

NORGES SVALBARD- OG ISHAVS-UNDERSØKELSER
LEDER: ADOLF HOEL

SKRIFTER

Nr. 82

THE DOWNTONIAN AND DEVONIAN
VERTEBRATES OF SPITSBERGEN

VII
ORDER ANTIARCHI

BY
TAGE NILSSON

WITH 26 FIGURES IN THE TEXT
AND 16 PLATES



OSLO
I KOMMISJON HOS JACOB DYBWAD
1941

RESULTS OF THE NORWEGIAN EXPEDITIONS TO SVALBARD
1906—1926 PUBLISHED IN OTHER SERIES

(See Nr. 1 of this series.)

The results of the Prince of Monaco's expeditions (*Mission Isachsen*) in 1906 and 1907 were published under the title of 'Exploration du Nord-Ouest du Spitsberg entreprise sous les auspices de S. A. S. le Prince de Monaco par la Mission Isachsen', in *Résultats des Campagnes scientifiques, Albert 1^{er}, Prince de Monaco, Fasc. XL—XLIV*. Monaco.

ISACHSEN, GUNNAR. Première Partie. Récit de voyage. Fasc. XL. 1912. Fr. 120.00.

With map: Spitsberg (Côte Nord-Ouest). Scale 1:100 000. (2 sheets.) Charts: De la Partie Nord du Foreland à la Baie Magdalena, and Mouillages de la Côte Ouest du Spitsberg. ISACHSEN, GUNNAR et ADOLF HOEL, Deuxième Partie. Description du champ d'opération. Fasc. XLI. 1913. Fr. 80.00.

HOEL, ADOLF, Troisième Partie. Géologie. Fasc. XLII. 1914. Fr. 100.00.

SCHETELIG, JAKOB, Quatrième Partie. Les formations primitives. Fasc. XLIII. 1912. Fr. 16.00.

RESVOLL HOLMSEN, HANNA, Cinquième Partie. Observations botaniques. Fasc. XLIV, 1913. Fr. 40.00.

A considerable part of the results of the ISACHSEN expeditions in 1909 and 1910 has been published in *Videnskapsselskapets Skrifter. I. Mat.-Naturv. Klasse. Kristiania (Oslo)*.

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BACKLUND, H., Über einige Olivinknollen aus der Lava von Wood-Bay, Spitzbergen. 1911, No. 16. Kr. 0.60.

HOLTEDAHL, OLAF, Zur Kenntnis der Karbonablagerungen des westlichen Spitzbergens. I. Eine Fauna der Moskauer Stufe. 1911, No. 10. Kr. 3.00. II. Allgemeine stratigraphische und tektonische Beobachtungen. 1912, No. 23. Kr. 5.00.

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GUNNAR ISACHSEN has also published: Green Harbour, in *Norsk Geogr. Selsk. Aarb.*, Kristiania, 1912—13, Green Harbour, Spitsbergen, in *Scot. geogr. Mag.*, Edinburgh, 1915, and Spitsbergen: Notes to accompany map, in *Geogr. Journ.*, London, 1915.

All the above publications have been collected into two volumes as *Expédition Isachsen au Spitsberg 1909—1910. Résultats scientifiques. I, II*. Christiania 1916.

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HOEL, ADOLF, Nouvelles observations sur le district volcanique du Spitsberg du Nord. 1914, No. 9. Kr. 2.50.

Expeditions of TH. VOGT 1925 and 1928:

STØRMER, LEIF, Downtonian Merostomata from Spitsbergen. — *Skr. Norske Vid.-Akad. I. Mat.-Nat. Kl.* 1934. No. 3. Kr. 3.00.

The following topographical maps and charts have been published separately:

Maps:

Bear Island. 1:25 000. 1925. Kr. 10.00.

Bear Island. 1:10 000. (In six sheets). 1925. Kr. 30.00.

East Greenland. Eirik Raudes Land from Sofiasund to Youngsund. 1:200 000. 1932. Kr. 5.00.

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A. W. BRØGGERS BOKTRYKKERI A/S

INTRODUCTION

In Mimer Valley at the inner end of Klaas Billen Bay, in deposits at that time considered as Upper Devonian, Nathorst discovered in 1882 a locality very rich in fish. This locality was referred to by Nathorst as the "Fish Cleft" (Nathorst 1884, pp. 57—58; 1894, pp. 10—11; 1910, pp. 309—315). The material brought home from there included among other things an imperfect cranial shield of a fish described by A. S. Woodward (1891, pp. 11—13, pl. III) under the name of *Asterolepis scabra* and referred by him, with some hesitation, to the Arthrodirea.

In 1916 and 1917 the "Fish Cleft" was visited by E. Stensiö, whose new collections enabled him to recognize *Asterolepis scabra* as an Antiarch, belonging to the old genus *Asterolepis* (Stensiö 1918 a, p. 69). Stensiö's new material of *Asterolepis scabra* (Woodw.), as the form under consideration thus must be named, consisted of a big, fairly complete specimen from the "Fish Cleft" and, in addition, of detached plates of the trunk armour, in part from a new locality in Mimer Valley. This new locality lies on the northern slope of Estheria Hill, in layers of the same petrological character (black shales [Sk_g] with ironstone nodules) as those in which the fish material occurs in the "Fish Cleft", and it is, therefore, beyond question of the same age as that (l. c., pp. 71—72). In the above paper by Stensiö no description of the new *Asterolepis*-material is given, neither is this done in a later work by Stensiö dealing with the organization of the *Antiarchi*. In the latter work Stensiö has, however, published a few figures of certain skeletal elements of *A. scabra* (Stensiö 1931).

In 1928 further important material of *A. scabra* was collected by Th. Vogt's Spitsbergen expedition. This new material comprises in the main only detached plates or plate-fragments. Except for one specimen found in equivalent layers in a brook-cleft 1 km W of the "Fish Cleft", all this material is derived from the "Fish Cleft".

It has long been desirable to have a proper description of *A. scabra*, and for this reason the material at hand will be treated here.

In addition to the material just referred to, fragmentary remains of some other Asterolepids from Spitsbergen will also be described in this paper (pp. 35—41). The last-mentioned remains are in part from a locality in Mimer Valley and in part from the west side of Wijde Bay, more precisely Andredalen. Those from Mimer Valley were collected by Stensiö in 1918, those from the west side of Wijde Bay by Th. Vogt in 1925.

The preparation has been made with a dental mallet.

The material examined belongs to the Palaeozoological Department of the Swedish Museum of Natural History, Stockholm, the Palaeontological Institute of the University of Uppsala, and the Palaeontological Museum, Oslo. It has been placed at my disposal by Professors E. Stensiö, G. Säve-Söderbergh, A. Heintz, and Th. Vogt, to all of which I here wish to express my gratitude. I also wish to thank Professor Stensiö for his great interest in my work and for excellent working facilities at his institute.

ORDER ANTIARCHI

Family *Asterolepidae* (Subfam. *Asterolepinae*).

Genus *Asterolepis* Eichwald (1840).

As to the history of the genus the reader is referred to a recently published paper by Stensiö (1938, p. 8). The species nearer determined as yet of the genus are as follows: *A. ornata* Eichwald (1840; genotype), *A. maxima* (Agassiz 1845), *A. scabra* (Woodward 1891), *A. radiata* Rohon (1900), *A. cristata* Obrutshv (1933 a), *A. orcadensis* Watson (1932), *A. thule* Watson (1932), *A. säve-söderberghi* Stensiö (1938). (Cf. Addendum, p. 52.)

Asterolepis scabra (Woodward).

(Text-figs. 1 A. 3—5, 7—11, 13—16; pls. I—XIV; pl. XV, figs. 1—3.)

1891. *Asteroplax scabra*, Woodward, pp. 11—13; pl. III, figs. 1, 2.
1918. *Asterolepis scabra*, Stensiö, 1918 a, pp. 69, 72.
1918. *Asterolepis scabra*, Stensiö, 1918 b, p. 115.
1931. *Asterolepis scabra*, Gross, pp. 27, 59.
1931. *Asterolepis scabra*, Stensiö, pp. 58, 60, 62, 75—77, 105, 106, 150; text-figs. 9, 24, 37, 52, 58.
1932. *Asterolepis scabra*, Gross, p. 15.
1938. *Asterolepis scabra*, Stensiö, pp. 8, 13.

With the knowledge that we have at present of *A. scabra* it is easily seen that the specimen figured by Woodward in 1891, in pl. III, fig. 1, is a left posterior part of the cranial roof. The plate interpreted by Woodward at that occasion as a "median occipital plate" (Woodward l. c., pl. III, fig. 1, *o*) is a postmedian¹ plate. Of the plates described by him as the "posterior lateral plates" (l. c., *l*) the left one is a lateral plate, the right one a median nuchal plate. The "second median plate" (l. c., *o*₁) of his description is a lateral nuchal plate, the "anterior or second lateral plate" a sufflaminal plate, and the "cheek-plate" or "facial plate" (l. c., *x*) an opercular or extralateral plate. The bones denoted by Woodward with the letters *y* and *z* represent together the foremost part of the anterior dorso-lateral plate of the trunk-cara-

¹ I have here used the same bone-terminology as Stensiö in 1931.

pace with a portion of the main lateral line groove. The problematic bone, figured by Woodward in pl. III, fig. 2, is the subcephalic division of the anterior ventro-lateral plate. — Many of the plates, which Woodward (1891, pp. 14—15) referred, with doubt, to “an unknown large Ostracoderm”, also belong to this species.

Diagnosis. — An *Asterolepis* of a very large size; length of the ventral wall of the trunk-carapace attaining 57 cm approximately. Dermal bones of the skull-roof, the larger part of the pectoral fins, the anterior and lateral parts of the ventral face of the trunk-carapace and certain parts of the lateral face of the trunk-carapace ornamented with coarse, rounded tubercles, as a rule fused into nodose ridges of varying length; these ridges have an irregular or radiating disposition and are often confluent so as to form a network. The remaining, greater part of the carapace and the most distal part of the pectoral fins devoid of ornament and smooth. — Skull roof with a rather short, slightly concave rostral margin, a very broad, posterior margin, and rather strongly concave lateral margins. Sufflaminal plates projecting backwards and laterally, separated from the lateral nuchals by rather deep notches. Median nuchal, postmedian and premedian plates relatively broad; the lateral line groove on the premedian plate fairly far from the rostral margin. Extralateral plate moderately high. — Trunk-carapace rather low and not particularly wide. Posterior end of its ventral wall rather well rounded off; subcephalic division relatively short. Anterior median dorsal plate not particularly wide, tapering forwards a great deal; anterior margin short and straight, posterior margin rather broad, distinctly concave both on the outer and inner face of the carapace; dorsal median ridge and dorsal angle absent; dorsal outline in lateral view gently rounded with the highest part in front of the middle. Anterior dorso-lateral plate rather long and narrow. Lateral lamina of the anterior ventro-lateral plate rather high, comparatively slowly decreasing in height in anterior and posterior directions. Posterior ventro-lateral plate neither particularly long nor particularly high. Median ventral plate relatively large. Semilunar plate moderately broad. Posterior face of the pars pedalis of the processus brachialis rather high; posterior face of the pars condyloidea almost vertical; posterior opening of the funnel pit rather large; dorsal and ventral margo limitans of the fossae articulares robust. — Pectoral fin relatively short, probably only reaching a little beyond the posterior margin of the anterior ventro-lateral plate. Dorsal articular plate relatively broad with a high dorso-medial crista. Dorsal and ventral articular plates and dorsal anconeal plate rather large. Axial plate with a relatively short postero-dorsal and a long dorsal margin; a distinctly marked deep antero-dorsal depression present. Lateral marginal plate of the proximal segment rather long and narrow, medial marginal plate rather short

and broad; the lateral and marginal plates of the anterior part of the distal segment rather short and broad; boundaries between the dorsal central plate and the posterior lateral and medial marginal plates relatively long. The lateral sensory canal groove of the proximal segment rather strongly curved.

Material. — The material at my disposal consists of the following specimens. Woodward's type specimen, the left posterior part of a well preserved cranial shield with fragments of the adjoining bones of the trunk armour (specimen A; Riksm.¹ no. P. 1130; from the "Fish Cleft"; coll. Nathorst 1882). A large fairly complete specimen (referred to as specimen B in the subsequent description; Upps.¹ no. P. 1054; from the "Fish Cleft"; coll. Stensiö 1917). This specimen has the ventral part and the lowermost portions of the lateral parts of the carapace fairly well preserved, though somewhat fractured. It exhibits also most of the bones of the skull roof, partly in their original position, partly somewhat displaced, and in addition certain of the jaw bones. It lacks only the dorsal wall and the upper parts of the lateral walls of the carapace and the median nuchal plate of the skull roof. A part of a third individual with more or less complete remains of *i. a.* the following bones: the anterior median dorsal plate, the anterior ventro-lateral plate, the dorsal and ventral articular plates, and the axial plate of the left pectoral fin (Osl.¹ nos. A. 21858—21861; from a brook-cleft, situated 1 km W of the "Fish Cleft" and cutting through the same layers as this one; coll. Vogt 1928). Two detached anterior median dorsal plates; one of these lacks only the left posterior part (Upps. no. P. 437 *a—b*; from the northern slope of Estheria Hill, *Sk*_g; coll. Stensiö 1916); the other is represented only by a posterior part (Osl. nos. A. 21897—21900; from the "Fish Cleft"; coll. Vogt 1928). Two imperfect detached anterior dorso-lateral plates (Riksm. nos. P. 1150, 1152; from the "Fish Cleft"; coll. Nathorst 1882). Three fragmentary detached mixi-lateral plates (from the "Fish Cleft"; Riksm. nos. P. 1131—1132, P. 1941, coll. Nathorst 1882; Osl. no. A. 21872, coll. Vogt 1928). Three detached fragments with the processus brachialis and the subcephalic part of the anterior ventro-lateral plate (Osl. nos. A. 21928, 21968, 21969, 21974, 21975; from the "Fish Cleft"; coll. Vogt 1928). A posterior part of the anterior ventro-lateral plate (Osl. no. A. 21834; from the "Fish Cleft"; coll. Vogt 1928). A posterior ventro-lateral plate represented by the larger part of the ventral lamina and the lower part of the lateral lamina (Upps. no. P. 438 *a—c*; from the northern slope of Estheria Hill, *Sk*_g; coll. Stensiö 1916). Two

¹ Riksm. = the Palaeozoological Department of the Swedish Museum of Natural History, Stockholm; Upps. = the Palaeontological Institute of the University of Uppsala; Osl. = the Palaeontological Museum, Oslo.

other fragments of the posterior ventro-lateral plate (from the "Fish Cleft"; Upps. no. P. 441, coll. Stensiö 1916; Osl. no. A. 21835, coll. Vogt 1928). A detached dorsal articular plate of the right pectoral fin (Osl. no. A. 21920: from the "Fish Cleft"; coll. Vogt 1928). A detached medial marginal plate of the pectoral fin (Osl. nos. A. 21840—21843, 21845; from the "Fish Cleft"; coll. Vogt 1928).

Several nearer determinable detached plate-fragments may probably also be referred to this species (from the "Fish Cleft"; *i. a.* Riksm. nos. P. 1133, 1135, 1137, 1153, coll. Nathorst 1882; Osl. nos. A. 21871, 21891, 21895, 21896, coll. Vogt 1928).

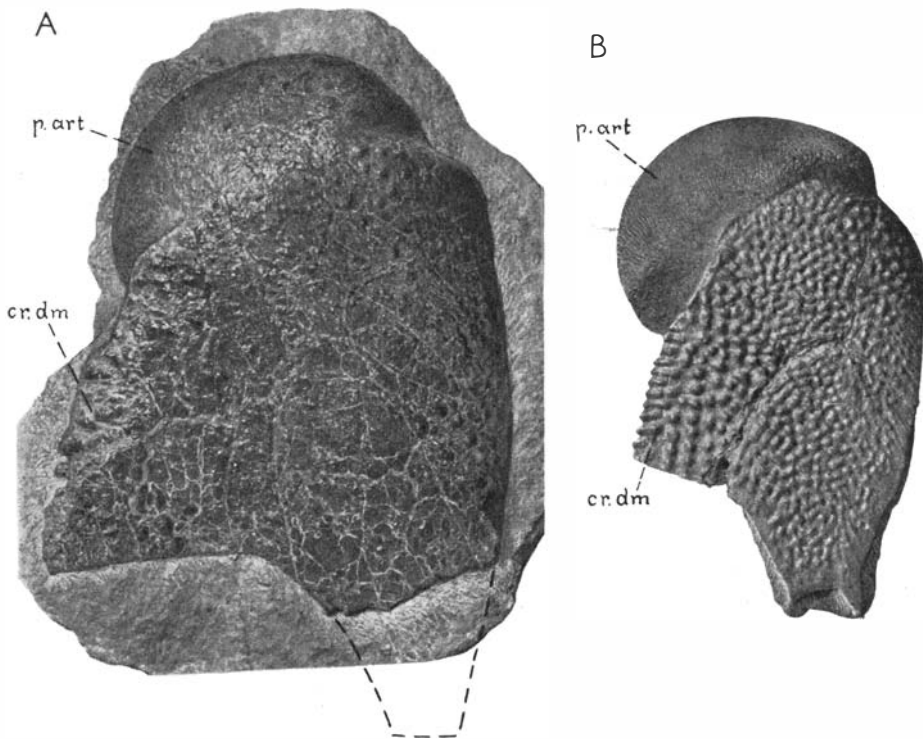
From their considerable size and the development of their ornament one may be justified in concluding that all the specimens enumerated above in all probability belong to one species. All the larger dermal bones of the species are thus more or less well known with the exception of the posterior median dorsal plate and certain plates of the pectoral fin (terminal plate, all ventral plates except the ventral articular plate).

Among the material at hand there is also an undeterminable fragment of a rather large dermal bone (Upps. no. P. 443), preserved as an impression in a shaly rock. This dermal bone is ornamented with coarse, more or less confluent tubercles. It comes from a locality, situated on the southern slope of Estheria Hill, from a layer which is considered to represent a higher stratigraphical horizon than the "Fish Cleft" (the shales *Sk*₄, Stensiö 1918 a, p. 71). As this bone-fragment in its ornament is suggestive of *Asterolepis scabra*, it may provisionally be placed under this species.

The material from the "Fish Cleft" and from the equivalent horizons in Estheria Hill is embedded in hard nodules of ironstone. These nodules occur in dark shales. All the skeletal remains are brown, black brown or black in colour.

Type. — Holotype and only type is the imperfect cranial shield (Riksm. no. P. 1130) described by Woodward (1891, pp. 11—13, pl. III) and figured in the present paper in text-figs. 5 D, G; pl. VI, figs. 1—3.

Reconstructions. — The restorations of the head and carapace shown in text-figs. 3—5, 7—11, 13—16 have been made on the basis of photographs. In reconstructing displaced bones or bone-fragments due regard has been taken to the perspective. Corrections have been made to some extent to level deformities caused by breaks, compressions, distortions, and displacements. The rather strong convexity of the ventral outline of specimen B, as found in the fossil, is not quite original. This may be concluded from the normally ornamented small area *s* (pl. III, fig. 1) of the mixilateral plate. During the fossilisation this area became covered by the somewhat displaced anterior ventro-lateral plate. The extent of the displacement is shown in this case by the presence and position of the original overlapped area of the mixilateral



Text-fig. 1. Dorsal articular plates of the right pectoral fin. Dorsal aspect. A, of an especially large individual of *Asterolepis scabra* (specimen Osl. no. A. 21920); B, of an especially large individual of *A. ornata* (specimen Riksm. no. P. 3041, from Ehrmann b. Ligat, Livonia, beds Dm₄). Nat. size.

cr. dm, dorso-medial crista; *p. art*, pars articularis.

plate. The anterior median dorsal plate has been drawn after the most complete one of the two detached ones known hitherto (pl. VII, fig. 3; pl. VIII; pl. IX, fig. 1). The hindmost part of the posterior ventro-lateral plate has to some extent been completed from the plate Upps. no. P. 438.

Size. — Specimen B has the following measurements. Head in dorsal view (restored): length along the median line approximately 8—9 cm; breadth across the posterior lateral angles of the extralaterals about 18.5 cm, across the posterior lateral angles of the sufflaminals about 15.5 cm, and across the lateral margins of the lateral nuchals about 10 cm; breadth across the anterior parts of the lateral margins of the lateral plates about 7 cm. Trunk-carapace: length of the ventral wall (the hindmost part a little restored) approximately 44 cm; maximum breadth somewhat in front of the middle about 25.5 cm; the length of the dorsal wall (the posterior part restored) may be estimated at about 35 cm, the greatest height at about 17 cm. Pectoral fin: the length of the proximal segment is about 12.8 cm, the breadth of the distal part of the segment approximately 5 cm; the breadth of the distal

Table, showing the measures of the dorsal articular plate of the pectoral fin in three specimens of *A. scabra* and one especially large specimen of *A. ornata*.

	Length (mm)	Breadth (mm)	Ratio length: breadth	Length in relation to spec. no. 3 (= 1.00)	Breadth in relation to spec. no. 3 (= 1.00)
1) <i>A. scabra</i> , spec. Osl. A. 21920 (text- fig. 1 A)	93 ¹	62	1.50 : 1	1.31	1.34
2) <i>A. scabra</i> , spec. Osl. A. 21858 (text- fig. 15; pl. XV, fig. 2)	80	52	1.54 : 1	1.13	1.14
3) <i>A. scabra</i> , spec. B (text-fig. 13)	71 ¹	46 ¹	1.54 : 1	1.00	1.00
4) <i>A. ornata</i> , spec. Riksm. P. 3041 (text-fig. 1 B)	65	35	1.86 : 1	0.92	0.76

segment in the proximal part 3.7 cm; length of its preserved part 7.8 cm; its total length may be estimated at about 12.5 cm.

The holotype seems to be of an approximately similar size to specimen B. Some of the detached plates are from animals of somewhat smaller size than spec. B, *e. g.* the anterior median dorsal plate, figured in pl. VIII. This plate is 23.5 cm long and 15.5 cm broad. Several of the detached plates, on the other hand, are from individuals considerably larger than spec. B. It is of special interest to compare the measurements of the dorsal articular plate of the pectoral fin in the specimens available (see table above, in which an exceptionally large specimen of *A. ornata* has also been measured for comparison). The largest of these plates attain a length and breadth of somewhat more than 1.3 times the corresponding measurements in specimen B of *A. scabra*. Judging from these proportions the ventral wall of the carapace in the largest specimens may probably have attained a length of more than 57 cm and a maximum breadth of more than 33 cm. The total length of the largest individuals from head to tail may be estimated at about 1.1 m.

The measurements given indicate that we are concerned here with a species decidedly larger than the other *Asterolepis*-species. Both *A. maxima* and *A. ornata* are generally considerably smaller than the species under description, as is clearly shown by the restorations

¹ restored.

published (Traquair 1894, pl. XV—XVIII; Gross 1931) and by material of *A. ornata* in the possession of the Swedish Museum of Natural History in Stockholm. Certain individuals of these two species may, however, have attained a size only slightly smaller than that of the average-sized specimen B of *A. scabra*. Thus the length of the carapace and the length of the head may probably together be about 35—38 cm in large specimens of *A. maxima* (Traquair 1894, p. 75). According to observations made by the writer, certain of the head bones of *A. ornata* are of an approximately similar size to the corresponding ones of the present species. The table given above is also very instructive in this respect. It shows, that one of the largest dorsal articular plates of *A. ornata* does not quite attain the size of the corresponding plate in specimen B of *A. scabra*. The same conditions are indicated by a statement received from W. Gross (cfr. below p. 27 f., foot-note), according to which the ventral wall of the trunk-carapace in *A. ornata* may attain a length of about 40 cm.

As may be gathered, *A. scabra* seems thus to be the largest *Asterolepis*-species known at present. Among the *Antiarchi* in general, it is comparable as to size to *Bothriolepis maxima* (Gross 1933 a, p. 43).

Ornaments. — All the dermal bones of the skull roof and several bones of the trunk-carapace and pectoral fins are ornamented with coarse tubercles, as a rule more or less fused so as to form nodose ridges. The tubercles are sometimes distinctly stellate at their bases (pl. VI, fig. 1), exactly as in other *Asterolepis*-species (text-fig. 2 A). The ornament varies a good deal and may be different, in part in different regions of the carapace in one and the same individual, in part in corresponding regions in different stages of age. The latter case is illustrated in pl. XI, figs. 1—2. In young individuals the tubercles are relatively small and connected with each other only by narrow anastomoses. In old individuals the tubercles are coarser and broadly connected with each other, forming coarse winding ridges. — Mostly the ridges are connected with each other so as to form a network. On certain plates the ridges have a more or less regular disposition, usually radiating. This latter type of ornament is most frequently found on the following plates: the bones of the skull roof, the dorsal articular plate and the medial marginal plate of the pectoral fin, and the lateral lamina of the anterior ventro-lateral plate; the mixilateral plate has immediately beneath the main lateral line groove an ornament of rather straight rostro-caudal ridges parallel with the said groove (text-fig. 8; pl. III, fig. 1).

Especially characteristic of the species is, however, the fact that considerable parts of the carapace are devoid of or have only faint

traces of ornament¹ (text-figs. 7, 8; pls. I—II; pl. III, fig. 1). In the skull roof all bones are ornamented. As to the trunk-carapace, the development of ornament of the dorsal and lateral faces is insufficiently known. It is evident, however, that the anterior median dorsal plate is entirely without ornament. Text-fig. 8 gives a suggestion of the distribution of ornamented and unornamented areas of the lateral face, as far as could be established from the fragments preserved. As to the ventral face of the trunk-carapace, the following statements may be given. The anterior ventro-lateral plate is ornamented only on its anterior and antero-lateral parts and also on a narrow stripe along the ventro-lateral ridge. The posterior ventro-lateral plate is ornamented only laterally; the ornamented part forms an area rather broad in its middle part and tapering rapidly in an anterior and posterior direction towards the ventro-lateral ridge. The median ventral plate is devoid of ornament; the semilunar plate is, on the contrary, ornamented in the normal way. The ventral face of the carapace is thus ornamented in its anterior part and along the ventro-lateral ridges in stripes, increasing in breadth on the middle part of the posterior ventro-lateral plates. The remaining part of the ventral face is destitute of ornaments. — The pectoral fins are ornamented except on the distal part of the distal segment.

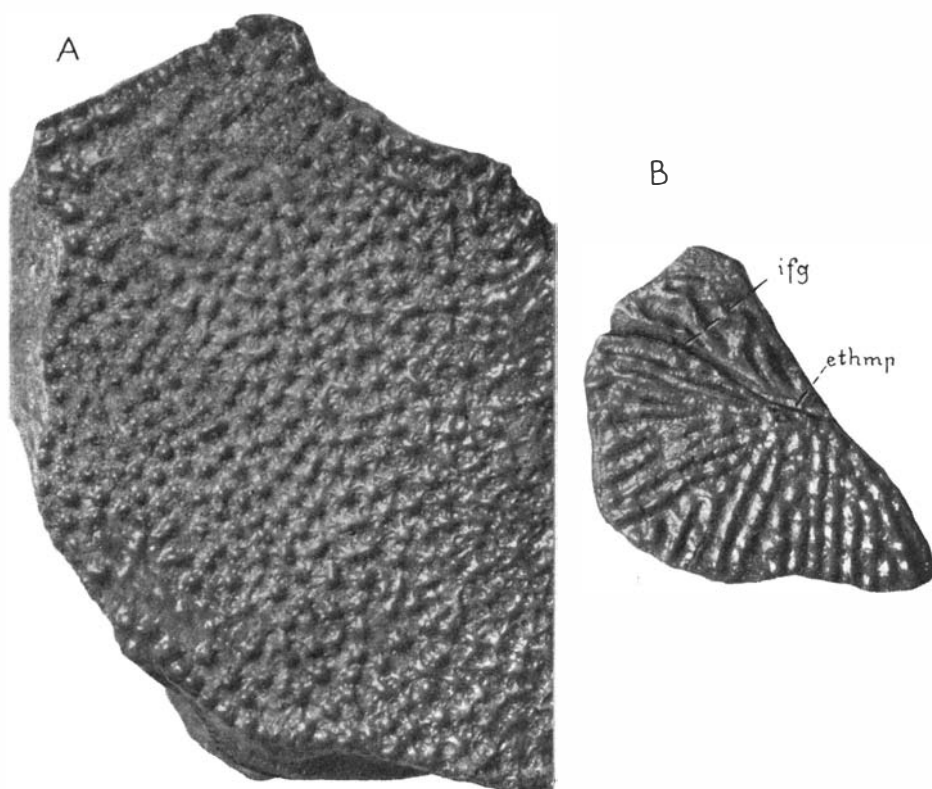
The inner faces of the bones are smooth or marked with fine radiating grooves for blood vessels and nerves (pls. I, II). The inner face of the middle median part of the left posterior ventro-lateral plate shows rather coarse tuberosities (pls. I, II, *tub*), probably of a pathological origin.

