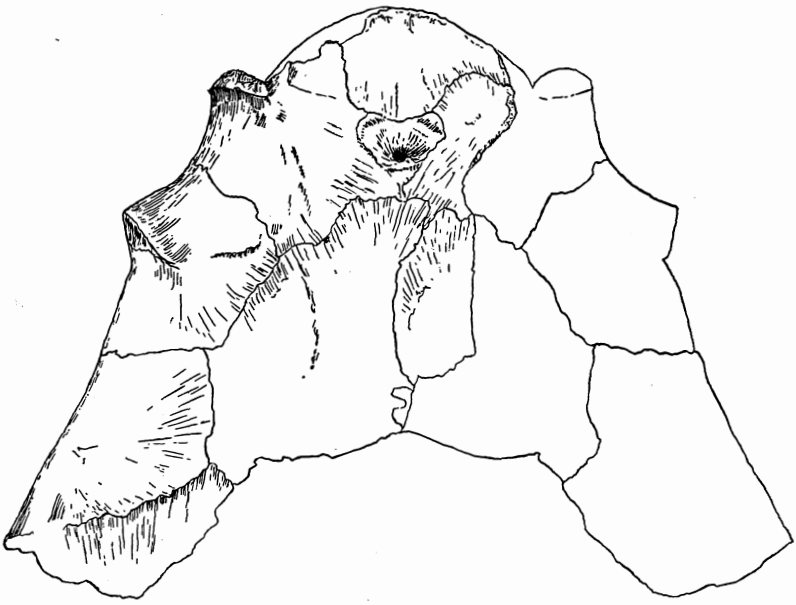

FIG. 5. Cephalic shield of *Protitanichthys rockportensis*, lower surface. Left side restored from the right. Number 12979 U.M. × about $\frac{2}{3}$

trates how different the pattern of the sutures is upon the two surfaces. There was very extensive overlap, but the limits of the plates are very clearly marked by the edges of the bones and by the course of the fibers. It has been very difficult to harmonize the pattern of the sutures on the two surfaces; it would appear that some of the plates clasp the adjacent plate, overlapping on both surfaces. This demonstrates how uncertain any restoration

of one surface from the other must be. The appearance of the lower surface, shown in specimen 12979, is very similar to that of *P. fossatus* as shown in photographic reproduction by Eastman. The pineal plate is almost identical in the two. It is by a study of this specimen and its comparison with others that it can be demonstrated that the preorbital plates meet between the pineal plate and the paired centrals. Specimen 12978 shows the sutures and the sensory grooves of the anterior part of the cephalic shield with exceptional clarity. See Plate III, Figure 1.

No gnathal elements nor any other plates of the cephalic or ventral shields have been found that can be associated with *Protitanichthys.*

The dorsal shield is represented by three median dorsal plates, numbers 12975, 12977 and 13049, all U.M. Specimen number 12977 is preserved in two blocks, having been split through the substance of the bone. It is somewhat distorted by the impression of the rough surface upon which it lay and, unfortunately, the extreme tip of the posterior process was lost. This tip was complete when the specimen was found, but fell between two large blocks of limestone and could not be recovered. The author closely questioned the finder without revealing the significance of the questions and was assured that the whole tip was not over an inch and a half long and came to a sharp point without any terminal thickening. This, with the evidence of the specimen itself, confirms the Coccostean nature of the process as contrasted with the expanded, spoon-shaped termination of the process present in the Dinichthids. The median dorsal plate is slightly convex, with a bifurcate anterior border and a strong median keel on the lower surface. The keel extended from near the anterior border to a point about three centimeters from the posterior border, where it terminated abruptly. See text Figure 6 and Plate II, Figure 1.

The upper surface is shown in number 13049. It is ornamented with tubercles of the same size as those on the cephalic shield, but there are three areas devoid of tubercles, one median and two lateral, which converge toward the posterior edge. No trace of the sensory grooves can be detected on any of the specimens. See Plate II, Figure 2.

Specimen number 13046 U.M. — This is a small, complete spine-like plate with the characteristic tuberculate ornamentation. One end, apparently the attached end, is thinner and spatulate in outline, the main portion is narrow, with nearly parallel edges drawing to a pointed extremity. The plate was found isolated, and no suggestion for its position can be made unless it is a clavicular element. See Plate III, Figure 2.

