REVISION

OF THE

CARADOCIAN-ASHGILLIAN CYSTOID FAUNA OF BELGIUM

WITH NOTES ON ISOLATED PELMATOZOAN STEM FRAGMENTS

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1. INTRODUCTION.

Cystoids were announced from the Ordovician (being included in the conception « terrain silurien ») of Belgium for the first time in 1873 by C. MALAISE (1873*a*) in his monograph entitled « Description du terrain silurien du centre de la Belgique ». Figures were given (Pl. 6, fig. 8-9) of two specimens referred to as *Sphæronites stelluliferus* SALTER (fig. 8 = *Echinosphærites barrandei belgicus* JAEKEL; fig. 9 = *Heliocrinites malaisei* nov. sp.), and the same was recorded in faunal lists from a number of fossil sites, first and foremost of the « Massif du Brabant » but also of the « Massif de Sambre-et-Meuse ».

Our knowledge of the Cystoids of Belgium has not made much progress since that date. It is true that a few more species have been reported in the literature. But they are mere names, not being accompanied by any figures, nor — with the exception of *Echinosphærites belgicus* JAEKEL, 1899 (p. 337) — by any descriptions. And it is significant that the only species listed from Belgium by R. S. BASSLER & M. V. MOODEY (1943, p. 33) in their Index of Paleozoic Pelmatozoans is that last mentioned. Obviously they did not consider it necessary to repeat the other, insufficiently corroborated statements.

Especially the papers by J. CHAUVEL (1941) and M. DREYFUSS (1939) contributed materially to a better knowledge of the Ordovician Cystoid fauna of West Europe. But there were — and still remain — gaps to be bridged. Therefore, the present writer greeted with very great satisfaction a suggestion by Dr. G. UBAGHS, of Liège, to undertake a revision of the material available of Belgian Upper Ordovician Cystoids. Three years ago — owing to other work

the investigation had to be postponed until recently — collections were received from the following Institutions and Museums :

Institut royal des Sciences naturelles de Belgique (formerly : Musée royal d'Histoire naturelle de Belgique) (Section Invertébrés primaires I), Bruxelles (referred to below as « I.R.Sc.N.B. »).

Institut de Paléontologie de l'Université, Liège (referred to below as « Liège »).

Université de Louvain (referred to below as « Louvain »).

Musée de Paléontologie de l'Abbaye de Maredsous (referred to below as « Maredsous »).

Along with the specimens from the Institut de Paléontologie of Liège there was one belonging to the Collection R. Roncart of Liège.

The collections of the Paleozoological Department of the Swedish Museum of Natural History, Stockholm, contain only two specimens of Belgian Cystoids.

The author is deeply indebted to the Directors and Keepers of these Institutions and Museums for generously entrusting him with the elaboration of material of wich they are in charge. He wishes to mention Professor V. Van Straelen (Directeur de l'Institut royal des Sciences naturelles de Belgique), Dr. M. Lecompte, conservateur at the same Institution, Dr. G. Ubaghs, Liège, and Dom Felix Anciaux, Abbaye de Maredsous. Special thanks are due to Dr. Ubaghs, who not only proposed to the writer to make this study and arranged for the material of the above-mentioned Institutions to be placed at his disposal, but also supplied references to important Belgian literature. Special obligations should also be expressed to the Direction of the Institut Royal des Sciences Naturelles de Belgique for accepting the present paper to appear in this Memoir.

2. DISTRIBUTION OF THE OLD PALEOZOIC DEPOSITS OF BELGIUM. STRATIGRAPHY OF THE UPPER ORDOVICIAN.

Ordovician deposits — and Cambro-Silurian deposits on the whole — occupy a very restricted area of the rock-floor of Belgium (see map, Pl. 1, facing p. 12, in E. Maillieux, 1933). The Old Paleozoic rocks have been known since the beginning of the 19th century. Their presence was first established in 1808 by J. J. D'Omalius D'Halloy. By A. H. Dumont and others these formations were considered to be Lower Devonian, and not until 1860 was their true age recognized by J. Gosselet. His interpretation of the fossil record was confirmed by J. Barrande and was accepted gradually. A summary of the advancement of the knowledge of the Cambro-Silurian of Belgium was given i. a. by C. Malaise (1873*a*, pp. II-IV in wich is presented a reasoning bibliog-

raphy arranged chronologically; 1900, pp. 182-184; 1901, p. 563) and by J. GOSSELET (1888, pp. 137-138). The basic work is MALAISE's monograph of 1873*a*, which was preceded by a few minor papers by the same author and followed by several others. Of later authors, E. MAILLIEUX (1926) devoted a special paper to the stratigraphy and development of the Ordovician of Belgium and gave a review of this subject in his book on the geology of that country (E. MAILLIEUX, 1933, pp. 30-35). As far as the writer is aware, this is the most recent contribution relative to the matter.