The ornament of the present species differs considerably from that in all the other *Asterolepis*-species, the dermal bones of which generally are closely set with tubercles, rarely fusing or reticulating. *A. radiata* (Gross 1933 a, pl. III, figs. 11, 15) has, as is well known, tubercles or radiating, high ridges on all its dermal bones.²

The lateral line system. — The lateral line system is generally well preserved. It is developed mainly as in *A. ornata* and the other *Asterolepis*-species (cf. Stensiö 1931, pp. 141—150). As in *Remigolepis* and *Bothriolepis*, the anterior ends of the infraorbital grooves on the

¹ The absence of ornament on the anterior median dorsal plate and on certain areas of other plates is a constant character. The three anterior median dorsal plates known are all devoid of ornament and so are also the areas mentioned below on all the ventral bones of the trunk-carapace of which the external face is preserved.

² It may be pointed out by the way, that among the material of *A. ornata* in the possession of the Swedish Museum of Natural History certain plates are found, which in regard to their ornament are somewhat suggestive of *A. radiata*. They have (indeed rather low) ridges over the whole face (text-fig. 2 B). Transitional stages can, however, be found between these and normally ornamented plates (cf. Stensiö 1931, text-fig. 8 A).

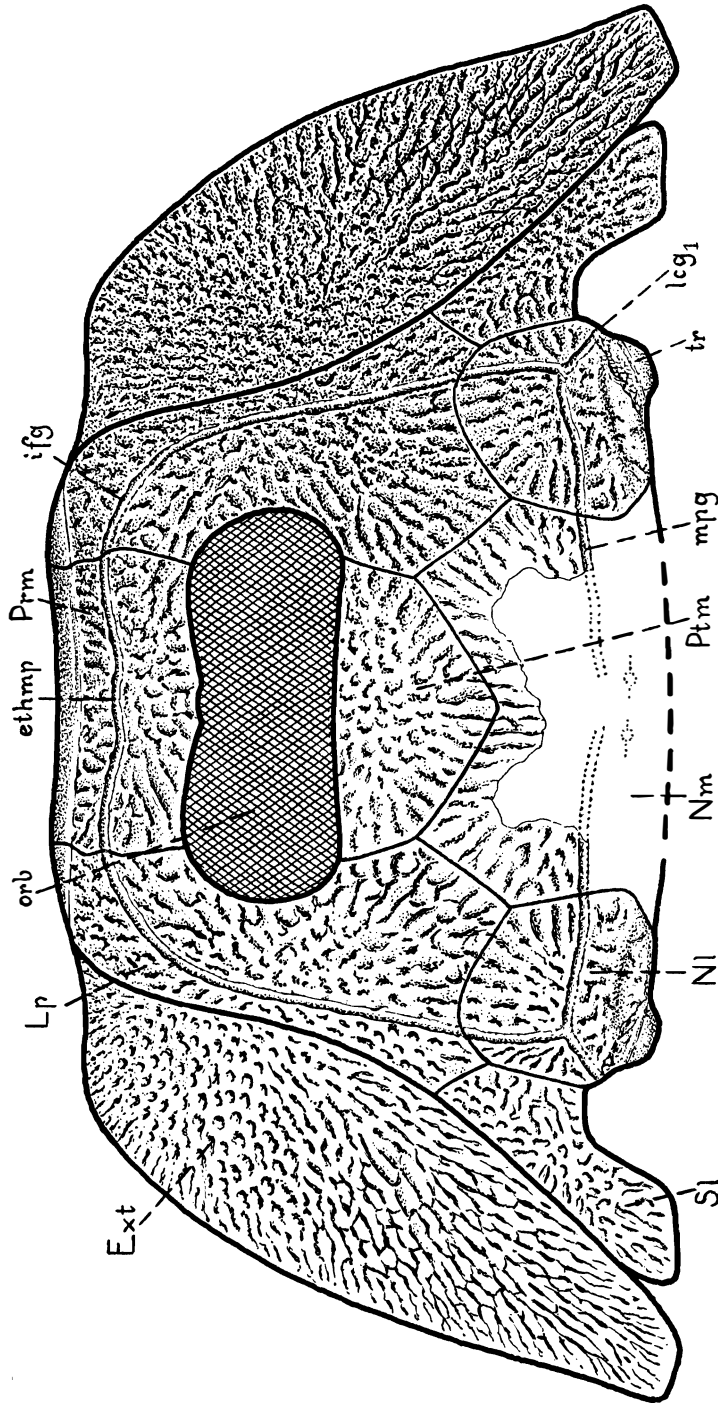


Text-fig. 2. *Asterolepis ornata*. Two plates, showing different types of ornament. Ehrmann b. Ligat, Livonia, beds Dm₄. A, ventral face of the subcephalic division of the anterior ventro-lateral plate. Tubercles with stellate bases. Specimen Riksm. no. P. 3019. B, part of a premedian plate with radiating ridges over the whole surface. Specimen Riksm. no. P. 3045. $\times 2$ diam.

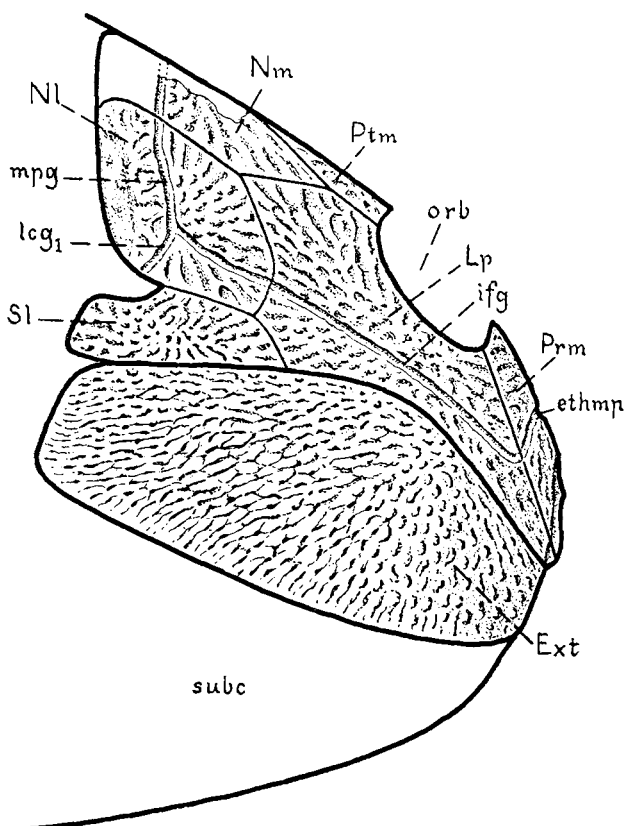
ifg, infraorbital lateral line groove; *ethmp*, pit-line uniting the main divisions of the infraorbital lateral line grooves of both sides.

premedian plate are connected with each other by a shallow transverse pit-line (cf. Stensiö 1931, p. 142). Whether the pit-line regarded by Stensiö (1931, pp. 146—148; 1938) as representing the middle head-line of pit-organs of fishes in general (*mpg*) is connected with its fellow of the other side, cannot be established, for the posterior part of the median nuchal plate on which this pit-line is situated is missing. On the semilunar plate there is a shallow transverse groove (*sg*; text-fig. 7; pls. I, II; pl. VII, figs. 1—2), which probably may be interpreted as a pit-line (Stensiö 1931, pp. 142, 150). The anterior median dorsal plate exhibits no traces of any lateral line-grooves.

Head. (Text-figs. 3—5; pl. III, fig. 2; pls. IV—VI; pl. VII, figs. 1—2). — General shape. The cranial shield except the extralaterals has a rather short rostral margin and a long posterior margin. As restored,



Text-fig. 3. *Asterolepis scabra*. Restoration of the head of an average-sized specimen in natural size. Dorsal aspect
Ext, extralateral plate; *Lp*, lateral plate; *Nl*, lateral nuchal plate; *Nm*, median nuchal plate; *Prm*, premedian plate; *Ptm*, postmedian plate; *Sl*, sufflamminal plate; *ethmp*, pit-line uniting the main divisions of the infraorbital lateral line grooves of both sides; *ifg*, infraorbital sensory canal groove; *icg₁*, cephalic division of the main lateral line groove; *mpg*, transverse commissure, probably corresponding to the middle head-line of pit-organs in general; *orb*, orbital cavity; *tr*, articular trochlea of the lateral nuchal plate.



Text-fig. 4. *Asterolepis scabra*. Restoration of the head of an average-sized specimen in natural size. Lateral aspect. (Cf. also Addendum, p. 52.)

subc, subcephalic division of the anterior ventro-lateral plate; for other explanations see the preceding text-fig.

the posterior margin is more than $2\frac{1}{2}$ times as long as the rostral margin. The lateral margins are rather strongly concave. In an anterior and, to some extent, also in a dorso-anterior view the rostral margin also appears to be much concave; its concavity is situated on the pre-median plate. The median part of the posterior margin formed by the median nuchal plate is not preserved; the most lateral part of the posterior margin formed by the sufflaminal plates projects in a characteristic way backwards to a point which must be assumed to be approximately opposite or somewhat beyond the posterior end of the median nuchal plate. Between the lateral nuchal and the posteriorly projecting part of the sufflaminal of each side there is a rather deep notch. — The fenestra orbitalis is broad and large and of the normal form characteristic of the genus *Asterolepis*.

Except possibly for the configuration of its posterior margin, the head is in its general shape much as in *A. maxima*. In the figures

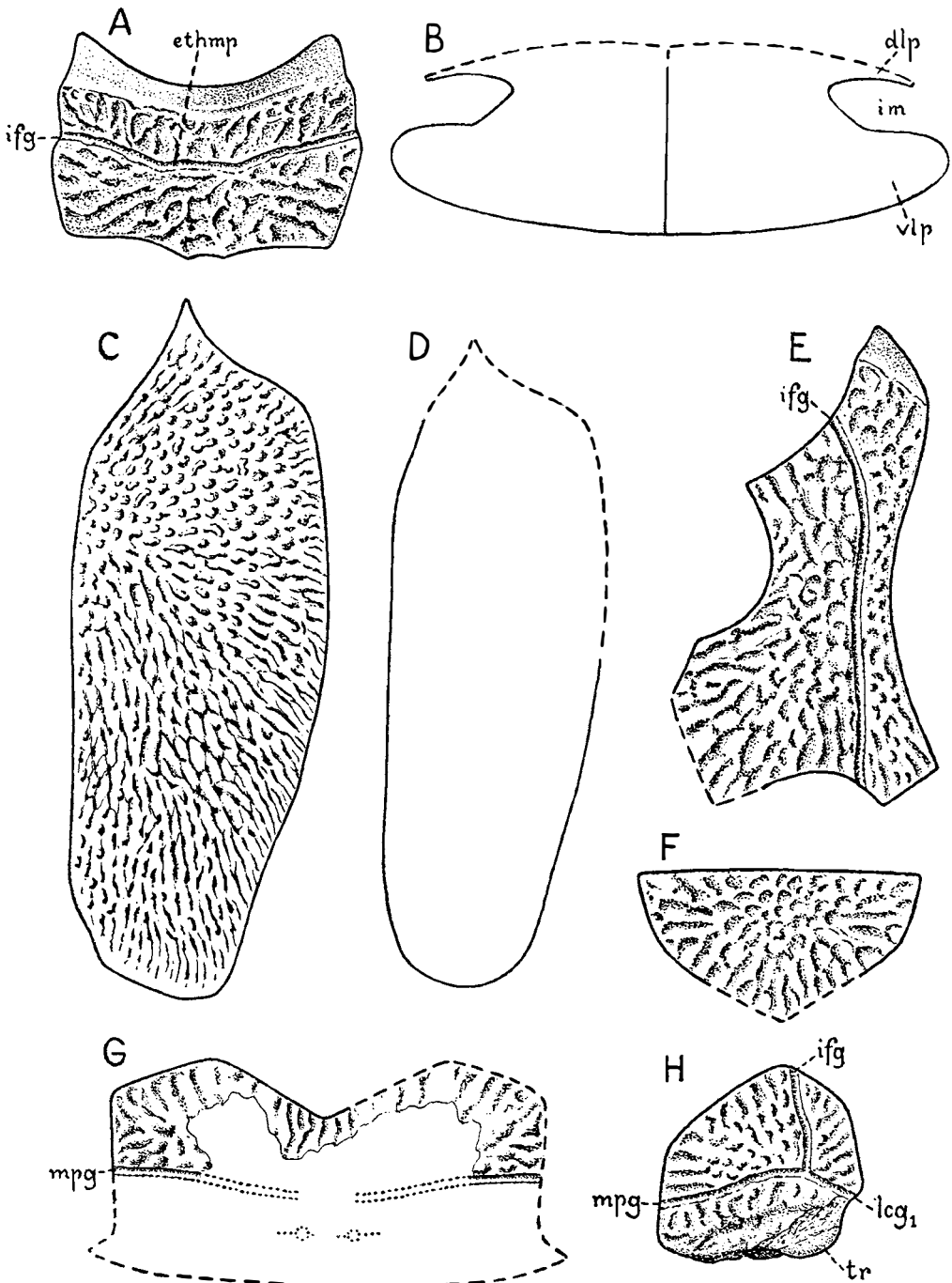
given by Traquair (1894, pl. XVII, fig. 1) the sufflaminal of *A. maxima* is narrow and short and not produced backwards, but it is impossible to decide whether this is an original condition or not. The sufflaminal of *A. scabra* resembles closely that of *A. ornata* (Gross 1931, pl. IV, figs. 2, 3; pl. XII, fig. 7), but its posterior process is a little longer than in the latter species. *A. scabra* differs further from *A. ornata* as restored by Gross in a broader posterior margin and more concave lateral margins of the cranial shield. As to the general shape of the skull roof, *A. scabra* seems to be suggestive of *A. cristata* (Obrutshev 1933 a, pl. I, fig. 3). The sufflaminals of *A. cristata*, however, are unknown. The skull roof of *A. scabra* differs from that in *A. säve-söderberghi* (Stensiö 1938, text-fig. 1) in its somewhat longer rostral margin, in its shorter and broader orbital fenestra and, above all, in its much narrower and longer sufflaminal. It is in addition clearly distinguished from that in *A. orcadensis* (Watson 1932, text-fig. 3; pl. IV, fig. 1) in its concave lateral margins. It differs from that in *A. thule* (Watson 1932, text-fig. 4) in a greater breadth and in a much smaller length.

The premedian plate (*Prm*; text-fig. 5 A; pl. V, fig. 1) is of the same fundamental type as that of *Asterolepis* in general (Stensiö 1931, pp. 31—36), but seems to be much broader and to have its sensory grooves (the infraorbital grooves) situated further posteriorly than in the other species. In this connection it should be mentioned, however, that the plate under consideration is unknown in *A. thule* and *A. radiata*.

The lateral plate (*Lp*; text-fig. 5 E; pl. III, fig. 2; pls. IV, V; pl. VI, fig. 1) is in all fundamental respects as in the other *Asterolepis*-species (Stensiö 1931, pp. 36—39). The lateral margins are rather strongly concave. The posterior end of the bone, which has a rather large face, the posterior face, exhibits laterally to the infraorbital sensory groove a rather large opening leading into a deep funnel-shaped pit (pl. III, fig. 2, *f*), which enters the bone in an anterior direction. This funnel-shaped pit agrees fairly well with the corresponding structure in *A. ornata* (Gross 1931, p. 27; pl. IV, fig. 14; Stensiö 1931, text-fig. 8 B, E), but its ventral and lateral walls are better developed

Text-fig. 5. *Asterolepis scabra*. Restorations of the various head-bones. External view. Nat. size. A, premedian plate; B, mental plates of both sides; C, a right extralateral plate (after specimen B); D, a right extralateral plate (after the type specimen); E, a right lateral plate; F, postmedian plate; G, median nuchal plate (after the type specimen); H, a right lateral nuchal plate.

dlp, dorso-lateral process of the mental plate; *ethmp*, pit-line uniting the main divisions of the infraorbital lateral line grooves of both sides; *ifg*, infraorbital lateral line groove; *im*, mental incisure; *lcg*, cephalic division of the main lateral line groove; *mpg*, transverse commissure, probably corresponding to the middle head-line of pit-organs of fishes in general; *tr*, articular trochlea of the lateral nuchal plate; *vlp*, ventro-lateral process of the mental plate.



Text-fig. 5.

and more backward-produced. Immediately medially to the lateral line groove, the posterior face of the bone has a vertical, rather strongly developed wall (pl. III, fig. 2, Lp_1). In the material of *A. ornata* at my disposal there are only slight indications of such a wall.

The problematic bone in the orbital fenestra, denoted with the letter *y* in the plates (pls. IV—V), has the normal ornament characteristic of dermal bones and exhibits an S-formed, relatively broad, shallow groove along one of its margins. It may be either a displaced fragment of a pineal-plate with the anterior margin turned somewhat to the left side, or else a sclerotic plate. If the latter alternative should be true, it would be nearest comparable to the bone called by Patten the posterior dorsal sclerotic plate (Patten 1912, p. 375; text-fig. 255, *d. s.*). It may be mentioned that among the *Antiarchi* sclerotic bones are hitherto found in *Bothriolepis* (Patten, l. c.; etc.), *Remigolepis* (Stensiö 1931, p. 57), *Pterichthyodes* (Traquair 1904, pp. 99—100; pl. XX, fig. 3; "ocular plates") and possibly also in *Asterolepis* (Gross 1933 a, pp. 34—35).

The postmedian plate (*Ptm*; text-figs. 3, 5 F; pl. IV; pl. VI, fig. 1) is of a type normal to the genus (Stensiö 1931, pp. 41—43). It is almost as broad as in *A. maxima*, but, judging from Traquair's restoration (1894, text-fig. 37), it is somewhat longer than in that species. On the other hand, it is a little broader in proportion to its length than in *A. ornata* (Gross 1931, pl. IV, fig. 1; pl. XII, fig. 7; Stensiö 1931, text-fig. 12). It differs also only slightly from the corresponding plate in *A. orcadensis* (Watson 1932, text-fig. 3).

The median nuchal plate (*Nm*, Nm_1 ; text-figs. 3, 5 G; pl. VI) is missing in spec. B and very imperfectly preserved in the type-specimen, but its shape can be restored in both these specimens, in the former with the guidance of the extent of the surrounding bones (text-fig. 3). In the type specimen it seems to have been much broader and shorter than in spec. B; and it is therefore likely that it may vary rather much in shape here in different individuals as it does also in *A. säve-söderberghi* (Stensiö 1938, p. 11, text-figs. 2, 7, ?9) and *A. ornata* (Stensiö 1931, text-fig. 13). It is of a similar general type to that in the other *Asterolepis*-species (l. c., pp. 42—49). The occipital face (Nm_1) was probably lower than is generally the case in *A. ornata*.

The lateral nuchal plate (*Nl*, Nl_1 ; text-figs. 3, 5 H; pl. III, fig. 2; pl. IV; pl. VI, figs. 1, 2) is in all main characters as in the other species of the genus (Stensiö 1931, pp. 49—51). The part situated behind the transverse pit-line is rather broad. The occipital face (Nl_1 ; pl. III, fig. 2; pl. VI, fig. 2) with the trochlea (*tr*) for the articulation with the anterior dorso-lateral plate of the trunk-carapace is completely preserved and in the main developed as in *A. ornata* (l. c., text-fig. 19).

The sufflaminal plate (*Sl*, text-figs. 3, 4; pl. VI, fig. 1) is of much the same type as that in *A. ornata* (Gross 1931, pl. IV, fig. 2, 3), but its free posterior part is still more produced in a backward direction (see also pp. 15 f. above).

The extralateral or opercular plate (*Ext*; text-figs. 3, 4, 5 C, D; pls. IV—VI) is well preserved both in the type-specimen and in spec. B. In the former specimen it lacks its most anterior part, in the latter specimen its posterior parts are somewhat damaged. The bone is quadrangular in shape, but it is much more long than broad. It is broadest in its anterior half, thence gradually decreasing in breadth in a backward direction. As it is considerably lower in the type specimen than in specimen B, its length: breadth ratio in these two specimens being respectively 3:1 and 2.5:1, it seems to vary fairly much in its proportions in different individuals. The margins are directed dorsally, anteriorly, ventrally, and posteriorly. The antero-dorsal corner, that is the corner between the dorsal and anterior margins, is produced forwards into a rather strong pointed process, the antero-dorsal process. The other corners are all well rounded off. The dorsal margin is in its by far larger posterior part almost straight or slightly convex. In the anterior part it is slightly concave and curved downwards towards its anterior end. The anterior margin is slightly concave, whereas the ventral and posterior margins are both slightly convex.

The centre from which the ridges forming the ornament radiate is situated in the anterior half of the plate close to the dorsal margin. The inner face (pl. VI, fig. 1) is as a rule smooth. Underneath the centre of radiation of the ornament it has, however, a somewhat rough area. From this area a groove (*gr*) passes downwards and somewhat backwards to a foramen (*for*) which leads into a canal in the bone.

The plate under consideration seems to be higher than in *A. ornata* (Gross 1933 a, pl. III, fig. 4) and decreases also more slowly in breadth backwards and forwards than in this species. Whether it is much different from that in *A. maxima* is impossible to say at present (cf. Traquair 1894, pp. 79—80; pl. XV). In the other *Asterolepis*-species it is still unknown.

Any prelateral plate is not preserved. The anterior margin of the extralateral plate shows no indications of a firm connection with a prelateral plate, but in spite of this such a plate may of course have been present. In such a case it must have lain loosely in the skin in its normal place in the angle (pl. V, fig. 1) between the anterior margin of the extralateral plate and the skull roof (cf. Stensiö 1931, pp. 58—60; Gross 1933 a, p. 34).

Of the mental plates (text-fig. 5 B; pl. VII, fig. 1) only one is found preserved. This plate is mainly represented by an impression of its inner face. Being situated so as to have its inner face down-

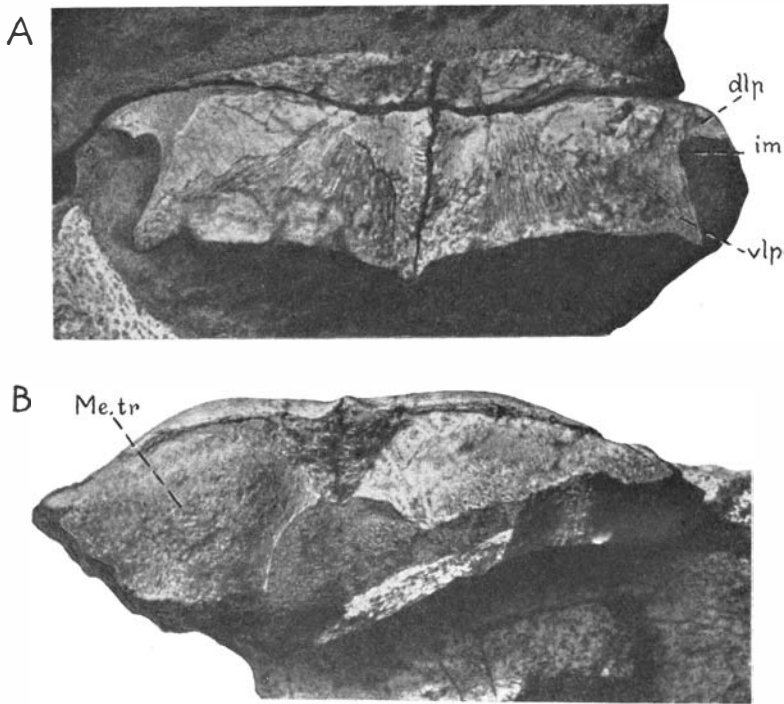
wards, it has been displaced and turned upside down before the embedding in the rock. Obviously influenced by its shape in *Pterichthyodes* and by its position in the fossil, Stensiö (1931, text-fig. 24 B) has orientated the plate in such a way that the margin, which in the fossil is the posterior one, is considered as the aboral one. The plate should then be derived from the right side. It is very difficult to decide, whether this orientation is correct. It is also possible, that the present posterior margin may indeed be the oral margin; if this is so, the plate would of course be from the left side.

New material of *Remigolepis* from East Greenland has widened our knowledge of the structure of the mental plate in general, and has thus given us a new basis for a discussion of the above question. From the aboral part of the interior face of the plate in *Remigolepis* (text-fig. 6 A, B), a high, transverse lamina arises somewhat below the aboral margin perpendicularly to the plate proper. This transverse lamina is bent so as to have a convex upper and a concave lower face. It extends as far laterally as to be present also inside a well developed process from the dorso-lateral corner of the plate proper, a process which may be called the dorso-lateral process.

The margin of the mental plate in *A. scabra* which, in the fossil, is aboral, is damaged; it has, however, such a shape that it might possibly include vestiges of a transverse lamina corresponding to that in *Remigolepis*. This condition would support the opinion that the plate would be orientated not as supposed by Stensiö but as shown in text-fig. 5 B. The question of orientation of the plate here under description cannot, however, be definitely solved without new material.

The plate may preliminarily be described in the following way, according to the changed orientation.