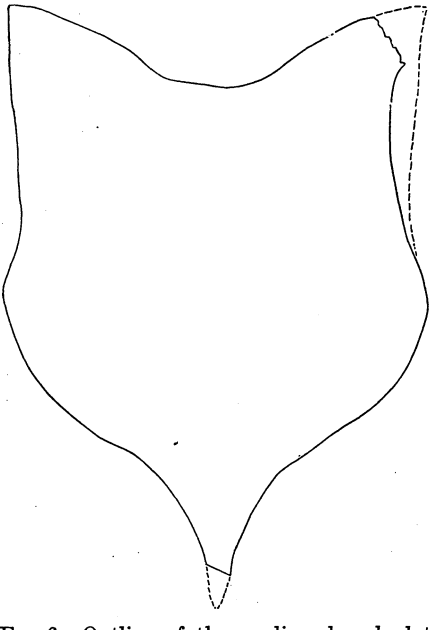

FIG. 6. Outline of the median dorsal plate of *Protitanichthys rockportensis*. Number 12977 U.M. × ½

There are present in the collection several fairly complete plates of the large arthrodire *Holonema*. All are characteristically thin and show the linear sculpture. Plates IV and V show the ornamentation of different regions. So little is known of the plan of the armor of *Holonema* that any assignment of the plates to a definite position must be very tentative. The most interesting point is the occurrence of the genus at this horizon. Most of the recorded specimens have been found in higher beds, none older than the Genesee. Only two specimens have been described, by Hussakof and Bryant,[3] from the Hydraulic Limestone of Milwaukee, which is regarded as the equivalent of the Hamilton and Tully, just above the Marcellus. Since the plates are typically charactetistic of *Holonema*, it must be recognized that this highly

[3] Hussakof, Louis, and Bryant, W. L., *Catalog of the Fossil Fishes in the Museum of the Buffalo Society of Natural Sciences*, *Bulletin of the Buffalo Society of Natural Sciences*, Vol. 12, pp. 104–105, pls. 32 and 33, 1918.

specialized form was present at the time of the deposition of the Rockport limestone in the Long Lake formation of the Traverse. The Long Lake is regarded by Pohl as equivalent to the Marcellus and as lying below the Milwaukee Limestone. The presence of *Holonema* does not help in fixing the horizon of the Rockport, since this is the lowest bed in which it has been found, unless it be regarded as evidence that the Traverse is equivalent to the Hamilton as represented at Milwaukee.

Specimen number 13040 U.M. — This specimen, which is shown in Plate IV, Figure 1, is one of the most interesting. There are portions of three plates on the block, a central shield-shaped plate, and parts of two lateral plates. The sutures are clearly shown and there is a sensory groove on the left lateral plate. Such a juxtaposition of plates might occur in four places in the pattern of the arthrodire shields, but it seems most probable that these plates are a portion of the anterior part of the cephalic shield. Unfortunately, the median plate has lost the median portion, but there is no indication on the bone preserved, or on the impression, of the presence of a pineal foramen. The outline of the plate is clearly shown either by the bone or by the impression of the lost part. It has the form and relations of a rostral plate in more completely known cephalic shields. The impression shows the mark of a low median keel, deeper posteriorly, where a fragment of bone is still preserved. The course of the sensory groove is that of the well-known lateral groove, which reaches the edge of the shield anterior to the orbit.

Specimen number 13043 U.M. — This is a plate complete on three sides and, apparently, at the lower right-hand corner, as placed on the plate (see Plate IV, Fig. 2), approaches very closely to the edge of the fourth side. The bone is preserved and shows the pattern of the sculpture and the course of a sensory groove very perfectly. The author has attempted to set this plate in the common pattern of the arthrodire cephalic dorsal shield, but without success. It cannot be supposed that the shapes of the plates or the courses of the sensory grooves were closely similar in all the different genera and species, but all descriptions and figures agree within certain limits, and the curvature of the grooves is in a fixed

direction. The only position in which this plate could be placed is that of the left external occipital, but there is not the slightest indication, either in shape, thickness of bone, or modification of sculpture, of any articulation with the dorsal shield. Such an articulation was absent in some forms and may well have been absent in *Holonema*, which is notable for the thinness of the plates as well as for the peculiar sculpture.