Cambrian rocks are exposed in the Ardennes (« Massif de l'Ardenne ») in the south and in Brabant (« Massif du Brabant ») in the north, in the central part of the country. They have yielded no fossils but the problematic *Oldhamia* and a few other forms (see M. LECOMPTE, 1948, p. 678).

Ordovician-Silurian deposits are not present in the Ardennes, but are developed in Brabant and within an area extending in an east-westerly direction between those others just mentioned and separating the Belgian north-trough (Bassin de Namur) from the south-trough (Bassin de Dinant). This area is parallel to the Rivers Sambre and Meuse and is known as the « Bande de Sambre-et-Meuse » (« Massif Rhénan du Condroz » of A. H. DUMONT). No Cystoids have been found in the lower and middle parts of the Ordovician. Plates of « *Sphæronites* sp. » — the generic name used probably in a very wide sense — were reported by C. MALAISE (1900, p. 219; 1901, p. 566) from strata referred to as Llandoverian (which may not be correct).

However, in this connexion we are only concerned with the part of the series of strata that has been correlated with the Caradocian and the Ashgillian. In faunal facies, these deposits are said to be developed similar to the corresponding strata of the Shropshire and Wales sequences of Britain.

According to E. MAILLIEUX (1933, p. 32) they are to be correlated thus :

	Massif du Brabant	Bande de Sambre-et-Meuse
Ashgillian.	Unknown.	Fosse Shales with *Christiania tenuicincta* (M'COY).
Caradocian.	*b*. Gembloux Shales with *Nicolella actoniæ* (SOWERBY).	*b*. Unknown ?
	a. Fauquez Shales with *Pleurograptus linearis* (CARRUTHERS).	*a*. Oxhe Sandstone with *Cryptolithus gibbifrons* (M'COY).

On the evidence of the fossil-lists published (E. MAILLIEUX, 1933, pp. 33-34) we may rely on the above classification, which differs from similar tables of preceding papers i. a. in that the Fosse Shales are placed in the Ashgillian instead of being considered equivalent to the Gembloux Shales. It seems to the

present writer, however, that some of the determinations of the fossils in the Belgian Caradocian-Ashgillian beds require further confirmation. This applies to e. g. *Orthis calligramma* DALMAN (Gembloux Shales, Fosse Shales), which in the Scandinavian region occurs in the Upper Arenigian. Other somewhat dubious determinations are *Leptœna rhomboidalis* (WILCKENS) and *Atrypa* [*Nalivkinia*] *marginalis* (DALMAN), both recorded from the Gembloux Shales and the Fosse Shales. In other areas these species are Silurian.

Without entering on a discussion of the faunal lists, the writer may be allowed to make a few remarks on the subject.

The assemblage of graptolites in the Fauquez Shales places this horizon beyond doubt in the zone of *Pleurograptus linearis* (CARRUTHERS). Since the zone mentioned forms the top of the Caradocian, we might be inclined to conclude that the Gembloux Shales also belong to that zone, representing an upper part of it. This is also made probable by the presence of *Tretaspis seticornis* (HISINGER), which in Sweden is characteristic of the Black Tretaspis Shale which must be referred to the zone of *Pleurograptus linearis* (CARRUTHERS). The determination is confirmed by the fact that some specimens from Grand-Manil — preserved in the Swedish Museum of Natural History, Stockholm — according to L. STØRMER, 1930, p. 58, probably belong to this species. *Tretaspis seticornis* (HISINGER) is quoted by E. MAILLIEUX from the Fosse Shales as well.

The Fauquez Shales have only yielded Graptolites, whereas the other horizons bear a shelly fauna. Cystoids have been met with in the Gembloux Shales and in the Fosse Shales. The rocks of the Gembloux Shales may be characterized as varieties of muddy greywackes, usually bluish grey in colour and with yellow weathering. These are the « phyllades » or « phyllades quartzeux » of C. MALAISE and others. The Fosse Shales are partially of a similar type of rock. They seem, as a rule, to be more light-coloured, however, being rather ash-grey. There is also a greenish grey shale. The term usually applied to the Ashgillian rocks of Sambre-et-Meuse is « schiste quartzeux ».