It is somewhat more broad than long (ratio breadth : length about 3 : 2) and presents an aboral, an oral, a medial, and a lateral margin. Its internal face is fairly strongly concave in the antero-caudal and transverse directions. Its outer face is very imperfectly preserved and owing to this its exact shape cannot be ascertained. The ornament is unknown. The medial margin is perfectly straight and may, therefore, be assumed to have been in contact with the corresponding margin of the plate of the other side, as in *Remigolepis* (text-fig. 6 A) and *Pterichthyodes* (Traquair 1894, text-fig. 35). The margin supposed to be the oral one by the present writer seems to have had such a position that together with the corresponding margin of the plate of the other side it formed a convex dorsal boundary of the mouth. The aboral margin also formed a convex outline together with the corresponding margin of the plate of the other side. The lateral margin exhibits a deep lateral notch (*im*), the mental incisure, bounded in front by the process considered to correspond to the dorso-lateral process (*dlp*) of the mental



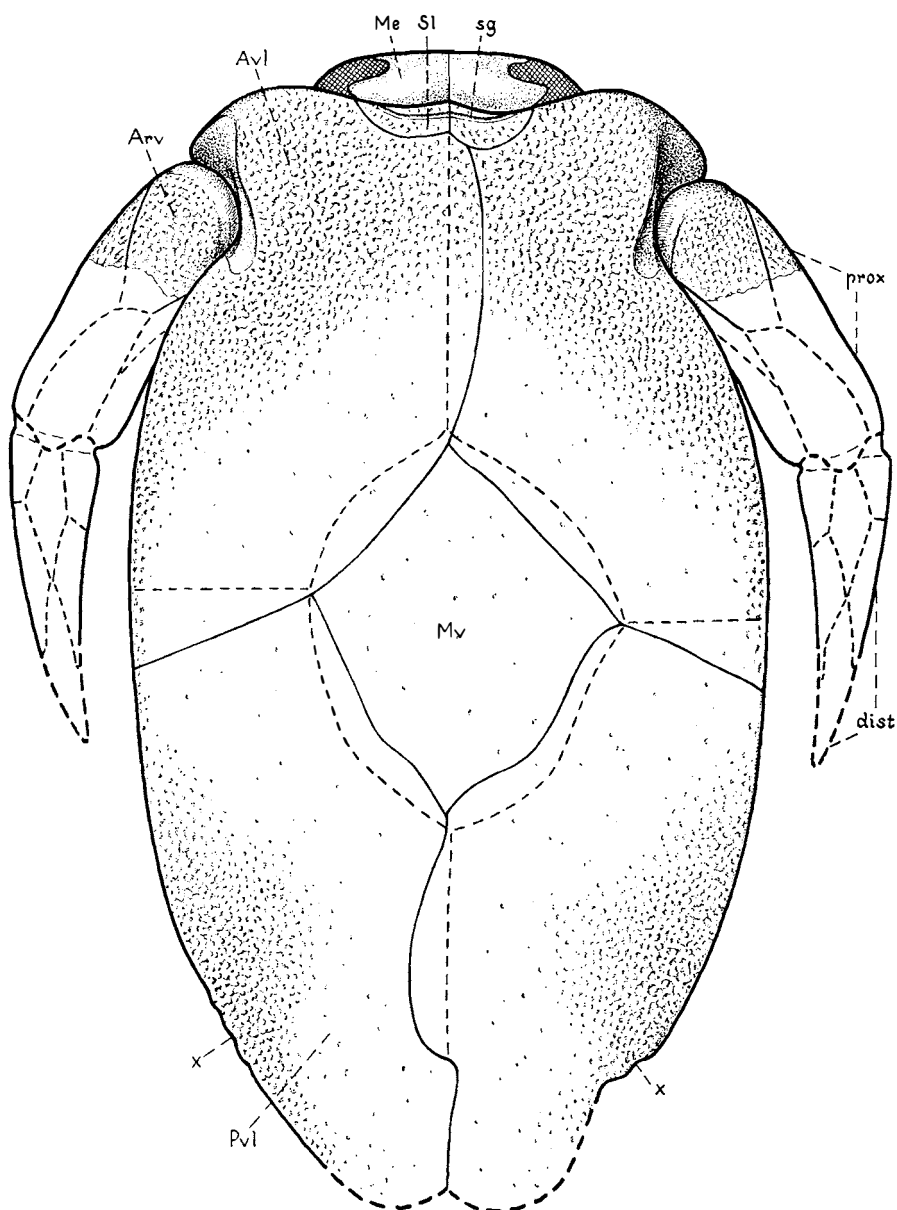
Text-fig. 6. *Remigolepis* sp. Mental plates of both sides in juxtaposition. A, anterior view. B, dorsal view; the part dorsally to the crack shown in fig. A removed. Specimen in the possession of the Geological Survey of Greenland, Copenhagen, no. 500 a—b. From the Upper Devonian (*Remigolepis* Series) of Mt. Celsius (East Plateau), East Greenland. $\times 2\frac{1}{2}$ diam.

Me.tr, transverse lamina of the mental plate; *dlp*, dorso-lateral process; *im*, mental incisure; *vlp*, ventro-lateral process.

plate in *Remigolepis* and below by a still longer and very robust ventro-lateral process (*vlp*). A notch which certainly is homologous to the mental incisure is also found in *Pterichthyodes*, *Remigolepis* and *Bothriolepis*. The notch in these forms, however, has a position which is more or less different from that in *A. scabra*. Thus in *Pterichthyodes* it lies in the oral part, in *Remigolepis* in the middle part and in *Bothriolepis* more in the aboral part of the lateral margin of the plate.

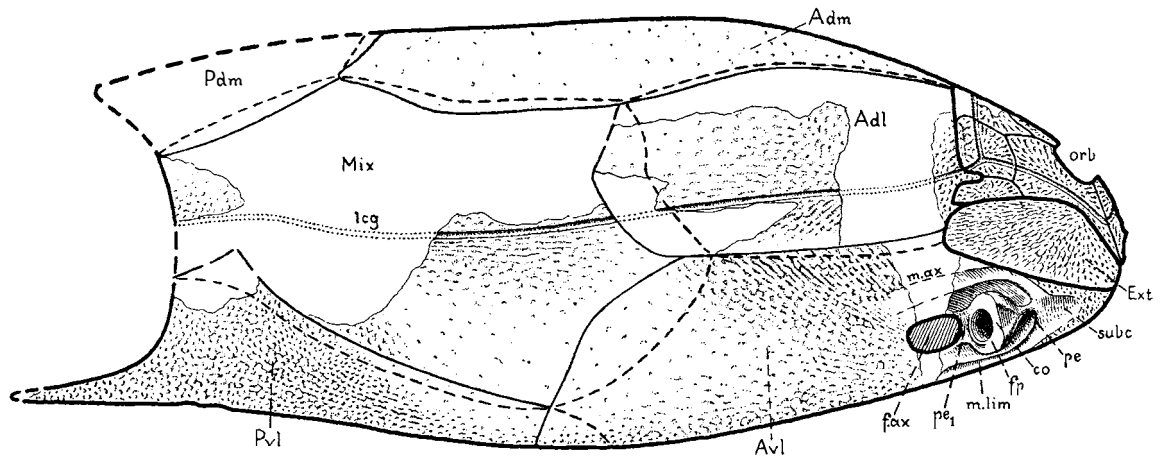
Below the ventral margin of the premedian plate and dorsally to the mental plate there is in spec. B a fragment (*x*; pl. V) of a problematic bone.

Behind the mental plate there are preserved several bones or bone-fragments (*a—d*; pl. VII, figs. 1—2), partly or entirely belonging to the visceral skeleton. Because of their imperfect state of preservation they cannot be compared to the visceral bones known in *Bothriolepis*



Text-fig. 7. *Asterolepis scabra*. Restoration of the carapace of an average-sized specimen (spec. B) in $\frac{1}{3}$ of the natural size. Ventral aspect. The internal boundaries of the plates are marked with broken lines.

Arv, ventral articular plate; *Avl*, anterior ventro-lateral plate; *Me*, mental plate; *Mv*, median ventral plate; *Pvl*, posterior ventro-lateral plate; *Sl*, semilunar plate; *dist*, distal segment, *prox*, proximal segment of the pectoral fin; *sg*, groove probably for a pit-line; *x*, normally ornamented irregular pit or shallow depressions on the ventro-lateral ridge.

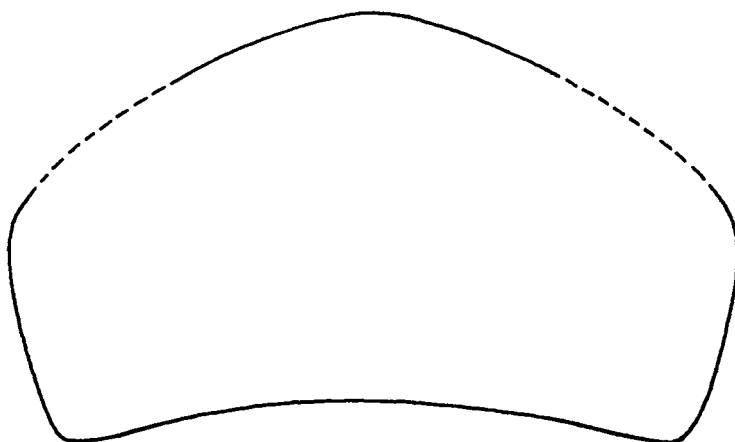


Text-fig. 8. *Asterolepis scabra*. Attempted restoration of the carapace of an average-sized specimen in $\frac{1}{3}$ of the natural size. Lateral aspect. The internal boundaries of the plates are marked with broken lines. For explanation of the head see text-fig. 4.

Adl, anterior dorso-lateral plate; *Adm*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; *Ext*, extralateral plate; *Mix*, mixilateral plate; *Pdm*, posterior median dorsal plate; *Pvl*, posterior ventro-lateral plate; *co*, pars condyloidea of the processus brachialis; *fax*, foramen axillare; *fp*, funnel pit of the processus brachialis; *lcg*, main lateral line groove; *m.ax*, dorsal margin of the fossa axillaris; *m.lim*, margo limitans of the fossa articularis pectoralis; *orb*, orbital cavity; *pe*₁, posterior face of *pe*, pars pedalis of the processus brachialis; *subc*, subcephalic division of the anterior ventro-lateral plate.

(Stensiö 1931, pp. 63—69); the suspicion may be advanced, however, that the plate *b* possibly represents the bone in *Bothriolepis*, termed pentagonal plate by Stensiö.

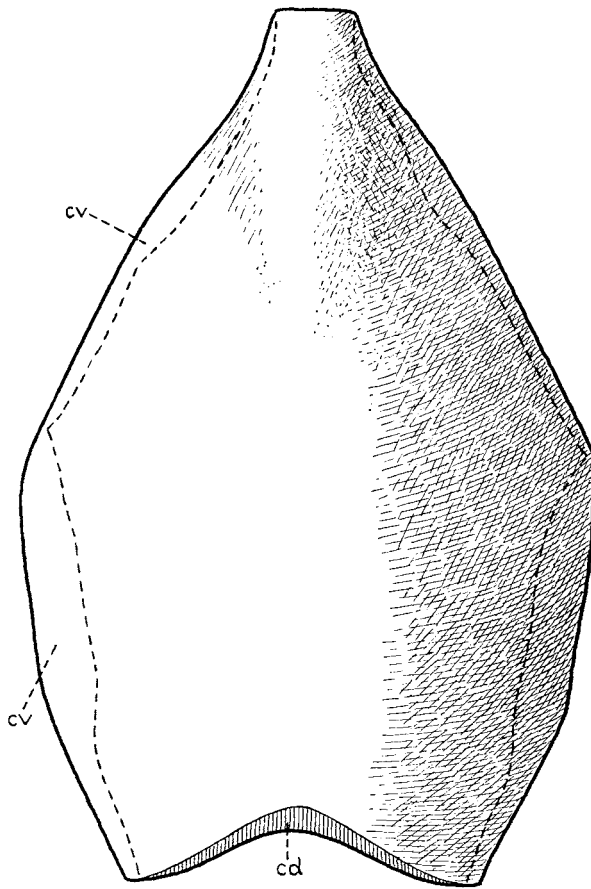
The trunk-carapace (text-figs. 7—11; pls. I—II, pl. III, fig. 1; pls. VI—XIII; pl. XIV, fig. 1) is in its general shape fundamentally as in the other *Asterolepis*-species (cf. Stensiö 1931, pp. 72—107). The breadth: length ratio of the ventral wall is about 1.15:2, and this wall is therefore proportionally narrower than in *A. orcadensis* (Watson 1932, text-fig. 3) and probably also than in *A. säve-söderberghi* (Stensiö 1938, text-fig. 7). In regard to breadth it thus approaches *A. maxima* (Traquair 1894, text-figs. 37—39) and *A. ornata* (Gross 1931, text-fig. 12; 1933 a, text-fig. 16; cf. also below pp. 27 f., footn.). The height of the carapace in proportion to the breadth of the ventral wall seems, according to the reconstructions, to have been almost as in *A. maxima*, but considerably smaller than in *A. ornata*. The posterior part of the ventral wall is rather rounded off at its posterior end and broader and shorter than in *A. maxima*, but narrower and more obtuse than in *A. ornata*. The part of the ventral wall (the subcephalic division) situated anterior to the axial joints is short. The ventral face is, in the fossil state and presumably also



Text-fig. 9. *Asterolepis scabra*. Attempted transverse section of the trunk-carapace a little behind its middle part. $\times 1/3$ diam.

originally (cf. above p. 8), slightly convex in a longitudinal direction and concave in a transverse direction. The dorsal outline is in lateral view as in *A. ornata*, and is thus less angular than in *A. maxima*. It does not curve downward until far anteriorly, at the transition between its middle and anterior thirds approximately, not, as in *A. ornata* and *A. maxima*, approximately at the middle of its length.

The anterior median dorsal plate (*Adm*, text-figs. 8, 10; pl. VII, fig. 3; pl. VIII; pl. IX, fig. 1) agrees in its length: breadth ratio with that in *A. ornata* (Gross 1931, text-fig. 14), *A. radiata* (Rohon 1900, text-fig. 11), and *A. säve-söderberghi* (Stensiö 1938, text-fig. 3). The greatest breadth is, as in the two first-mentioned species, across the anterior of the two lateral angles. It is broader than in *A. maxima* (Traquair 1894, text-fig. 40; pl. XVI, fig. 1) and *A. thule* (Watson 1932, text-fig. 5), narrower than in *A. orcadensis* (Watson 1932, pl. IV, fig. 2) and *A. cristata* (Obrutshv 1933 a, pl. 14). Its dorsal outline is in lateral view gently convex, without any pronounced dorsal angle, and characteristic of this outline is also that it begins to curve downwards first at the transition between its middle and anterior thirds (cf. above). The most anterior part of the plate is slender and the anterior margin shorter even than in *A. ornata*, the ratio breadth of anterior margin: breadth of posterior margin being here about 1:4, in *A. ornata* 1:3. The anterior margin is approximately straight, as in *A. ornata* and *A. orcadensis*, not convex, as in *A. maxima* and *A. thule*, or concave, as in *A. säve-söderberghi*. The posterior margin is comparatively broad, broader than in *A. ornata* and *A. maxima*. As normally in the genus, the caudal margin of the external face is rather concave. The posterior margin of the internal face, which is also preserved, is also distinctly concave, and it has, therefore, a different configuration than in the other

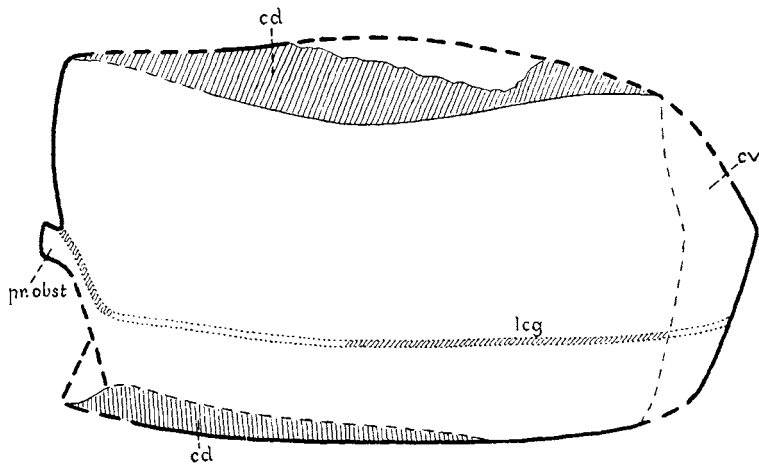


Text-fig. 10. *Asterolepis scabra*. Restoration of the anterior median dorsal plate (after the specimen figured in pl. VIII and its counterpart, spec. Upps. no. P. 437 b).

Dorsal aspect. $\times \frac{1}{2}$ diam.

cd, overlapped area; *cv*, overlapping area (on the internal face).

Asterolepis-species, in which, taken as a whole, it is straight. The anterior lateral overlapping area is rather narrow (*cv*, pl. VIII; the corresponding overlapped area on the detached anterior dorso-lateral plate reproduced in pl. IX, fig. 2 is broader). The external face is rounded in a transverse direction and contrary to what is the case in the other *Asterolepis*-species it has no traces of any dorsal median ridge. The internal face is smooth in its posterior half, whereas in its anterior half it exhibits a somewhat raised area situated as the ventral process in *Bothriolepis canadensis* (Stensiö 1931, text-fig. 33, *prv*). From this area a paired well developed antero-lateral ridge (*alr*, pl. VIII) extends forwards to the anterior part of the lateral margin. Between the two antero-lateral ridges there is a median fossa, certainly for the levator muscles of the head (levator fossa, *f. retr*; cf. Stensiö 1931, p. 76).



Text-fig. 11. *Asterolepis scabra*. Restoration of a left anterior dorso-lateral plate (after the specimen figured in pl. IX, fig. 2). External view. $\times 3/4$ diam.

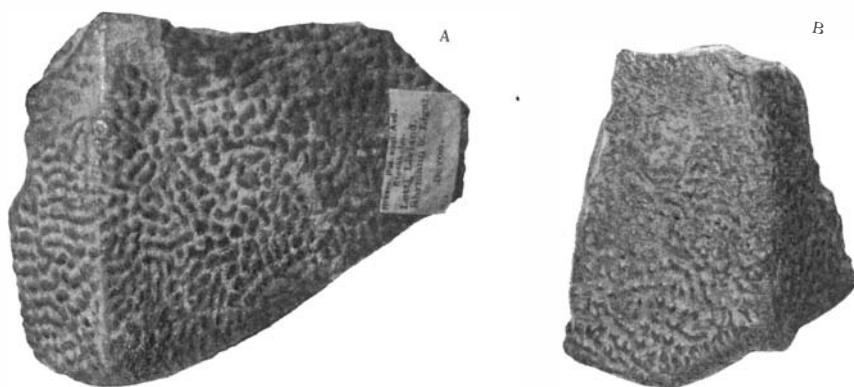
cd, overlapped area; *cv*, overlapping area (on the internal face); *lcg*, main lateral line groove; *pr.obst*, processus obstans.

The posterior median dorsal plate¹ is not preserved in the material at hand.

The anterior dorso-lateral plate (*Adl*, text-figs. 8, 11; pl. III, fig. 1; pl. VI, figs. 1, 3; pl. IX, fig. 2) is of a type very similar to that in *A. ornata* (Gross 1931, text-fig. 16; 1933 a, text-fig. 17:3) and *A. maxima* (Traquair 1894, text-figs. 42—43; pl. XVI, fig. 3), but distinctly longer and narrower than that in *A. säve-söderberghi* (Stensiö 1938, text-fig. 5). The lateral line canal runs more dorsally than in *A. ornata*. The dorsal external margin is somewhat convex, the ventral margin almost straight. The angle between the dorsal and the ventral divisions in the anterior part of the plate amounts to almost 120° .

The anterior part with the crista transversalis interna anterior (*Adl*₁) is well preserved in the type specimen. The crista mentioned is to be seen both in anterior and posterior view (pl. VI). It is shaped much as in *A. ornata* (Gross 1931, pp. 30—31; pl. V, fig. 4; pl. VII, fig. 9; 1933 a, text-figs. 2, 3; Stensiö 1931, pp. 80—82), but is a little higher and stronger. It has a well developed horizontal, medially

¹ According to Gross (1933 a, p. 35; cf. Gross 1931, pp. 29—30, text-fig. 15) the principal difference between *A. ornata* and *A. maxima* is, that the posterior median dorsal plate in the former species has a concave posterior margin. Among the material of *A. ornata* in the possession of the Swedish Museum of Natural History there are, in addition to plates of this type (text-fig. 12 B), also several other plates (text-fig. 12 A), in which the posterior margin is produced backwards. In such circumstances the difference between *A. ornata* and *A. maxima* (Traquair 1894, pl. XV; pl. XVI, fig. 2) seems to be rather slight.



Text-fig. 12. *Asterolepis ornata*. Two fragmentary posterior median dorsal plates in dorsal aspect, showing the outline of the posterior margin, A with the posterior end produced backwards, B with concave posterior outline. Specimens Riksm. nos. P. 3029 a (A) and P. 3029 b (B). Ehrmann b. Ligat, Livonia, beds Dm₄. Nat. size.

directed process (*pr.art*) bearing the articular fossa for the trochlea of the head. The anterior face of this crista shows a few foramina (*for*) for nerves and vessels. The dorsally ornamented processus obstans (*pr.obst*) is rather strong, broad, and truncated, and situated so as to fit in the notch between the lateral nuchal and the sufflaminal plate of the head.

The mixilateral plate (*Mix*, text-fig. 8; pl. III, fig. 1; pl. X) is very imperfectly known, but as far as may be seen it does not differ much from that in *A. maxima* and *A. ornata*.

The anterior ventro-lateral plate (*Avl*, text-figs. 7, 8; pls. I—V; pl. VII, figs. 1—2; pls. XI—XIII; pl. XIV, fig. 1) is completely preserved and agrees in the main with that in other *Asterolepis*-species (cf. Stensiö 1931, pp. 89—102). The length: breadth ratio of the ventral lamina is only slightly larger than in *A. ornata* (Gross 1931, text-fig. 19)¹ and *A. maxima* (Traquair 1894, text-figs. 45—46; pl. XVII,

¹ In a letter Dr. Gross has kindly given me some new measurements in *A. ornata*. The part of the letter dealing with these measurements is as follows. "Meine Maßangaben über *Asterolepis ornata* (1933) sollen nur die Maximalangaben sein, die ich auf Grund bestimmter Stücke errechnen konnte. Diese Zahlen sollen daher nicht reine Verhältniszahlen an einem Individuum sein. In meiner Arbeit (1931) habe ich das AVL (Abb. 19) etwas zu breit rekonstruiert; die Breite muß statt 4.8 cm nur 4.2 cm betragen. Leider liegt mir kein intaktes AVL und kein intaktes PVL vor. Sicher kann ich nur die Länge und die Breite des AVL berechnen. Die zwei größten AVL aneinandergesetzt ergeben eine maximale Breite des Ventralpanzers von 19 cm; die Länge dieser AVL muß dann 21.5 cm betragen, was sogar auf eine Gesamtlänge des Ventralpanzers von 40 cm schließen läßt. Das Modell, das ich 1928 anfertigte, und das den Gesamtrekonstruktionen in meiner älteren Arbeit (1931) zu Grunde liegt, hat folgende Maße: Länge des Dorsalpanzers 30.5 cm; Länge des Ventralpanzers 34 cm; größte Breite 19 cm. Unter

figs. 3—4). The subcephalic division (situated in front of the axial joint; *subc*) is rather short. The lateral lamina is approximately as high as in *A. ornata*, considerably higher, however, than in *A. maxima*, and not so strongly declining in an anterior direction. The posterior margin of the lateral lamina slopes less steeply backwards than in both these species.

The articulation apparatus for the pectoral fin is completely exposed (text-fig. 8; pl. XI, figs. 2—3; pl. XII). It is developed in the main as in *A. ornata* (cf. Stensiö 1931, pp. 92—96, text-figs. 41—42; Gross 1931, pp. 39—40, text-figs. 18—19; pl. V, figs. 5, 6; pl. VII, figs. 12—14), but it differs from the one of this species in the following details. The posterior face of the pars pedalis (*pe*₁) is relatively much higher than that in *A. ornata* as compared to its breadth as well as to the length of the antero-posterior extent of the pars pedalis and to the height of the pars condyloidea (*co*). The posterior, more plane face of the pars condyloidea seems to have a more vertical position than in *A. ornata*, where it faces somewhat ventrally. The posterior opening of the funnel-pit (*fp*) occupies a larger part proportionally of the posterior face of the pars condyloidea. In the dorso-medial corner of this funnel-pit there is in both species a groove (*gr*), which seems to be deeper in the species here under description than in *A. ornata*. The dorsal and ventral margo limitans of the dorsal and ventral fossa articularis (*m.lim*) is much more robust than in *A. ornata*. The groove between the dorsal margo limitans and the dorsal margin of the fossa axillaris (*m.ax*) is more strongly developed than in *A. ornata*. Close below the anterior end of the ventral margo limitans three foramina are to be seen (*c.rca*). The foramen axillare (*f.ax*), the approximate shape of which may be ascertained (text-fig. 8), is oval and more long than high.

The external face of the lateral lamina is distinctly concave in a dorso-ventral direction. In addition to traces of the anterior higher branch of the crista transversalis interna anterior, which in the present material is mostly broken off (*cit*₁), a well defined low, rounded posterior branch

Gesamtlänge des Ventralpanzers verstehe ich eine Länge vom vordersten Endpunkt des AVL (also nicht an der Mittellinie) bis zum hintersten Punkt des PVL. Wie variabel diese Größen bei verschiedenen Exemplaren des gleichen Knochens sein können, zeigt einem besonders deutlich die Betrachtung des Hinterendes des PMD: bei gleicher maximaler Breite können die Knochen mehr als ein cm länger oder kürzer sein.

Zu meiner 1931 erschienenen Arbeit lag mir nicht ein so großes Material vor wie zu der Arbeit von 1933. Mir fehlt aber auch jetzt noch ein PVL, an dem ich ganz sicher das Verhältnis von Länge und Breite der Ventralseite dieses Knochens errechnen kann. Auf alle Fälle ist der Dorsalpanzer kürzer als der Ventralpanzer. Das Längenverhältnis von AVL zu PVL scheint mir etwa wie 21.5 zu 19 zu sein."

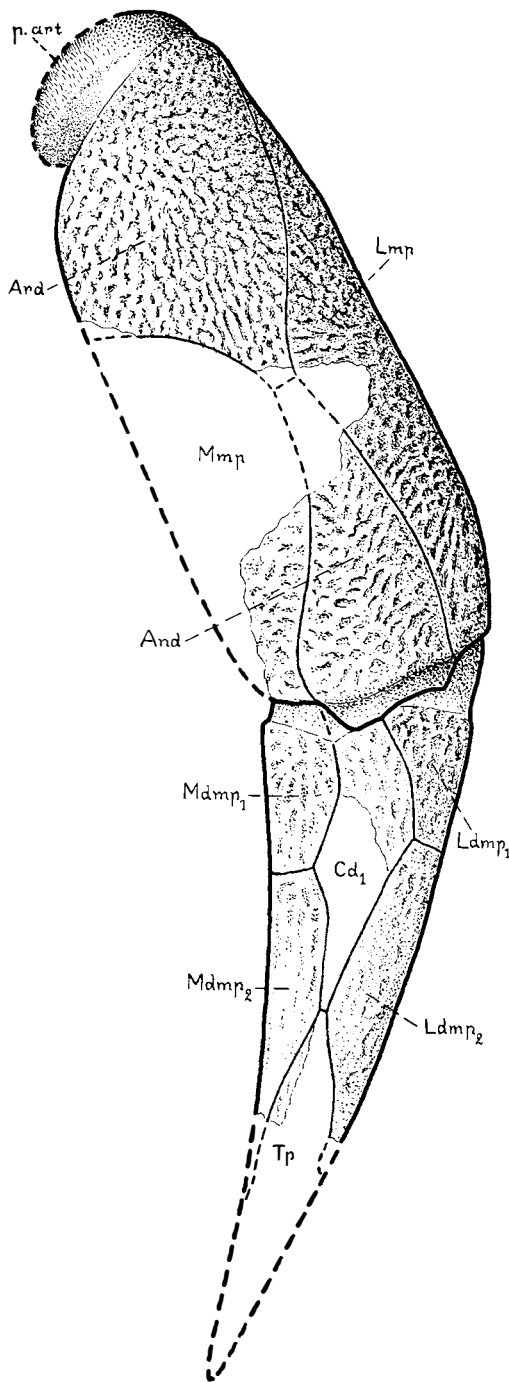
Text-fig. 13. *Asterolepis scabra*. Restoration of the right pectoral fin in dorsal aspect (after spec. B).

$\times \frac{3}{4}$ diam.