Specimen number 13051 U.M. — This is a very nearly complete plate, but, unfortunately, only the lower surface is exposed. In a few places the bone is loose and has been removed, thus revealing the beautiful sculpture. Unhappily, the matrix is soft and shaly and any attempt to remove the more adherent bone brings away a thin layer of matrix, which carries the impression. In outline the plate resembles the one figured by Hussakof and Bryant (Plate 30, Fig. 2) and designated by them as the anterior ventro-lateral of *Acanthaspis*, but is about three times the size of their specimen. Especially characteristic is the projection at one corner of the plate. The objection to the assignment to this position is the presence of a sensory groove.

Specimen number 13050 U.M. — This plate is similar to the preceding one, especially in the projection of one corner. It reveals somewhat more of the sculpture, notably an area of reticulate instead of radiating lines near the projection. Only a portion of the very thin bone is preserved, and an effort to remove it was unsuccessful, so that the pattern of the sculpture is not completely shown.

Specimen number 13039 U.M. — This plate is nearly complete and is remarkable for the extreme thinness of the bone. The lower surface is presented; in the few spots where the bone is broken away there is no trace of sculpture revealed by impression, except an extremely fine reticulation near the edge of the plate, such as occurs in similar positions in other plates. The under surface of the plate is marked by a series of broad parallel lines or areas indented with minute pits. It appears as if these were due to a partial solution of the inner surface of the extremely thin bone etching into visibility a sculpture so low that it has left no impression on the matrix; rather a structure of the bone than a

surface relief. The elongate, narrow shape of the plate suggests that it may be one of the posterior latero-ventrals.

Specimen number 13048 U.M. — This is the impression of a small, broadly oval plate. Near one end the sculpture is reticulate, shading into an area of small tubercles at the other. The sides of the oval are marked by fine radiating ridges, with the edges of the ridges divided into minute denticulations. These denticulations are reminiscent of *Glyptaspis*, but there is no concentric

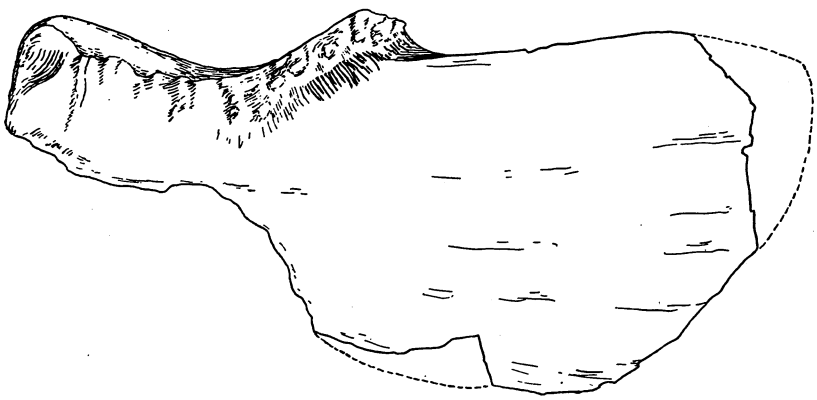

FIG. 7. Outer surface of the left lower gnathal element of *Dinomylostoma* (?), spec. nov. × ⅔

arrangement of the lines in the center of the plate. It resembles most closely the figure of *Holonema abbreviatum* (Eastman) given by Hussakof and Bryant, or the *Glyptaspis eastmani* of Schwartz,[4] which the former authors place in the genus *Holonema* and perhaps the species *rugosum* of Claypole.

The position of the plate is uncertain, it might be either an anterior or a posterior median ventral. See Plate V, Figure 1.

Specimen number 12974 U.M. — This is a nearly complete lower gnathal element of the left side. It lacks only a small fragment from the posterior end and a small bit of the inner side of the tritoral edge. This specimen has been most kindly examined

[4] Schwartz, C. K., "Middle and Upper Devonian," *Maryland Geological Survey*, p. 700, pl. 73, fig. 1, 1913.