3. CARADOCIAN-ASHGILLIAN LOCALITIES THAT HAVE YIELDED CYSTOIDS.

As far as can be inferred from the material at the author's disposal, Cystoids are, numerically, a much more important element in the fossil record of the Caradocian of Belgium than in that of the Ashgillian. The material from Brabant — although in fact not very extensive — is abundant as compared with that from Sambre-et-Meuse.

In order to give a rough idea of the general distribution of Cystoids at the several localities from where such fossils have been obtained, the number or approximate number of specimens, or fragments of specimens, will be given for each locality (in brackets).

In our material the following localities in Brabant are represented :

Fauquez (on the River Senne), the old quarry NW of Fauquez Castle (15).

Fauquez (without close localization; see also C. MALAISE, 1873*a*, pp. 18-19) (45).

Grand-Manil (SW of Gembloux), the old Lefèvre Quarry (35).

Grand-Manil (without close localization; see C. MALAISE, 1873*a*, pp. 30-33) (10).

Rebecq-Rognon (on the River Senne), the old quarry between Rebecq and the Grande-Haie Farm (in some instances this locality is referred to as « Rebecq-Grande Haye ») (10).

Rebecq (without close localization; see C. MALAISE, 1873*a*, pp. 22-23) (15).

Ronquières (in the valley of the River Sennette; see C. MALAISE, 1873*a*, p. 16) (10).

In the literature Cystoids have been recorded from all these localities, save Ronquières. « *Sphæronites stelluliferus* » was obtained by C. MALAISE (1873*a*, p. 23) at another locality as well, situated on the road between Clabecq and Grande-Haie.

The material available from Sambre-et-Meuse originates from the following localities :

Arville (very likely the locality between Wierde and Arville Castle mentioned by C. MALAISE, 1873*a*, p. 62; 1897, p. 3; Arville-Mozet of E. MAILLIEUX, 1926, p. 77) (3).

Fosse (Fosses, see C. MALAISE, 1873*a*, pp. 60-61) (10).

Le Roux (C. MALISE, 1873*a*, p. 60 (2).

Les Tombes (C. MALAISE, 1873*a*, p. 62; Mozet-les-Tombes of E. MAILLIEUX, 1926, p. 77) (3).

Presles (might refer to « Burnot à Presles » of C. MALAISE, 1873*a*, p. 58) (2).

Vitrival (C. MALAISE, 1873*a*, p. 60) (1).

Cystoids have been reported previously from no localities in Sambre-et-Meuse but Fosse and Vitrival.

4. PREVIOUS REFERENCES TO BELGIAN UPPER ORDOVICIAN CYSTOIDS.

It was mentioned above that nothing was known about the Ordovician Cystoid fauna of Belgium until, in 1873, C. MALAISE figured a few species, both of which he called *Sphæronites stelluliferus* SALTER. In reality, one of them (C. MALAISE, 1873*a*, Pl. 6, fig. 8) is *Echinosphærites barrandei belgicus* JAEKEL and the other one (ibid., Pl. 6, fig. 9) *Heliocrinites malaisei* nov. sp. (cf. the description of species below). C. MALAISE (ibid., pp. 19, 106) observed that the so-called *Sphæronites stelluliferus* SALTER (wich, as we have seen, is a conception of different meanings), along with some Brachiopods, is the predominant fossil at the locality NW of Fauquez Castle. As appears from the above list of localities — practically all statements in the literature on the occurrence of Cystoids in the Old Palcozoic of Belgium return upon MALAISE's monograph — C. MALAISE knew Cystoids from a number of other fossil sites (1873*a*, pp. 19, 22, 23, 30, 31, 60, 61). In the same year C. MALAISE (1873*b*) published an epitome of his monograph, in which he stated the Cystoids in the Upper Ordovician rocks of Belgium to occur « assez abondamment » (op. cit., p. CII) and mentioned « *Sphæronites stelluliferus* » in a list of fossils (p. CV).

In the second part of his hand-book on the geology of Belgium M. MOURLON (1881, p. 2), referring to C. MALAISE, listed *Sphæronites stelluliferus* SALTER among fossils from the « terrain silurien » of central Belgium, both from Brabant and Sambre-et-Meuse. MALAISE's statements were also repeated by J.GOSSELET (1888, p. 140) (1).

J. BARRANDE (1887, p. 18) referred to MALAISE's announcement of *Sphæronites stelluliferus* SALTER from central Belgium but expressed some doubt about the correctness of the determination.