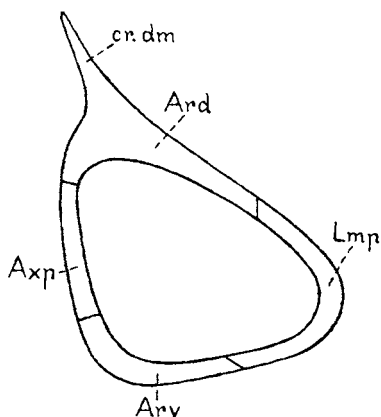
And, dorsal anconeal plate; *Ard*, dorsal articular plate; *Cd*₁, dorsal central plate; *Ldmp*₁, *Ldmp*₂, lateral marginal plates of the distal segment; *Lmp*, lateral marginal plate of the proximal segment; *Mdmp*₁, *Mdmp*₂, median marginal plates of the distal segment; *Mmp*, medial marginal plate of the proximal segment; *Tp*, terminal plate; *p.art*, pars articularis of the dorsal articular plate.

of the said crista (*cit*₂) is present on the internal face of the ventral lamina, quite as in *A. ornata*.

The posterior ventro-lateral plate (*Pvl*, text-figs. 7, 8; pls. I—II; pl. III, fig. 1; pl. IX, figs. 3, 4) lacks its most posterior part. It is very likely, however, that this part was as shown in the restoration given in text-figs. 7, 8 (cf. above p. 9). In proportion to its breadth (length : breadth ratio 2 : 1) as well as to the length of the anterior ventro-lateral plate, the ventral lamina is longer than in *A. ornata* (Gross 1931, text-fig. 20), but shorter than in *A. maxima* (Traquair 1894, text-figs. 47—50; pl. XVII, figs. 5—6), a condition due mainly to the posterior extent of its hindmost part. This part, which has its posterior end well rounded off, is broader and shorter than in *A. maxima*. On the other hand, it is narrower and less truncated posteriorly



Text-fig. 13.



Text-fig. 14.

Text-fig. 14. *Asterolepis scabra*. Restored transverse section through the anterior part of the proximal segment of the right pectoral fin (after spec. B). Nat. size.

Ard, dorsal articular plate; *Arv*, ventral articular plate; *Axp*, axial plate; *Lmp*, lateral marginal plate; *cr.dm*, dorso-medial crista of the dorsal articular plate.

than in *A. ornata*. The posterior part of the medial margin in spec. B (text-fig. 7) is characteristically curved, but this feature seems to be rather individual, as it does not occur in the specimen Upps. no. P. 438.

The lateral lamina of the plate is lower than in *A. ornata*, higher, however, than in *A. maxima*. Just in front of the posterior margin of this lamina there is on the ventrolateral ridge a peculiar structure (*x*, pl. IX, figs. 3—4), which on the left side of the carapace consists of a 3 cm long, 5—7 mm broad, and 3 mm deep, somewhat irregular pit with rather steep walls, whereas on the right side it is formed by several small shallow depressions. Both the pit mentioned and the depressions are ornamented at their bottom. Nothing can as yet be said as to the significance of this structure.

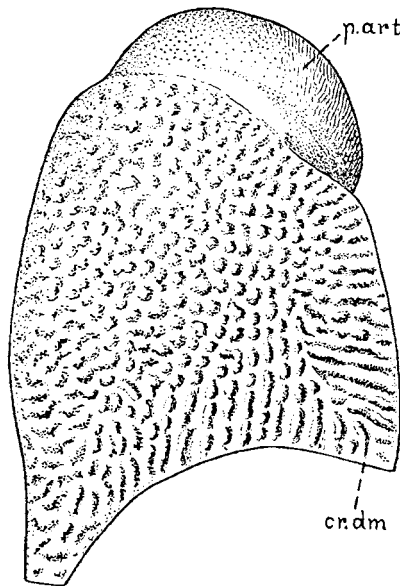
The median ventral plate (*Mv*, text-fig. 7; pls. I, II) is of the type normal to the genus *Asterolepis*. It differs from that in *A. ornata* and still more from that in *A. maxima* (Traquair 1894, text-fig. 38) in its larger size, in proportion to the total area of the ventral face of the carapace.

The semilunar plate (*Sm*, text-fig. 7; pls. I, II; pl. VII, figs. 1—2) is shaped much as in *A. ornata* (Gross 1931, pl. VII, figs. 5—7). It is not so broad as in *A. maxima* (Traquair 1894, text-figs. 45—46), its breadth: length ratio being only about 2.5: 1. Its external face exhibits a transverse groove, conceivably belonging to the sensory canal system (cf. above p. 13).

Pectoral fins (text-figs. 1 A, 7, 13—16; pls. I—II; pl. III, fig. 1; pl. XI, fig. 3; pls. XIII, XIV; pl. XV, figs. 1—3). The pectoral fins are preserved, but they are somewhat imperfect. What is present of them is as follows: the most proximal part of the ventral side; the dorsal side except the most distal part of the distal segment. They are developed (cf. Stensiö 1931, pp. 109—138) fundamentally as in *A. maxima* (Traquair 1894, text-figs. 37—38; pl. XVIII, figs. 1—6) and *A. ornata* (Gross 1931, pls. V—VIII; 1933 a, text-fig. 17: 1—2; 1941 a, text-figs. 44 K, L, 45 B, C; Stensiö 1931, text-figs. 59—61, 64—70), the only two species of the genus in which they are known otherwise.

Text-fig. 15. *Asterolepis scabra*. Restored dorsal articular plate of the left pectoral fin. Nat. size. (Corresponding to the specimen figured in pl. XV, fig. 2).

cr.dm, dorso-medial crista; *p.art*, pars articularis.



Text-fig. 15.

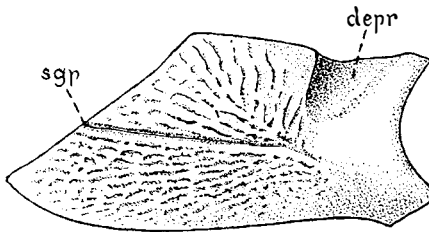
Size and general shape. — As to the relative length of the pectoral fins it may be noted here that the distal end of the dorsal central plate (Cd_1) reaches approximately as far back as to the internal boundary between the anterior and posterior ventro-lateral plates; the distal end of the terminal plate may be supposed to have reached a little beyond the external boundary between the same bones. As far as may be judged from the restorations of *A. maxima* and

A. ornata, already the distal end of the dorsal central plate extends in these species backwards beyond the last-mentioned boundary. The pectoral fin of *A. scabra* is thus relatively short as compared to the anterior ventro-lateral plate. As compared to the total length of the trunk-carapace, it is relatively longer than that in *A. maxima* (owing to the greater length of the posterior ventro-lateral plate in this species).

The ratio between the length of the proximal segment and the entire length of the distal segment seems to be about the same as in *A. ornata* (Gross 1941 a), but distinctly smaller than in *A. maxima*, to judge from Traquair's restoration. When only the length of the dorsal central plate of the distal segment is compared with the length of the proximal segment, the differences between the three species appear to be rather insignificant. The breadth of the proximal segment is probably intermediate between *A. maxima* and *A. ornata*. In text-fig. 14a restored transverse section through the proximal part of the proximal segment of *A. scabra* is given. This section differs from a corresponding one in *A. ornata* (Gross 1933 a, text-fig. 17 : 2 a—b) mainly in the stronger development of the dorso-medial crista (cf. Stensiö 1931, pp. 115—116).

The various plates, as a rule, agree well with those in *A. ornata* and *A. maxima*.

The dorsal articular plate (*Ard*; text-figs. 1A, 13—15; pl. XIII, fig. 2; pl. XIV, fig. 1; pl. XV, figs. 1—2), is, as mentioned, provided with a more strongly developed dorso-medial crista than in *A. ornata*



Text-fig. 16.

Text-fig. 16. *Asterolepis scabra*. Axial plate from the left pectoral fin (after the specimen figured in pl. XV, fig. 3).

Nat. size.

depr, dorso-anterior depression; *sgp*, groove of the pit-line type probably belonging to the sensory canal system.

and probably also than in *A. maxima*. It has therefore a greater relative breadth than in these species (as to measurements cf. table above p. 10). The medial face of this crista is ornamented as in *A. ornata* only on its posterior part. Its anterior part is provided with a low rounded ridge, running in a dorso-anterior direction.

The dorsal articular plate, the ventral articular plate (*Arv*), and the dorsal anconeal plate (*And*) seem all to be relatively larger than in *A. ornata*.

The axial plate (*Axp*; text-figs. 14, 16; pl. XIII, fig. 2; pl. XV, fig. 3) is completely preserved. In its general shape it is much as in *A. ornata*. It is a little higher relatively to its length, however, and has a shorter postero-dorsal margin and a correspondingly longer dorsal margin; in the antero-dorsal part of the bone we find a more pronounced and backwards more clearly defined depression (*depr*). Except on the most anterior part, the external face bears an ornament of rather fine, radiating, and reticulating ridges. This ornament is especially well developed on the ventral part of the face.

The lateral marginal plate (*Lmp*) seems to be as in *A. maxima*, but is longer and narrower than in *A. ornata*.

The medial marginal plate (*Mmp*; pl. XIV; figs. 3—6) is relatively broader than in *A. maxima* and generally also than in *A. ornata* (text-fig. 17); in certain cases in the last-mentioned species it may, however, also be rather broad. The medio-ventral face is crossed in its longitudinal direction by a canal groove of the pit-line type (*sgp*). This groove is more curved than in *A. ornata*. The medial margin of the plate has no clear traces of any denticles. Along the medial margin the ventral face is almost devoid of ornaments.

The anterior lateral marginal plate (*Ldmp*₁) and the anterior medial marginal plate (*Mdmp*₁) of the distal segment are rather similar to the corresponding plates in *A. ornata*, but shorter and broader than in *A. maxima*. The medial margin of the medial one of the two plates under consideration seems, however, to be anterolaterally less produced than in *A. ornata*.

The boundaries between the (proximal) dorsal central plate (*Cd*₁) and the posterior lateral marginal plate (*Ldmp*₂) resp.

Text-fig. 17. *Asterolepis ornata*. Two medial marginal plates of the proximal segment of the pectoral fin. A—B, a relatively broad plate, A, in dorsal, B, in ventral aspect. C—D, a relatively narrow plate, C, in dorsal, D, in ventral aspect. Specimens Riksm. nos. P. 3068 *a* (A—B) and P. 3068 *b* (C—D). Ehrmann b. Ligat, Livonia, beds Dm₄. Nat. size.

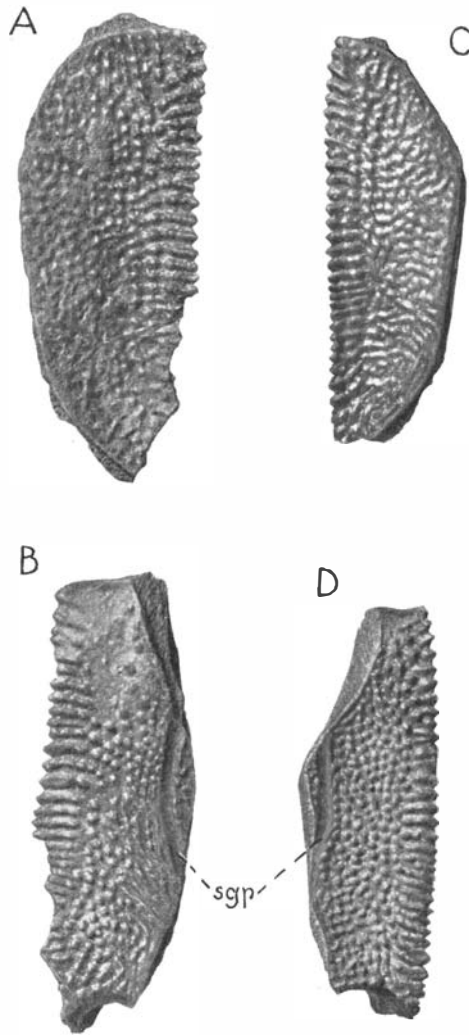
sgp. groove of the pit-line type probably belonging to the sensory canal system.

the posterior medial marginal plate (*Mdmp*₂) are relatively longer than in *A. ornata* and *A. maxima*.

The most distal, fragmentary plate is probably a normal terminal plate (*Tp*), similar to that in *A. maxima* and *A. ornata*.

Remarks. — As proved by several features, among others the presence of overlapping areas along the posterior divisions of the lateral margins of the anterior median dorsal plate, *A. scabra* is an undoubted representative of the genus *Asterolepis*. Of the *Asterolepis*-species previously described only *A. ornata* and *A. maxima* are known to a similar extent as *A. scabra*. Of *A. radiata* only detached

bones are found, and of *A. cristata* we know in the main nothing but the general shape of the skull roof. Only a very incomplete comparison can, therefore, be made between *A. scabra* and these species. Judging from the ornament, the size, and some other features, *A. radiata* and *A. cristata* do not seem to be especially nearly akin to *A. scabra*. The small, elongated species *A. thule* and the fairly small and broad forms *A. orcadensis* and *A. säve-söderberghi* are also not quite closely related to *A. scabra*. In *A. thule*, *A. orcadensis*, and *A. säve-söderberghi* the sufflaminal plate is, for instance, of an entirely different type than in *A. scabra*; it is short and broad, only slightly produced backward,



Text-fig. 17.

and separated from the lateral nuchal only by a shallow emargination. These three species are also distinguished from *A. scabra* by a different shape of the head as well as of several of the plates in the head and the trunk-carapace.

In its large size, in the general shape of the head, in the general shape of the trunk-carapace and in many features otherwise *A. scabra* is suggestive of and seems to be most nearly related to *A. ornata* and *A. maxima*, which are mutually closely akin. The sufflaminal plate is of a similar type, at any rate, to that in *A. ornata* (concerning *A. maxima* cf. above p. 16). In certain respects *A. scabra* approaches more to *A. ornata*, in other respects more to *A. maxima*. On the other hand, it differs clearly from both these species in a number of characters, which may be summarized as follows: the larger average size; the type of ornament and the absence of ornament on certain areas; the relatively great breadth of the premedian plate and the more posterior position of the sensory canal grooves on this plate; the shape of the anterior median dorsal plate, particularly the narrow anterior part and anterior margin, the rather broad, concave posterior end of the inner face, the short forward curved anterior part, and the absence of a median dorsal ridge; the less abrupt sloping backward of the posterior margin of the lateral lamina of the anterior ventro-lateral plate; the presence of a pit on the ventro-lateral ridge of the posterior ventro-lateral plate; the relatively large size of the median ventral plate; the rather small length of the pectoral fins; the stronger development of the dorso-medial crista of the dorsal articular plate; the longer boundaries between the dorsal central plate and the posterior lateral resp. the medial marginal plates of the distal segment of the pectoral fin.

A. scabra differs from *A. ornata* in the following special characters: the broader posterior margin and more concave lateral margin of the skull roof; the somewhat greater length of the backward produced part of the sufflaminal plate; the stronger development of the postero-medial lamina of the lateral plate; the somewhat greater breadth of the postmedian plate; the higher and more rounded shape of the extralateral plate; the much lower trunk-carapace; the somewhat smaller breadth of the posterior part of the ventral wall of the trunk-carapace and the more rounded shape of the posterior end of this wall; the more dorsal position of the main lateral line groove on the anterior dorso-lateral plate; the somewhat greater length of the ventral lamina and minor height of the lateral lamina of the posterior ventro-lateral plate; the higher posterior face of the pars pedalis of the processus brachialis; the more vertical position of the posterior face of the pars condyloidea; the larger posterior opening of the funnel-pit; the more robust development of the dorsal and ventral margo limitans of the fossae articulares; the somewhat larger size of the dorsal and ventral articular plates and of the

dorsal anconeal plate; the greater length and smaller breadth of the lateral marginal plates of the proximal segment; the more curved course of the sensory canal groove on the ventral face of the proximal segment.

Finally, it is distinguished from *A. maxima* in the following special characters: the somewhat greater length of the postmedian plate; the smaller length of the ventral wall of the trunk-carapace, especially of the posterior ventro-lateral plate, and the greater breadth of the posterior end of this lamina; the less angular shape of the dorsal outline of the carapace and the anterior median dorsal plate in lateral view; the greater breadth of the anterior median dorsal plate and the straight anterior margin of this plate; the much greater height of the lateral lamina of the anterior ventro-lateral plate and a less rapid decreasing of the height of the lamina in an anterior direction; the relatively great height of the lateral lamina of the posterior ventro-lateral plate; the rather small breadth of the semilunar plate; the shorter and broader shape of the medial marginal plates of the proximal segment of the pectoral fin; the rather short and broad shape of the anterior lateral and medial marginal plates of the distal segment.

Several of the enumerated features indicate that *A. scabra* is in a more highly advanced stage of specialization than *A. ornata* and *A. maxima*. This is especially the case with such features as the absence of ornament on certain areas, the great size, the small height of the body, the absence of a median dorsal ridge on the anterior median dorsal plate and the rapid tapering of the anterior part of the anterior median dorsal plate.

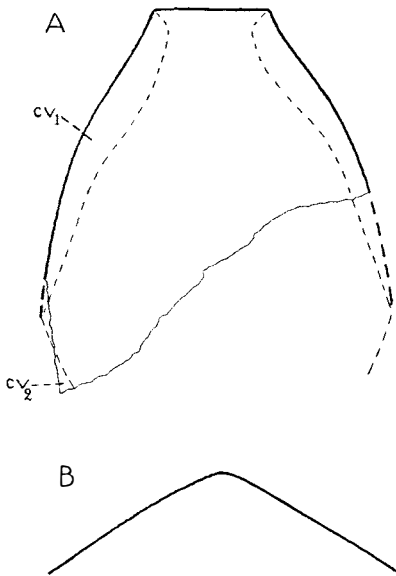
Geological horizon and localities: Series with *Asterolepis scabra*. Mimer Valley. Localities: the "Fish Cleft" (locus typicus); a brook-cleft 1 km W for the "Fish Cleft", cutting through the same layers as this one; "shale Sk_3 " (cf. Stensiö 1918 a, pp.71—72) on the northern slope of Estheria Hill in layers of the same petrological character; *Asterolepis* cf. *scabra* from "shales Sk_4 " on the southern slope of Estheria Hill (cf. above p. 8).

Asterolepis cf. *orcadensis* Watson.

(Text-fig. 18; pl. XV, figs. 4—5.)

1937. *Pterichthys*? or *Asterolepis*?, Heintz, p. 17.

Material and description. — The only material found of this species consists of an anterior half of an anterior median dorsal plate (Osl. no. A. 24374), preserved in a calcareous rock as an impression of the internal face. The dimensions of this imperfect plate are: length from the anterior margin to a line across the plate at the anterior lateral angles about 3.9 cm; breadth along this line 4,6 cm;



Text-fig. 18.

Text-fig. 18. *Asterolepis* cf. *orcadensis* Watson. Restoration of the anterior half of the anterior median dorsal plate. A, dorsal view. B, transverse section, a little in front of the middle of the plate. Nat. size.

cv_1 , cv_2 , overlapping areas (on the internal surface).

breadth of the anterior margin 1.5 cm. The anterior margin is relatively broad and perfectly straight. The antero-lateral division of the lateral margin is as a whole rather strongly convex. The postero-lateral division of the lateral margin is unknown. The well preserved anterior overlapping areas (cv_1) are broadest in their anterior half. Of the posterior overlapping area only a very small anterior part is preserved (cv_2) on the left side. This together with what is otherwise known of the details of the plate seems to indicate that most probably we are concerned here with an *Asterolepis*-species.¹

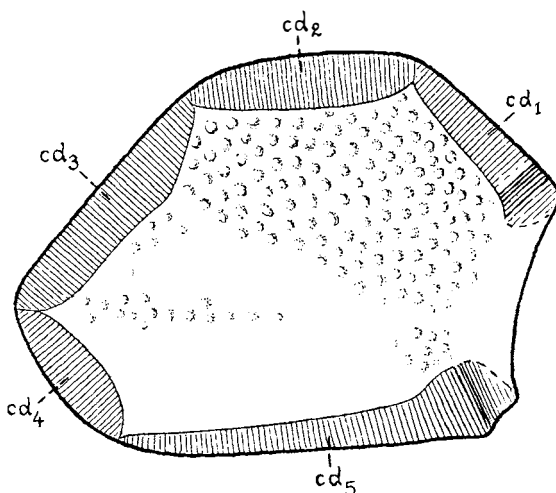
The lower face of the plate has no median ridge and no ventral process and is also almost devoid of the antero-lateral ridges. Only faint traces are preserved of the ornament of the external face (pl. XV, fig. 4, *tub*). It is formed of delicate, closely set tubercles.

Remarks. — The anterior median dorsal plate here described is to some extent *Remigolepis*-like, but for several reasons it is likely that it belongs to the genus *Asterolepis*. As to size it agrees with that in the smaller species of *Asterolepis*. It is of almost the same size as that in *A. thule* (Watson 1932, text-fig. 5), only slightly smaller than that in *A. säve-söderberghi* (Stensiö 1938, pl. II, fig. 3; pl. III, fig. 2; pl. IV, fig. 1), and clearly smaller than that in the typical *A. orcadensis* (Watson 1932, text-fig. 3; pl. IV, fig. 2). It differs from that in *A. thule* in its greater breadth and its broader, not convex anterior margin, from that in the typical *A. orcadensis* in its smaller breadth. Besides in size it differs from the corresponding plate in *A. ornata*, *A. maxima*, *A. scabra*, and *A. radiata* (Rohon 1900, text-fig. 11) *i. a.* in its broader anterior margin and the more convex antero-lateral division of its lateral margin. It seems to agree to a certain extent with that in

¹ The presence of this anterior part of a posterior overlapping area alone is not a character sufficient for a determination as to genus in this case, as a more or less long overlapping area along the anterior part of the postero-lateral division of the lateral margin of the plate under consideration is always found in *Remigolepis* and in addition is not rarely met with in *Bothriolepis*.

Text-fig. 19. *Asterolepis* sp.
Restored mixilateral plate
from the right side of the
trunk. $\times 3$ diam.

cd_1 — cd_5 , overlapped areas.



Text-fig. 19.

A. säve-söderberghi, particularly with the plate of this species figured by Stensiö (1938, pl. II, fig. 3), a plate which also has a straight anterior margin, quite as *A. orcadensis*. The antero-lateral margin is, however, more convex than in *A. säve-söderberghi* and the plate

agrees, therefore, upon the whole more with that in *A. orcadensis*. The plate differs also from that in *A. säve-söderberghi* in the very slight development of the antero-lateral ridges. As its posterior division is lacking, the plate cannot at present be determined with full certainty; it may provisionally be referred to *A. cf. orcadensis*, but it is likely that it also has affinities to *A. säve-söderberghi*.

Geological horizon and locality. — Wijde Bay Series. Andre-dalen (Second Valley), southern slope, 500 m, Wijde Bay (see map in Heintz 1937, p. 2). Coll. Th. Vogt 1925.

Asterolepis sp.

(Text-fig. 19; pl. XVI, fig. 1.)

Under this title a very small, right mixilateral plate will be described. This plate, which is embedded in a dark shale, is represented by an impression of its outer side (Osl. no. A 24383). A fragment of a plate not more closely determinable (Osl. no. A 24382), which comes from the same locality as the mixilateral plate just mentioned, may possibly also belong to the same species.

The mixilateral plate here under consideration has its free posterior margin and its five overlapped areas (cd_1 — cd_5) well preserved. The occurrence of an area overlapped by the anterior median dorsal plate (cd_3) shows, that we are probably concerned with a species of the genus *Asterolepis*. Its greatest length is 25 mm and its maximum height 18 mm; and it is thus high in proportion to its length, distinctly higher than the same bone in *A. maxima* and *A. ornata* and also somewhat higher than that in *A. säve-söderberghi* (Stensiö 1938, text-fig. 6), but

not so high as that in *Pterichthyodes* and *Gerdalepis* (Traquair 1894, text-fig. 36; Gross 1933 a, text-fig. 15; 1933 b, text-fig. 1; 1941 b, text-figs. 2, 5). The overlapped areas are relatively broad. The postero-dorsal margin slopes more steeply backwards and the antero-dorsal external margin is much less angular than in the previously known *Asterolepis*-species; and in these characters the plate is, therefore, somewhat suggestive of that in *Pterichthyodes* and *Gerdalepis* (Gross l. c.).

The external face shows a dorso-lateral ridge situated rather far ventrally. No clear traces of any lateral line canal are to be seen. The greater part of the external face is ornamented with rounded tubercles, well separated from each other. The most ventral part of the face, however, is smooth.

The plate may possibly belong to a young individual.

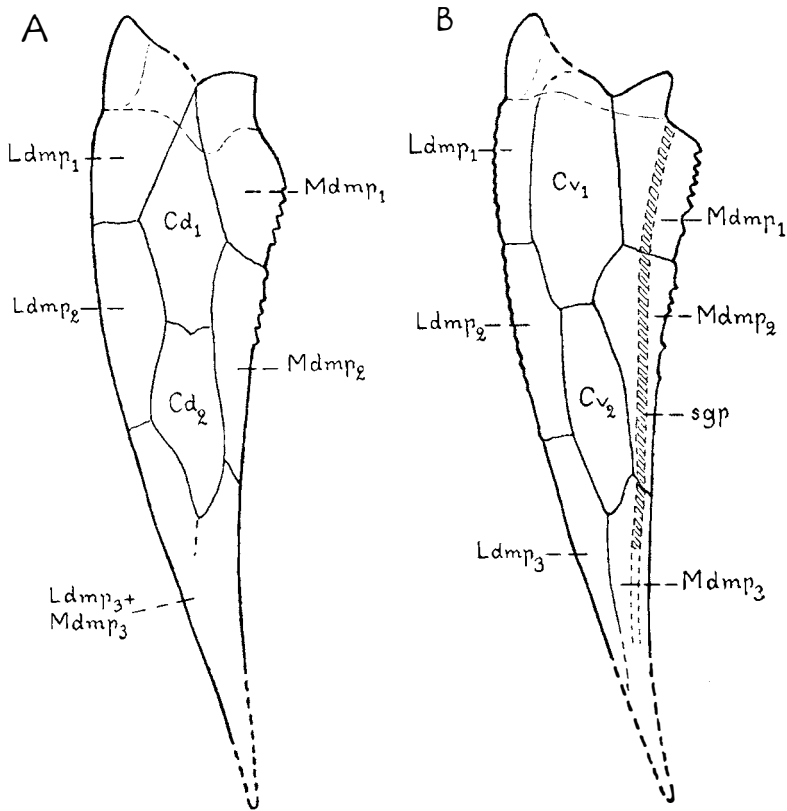
Geological horizon and locality. — Wijde Bay Series, Andredalen, "Shore Profile", Wijde Bay. Coll. Th. Vogt 1925. (According to information received from Prof. A. Heintz, incorrectly mentioned by him (1937) from Forkdalen instead of Andredalen.)

Asterolepidae gen. et sp. indet.

(Text-fig. 20 A, B; pl. XVI, figs. 2—3.)

Material. — Among the material at hand there are two detached distal segments of pectoral fins, a right and a left one (Upps. no. P. 442). These two distal segments are found in the same slab of a shaly rock, and as they are of the same size, they are probably from the same individual. They are almost completely preserved, lacking only their most distal parts, which have been restored in text-fig. 20. One of them is exposed in dorsal, the other one in ventral view.

Description and remarks. — The two distal segments are small, their length (restored) being only about 21.5 mm (except the processus anconealis of the first lateral marginal plate about 19 mm) and their breadth at the proximal end only 5.5 mm. If they are from an adult individual, this must have been of a size intermediate between that of *Microbrachius dicki* (Traquair 1904, pl. XXII, figs. 5—8) and that of the *Pterichthyodes*-species of the Scottish Old Red (text-fig. 21 A, B; cf. also Traquair 1904). In their general somewhat curved shape they agree with those in the forms just mentioned and also with those in the genus *Asterolepis*. They are ornamented with tubercles on small areas, mostly proximally, otherwise with nodose ridges, mainly disposed in a longitudinal direction. Their most distal part is almost smooth. The proximal part of the dorso-medial crista is distinctly serrated. As to the ornament, the two segments thus seem to differ from the majority of the *Asterolepidae* and to approach somewhat *Microbrachius dicki*



Text-fig. 20. *Asterolepidae* gen. et sp. indet. Restorations of the distal segment of the pectoral fin, A of the left pectoral fin, in dorsal view, B of the right pectoral fin, in ventral view. $\times 5$ diam.