FIG. 8

FIG. 9

FIG. 10

FIG. 8. Upper surface of left lower gnathal element of *Dinomylostoma* (?), spec. nov. Number 12974 U.M. × ⅔

FIG. 9. Upper surface of lower gnathal element of *Dinomylostoma beecheri*, after Hussakof. × about ⅔

FIG. 10. Upper surface of lower gnathal element of *Dinomylostoma eastmani*, after Hussakof. × about ⅔

for the author by Dr. Louis Hussakof, who identifies it as belonging to the genus *Dinomylostoma* and as a new species. The

form of the element is shown in Figures 7 and 8. The tritoral face is smooth, lacking any tubercles, convex laterally and concave antero-posteriorly. The anterior half of the tritoral face is more nearly horizontal, but is inclined outward and downward; the posterior half rises sharply and is inclined inward and downward. This arrangement gives the whole face a twisted surface, so that any opposed plate moving forward and back upon it would also be shifted from side to side. Both the inner and outer edges of the tritoral face are marked by coarse tubercles. Dr. Hussakof remarks that the presence of tubercles on the inner edge is unknown to him in any other arthrodire. The inner face shows the deep groove below the tritoral face described in other specimens of the genus and there is a deep pit near the anterior edge, evidently for the attachment of a strong ligament connecting the elements of the two sides. As shown in Figures 8, 9 and 10, the outline of the tritoral surface is very different from that of *D. eastmani* and *D. beecheri* and is intermediate between them in breadth.

Specimen number 13056 U.M. — This is a smaller and incomplete lower gnathal element, similar in all preserved parts to number 12974.

Specimens number 13041 U.M. and 13042 U.M. — These specimens are upper anterior gnathal elements of opposite sides, but of different size, evidently from different individuals. Dr. Hussakof is of the opinion that these most probably belong to the same genus as the lower element. These gnathal elements are possibly to be associated with the genus *Holonema* for the following reasons: (1) They are found in the same bed as the rather abundant plates of *Holonema;* (2) Professor Lull of Yale University has kindly examined the type of *Dinomylostoma beecheri* in the Peabody Museum and assures the author that, though the plates associated with the gnathals are exposed on the ventral surface, certain breaks reveal the characteristic sculpture of *Holonema.*

The character of the upper gnathal elements is shown in Figures 11, 12, 13, and in Plate V, Figure 2.

It is assumed that these upper plates belong to the same genus and species as the lower one, because: (1) they are the only gnathals that have been found in the collection; (2) they have the

same form of coarse tuberculations around the edges of the tritoral surface; and (3) the faces can be brought into a usable opposition. It is further tentatively suggested that, (1) as these could not belong to *Protitanichthys*, which is of the Coccostid type, (2) as *Dinomylostoma* gnathals are associated with plates having the sculpture of *Holonema*, in *D. beecheri*, (3) as the only other form of body plates found in the collection belong to the form *Holonema*, and (4) as the gnathal elements of *Holonema* have never been identified, these gnathals described as *Dinomylostoma* may belong to the previously described *Holonema*. These elements have been examined for the author by Dr. Hussakof, who writes: "The thickened cusp with the denticles is the biting point. The convex surface is the outer face; the concave side (bluish color), which you thought might be the triturating surface, is the side that was set in muscle, or overlapped the front edge of the head. The broad, flattened expansion is the flange for articulation with the head." Dr. Hussakof sets the elements up as in *Dinichthys herzeri* and *D. lincolni* and notes upon an accompanying sketch that the tubercles on

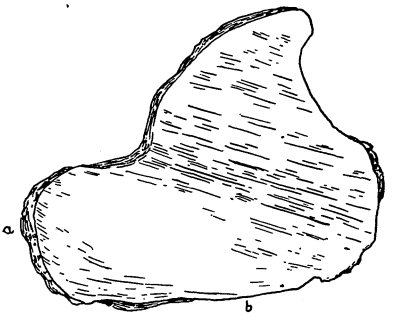

FIG. 11. Anterior upper gnathal element, showing the smooth concave face. Number 13041 U.M. The letters *a* and *b* in Figures 11, 12 and 13 indicate identical points in the three views. × ⅔