About 50 years ago MALAISE reconsidered the Old Paleozoic sequence of Belgium and devoted a series of papers to the subject. In a note on the « Bande silurienne » of Sambre-et-Meuse he had split up the « species » *Sphæronites stelluliferus* SALTER into two, one of which retained this name, whereas the other was called « *Echinosphærites balticus*, EICH. » (C. MALAISE, 1897, p. 4) what is presumably *Heliocrinites malaisei* nov. sp. A few years later (C. MALAISE, 1900, p. 219) he recognized four Ordovician species, namely « *Echinosphærites balticus*, EICH. » from Sambre-et-Meuse, « *Echinosphærites* (*Sphæronites*) *munitus*, FORBES », and « *Sphæronites punctatus*, FORBES » from Brabant, and « *Sphæronites stelluliferus*, SALT. » from both these areas. « *Sphæronites* sp. »

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(1) In GOSSELET's list of fossils from the Gembloux Shales, three names out of fifteen do not appear in their proper form. Thus *Trinucleus setiformis* for *T.* (*Tretaspis*) *seticornis*, *Orthis acteoniæ* for *O.* (*Nicolella*) *actoniæ*, and *Sphæronites stelliferus* for *S. stelluliferus*.

was reported from strata referred to the Llandoverian, of Brabant (cf. above, p. 5). The same information on Cystoids is given in the Compte Rendu of the 8th International Geological Congress (C. MALAISE, 1901, pp. 565, 566, 568).

As late as 1910 MALAISE gave a survey of the Old Paleozoic of Belgium and recorded the presence of four species of Cystoids (C. MALAISE, 1910, p. 963) in Brabant and Sambre-et-Meuse. They were not mentioned by name.

In his papers referred to above, E. MAILLIEUX listed a few Cystoids. These are « *Sphœronites stelluliferus* », « *Sphœronites punctatus* », and « *Echinosphœrites minutus* » [sic !] [E. MAILLIEUX, 1926, p. 72; 1933 ([2]), p. 33]. *Sphœronites stelluliferus* SALTER was recorded from Grand-Manil (the old Lefèvre Quarry) and Fauquez (the old quarry NW of Fauquez Castle), *Sphœronites punctatus* FORBES from Grand-Manil, and *Echinosphœrites munitus* FORBES from Fauquez and Robecq-Rognon (the old quarry between Rebecq and the Grande-Haie Farm). No species of Cystoids were recorded from Sambre-et-Meuse.

O. JAEKEL (1899, p. 337) established the new species *Echinosphœrites belgicus* on material from Gembloux, as we have had reason to point out above. Finally, F. A. BATHER (1913, p. 494, § 559) mentioned incidentally that C. MALAISE had recorded Cystoid species from Sambre-et-Meuse « which I suppose te be of *Heliocrinus* and *Echinosphœrites* ».

It was also pointed out above (p. 3) that the only Belgian Cystoid recorded by R. S. BASSLER & M. W. MOODEY (1943, p. 33) is *Echinosphœrites belgicus* JAEKEL.

This will be a fairly complete list of the existing literature relative to the Belgian Cystoids. The present writer has chosen to review in this way the entire information on this matter — which is indeed extremely meagre — because it is impossible in most cases to refer, in the descriptive part of the present paper, to the literature here reviewed. The reason for this is of course, as already emphasized, that the species recorded are almost throughout *nomina nuda*, the actual material having been studied and discussed but little or not at all.

5. THE STATE OF PRESERVATION OF THE MATERIAL AVAILABLE.

The Ordovician deposits of Belgium can be said to lack the qualifications necessary to produce well-preserved fossil material. The strata are generally more or less folded. During the crustal movements the fossils have not seldom become crushed and/or distorted. Probably they are not always very easy to extract from the rock either, because sometimes a certain angle seems to exist between the bedding plane and the cleavage plane.

([2]) The first edition of this work was not available to the present writer.

Further, where the Upper Ordovician is concerned, the rocks are more or less arenaceous. Consequently the calcareous matter has been leached out, and the fossils are as a rule preserved in the shape of internal casts. Less frequently are they found as external impressions. It is of course a serious drawback for the investigation that the test itself is not available for study.

Plate VI, figure 9, is intended to give an idea of the occurrence of the fossils as embedded in the rock (in this case Gembloux Shale from Fauquez).

Apart from *Heliocrinites* and *Echinosphærites*, the Hydrophoridea Rhombifera are represented by isolated thecal plates. In no case is there any trace of subvective appendages.

6. DESCRIPTION OF FOSSILS.

Class **CYSTOIDEA** Buch, 1844, emend. Jaekel, 1918.

Subclass **HYDROPHORIDEA** Zittel, 1903.

Order RHOMBIFERA Zittel, 1879, emend. Bather, 1899.