Cd₁, Cd₂, Cd₃, dorsal central plates. Cv₁, Cv₂, ventral central plates; Ldmp₁—Ldmp₃, lateral marginal plates of the distal segment; Mdma₁—Mdma₃, medial marginal plates of the distal segment; sgp, groove of the pit-line type, probably belonging to the sensory canal system.

(Traquair 1904, p. 106, pl. XXII, fig. 7) and *Pterichthyodes concatenatus*? Gross (1933 a, pl. III, fig. 10). On their ventral face a shallow groove (sgp) is found, which probably belongs to the sensory canal system (cf. Stensiö 1931, pp. 149—150). As this groove passes rather close to the medial margin, it is in regard to its position more in agreement with that in *Bothriolepis canadensis* than with that in *Asterolepis ornata* (l. c.; Gross 1931, pl. VI, fig. 4).

As to its various plates, the two distal segments show the nearest agreements to *Pterichthyodes*. Text-fig. 21 A, B illustrates the conditions in this genus after a specimen in the position of the Swedish Museum of Natural History in Stockholm. Traquair's views concerning the number of plates in the distal end of the segment are confirmed; the distal end appears, however, to be much longer than can be inferred

from the restorations published by Traquair (1904, text-figs. 51—53; cf. however, pl. XXII, fig. 1). The space corresponding to the terminal plate in *Asterolepis* is here occupied by four separate bones, a posterior ventral (Cv_2) and a posterior dorsal central plate (Cd_2), a third lateral marginal plate ($Ldmp_3$), and a third medial marginal plate ($Mdmp_3$), which latter also forms the very apex of the segment. Together these bones form a complex, the terminal complex, of the same shape as the terminal plate of *Asterolepis*, and owing to this it is probable that this latter bone, as has already been maintained by Stensiö (1931, pp. 136—137; cf. also Gross 1931, p. 38; pl. VIII, fig. 12), has arisen by a fusion of the four plates¹ mentioned.

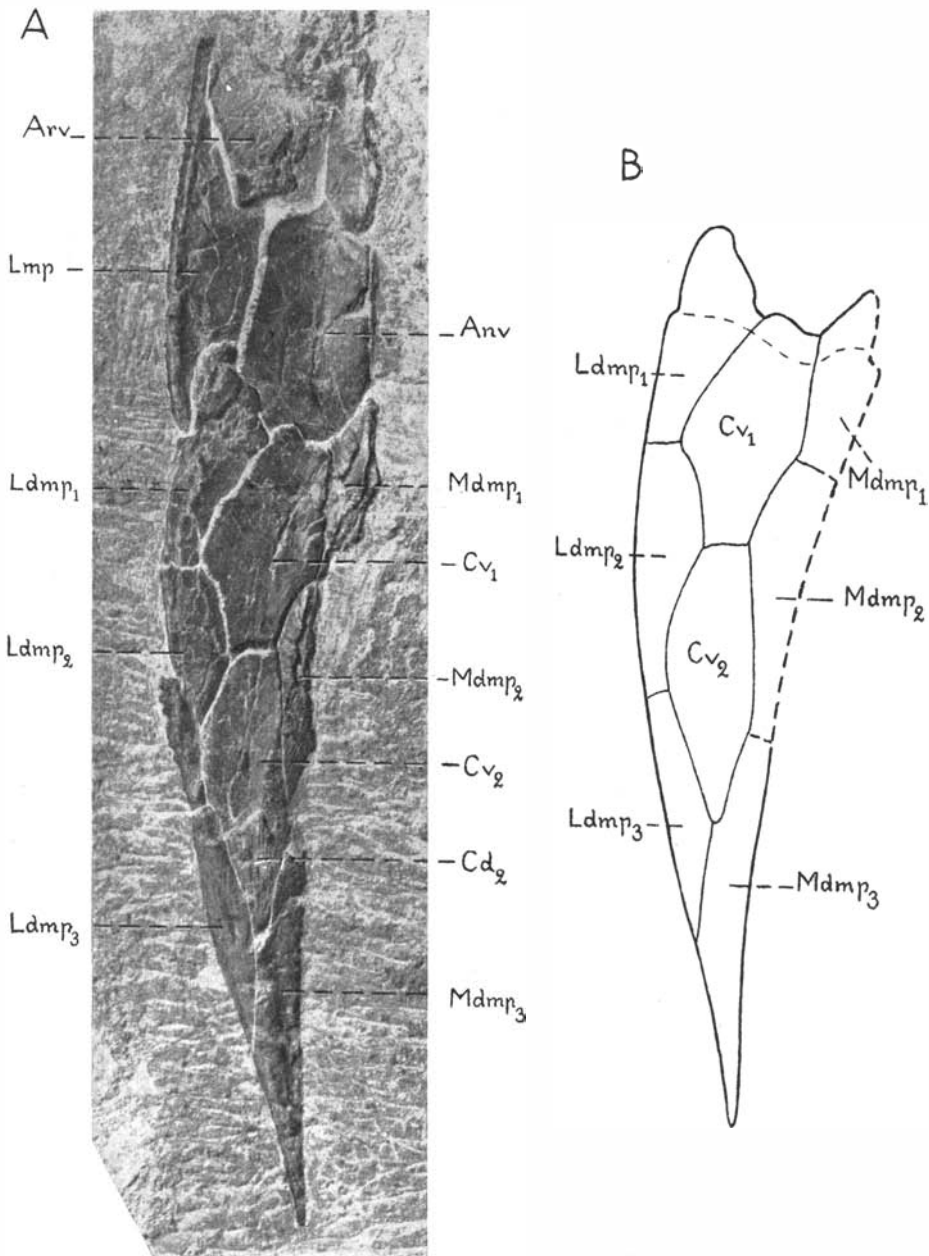
Of the two specimens of distal segments of pectoral fins at hand from Spitsbergen, the right one exhibits on the ventral side of its most distal part three independent elements, which correspond exactly to the three similarly situated ones just described in *Pterichthyodes*. The left segment, which exposes its dorsal side, shows on this a free posterior dorsal central plate and in the proximal part of the boundary between the $Ldmp_3$ and the $Mdmp_3$ possibly vestiges of a suture. At any rate, it is clearly seen in the left segment that the distal parts of $Ldmp_3$ and $Mdmp_3$ are fused, and accordingly that a beginning fusion of the distal elements of the segment is met with here.

In proportion to the total length of the distal segment the terminal complex of plates in the distal fin segments at hand is, as in *Pterichthyodes*, distinctly longer than the terminal plate of *Asterolepis*, a condition which is due to a greater relative length of the distal part of the proximal central plate in the latter genus. In addition the proximal central plate is also much broader in its distal end than that in *Asterolepis*.

The distal segments of pectoral fins here described, seem on the whole to be mostly suggestive of the corresponding structures in *Pterichthyodes*, but seem in their size and their ornament also to be somewhat *Microbrachius*-like. However, as the distal fin segment in *Microbrachius* is still very imperfectly known, it is impossible to say at present with any certainty whether they are nearer to *Pterichthyodes* or *Microbrachius*. As in addition the structure of the distal fin segment in very young individuals of *Asterolepis* is still unknown, the present writer has considered it most appropriate to desist from a determination of them, both as to genus and species.

Geological horizon and locality. — Series with *Asterolepis scabra*. Mimer Valley. Locality: shale Sk_4 (? cf. below p. 47) on the southern slope of Estheria Hill (cf. Stenstö 1918, p. 71). Coll. B. Högbom 1910.

¹ These bones may possibly themselves have a complex origin.



Text-fig. 21. *Pterichthyodes milleri*. A. Imperfect pectoral fin of the left side. Dorsal (internal) aspect of the ventral face (of the most distal parts, however, the dorsal, external, face is seen). Specimen Riksm. no. P. 1637. From the Middle Devonian of Scotland.

B. Restoration of the distal segment, shown in A. Ventral wall. $\times 2\frac{1}{2}$ diam.

Anv, ventral anconeal plate; *Arv*, ventral articular plate; *Cd*₂, distal dorsal central plate; *Cv*₁, *Cv*₂, ventral central plates, *Ldmp*₁–*Ldmp*₃, lateral marginal plates of the distal segment; *Lmp*, lateral marginal plate of the proximal segment; *Mdma*₁–*Mdma*₃, medial marginal plates of the distal segment.

Stratigraphical conclusions.

The *Antiarchi*-material dealt with in the present paper comes in part from deposits belonging to the Wijde Bay Series proper, immediately W of Wijde Bay. The bulk of it, however, is from deposits in Mimer Valley W of Klaas Billen Bay, deposits which have also been considered to belong to the Wijde Bay Series proper, but which, as we shall see, in all probability are a little younger.

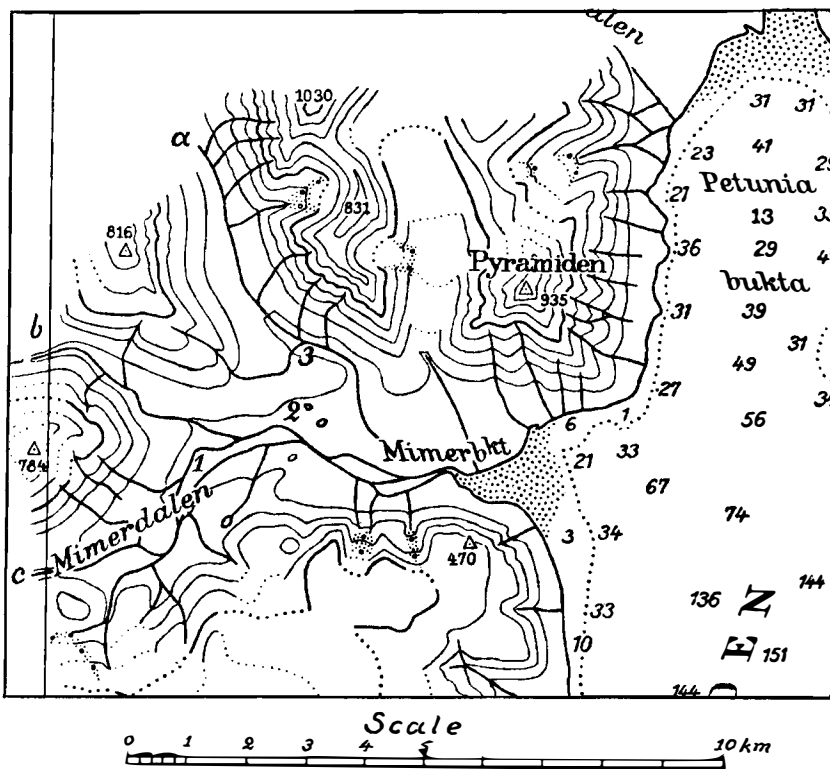
The Wijde Bay Series (Kiær 1918, pp. 496—497; Hoel in Stensiö 1927, p. X; Frebold 1935, pp. 27—28; Heintz 1937, pp. 15—18, see also map p. 2) consists of grey sandstones and grey or black shales. It is mostly found at a height of about 500—800 m above the sea-level (Vatnedalen—Skamdalen, Gråkammen); resting on marine deposits of the Grey Hoek Series, which are considered by Heintz to be of a middle and upper Lower Devonian age (cf. also Quenstedt 1926, p. 92).

The Wijde Bay Series itself was supposed by Kiær, Hoel (in Stensiö 1927, p. X) and other earlier writers to be Upper Devonian or possibly late Middle Devonian, by Heintz (1937, pp. 15—18) on the basis of new material to be of a middle Middle Devonian age, and to correspond most closely to the zones with *Pterichthyodes* and *Heterostius* in the Baltic States.

The richest Vertebrate fauna is brought home from Andredalen (Second Valley), where *Asterolepis* cf. *orcadensis* is found together with *Heterostius* sp. and remains of other Arthrodiros, undetermined Crossopterygians, and Psammosteids. The remains described in the present paper as *Asterolepis* sp. are derived from Andredalen, though they are from a somewhat lower level ("shore profile"). *Heterostius* is also met with at some other localities, Vatnedalen, Forkdalen(?), and Gråkammen; at the latter locality it occurs together with *Homostius*, Crossopterygians, and undetermined Invertebrates. *Homostius* occurs probably also in Skamdalen.

The type of *A. orcadensis* is, according to Watson (1935, p. 967) most probably characteristic of a special zone in the Orkneys, a zone above that with *Thursius pholidotus*, *Cocosteus minor*, *Homostius milleri*, *Dipterus platycephalus*, *Osteolepis microlepidotus* etc. (*Heterostius* is not known from the Scottish Orcadian!). The Wijde Bay Series seems, therefore, to have equivalents in both the zones mentioned in the Orkneys, and owing to this it may be placed most appropriately, at least for the time being, at the transition between them.

The Spitsbergen species described as *Asterolepis* cf. *orcadensis* was stated to have affinities to *A. säve-söderberghi* (cf. p. 36 f.), which is found in East Greenland associated with *Homostius kochi* Stensiö in a series



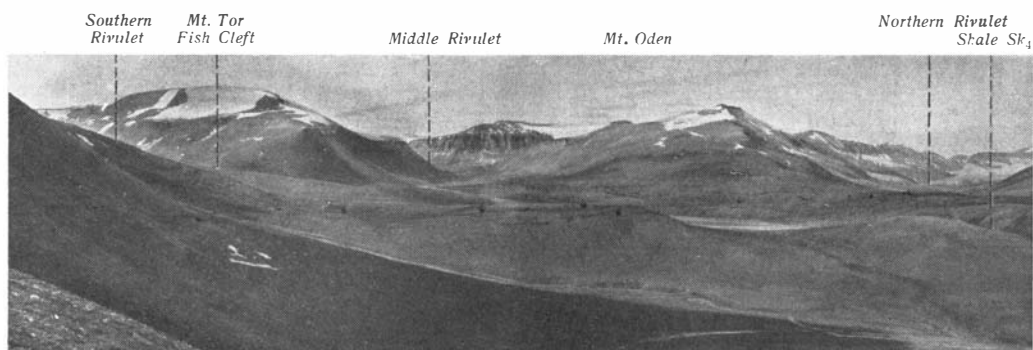
Text-fig. 22. Map showing the localities yielding fossil fish in the Series with *Asterolepis scabra* in Mimer Valley. 1, the "Fish Cleft"; 2, southern, 3, northern slope of Estheria Hill. a, Northern, b, Middle, c, Southern Rivulet. From map-sheet S3 of the map of the Arctic Sea and Svalbard, ed. by Norges Svalbard- og Ishavs-Undersøkelser, Oslo 1932.

termed after it: the Series with *A. säve-söderberghi*. Immediately below this series follows in East Greenland the *Heterostius* Series with *Heterostius groenlandicus* Stensiö, *Homostius kochi*, and probably *Asterolepis* sp. (Säve-Söderbergh 1937, pp. 28—35; Stensiö and Säve-Söderbergh 1938, pp. 6—7). The Wijde Bay Series has obviously faunal relations to both these series in East Greenland, and it may, therefore, be broadly correlated to them, perhaps most closely to the transition between them (see the scheme on p. 50).

Finally, the *Heterostius* Beds in the Baltic States (Gross 1933 a, pp. 66—67) quite as the Luga Beds in NW Russia (Obrutshev 1933 c, p. 420) have the genera *Heterostius* and *Homostius* in common with the Wijde Bay Series. In the Baltic States and Russia, a horizon has not been distinguished corresponding to those with *Asterolepis säve-söderberghi* and *A. orcadensis*, i. e. the zones with small, more primitive *Asterolepis*-species, in other Old Red districts. Säve-Söderbergh (1937, pp. 32—35) paralllizes both the mentioned zones with a part of the beds with the large *Asterolepis ornata* in the Baltics. These



Text-fig. 23. Mimer Valley. Panorama taken from the southern slope of Mimer Valley and its southern extent with



Text-fig. 24. Mimer Valley. Panorama, taken from the southern

beds have, however, in all probability in regard to their fauna more in common with the Scottish Nairn Beds with *A. maxima*, for *A. ornata* is obviously closely related to *A. maxima*. On the other hand, the Baltic and Russian Beds with *Heterostius* contain rather rare remains of *Antiarchi*, remains which are often determined as *Asterolepis ornata* or *Pterichthys concatenatus*. According to Gross (1933 a, p. 67) these *Antiarchi*-remains need a reexamination as to their generic and specific characters. In the light of the new Spitsbergen material with small *Asterolepis*-species associated with *Heterostius* it seems very likely that the Baltic *Antiarchi*-remains mentioned really belong to *Asterolepis*.¹ The Baltic and Russian *Heterostius* Beds would then correspond both to the *Heterostius* Series and the Series with *A. säve-söderberghi* in Greenland and to the zones with *Thursius pholidotus* and *A. orcadensis* in the Orkneys (and possibly also to parts of the

¹ Cf. Addendum, p. 52.

Plateau S. of Mimer Valley

The southern extent of Mimer Valley
Fish Cleft Mt. Tor

of Mt. Pyramid and showing Klaas Billen Bay with Mimer Bay, further the "Fish Cleft". Photo. A. Reuterskiöld 1917.

Mt. Reuterskiöld
Estheria Hill

Mt. Pyramid

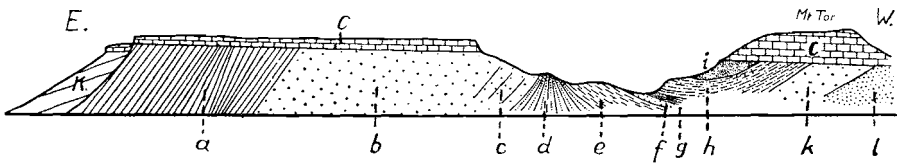
Mimer Bay



part of Mimer Valley. Photo. A. Reuterskiöld 1917.

younger zones, see scheme p. 50). In such circumstances, the Wijde Bay Series should obviously be correlated to a part of the Baltic *Heterostius* Beds. As the *Antiarchi* from the Wijde Bay Series all seem to belong to *Asterolepis* and not to *Pterichthyodes*, there is at present no reason for comparing the series mentioned with the Beds with *Pterichthyodes*. This has been done by Heintz (1937), who parallellizes the Wijde Bay Series both with the *Heterostius* Beds and with the *Pterichthyodes* Beds in the Baltics.

The strata in Mimer Valley (= Mimerdalen, see map text-fig. 22) are classic in the history of the investigation of the Spitsbergen Devonian (Nathorst 1884, pp. 57—58; 1910, pp. 309—310; Stensiö 1918 a, pp. 66—73). The stratigraphy of this area has been investigated by Stensiö, from a paper of whom the geological sections in text-figs. 25—26 are reproduced. The Devonian deposits are here much disturbed, strongly upraised and folded and partly intersected by faults, and in addition disconformably overlain by the almost horizontal Upper



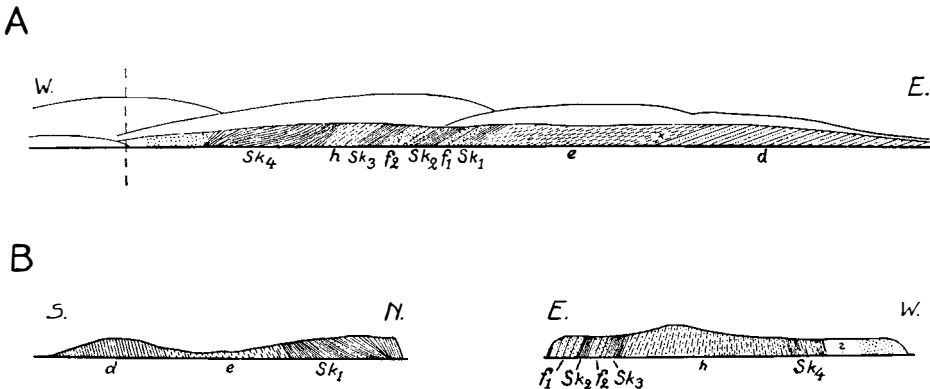
Text-fig. 25. Geological section along the southern side of Mimer Valley. After Stensiö 1918 a, text-fig. 1.

C, Cyathophyllum Limestone (Upper Carboniferous); K, Kulm; a, violet shales of an undetermined Devonian age; b—e, green and red sandstones etc. of Lower Devonian age, yielding *Pteraspis nathorsti* Lank. and *Porolepis posnaniensis* Kade; f, yellow sandstone; g, layers of the "Fish Cleft", black shales with ironstone nodules; h, green sandstone with *Psymphyllum williamsoni* Nath.; i, violet sandstone; k, bright sandstone, in part conglomeratic; l, red and green sandstone, in the western part with *Porolepis*. The layers f—k and in part l(?) are referred to the Series with *Asterolepis scabra*.

Carboniferous Cyathophyllum Limestone. They consist of a lower series of Lower Devonian age (b—e; l, partly) and an upper series (f—k; ρ l partly; Sk_{1-4}), among others containing *Asterolepis scabra*. The upper series consists of dark or black shales (partly with ironstone nodules) alternating with yellow and green sandstones. As has already been stated, the fossil-bearing localities in this series are as follows (see map text-fig. 22 and the panoramas text-figs. 23, 24): the "Fish Cleft" (text-fig. 22, 1), the locality 1 km W for the "Fish Cleft", the northern slope of Estheria Hill (3) and the southern slope of Estheria Hill (2). The horizons yielding fossils in the said localities are from bottom to top as follows:

1) Shales with ironstone nodules and a thin sandstone bed; northern slope of Estheria Hill (text-fig. 26 B, Sk_1); fossils: remains of a gigantic Psammosteid (*Psammosteus spinosus* Stensiö 1918 a, p. 72, nomen nudum; according to a verbal information by Professor Stensiö it is doubtful whether this species is different from *Psammolepis arenata*, cf. below); remains of large *Crossopterygii*, probably Rhizodontids.

2) Black shales with ironstone nodules; the "Fish Cleft" (text-fig. 25, g), the locality 1 km W for the "Fish Cleft", the northern slope of Estheria Hill (text-fig. 26 B, Sk_3); a rich fauna comprising the following forms (Lankester 1884; Woodward 1891; Stensiö 1918 a, b; Nathorst 1894, pp. 13, 15; Heintz 1935; 1937, p. 19): *Psammolepis arenata* (Ag.), several plates (this species cannot be distinguished from *P. paradoxa* Ag., according to Gross 1933 a, p. 8); *Asterolepis scabra* (Woodw.), several specimens; *Holonema* sp. Heintz, a few plate-fragments; remains of jaws of *Coccosteidae*, not more closely determinable; *Acondylacanthus* ρ sp. Stensiö, rare; *Onychodus arcticus* Woodw., rare; *Dictyonosteus arcticus* Stensiö, a large endocranium; several scales of undetermined *Rhizodontidae*; several teeth of *Crossopterygians*;



Text-fig. 26. A. Geological section along the southern slope of Estheria Hill. B. Geological sections along the northern slope of Estheria Hill. After Stensiö 1918 a, text-figs. 3, 4.

d—e, red and green sandstones of Lower Devonian age with *Pteraspis* and *Porolepis*; *Sk*₁, dark shales; *f*₁, yellow sandstone; *Sk*₂, dark shales; *f*₂, yellow sandstone; *Sk*₃, layers corresponding to the beds in the “Fish Cleft”; *h*, green sandstone; *Sk*₄, dark shales. The layers *Sk*₁—*Sk*₄ are referred to the Series with *Asterolepis scabra*.

Lepidodendron sp. Nathorst, one stem-fragment; *Bothrodendron* ? sp. Nathorst, one stem-fragment.

3) Green sandstone; the “Fish Cleft” (*h*); fossils (Stensiö 1918 a, p. 69; Nathorst 1893, pp. 15—16; 1920); *Psammolepis arenata* (Ag.); jaws of *Coccosteidae*; scales of *Rhizodontidae*; teeth of Crossopterygians; *Psygmophyllum williamsoni* Nath.; ? *Psygmophyllum* ? *pusillum* Nath.

4) Shales (*Sk*₄) on the southern slope of Estheria Hill (text-fig. 26 A); fossils: *Estheria nathorsti* Jones, abundant (Stensiö 1918 a, p. 71); *Asterolepis* cf. *scabra* (Woodw.), one fragment (cf. above p. 8); (? *Asterolepidae* gen. et sp. indet., two distal pectoral fin segments (cf. above pp. 35—37); (? *Rhadinichthys* sp. Stensiö (1918 a, p. 71), scales.

Of the fossils from the last-mentioned horizon *Estheria nathorsti* and *Asterolepis* cf. *scabra* were collected by Stensiö in connection with his stratigraphical investigations, the others by B. Högbom in 1910, at a time when the stratigraphical conditions in Mimer Valley were little known. There may, therefore, perhaps be somewhat uncertainty as to their stratigraphical occurrence. The petrographical character of the rock in which they are embedded seems, however, to indicate that they may hardly be from any other horizon.

As may be gathered from what has just been set forth the four horizons dealt with show so great similarities in regard to their faunas that, at least at present, they may be considered to belong to one single series. This series cannot possibly be of exactly the same age as the Wijde Bay Series in a strict sense, which Kiær (1918, p. 497) was inclined to believe. It should, therefore, be separated from the

Wijde Bay Series, and may be termed the Series with *Asterolepis scabra*.

As to its age, the series with *A. scabra* as thus defined was considered first by Lankester (1884) and then by Woodward (1891), Nathorst (1893, 1910), Kiær (1918), and Stensiö (1918 a, b) to be Upper Devonian. In a foot-note in a paper 1920 (p. 1) Nathorst mentions that Stensiö at that time was of the opinion that it was possibly Middle Devonian. Frebold (1935) considers it as Upper or Middle Devonian. Heintz maintained in 1935 (p. 120) the opinion that it was Upper Devonian, in 1937 (p. 19), however, agreeing with Säve-Söderbergh (1932, pp. 32—33, 37; 1937, pp. 30, 34), he considers it to belong to the upper Middle Devonian.

Though, as pointed out above (p. 35), it represents a somewhat more advanced stage of specialization, the index fossil of the series, *Asterolepis scabra*, is most closely related to the other two large *Asterolepis*-species, *A. maxima* and *A. ornata*. *Psammolepis arenata* (Ag.) cannot be distinguished from *P. paradoxa* Ag. in the Baltic Beds with *A. ornata*, according to Gross (1933 a, p. 8). *P. tessellata* (Traquair) of the Scottish Nairn Beds with *A. maxima* is also stated to be similar to *P. paradoxa* (Evans 1929, p. 150). Psammosteids are otherwise found in layers of rather different age (Middle and Upper Devonian). The genus *Holonema* has also a rather wide vertical distribution, occurring from the lower Middle Devonian to the Upper Devonian (Obrutshv 1933 b, pp. 98, 113). In the Bressay Series of Shetland, probably corresponding to the Beds with *A. maxima*, for instance *Holonema ornatum* Traquair is found together with *Asterolepis* sp. and *Holotychius* sp. (Evans 1929, pp. 149—150). *Rhadinichthys* comprises, according to Aldinger (1937, p. 204), in its present conception a number of heterogenous forms, and it is, therefore, in this conception, to be considered only as a provisional genus. It may, however, be pointed out, that a form *Stegotrachelus finlayi* Woodward (1926, p. 570), possibly related to *Rhadinichthys*, has been found in the Lerwick Series (Shetland) together with *Microbrachius* sp.