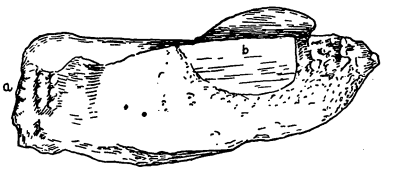

FIG. 12. Lateral view of specimen shown in Figure 11. × ⅔

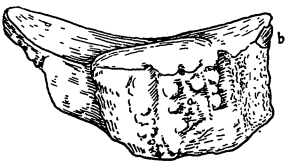

FIG. 13. Lower (anterior?) view of specimen shown in Figures 11 and 12. × ⅔

the thickened cusp possibly show wear. The points he mentions can be identified in Figures 11, 12 and 13.

It is with great diffidence that the author ventures to disagree with Dr. Hussakof in a matter dealing with arthrodires, but several points in the structure of the elements compel him to offer an alternative explanation. (1) Dr. Hussakof would set up the elements as in *Dinichthys*, with vertically biting jaws. In *Mylostoma* and *Dinomylostoma* the plates were horizontal and were adapted to crushing. (2) The tubercles are located on all portions of the periphery and so cannot be assumed to be a guide to the tritoral face. On the lower jaw the tubercles are on the side of the tritoral face. (3) The concave face is smooth and very hard and shows evidence of use. It does not have the appearance of having given rise to muscular attachments. (4) The convex face has the appearance of having been attached to cartilage. (5) The smooth convex face cannot be perfectly adjusted to the smooth tritoral face of the lower jaw, but this is equally true of the heavy cusp. The difficulty may be due to lack of correspondence in size of the plates, which are from different individuals. The author suggests that the elements may have been horizontally placed, as in *Mylostoma* and *Dinomylostoma*, with the concave face opposed to the convex tritoral face of the lower jaw. The plates are so placed in Figures 11, 12 and 13, and are so described below.

The tritoral face is smooth and concave both antero-posteriorly and, more sharply, from side to side. The narrow end, assumed anterior, is heavy and the broader, assumed posterior, one quite thin. The straight, assumed inner, side is heavy and mostly with a fine reticulation indicating cartilage attachment, but near the tritoral edge, nearer the posterior end than the anterior, is an area of smooth, hard bone, possibly permitting movement against a similar element on the opposite side. Except for the median portion of the inner edge the entire periphery is marked by coarse tuberculations. The crescent-shaped notch of the posterior edge shows a groove, possibly permitting a movable articulation with a posterior gnathal element. The specimen number 13041 U.M. is perhaps from a larger individual than the lower element, as it projects beyond the tritoral surface of the lower when in closest adjustment.

Because of the peculiar shape of the opposed surfaces, the action of the jaws must have resulted in a sliding motion in the complete act of occlusion. This is borne out by the much broader surface of the upper element and is confirmed by the presence of a multitude of scratches and grooves on the smooth tritoral faces (see Plate V, Fig. 2). These were in many places filled with matrix and were either *ante mortem* or immediately *post mortem* in formation. There is no definite or even dominant direction to the scratches and grooves, which suggests a grinding motion between the upper and lower jaws. This recalls the suggestion made by Dean that there was a rotary motion in the jaws of *Mylostoma*, which was later contested by Eastman. All necessary amount of motion could have been accomplished by the non-rigid attachment of the plates in the cartilage, with no necessary assumption of an anomalous motion of the jaws.

The surface of the plates is very hard, so hard that it cannot be scratched with a steel victrola needle, the cleaning instrument used, without the exercise of great pressure, and the scorings were probably due to the action of the jaws during life. It can hardly be assumed that they were due to the attack of other forms after death, since the plates are as hard as any equivalent structure in possible attacking forms and would offer no occasion for attack.

It is difficult to conceive what sort of food might have been taken that would result in such scorings. The habitat was in all probability the coral reef where the remains are found. There was no form of life that such a durophagous animal would feed upon with hard parts capable of inflicting the injury. The limestone is one of the very pure limestones of northern Michigan used for chemical manufactures, and there is no inclusion of quartz grains. A sample of some size dissolved in hydrochloric acid left only an impalpable slime. It is not possible that the siliceous skeletons of sponges or of plants could have caused the deep scorings. Only one suggestion has been made that would reasonably account for the feature — that the animal was a scavenger and devoured the cadavers of other like forms and of ganoid fishes. The teeth and scales of such forms are sufficiently resistant to do the damage noted. While this possibility is unproved and is un-

supported by other observations, it remains as the only explanation that has been offered for the condition of the tritoral surface of the plates.

Specimen number 13045 U.M. — This is a characteristic *Ptyctodus* tooth that cannot be assigned with certainty to any species. The tritoral surface is extremely narrow.

There are present in the collection fragments of ichthyodorulites of uncertain relations, one identified as *Ctenacanthus sp.*

DESCRIPTION OF PLATES

PLATE I

FIG. 1. Photograph of a plastic cast of the impression of the cephalic shield of *Protitanichthys rockportensis*. Specimen number 12980 U.M. × about $\frac{1}{2}$

FIG. 2. Lower surface of cephalic shield of *P. rockportensis*. Specimen number 12979 U.M. Compare with text Figure 5. × about $\frac{1}{2}$

PLATE II

FIG. 1. Median dorsal plate of *P. rockportensis*, showing lower surface and impression of upper surface. Specimen number 12977 U.M. × about $\frac{3}{4}$

FIG. 2. Median dorsal plate of *P. rockportensis*, showing ornamentation of upper surface. Specimen number 13049 U.M. × about $\frac{3}{4}$

PLATE III

FIG. 1. Anterior portion of cephalic shield of *P. rockportensis*, showing sutures and sensory grooves. Specimen number 12978 U.M. × about 1

FIG. 2. Small isolated spine of uncertain position. Specimen number 13046 U.M. × about $\frac{4}{3}$

PLATE IV

FIG. 1. Fragment of armor of *Holonema*, showing three plates, probably the rostral and right and left preorbitals. Specimen number 13040 U.M. × about $\frac{2}{3}$

FIG. 2. One nearly complete plate of *Holonema*, showing the sculpture and a sensory groove. Specimen number 13043 U.M. × about $\frac{3}{4}$

PLATE V

FIG. 1. Cast of the impression of a plate of uncertain position, probably an anterior or posterior median ventral of *Holonema*, showing the fine denticulations on the radiating ridges. Specimen number 13048 U.M. × about $\frac{7}{8}$

FIG. 2. Scored faces of anterior gnathal elements. Scorings filled with chalk. Specimens number 13041 U.M. (below) and 13042 U.M. (above). × 1