In regard to its fauna as a whole, the Series with *Asterolepis scabra* seems to be nearest to the Scottish Beds with *A. maxima* and to the Baltic-Russian Beds with *A. ornata*. As *Bothriolepis* is not found in it, it does not seem to reach so high as to include horizons equivalent to the beds with a fauna of mixed Middle and Upper Devonian elements (Whitemire, Snetnaia Beds, see scheme p. 50). The more advanced specialization of *A. scabra* perhaps indicates that it might be somewhat younger than the series characterized by *A. maxima* and *A. ornata*. On the other hand, it seems to contain also an *Asterolepid* of an older type (*Asterolepidae* gen. et sp. indet; cf. p. 47,

above).¹ At least at present the Series with *A. scabra* may, therefore, be broadly correlated to the Beds with *A. maxima* and *A. ornata*.

The correlation with the marine sequence in the scheme (p. 50) has been made on the same principals as by Säve-Söderbergh (1937, p. 32) and in fundamental agreement with him. It should only be pointed out, that the boundary between the Middle and Upper Devonian is to a certain extent approximate. It is, however, improbable that it will be displaced downwards in the stratigraphical scheme.

To sum up, both the Devonian series of strata from Spitsbergen dealt with in this work are of upper Middle Devonian age. The Wijde Bay Series corresponds to an upper series in the lower part of the upper Middle Devonian, the Series with *Asterolepis scabra* to the upper part of the upper Middle Devonian.

Summary.

1. *Asterolepis scabra* (Woodw.) is an *Asterolepis* of a very large size, the ventral wall of the trunk-carapace attaining a length of no less than 57 cm. Ornament of coarse tubercles, as a rule fused into nodose, irregular or radiating ridges, frequently anastomosing so as to form a network; large parts of the carapace, however, devoid of ornament. Sufflaminal plates much produced in a posterior direction. Trunk-carapace rather low and not particularly wide. Anterior median dorsal plate with a very narrow anterior part, and completely lacking a dorsal median ridge. Pectoral fins short. (Pp. 6 f.)

A. scabra is most nearly related to *A. maxima* and *A. scabra*, but differs from both of them in a number of characters (size, ornaments etc.), indicating a more advanced stage of specialization (pp. 33—35).

2. The strata in Mimer Valley W of Klaas Billen Bay in which the fauna with *A. scabra* is found have been conjoined under the common term of the Series with *A. scabra*. (Localities: the "Fish Cleft", the locality 1 km W of the "Fish Cleft", the northern and the southern slopes of Estheria Hill.) A not more closely determinable Asterolepid belonging either to a primitive Asterolepid or possibly to a young stage of a more specialized species is in all probability also from this series (pp. 38—40). The series has been considered equivalent to the Scottish Beds with *A. maxima* and to the Baltic-Russian Beds with *A. ornata*, and it would thus belong to the upper part of the upper Middle Devonian (pp. 45—49).

¹ As emphasized above (p. 40), it is not quite impossible that the Asterolepid of an older-looking type may reveal itself as a very young individual of a more specialized type.

Tentative correlation of the continental upper Middle Devonian strata of certain important districts.¹

(The occurrence of the genus *Asterolepis* is completely given in the scheme.)

Age (marine sequence)	NW. Russia	Baltic States	Scotland ²	Spitsbergen	Greenland		
Upper Devonian (lowermost part)	Pskov Beds <i>Bothriol. panderi</i>	Marine Series	Alves or Scaat Craig Beds <i>Bothriol. major</i>				
	Snetnaia Beds <i>Bothriol. panderi</i> <i>Asterol. sp.</i>		Whitemire (Boghole) Beds <i>Bothriol. major</i> <i>Asterolepis maxima</i>				
Upper Middle Devonian	Subsnetnaia Beds <i>Bothriol. cellulosa</i> <i>Aster. radiata</i>	<i>Cellulosa-Marl</i> <i>Bothriolepis cellulosa</i> <i>B. tuberculata</i>	Nairn Beds <i>Asterolepis maxima</i> ³	Series w. <i>Asterol. scabra</i> (?) undet. <i>Asterolepidae</i>	Series w. <i>Canningius groenlandicus</i>		
	Oredesh Beds <i>Asterolepis ornata</i> <i>A. cristata</i>	Dm ₃ : Beds w. <i>Asterolepis radiata</i>				Beds w. <i>Microbrachius</i> <i>Asterol. thule</i> ⁴	
		Luga Beds ? <i>Asterol. sp.</i> <i>Byssacanthus</i>	Dm ₄ : Beds w. <i>Asterolepis ornata</i> <i>Cyphol. livonica</i>			Zone w. <i>Coccosteus fletti</i> ⁵	?
	Lower part		Dm ₃ : <i>Heterostius</i> Beds <i>Asterolepis estonica</i> <i>A. dellei</i> <i>Byssacanthus</i>			Zone w. <i>Asterolepis orcadensis</i> ⁶	Wijde Bay Series <i>Asterolepis</i> cf. <i>orcadensis</i> <i>Heterostius</i> <i>Homostius</i> <i>Asterol. sp.</i>
Narowa Beds <i>Pterichth. concatenatus</i> <i>Byssacanthus</i>		Dm ₁₋₂ : Beds w. <i>Pterichth. concatenatus</i> <i>Byssacanthus</i>	Zone w. <i>Thursius pholidotus</i> ⁷ <i>Homostius milleri</i>				
Lower Middle Devonian							

3. The Wijde Bay Series s.str., with *Heterostius*, *Homostius* and two new described forms; *Asterolepis* cf. *orcadensis* Watson (a fragmentary anterior median dorsal plate; pp. 35—37) and *Asterolepis* sp. (a very small mixilateral plate; pp. 37 f.), has been correlated to the Baltic *Heterostius* Beds, to the Scottish-Orcadian zones with *Asterolepis orcadensis* and *Thursius pholidotus* respectively, and to the Series with *Asterolepis säve-söderberghi* and the *Heterostius* Series in Greenland (possibly to the transition between the respective Scottish and Greenlandian zones). The Wijde Bay Series is, therefore, considered to represent a late series in the lower part of the upper Middle Devonian (pp. 42—45).

4. Some new facts are given as to the morphology of *Asterolepis ornata* (pp. 10 f.; 12, foot-note; 26, foot-note; 27 f., foot-note; text-figs. 1 B, 2, 12, 17).

5. A new restoration is given of the distal segment of the pectoral fin in *Pterichthyodes milleri* (pp. 39 f.; text-fig. 21).

6. The mental plates in *Remigolepis* have been described and figured (p. 20; text-fig. 6) on the basis of a new material from East Greenland.

¹ Cf. Delle 1937; Evans 1929; Gross 1933 a, 1940, 1941 a; Heintz 1937; Hekker, Phillipova, Barkhatova 1932; Jarvik 1937; Kiær 1918; Nathorst 1910; Obrutshev 1933 c; Stensiö 1918 a; Stensiö & Säve-Söderbergh 1938; Watson 1935; Westoll 1937 a, b.

² With Orkneys and Shetland.

³ Here probably also the Bressay Series (Shetl.).

⁴ John o'Groats Sandstone Group; Eday Beds (Orkneys); (? Lerwick Series and) Brindister Flags (Shetl.).

⁵ Orkneys.

⁶ Upper Rousay Beds (Orkneys).

⁷ Thurso Flagstone Group; Lower Rousay Beds (Orkneys).

⁸ Achanarras Band, Tynet Burn, etc.; Stromness Beds (Orkneys); Sandness Beds (Shetl.).

Addendum.

The above paper was communicated to the editor in January 1939. In the long delay before printing, caused by the circumstances of the time, some important works, dealing with the Baltic and German *Antiarchi*, have appeared (Gross 1940; 1941 a, b). The new results could be considered to some extent in the proof-sheets. Of great importance for the present paper are the new finds of small Asterolepids, *Asterolepis estonica* Gross and *A. dellei* Gross, in the Baltic *Heterostius*-Beds (Gross 1940, pp. 18—44). These finds beautifully confirm my supposition concerning the *Antiarchi*-remains of the mentioned beds (p. 44 of the present paper). The new forms have been inserted in the scheme p. 50 but could not be considered otherwise. They have not caused any change of the correlations given in the mentioned scheme.

The new nomenclature of certain of the bones and sensory line canals of the Antiarchs proposed by Gross (1941 a) and Stensiö (in a very important, not yet published revision of the subfamily *Bothriolepinae*) could not, of course, be considered. In the last-mentioned work, which was kindly placed at my disposal by Prof. Stensiö, the author gives, among others, an account of a structure in *Bothriolepis*, which he interprets as a spiracular opening. A corresponding opening can also be seen in the material of *Asterolepis scabra*, figured in the present work, between the lateral and the extralateral plate (pl. V, figs. 1, 2; pl. VI, fig. 1).

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EXPLANATION OF PLATES

The specimens figured belong to the Palaeozoological Department of the Swedish Museum of Natural History (Riksm.), to the Palaeontological Institute of the University of Uppsala (Upps.), and to the Palaeontological Museum, Oslo (Osl.). They have been taken on Ilford special panchromatic plates. The objectives used were Zeiss Tessar 1:6,3, F. 36 cm, and 1:6,3, F. 25 cm.

PLATE I.

Asterolepis scabra (Woodward).

Ventral wall of the carapace, preserved in part as impression of the internal face. Ventral view. Specimen Upps. no. P. 1054 (spec. B). $\times 0,46$ diam.

Explanation of index letters.

Ard, dorsal articular plate; *Arv*, ventral articular plate; *Avl*, anterior ventro-lateral plate; *Lmp*, lateral marginal plate; *Mix*, mixilateral plate; *Mv*, median ventral plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semi-lunar plate; *cit₂*, posterior branch of the crista transversalis interna anterior; *sg*, groove, probably for a pit-line; *subc*, subcephalic division of the anterior ventro-lateral plate; *tub*, tuberosities, probably of a pathological origin; *x*, normally ornamented irregular pit or shallow depressions on the ventro-lateral ridge.

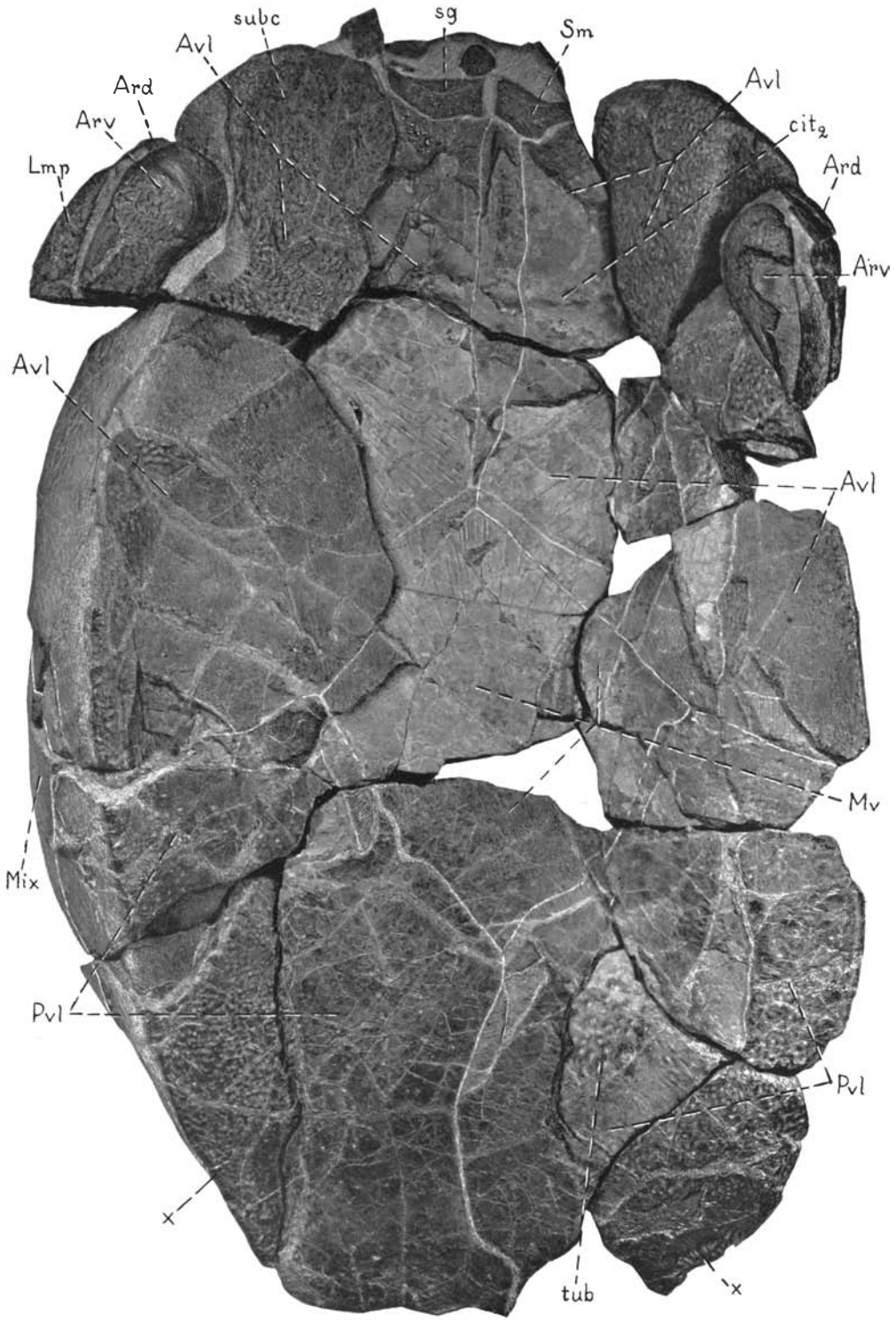


PLATE II.

Asterolepis scabra (Woodward).

Ventral part of carapace, preserved in the main as an impression of the external face. Dorsal view. Counterpart of the specimen figured in pl. I. $\times \frac{2}{5}$ diam.

Explanation of index letters.

Avl, anterior ventro-lateral plate; *Me*, mental plate; *Mv*, median ventral plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; *cit*₁, anterior, *cit*₂, posterior branch of the crista transversalis interna anterior; *dist*, distal segment of the pectoral fin; *f. ax*, foramen axillare; *prox*, proximal segment of the pectoral fin; *sg*, groove, probably for a pit-line; *subc*, subcephalic division of the anterior ventro-lateral plate; *tub*, tuberosities, probably of a pathological origin.

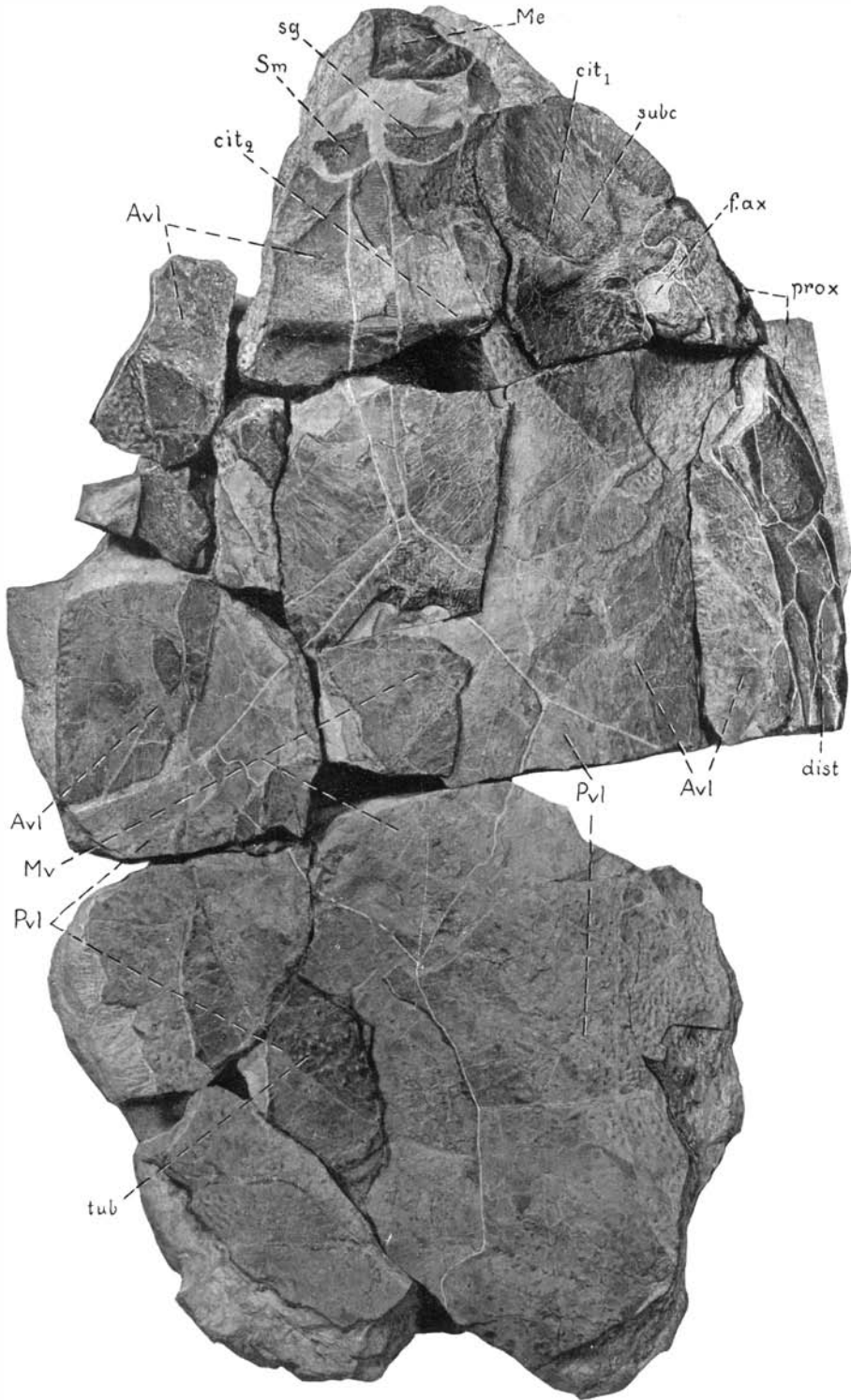


PLATE III.

Asterolepis scabra (Woodward).

Fig. 1. Lower part of trunk-carapace and head in lateral view. Same specimen as in pls. I—II. $\times 1/2$ diam.

Fig. 2. Certain of the head bones in posterior view. Spec. B. Nat. size.

Explanation of index letters.

Adl, anterior dorso-lateral plate; *Ard*, dorsal articular plate; *Arv*, ventral articular plate; *Avl*, anterior ventro-lateral plate; *Ext*, extralateral plate; *Lmp*, lateral marginal plate; *Lp₁*, posterior lamina of *Lp*, lateral plate; *Mix*, mixilateral plate; *Nl₁*, posterior lamina of *Nl*, lateral nuchal plate; *Ptm*, postmedian plate; *Pvl*, posterior ventro-lateral plate; *Sl*, suff-laminal plate; *cr. dm*, dorso-medial crista of the dorsal articular plate; *f*, funnel on the posterior surface of the lateral plate; *f. ax*, foramen axillare; *ifg*, infraorbital lateral line groove; *lcg*, main lateral line groove; *s*, normally ornamented face, secondarily overlapped by displacement; *subc*, subcephalic division of the anterior ventro-lateral plate; *tr*, articular trochlea of the lateral nuchal plate; *x*, normally ornamented irregular pit or shallow depressions on the ventro-lateral ridge.

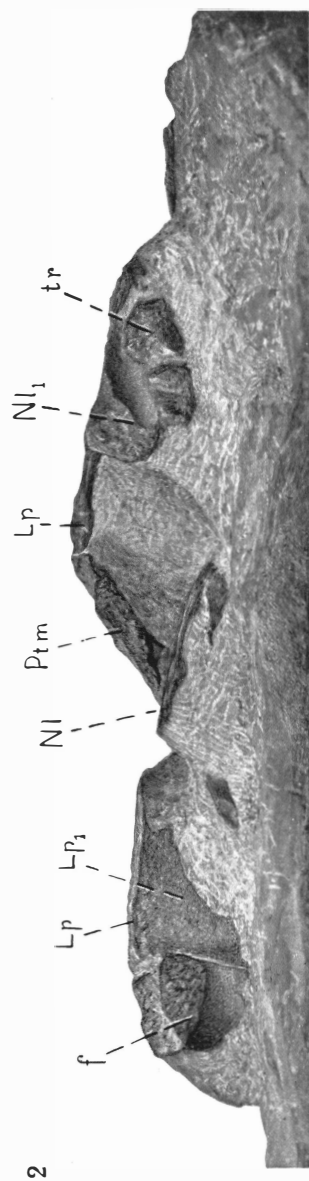
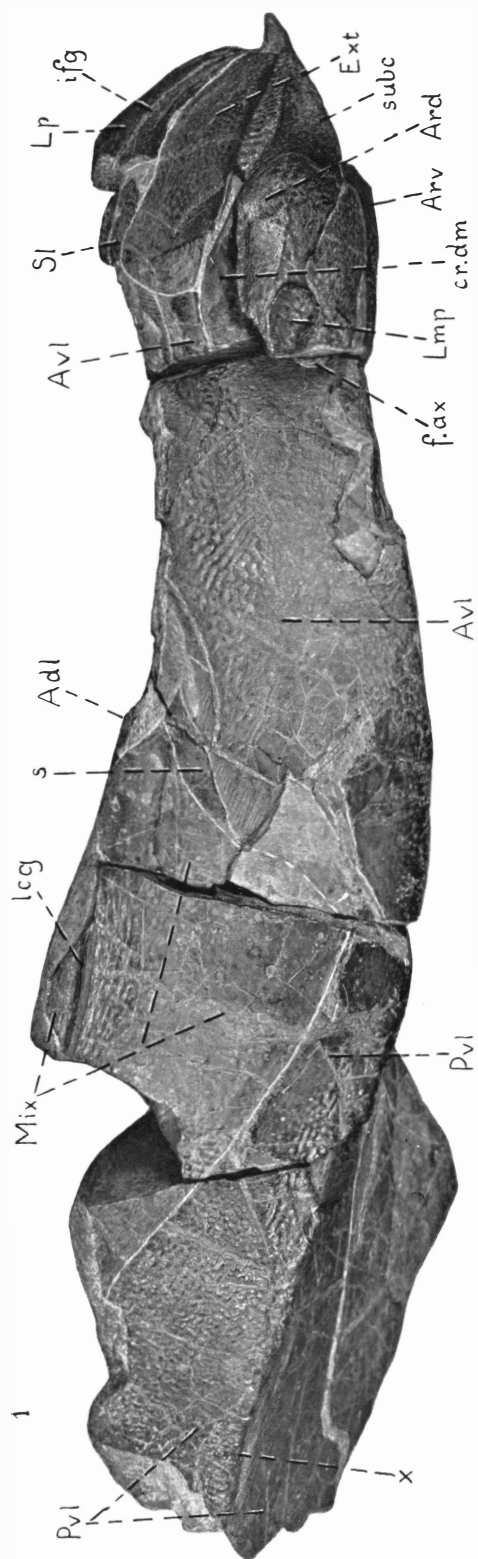


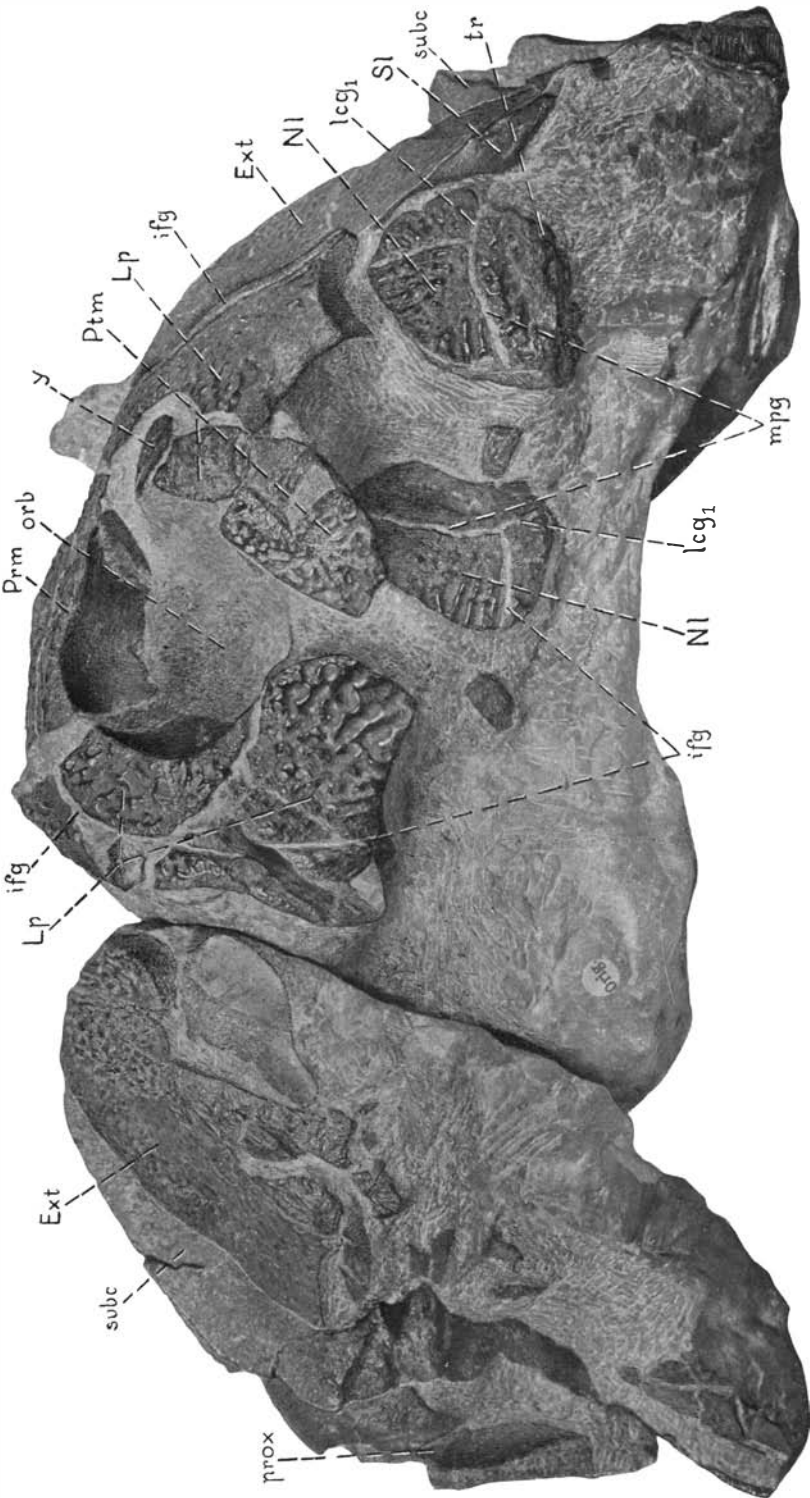
PLATE IV.

Asterolepis scabra (Woodward).

Head in dorsal view; much crushed. Specimen Upps. no. P. 1054 (spec. B); in part figured by Stensiö (1931, text-fig. 9). $\times 11/12$ diam.

Explanation of index letters.

Ext, extralateral plate; *Lp*, lateral plate; *Nl*, lateral nuchal plate; *Prm*, premedian plate; *Ptm*, postmedian plate; *Sl*, sufflaminal plate; *ifg*, infraorbital lateral line groove; *lcg*₁, cephalic division of the main lateral line groove; *mpg*, transverse commissure, probably corresponding to the middle head-line of pit-organs of fishes in general; *orb*, orbital cavity; *prox*, proximal segment of the pectoral fin; *subc*, subcephalic division of the anterior ventro-lateral plate; *tr*, articular trochlea of the lateral nuchal plate; *y*, problematic bone (fragment of a pineal plate or a sclerotic plate?).