PLATE I

FIG. 1

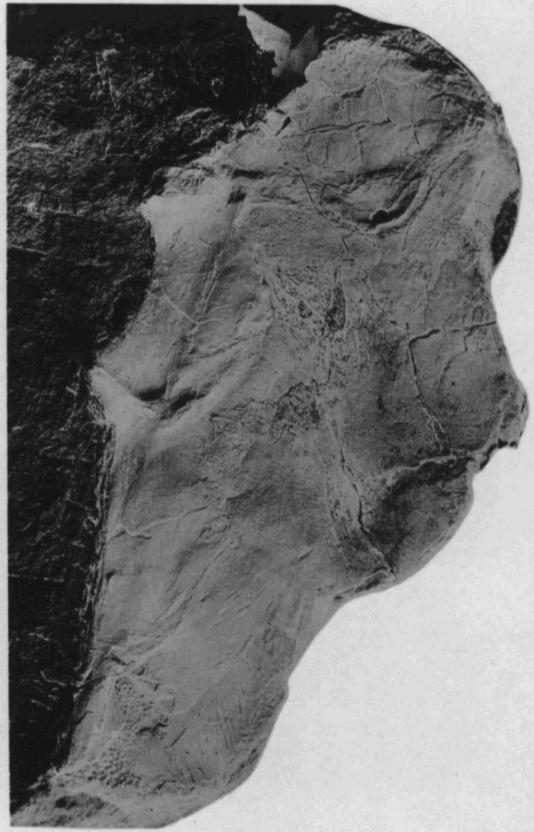

FIG. 2

PLATE II

FIG. 1

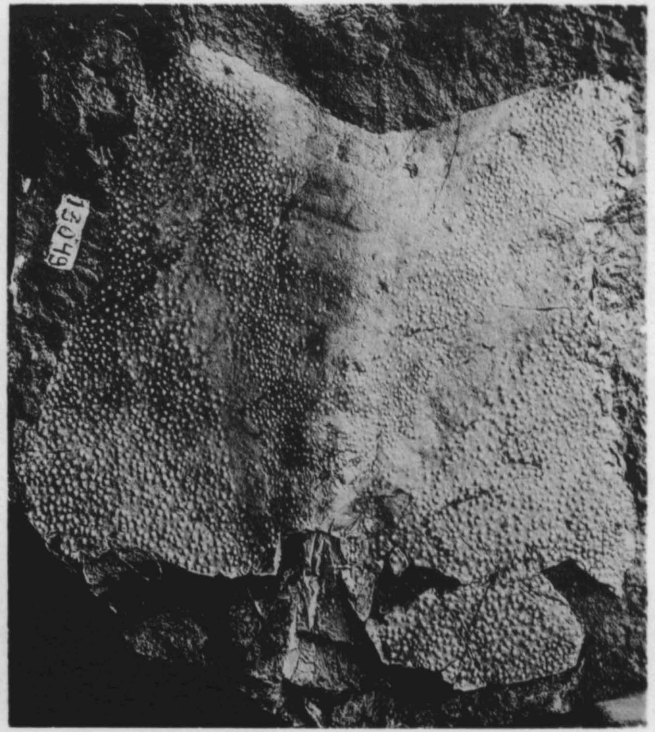

FIG. 2

PLATE III

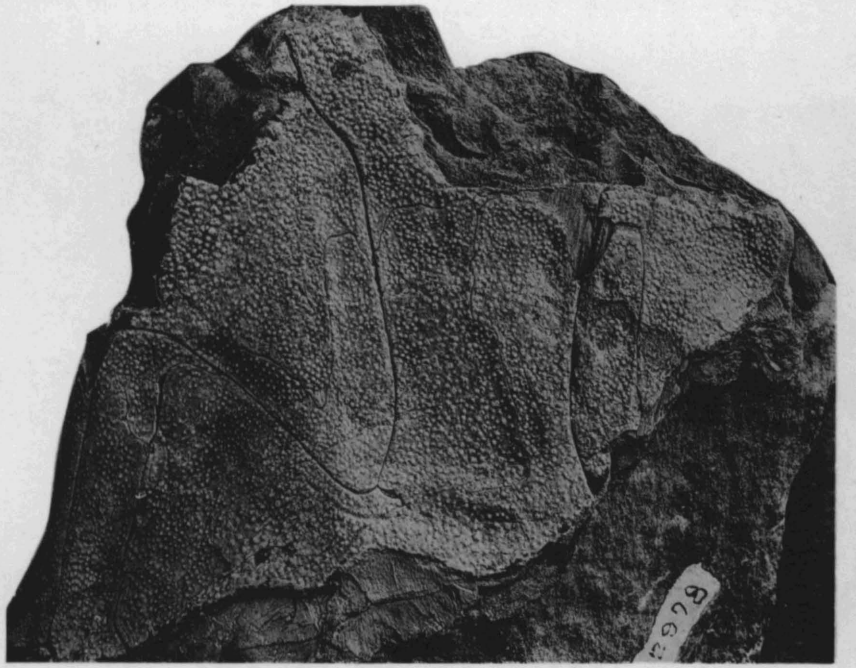