Labels on the illustration include: Ext, NI, leg1, Sl, sub, tr, ifg, Ptm, Lp, Prm orb, ifg, NI, leg1, mp, ifg, Lp, Ext, sub, prox, and Orb.

PLATE V.

Asterolepis scabra (Woodward).

Head in anterior (fig. 1) and antero-lateral (fig. 2) view; much crushed. Same specimen as in pl. IV. Nat. size.

Explanation of index letters.

Adl, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; *Ext*, extralateral plate; *Lp*, lateral plate; *Nl*, lateral nuchal plate; *Prm*, premedian plate; *Ptm*, postmedian plate; *Sl*, sufflaminal plate; *a*, area destitute of ornamentation; *cr. dm*, dorso-medial crista of the dorsal articular plate; *ethmp*, pit-line uniting the main divisions of the infra-orbital lateral line grooves of both sides; *ifg*, infraorbital lateral line groove; *lcg₁*, cephalic division of the main lateral line groove; *mpg*, transverse commissure, probably corresponding to the middle head-line or pit-organs of fishes in general; *n*, notch in the anterior margin of the premedian plate; *orb*, orbital cavity; *subc*, subcephalic division of the anterior ventro-lateral plate; *x*, fragment of a problematic bone; *y*, problematic bone (fragment of a pineal plate or a sclerotic plate?).

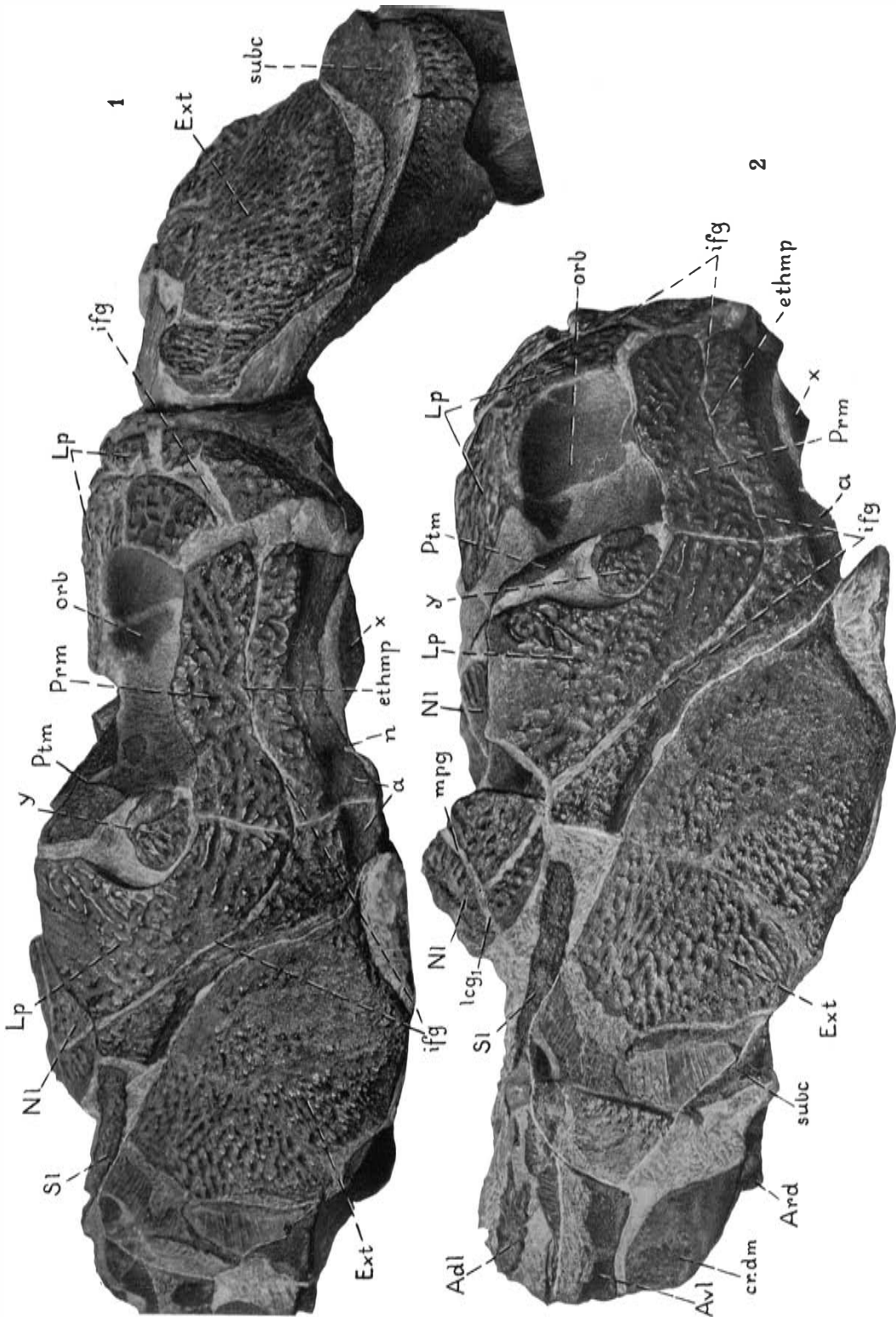


PLATE VI.

Asterolepis scabra (Woodward).

The left posterior part of a cranial shield and fragments of the adjacent plates of the trunk-carapace. Holotype (Woodward 1891, pl. III). Riksm. no. P. 1130. Nat. size.

Fig. 1. Dorsal aspect.

Fig. 2. Head in posterior aspect. Most parts of the anterior dorso-lateral plate split off. Several of the bones represented by impressions of their internal faces.

Fig. 3. Posterior aspect of the specimen in its unsplit state.

Explanation of index letters.

Adl, anterior dorso-lateral plate; *Ext*, extralateral plate; *Lp*, lateral plate; *Nl₁*, posterior lamina of *Nl*, lateral nuchal plate; *Nm₁*, posterior lamina of *Nm*, median nuchal plate; *Ptm*, postmedian plate; *Sl*, suff-laminal plate; *cit*, crista transversalis interna anterior, the part situated on the anterior dorso-lateral plate; *f*, *for*, foramen; *gr*, groove for vessels and nerves; *ifg*, infraorbital lateral line groove; *lcg₁*, cephalic division of *lcg*, main lateral line groove; *mpg*, transverse commissure, probably corresponding to the middle head-line of pit-organs of fishes in general; *pr. art*, the processus articularis of the anterior dorso-lateral plate; *pr. obst*, the processus obstans of the same plate; *subc*, subcephalic division of the anterior ventro-lateral plate.

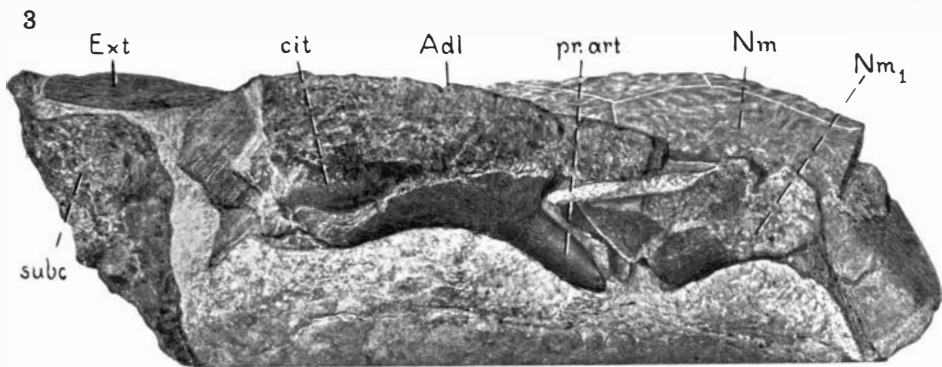
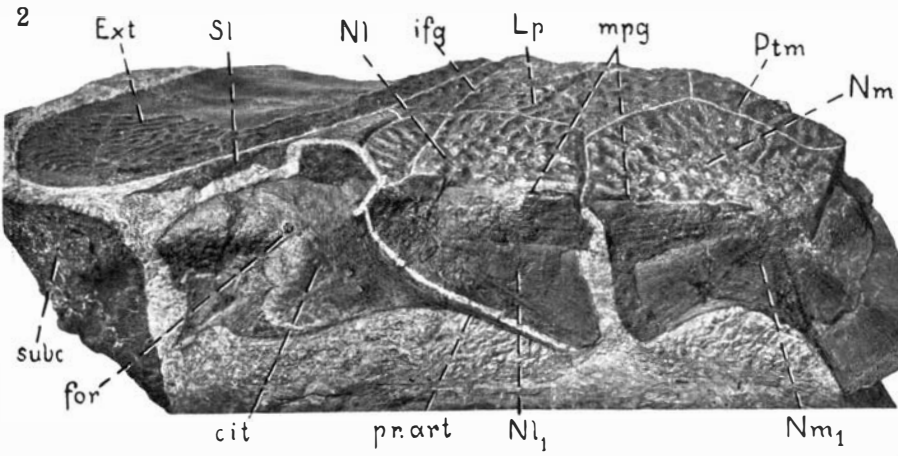
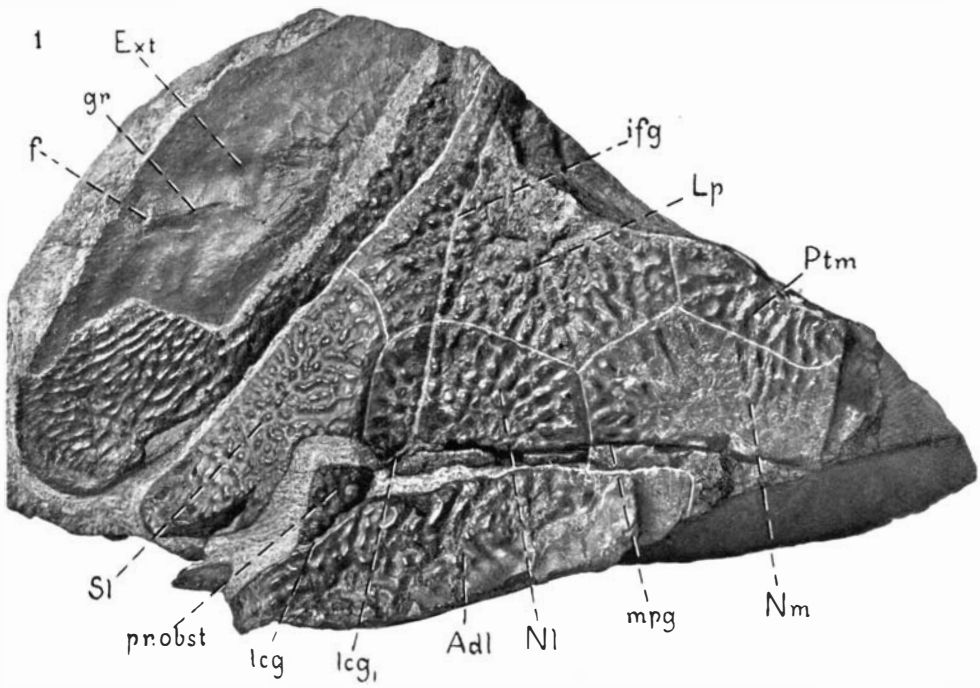


PLATE VII.

Asterolepis scabra (Woodward).

Fig. 1. The most anterior part of the ventral carapace with one mental plate. Dorsal aspect (impression of the ventral face). Specimen Upps. no. P. 1054 (spec. B). Figured also by Stensiö (1931, text-fig. 52 B). Nat. size.

Fig. 2. The counterpart (positive) in ventral view. Figured also by Stensiö (1931, text-fig. 52 A). Nat. size.

Fig. 3. Anterior median dorsal plate (impression of the internal face). Anterior view. Same specimen as in pl. VIII. $\times \frac{3}{4}$ diam.

Explanation of index letters.

avl, anterior ventro-lateral plate (subcephalic division); *Me*, mental plate (impression of internal face); *Sm*, semilunar plate; *a—d*, problematic bones, probably belonging to the visceral skeleton; *alr*, antero-lateral ridge (impression); *cv*, overlapping area (impression); *dlp*, dorso-lateral process of the mental plate; *f. retr*, retractor fossa (impression); *im*, mental incisure; *sg*, groove, probably for a pit-line; *vlp*, ventro-lateral process of the mental plate.

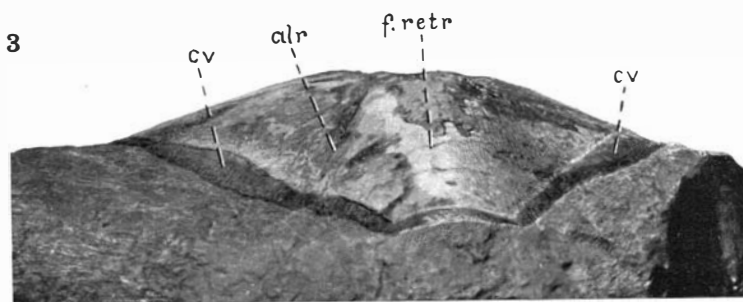
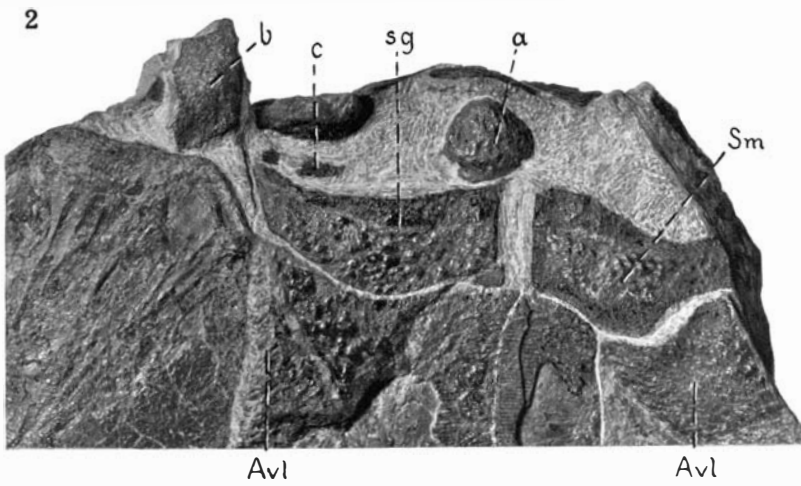
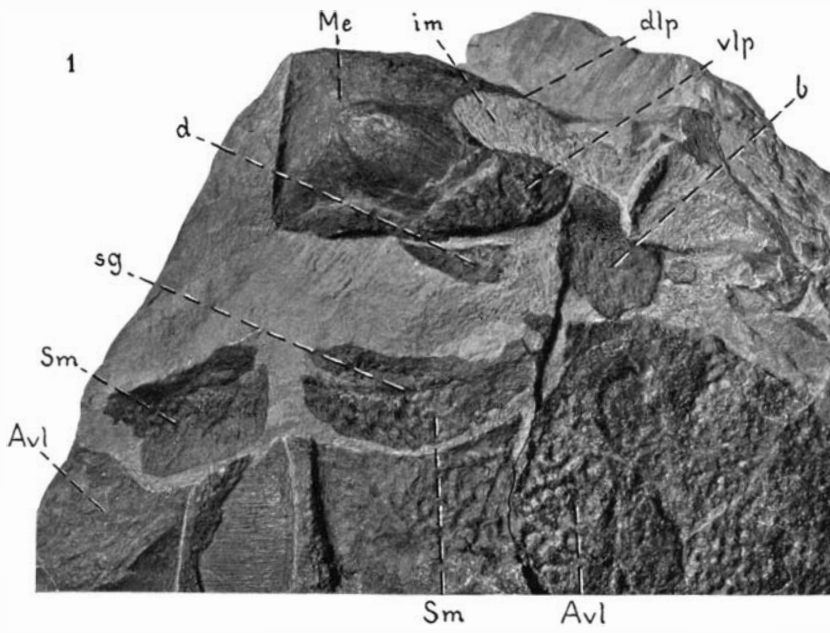


PLATE VIII.

Asterolepis scabra (Woodward).

Anterior median dorsal plate, preserved as impression of the internal face. Dorsal view. Specimen Upps. no. P. 437 a. Figured also by Stensiö (1931, text-fig. 37). $\times \frac{3}{4}$ diam.

Explanation of index letters.

alr, antero-lateral ridge (impression); *cv*, overlapping area (impression); *f. retr*, retractor fossa (impression).



PLATE IX.

Asterolepis scabra (Woodward).

Fig. 1. Anterior median dorsal plate (impression of the internal face). Lateral view. Same specimen as in pl. VIII. $\times \frac{3}{4}$ diam.

Fig. 2. A left anterior dorso-lateral plate. External face much damaged; in part impression of the internal face. Specimen Riksm. no. P. 1152. Nat. size.

Figs. 3, 4. A left (fig. 3) and a right (fig. 4) posterior ventro-lateral plate, showing a peculiar structure (*x*) on the ventro-lateral ridge. Ventro-lateral aspect. Specimen Upps. no. P. 1054 (spec. B). Nat. size.

Explanation of index letters.

*cd*₁-*cd*₂, overlapped areas; *cv*, overlapping area (impression); *lcg*, main lateral line groove; *x*, normally ornamented irregular pit or shallow depressions on the ventro-lateral ridge of the posterior ventro-lateral plate.

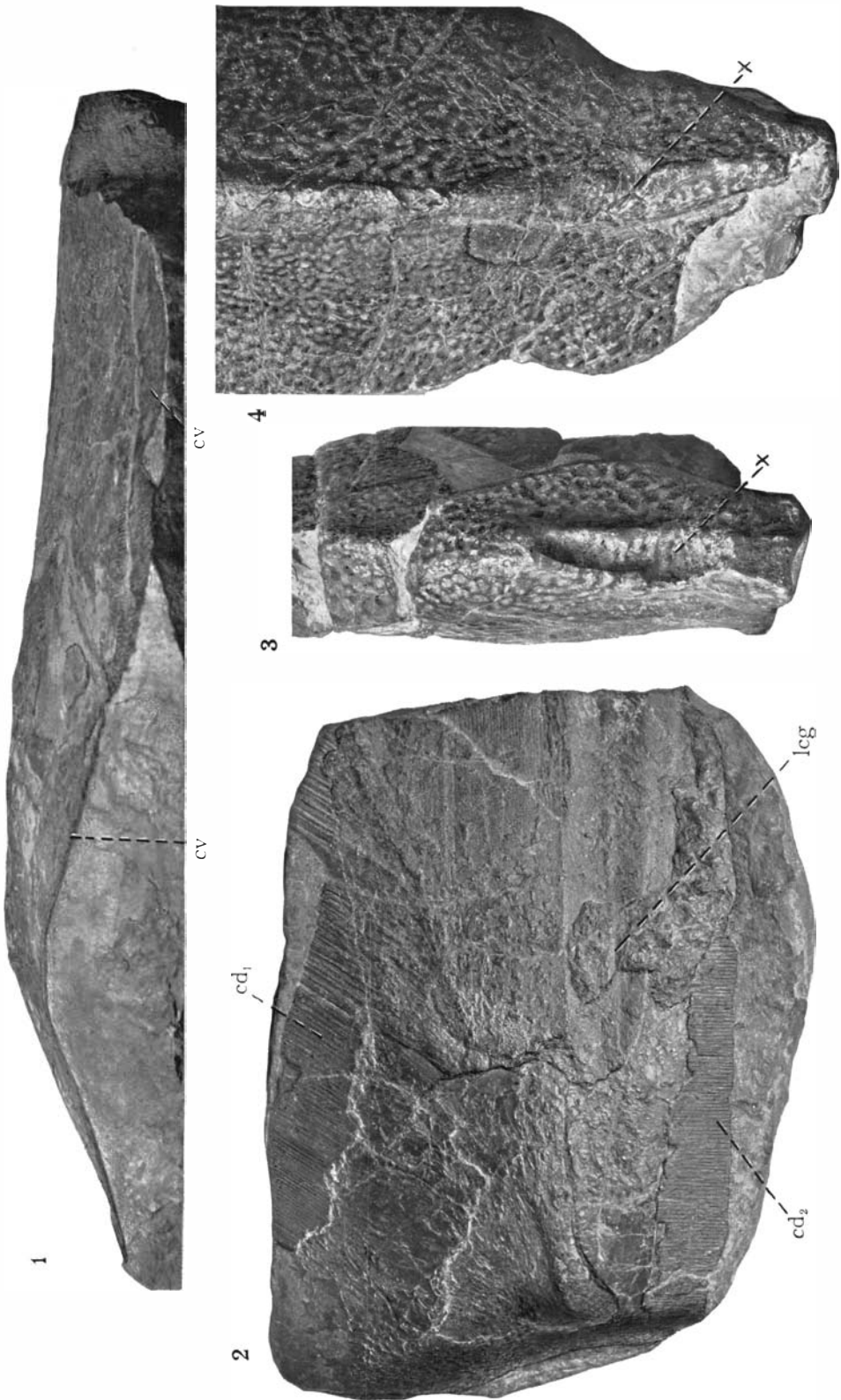


PLATE X.

Asterolepis scabra (Woodward).

Fig. 1. Fragment of a right mixilateral plate. Specimen Osl. no. A. 21872. $\times \frac{3}{4}$ diam.

Fig. 2. Fragment of a right mixilateral plate. Specimen Riksm. no. P. 1132. $\times \frac{3}{4}$ diam.

Explanation of index letters.

cd, overlapped area; *l_{cg}*, main lateral line groove; *m*, free posterior margin.

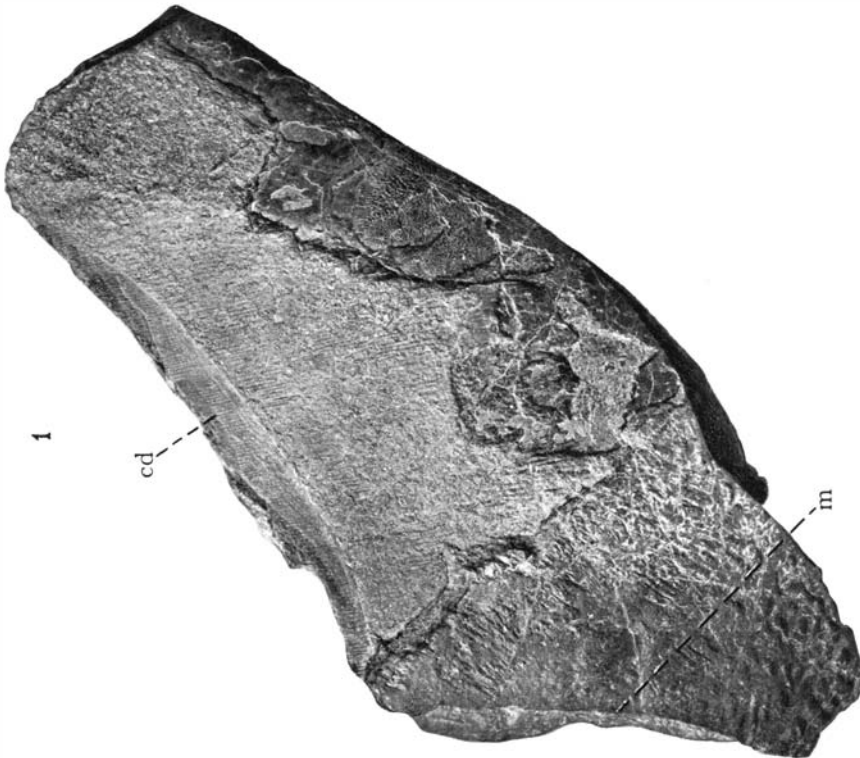
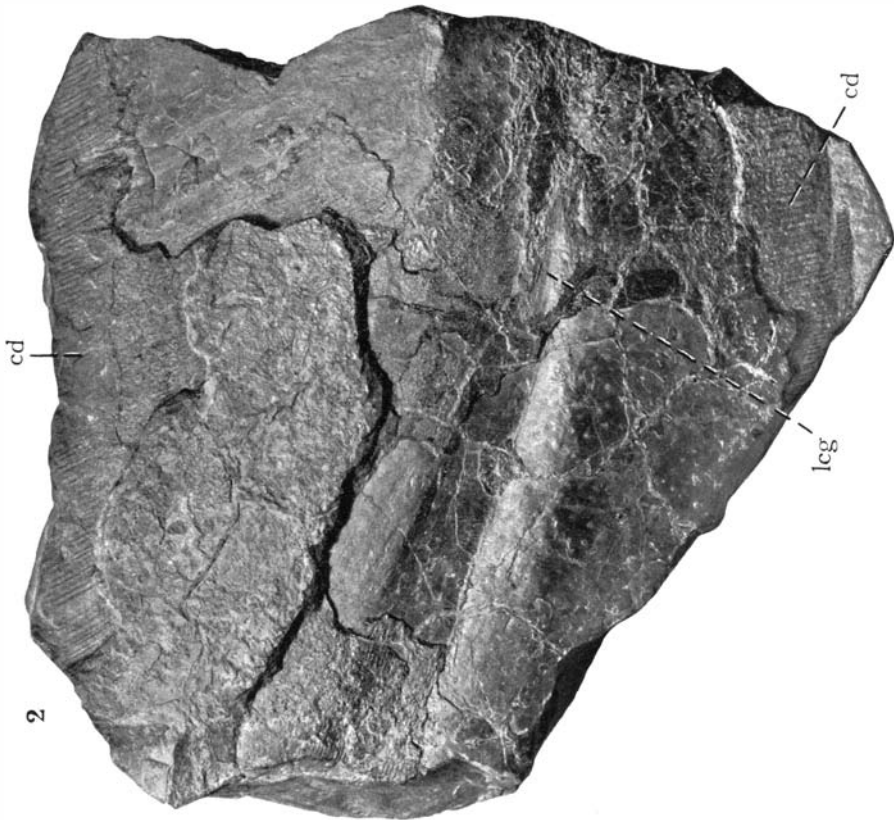


PLATE XI.

Asterolepis scabra (Woodward).

Fig. 1. Ventral face of the subcephalic division of a rather small (left) anterior ventro-lateral plate with relatively delicate ornamentation. Specimen Osl. no. A. 21860. Nat. size.

Fig. 2. Ventral face of the subcephalic division of a large left anterior ventro-lateral plate with coarse ornamentation. Processus brachialis in ventral view. Specimen Osl. nos. 21968—21969. Nat. size.

Fig. 3. Axial joint in lateral view. Specimen Upps. no. P. 1054 (spec. B). Nat. size.

Explanation of index letters.

Ard, dorsal articular plate; *Arv*, ventral articular plate; *Avl*, anterior ventro-lateral plate (subcephalic division); *Lmp*, lateral marginal plate; *a*, area destitute of ornamentation; *co*, pars condyloidea of the processus brachialis; *c. rca*, distal openings of canals; *f. art. d.*, *f. art. v.*, dorsal and ventral half respectively of the fossa articularis pectoralis; *f. ax*, foramen axillare; *f. mp*, protractor area (probably the place of origin of the protractor muscle of the pectoral fin); *m. lim*, margo limitans of the fossa articularis pectoralis; *p. art.*, pars articularis of the dorsal and ventral articular plates; *pe*, pars pedalis of the processus brachialis; *prox*, proximal segment of the pectoral fin.

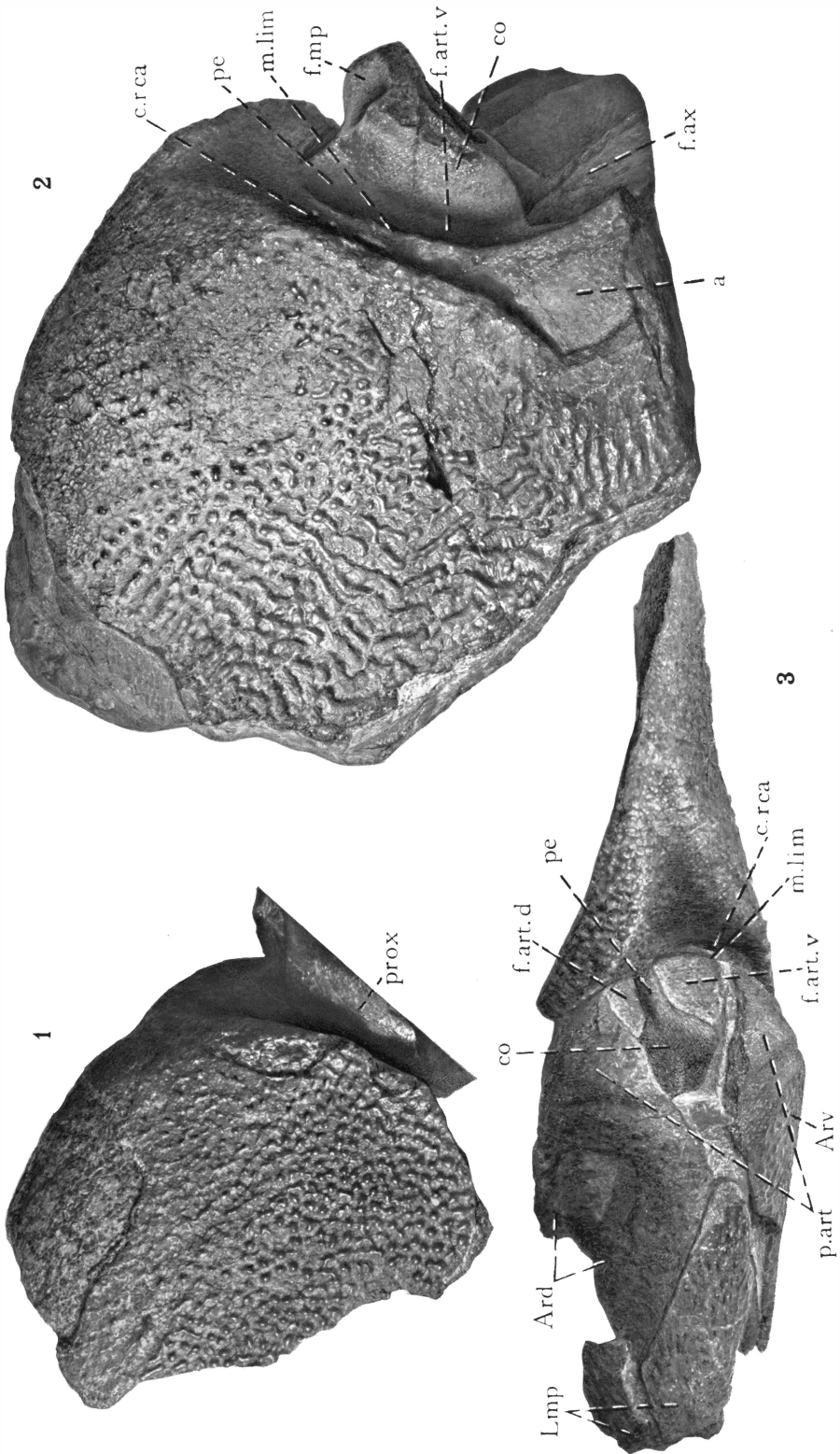


PLATE XII.

Asterolepis scabra (Woodward).

The anterior part of an anterior ventro-lateral plate with the processus brachialis in lateral (fig. 1) and posterior view (fig. 2). Same specimen as in pl. XI, fig. 2. Nat. size.

Explanation of index letters.

co, pars condyloidea of the processus brachialis; *c. rca*, distal openings of canals; *f. art. d.*, *f. art. v.*, dorsal and ventral half respectively of the fossa articularis pectoralis; *f. ax*, foramen axillare; *f. mp*, protractor area; *fp*, funnel pit of the processus brachialis; *gr*, groove in the dorso-medial corner of the funnel pit; *m. ax*, dorsal margin of the fossa axillaris; *m. lim*, margo limitans of the fossa articularis pectoralis; *pe₁*, posterior face of *pe*, pars pedalis of the processus brachialis; *subc*, subcephalic division of the anterior ventro-lateral plate.

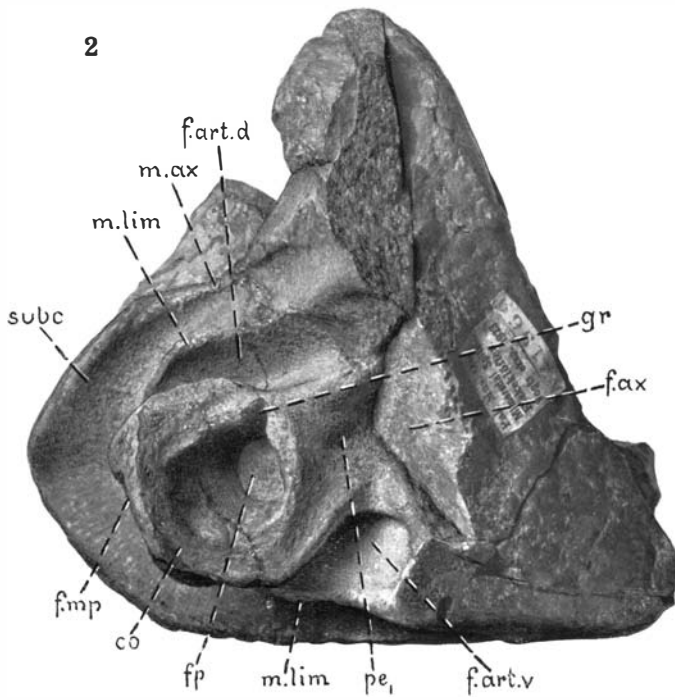
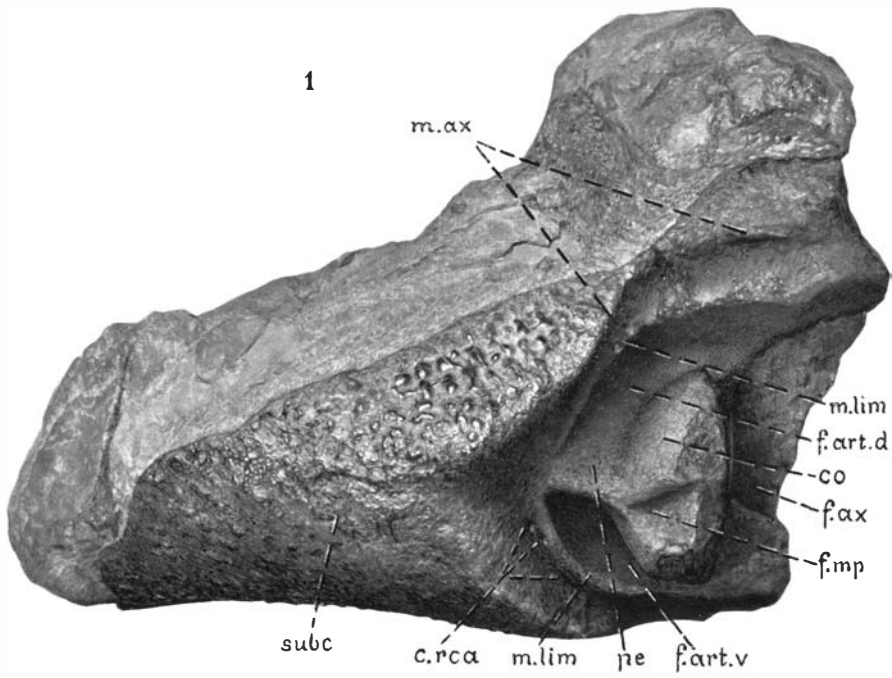


PLATE XIII.

Asterolepis scabra (Woodward).

Anterior part of a (right) anterior ventro-lateral plate with the proximal part of the proximal pectoral fin segment. Specimen Upps. no. P. 1054 (spec. B). Nat. size.

Fig. 1. In ventral view.

Fig. 2. In dorsal (internal) view.

Explanation of index letters.

Ard, dorsal articular plate; *Arv*, ventral articular plate; *Avl*, anterior ventro-lateral plate; *Axp*, axial plate; *Lmp*, lateral marginal plate; *a*, area destitute of ornament; *co*, pars condyloidea of the processus brachialis; *cit*₁, anterior, *cit*₂, posterior branch of the crista transversalis interna anterior; *c. rca*, distal opening of a canal; *f. ax*, foramen axillare; *m. lim*, margo limitans of the fossa articularis pectoralis; *p. art*, pars articularis of the dorsal and ventral articular plates; *pe*, pars pedalis of the processus brachialis; *subc*, subcephalic division of the anterior ventro-lateral plate.

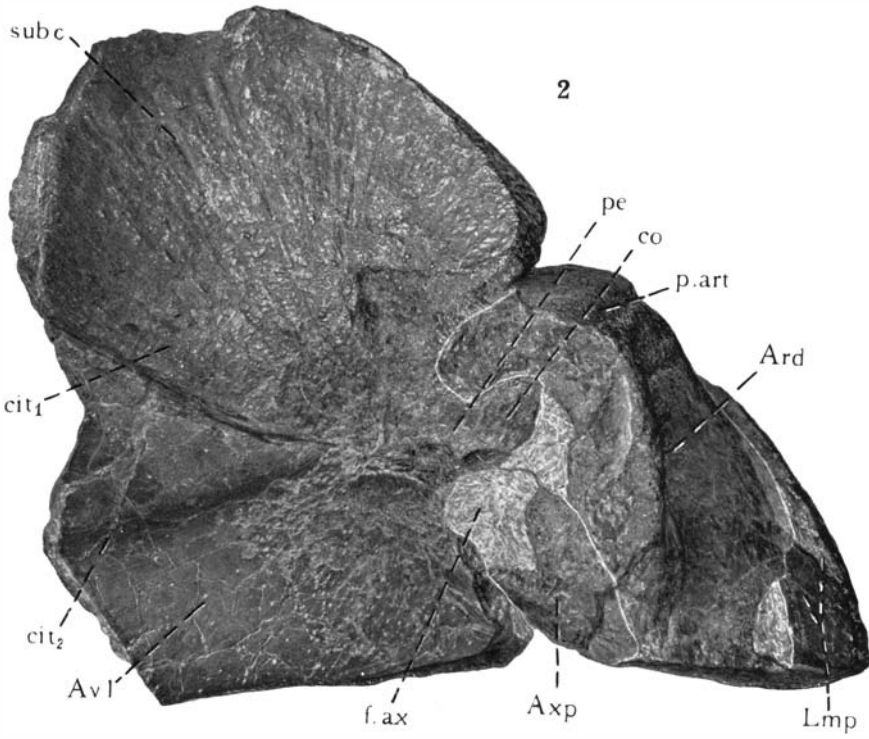
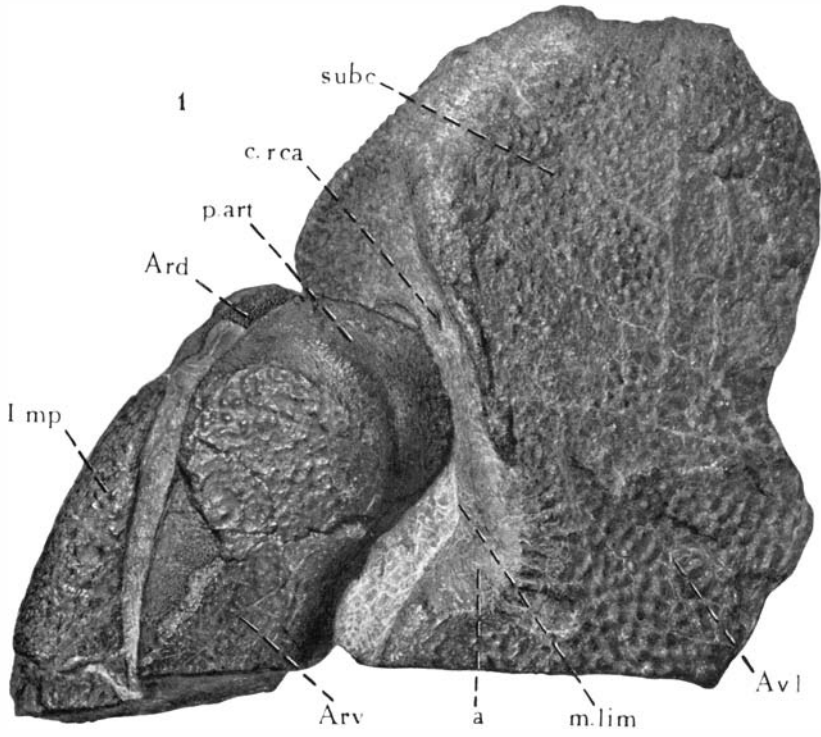


PLATE XIV.

Asterolepis scabra (Woodward).

Fig. 1. Section through the middle part of the anterior ventro-lateral plate and of the proximal segment of the pectoral fin. Same specimen as in pl. XIII. Nat. size.

Fig. 2. Imperfect pectoral fin of the right side. Dorsal aspect. Specimen Upps. no. P. 1054 (spec. B). Figured also by Stensiö (1931, text-fig. 58). Nat. size.

Fig. 3. Posterior part of a left medial marginal plate of the proximal pectoral fin segment. Dorsal aspect. Plaster cast. Specimen Osl. nos. A. 21840–21843, 21845. Nat. size.

Fig. 4. Section through the middle part of the preserved portion of the same specimen. Nat. size.

Fig. 5. The same specimen in lateral (internal) aspect. Nat. size.

Fig. 6. The same specimen in ventral aspect. Nat. size.

Explanation of index letters.

And, dorsal anconeal plate; *Ard*, dorsal articular plate; *Arv*, ventral articular plate; *Avl*, anterior ventro-lateral plate; *Axp*, axial plate; *Cd*₁, dorsal (proximal) central plate; *Ldmp*₁, *Ldmp*₂, lateral marginal plates of the distal segment; *Lmp*, lateral marginal plate of the proximal segment; *Mdmp*₁, *Mdmp*₂, medial marginal plates of the distal segment; *Mmp*, medial marginal plate of the proximal segment; *Tp*, terminal plate; *cr. dm*, dorso-medial crista of the dorsal articular plate; *sgp*, groove of the pit-line type, probably belonging to the sensory canal system.

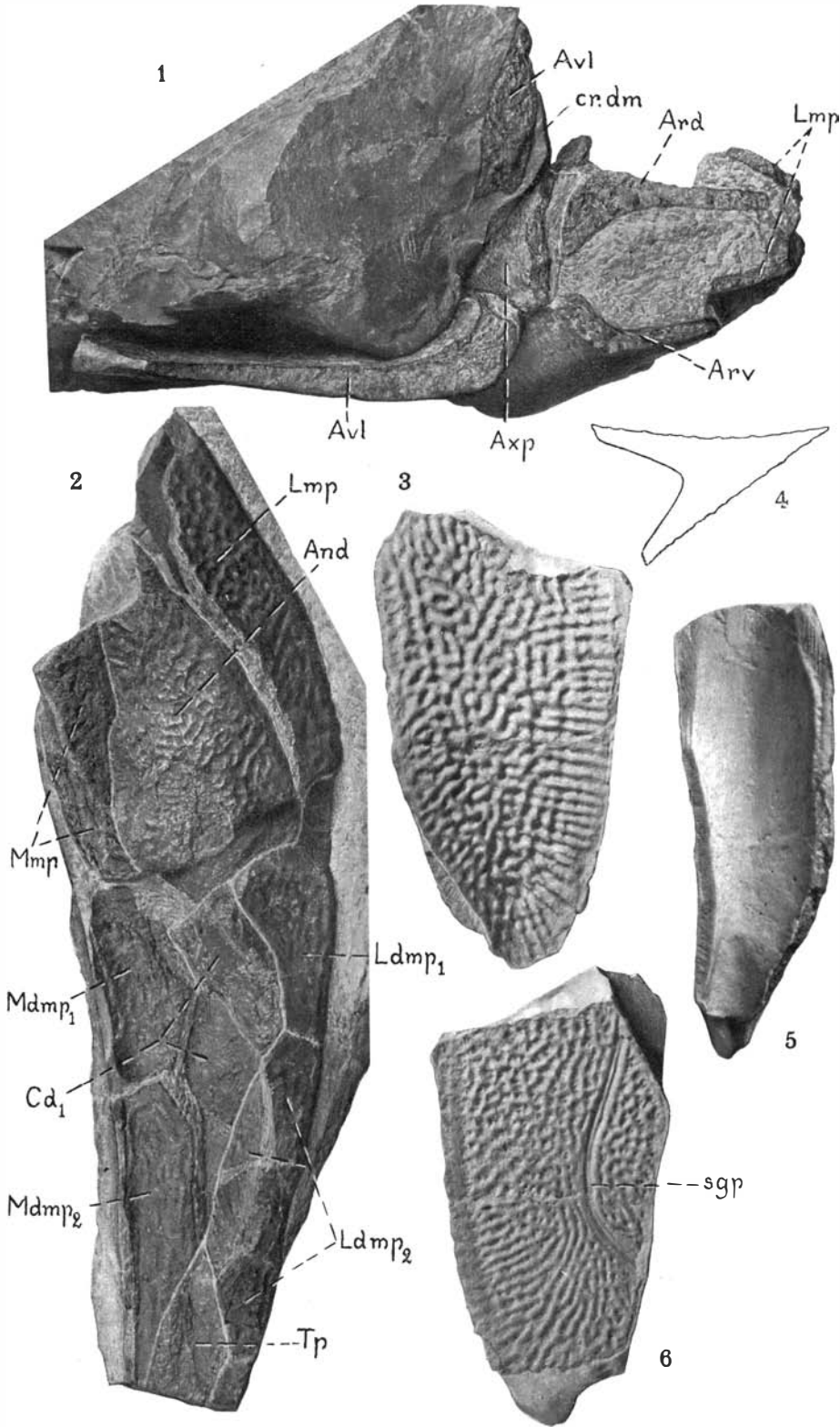


PLATE XV.

Asterolepis scabra (Woodward).

Fig. 1. Dorsal articular plate of the right pectoral fin. Medial aspect. Specimen Osl. no. A. 21920 (same specimen as in text-fig. 1 A). Nat. size.

Fig. 2. Dorsal articular plate of the left pectoral fin. Dorsal aspect. Specimen Osl. no. A. 21858. Nat. size.

Fig. 3. Axial plate of the left pectoral fin. Medial aspect. Specimen Osl. no. A. 21858. Nat. size.

Explanation of index letters.

cr. dm, dorso-medial crista of the dorsal articular plate; *depr*, dorso-anterior depression in the axial plate; *p. art*, pars articularis of the dorsal articular plate; *sgp*, groove of the pit-line type, probably belonging to the sensory canal system; *subc*, subcephalic division of the anterior ventro-lateral plate.

Asterolepis cf. *orcadensis* Watson.

Fig. 4. Anterior half of an anterior median dorsal plate. Impression of the internal face. Dorsal view. Specimen Osl. no. A. 24374. $\times 1\frac{1}{2}$ diam.

Fig. 5. The same in lateral view. $\times 1\frac{1}{2}$ diam.

Explanation of index letters.

alr, antero-lateral ridge (impression); *cv₁*, *cv₂*, overlapping areas (impressions); *tub*, traces of ornament.

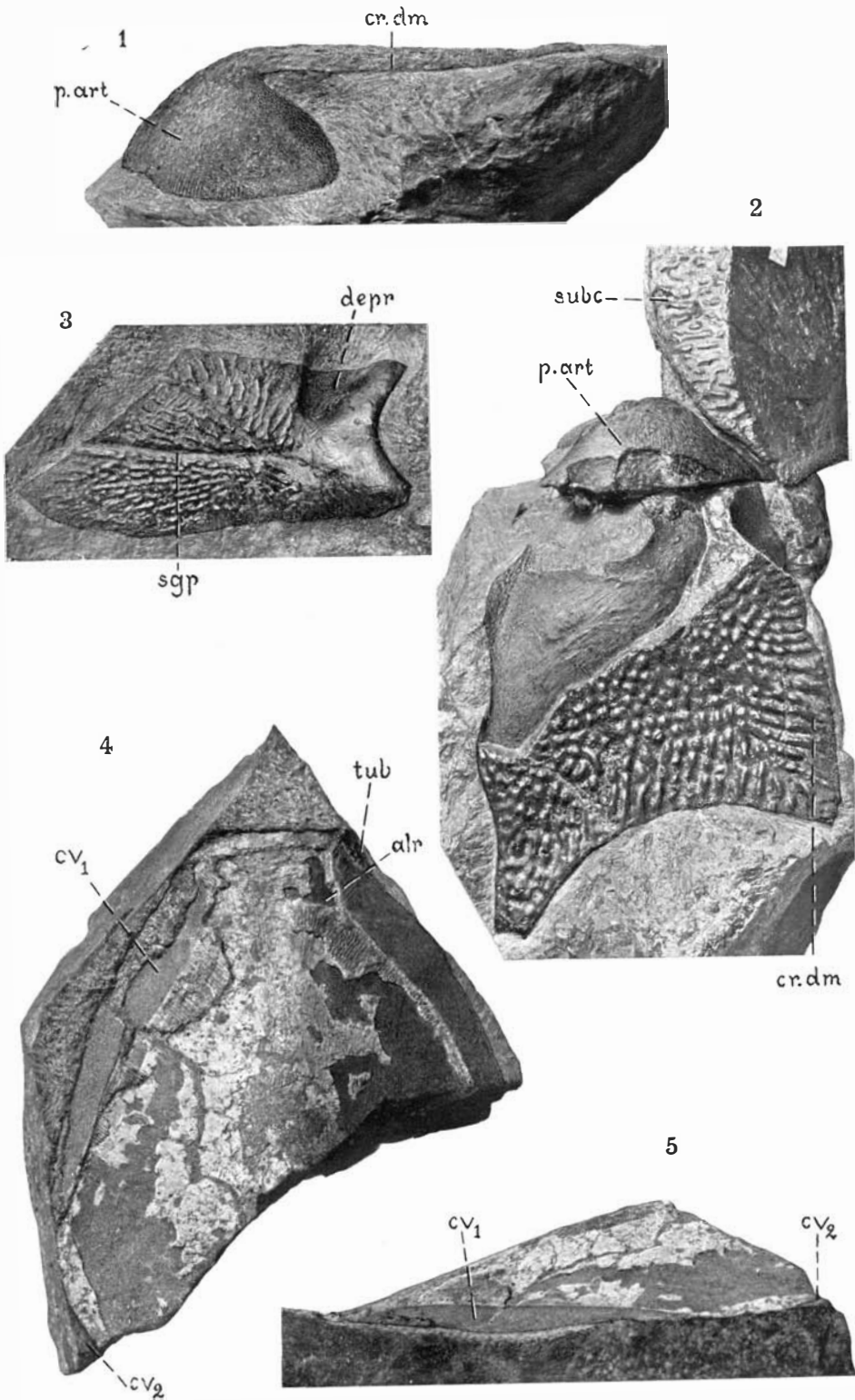


PLATE XVI.

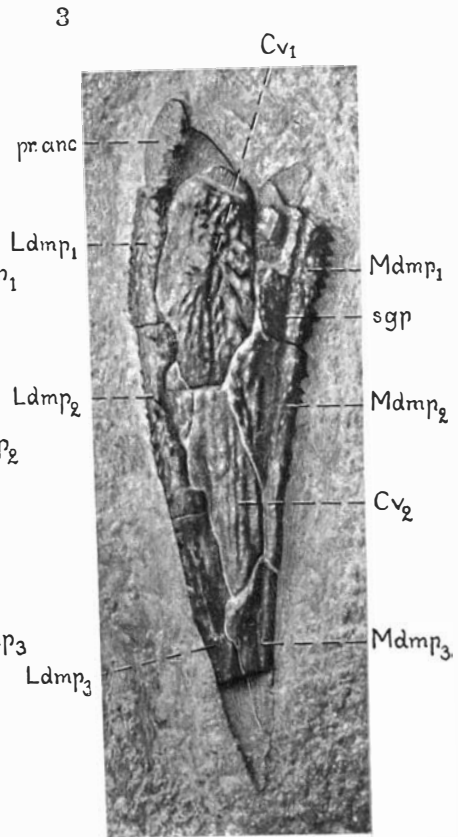
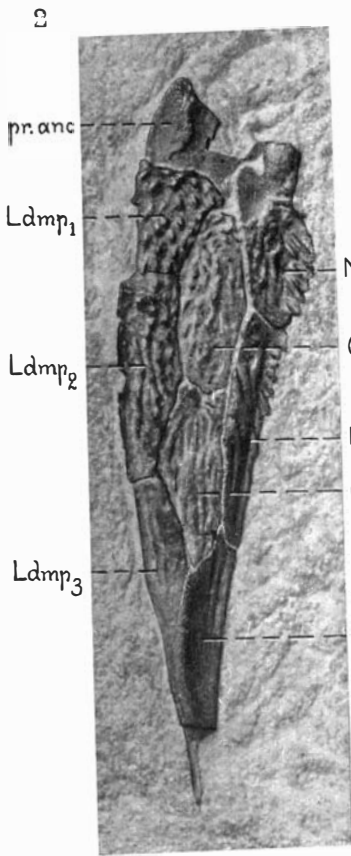
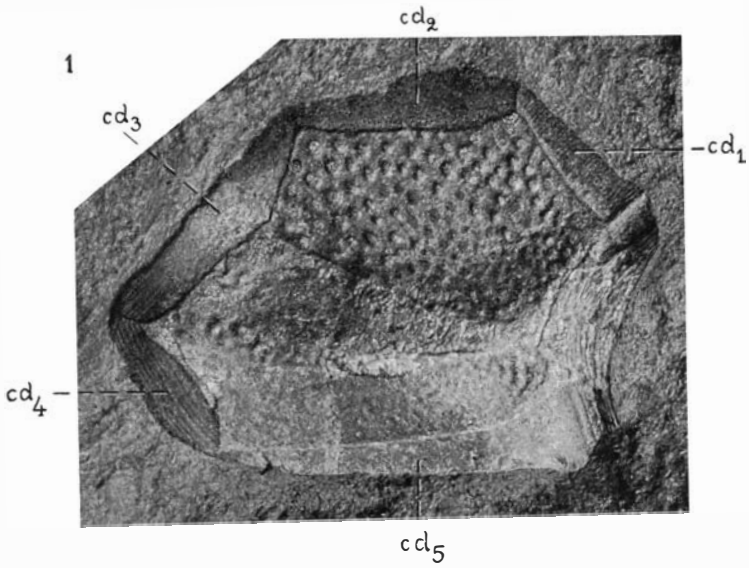
Fig. 1. *Asterolepis* sp. Mixilateral plate from the right side of the trunk. Impression of the external face. Specimen Osl. no. A. 24383. $\times 3$ diam.

Fig. 2. *Asterolepidae* gen. et sp. indet. Distal segment of a left pectoral fin. Dorsal view. Specimen Upps. no. P. 442. $\times 5$ diam.

Fig. 3. *Asterolepidae* gen. et sp. indet. Distal segment of a right pectoral fin. Ventral view. Specimen Upps. no. P. 442. $\times 5$ diam.

Explanation of index letters.

Cd_1 , Cd_2 , dorsal central plates; Cv_1 , Cv_2 , ventral central plates; $Ldmp_1$ — $Ldmp_3$, lateral marginal plates of the distal segment; $Mdmp_1$ — $Mdmp_3$, medial marginal plates of the distal segment; cd_1 — cd_5 , overlapped areas (impressions); *pr. anc*, processus anconalis of the proximal lateral marginal plate; *sgp*, groove of the pit-line type, probably belonging to the sensory canal system.



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