FIG. 1

FIG. 2

PLATE IV

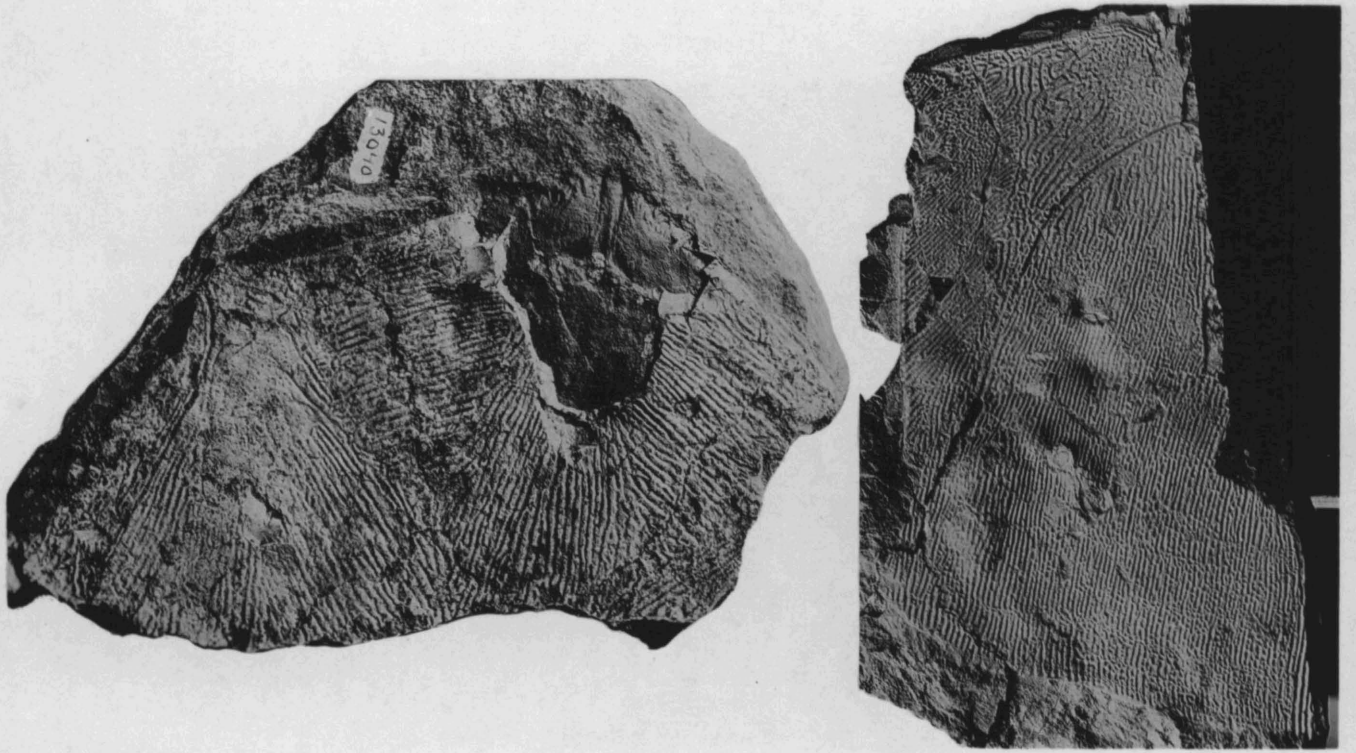

FIG. 1

FIG. 2

PLATE V

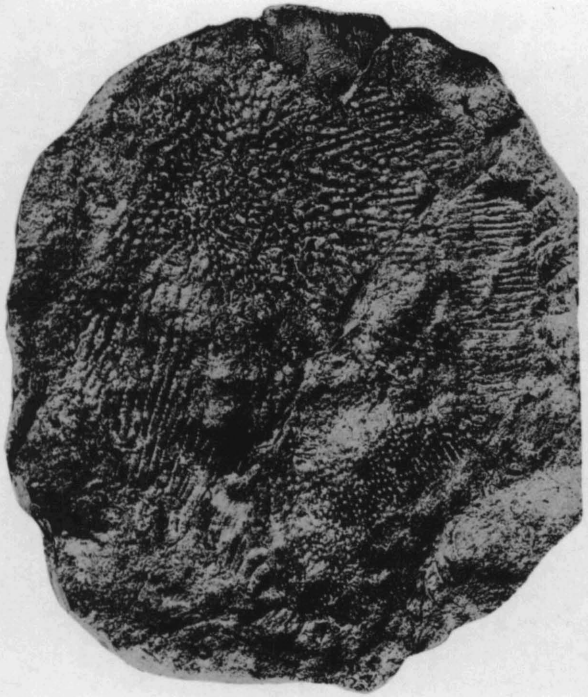

FIG. 1

FIG. 2

(*Continued from inside of front cover*)