Our material contains a number of isolated Pelmatozoan plates which frequently can hardly be determined conclusively as to genus. But there seems to be no reason to doubt that they belong to the Hydrophoridea Rhombifera. Where demirhombs are present, this interprètation is unassailable. However, in an attempt at a close determination we are handicapped by the rather unfavourable state of preservation of the fossils as indicated just above. In spite of this, we may fairly safely conclude that it is correct to attribute the bulk of them to the Glyptocystitida and, more precisely, to the Cheirocrinidæ.

Superfamily **GLYPTOCYSTITIDA** (Bather, 1913) Regnéll, 1945.

Family **CHEIROCRINIDÆ** Jaekel, 1899, emend. Bather, 1913.

Genus CHEIROCRINUS Eichwald, 1856.

Cheirocrinus cf. **constrictus** Bather, 1913.

Pl. I, fig. 1-8.

Cf. *Cheirocrinus constrictus* nov. sp. — F. A. Bather, 1913, p. 442, pl. 4, fig. 49-56, text-fig. 48-58.

Holotype of *Ch. constrictus*. — G 157 of the Grey Collection.

Type locality. — Thraive Glen, Girvan.

Type stratum. — The Starfish Bed in the Drummuck Group (Ashgillian).

Material. — The material at the writers disposal referred tentatively to this species consists of five internal casts of isolated plates (Louvain 10*c-e;* Maredsous I : 72*a-b*) and three imprints (Louvain 10*a-b;* Maredsous I : 72*c*).

Diagnosis of *Cheirocrinus constrictus.* — « A *Cheirocrinus* ... with pectinirhombs all conjunct, and only 1-5, 10-14, 13-18, 15-16, 16-17, 17-18, 18-19 developed; ornament of single axial ridges, faint radiate granulation, and very faint concentric folds » (F. A. Bather, 1913, p. 442, § 310; quoted only as far as relevant to the present material).

Description. — The plates vary a good deal in shape. They are mostly roughly hexagonal in outline, although rather irregular. A few plates are about as high as wide (Pl. I, fig. 2-3), whereas one (Pl. I, fig. 8) is considerably higher than broad. The specimen figured in plate I, figure 1, represents an intermediate type. This appears from the following measurements (it should be noted that the orientation of the plates is arbitrary so that « height » and « width » refer to an orientation more or less the same as that in our Pl.-figs.) :

Specimen No.	Height mm	Width mm
Louvain 10*c*	7,5	6,5
Louvain 10*a*	6	5,5
Maredsous I : 72*b*	7,5	5
Louvain 10*d*	9	5,5(3)

All plates are distinctly umbonated. In some cases the umbo is raised rather much over the margin of the plate, in others only slightly, owing perhaps to secondary depression. Four to six, generally sharply defined axial ridges radiate from the umbo, which is either subcentral or eccentric.

Most of the plates show a number of fine concentric folds (cf. the figures). The other ornamentation of the plates, a faint radiate granulation, is not visible otherwise than in the external impressions, in which it appears as minute pits arranged radially (Pl. I, fig. 5-7).

A demirhomb is present in one instance only, in the plate figured in plate I, figure 6. It is a conjunct pectinirhomb — as far as can be recognized — of some fifteen pore-slits. Judging from the outline of the pore-bearing plate, it is very likely an *IL2* (Pl. 5 in textfig. 49 of F. A. Bather, 1913, p. 443). An

(3) The actual width of this plate is a little greater than indicated by the measurement given, since the specimen is not perfectly complete.

attempt at fixing the location in the theca of the other plates would be too hazardous, but evidently we must search for them among the plates devoid of a demirhomb, especially in the *IL*- and *L*-circlets (see F. A. BATHER's fig. just referred to). For such a task we should also have to consider the position of the umbo, which varies in the several plates (cf. F. A. BATHER, 1913, p. 444, § 316).

Discussion. — As should have appeared from the above description, the present material conforms well with the diagnosis of *Cheirocrinus constrictus* BATHER. The reasons why the writer nevertheless hesitates to consent to an unreserved identification are as follows: We have no idea of the general shape of the theca, wich is a very characteristic one in *Ch. constrictus* BATHER. Further, we have no knowledge of the general development and distribution of the pectinirhombs. Finally, with regard to the shape, the individual thecal plates are on the whole conservative in *Cheirocrinus*, so that plates similar to those now under discussion are found in several species, e. g. the Kukruse (probably Caradocian) species *Ch. granulatus* JAEKEL (cf. F. SCHMIDT, 1874, Pl. 1, fig. 12, sub *Glytocystites penniger* F. SCHMIDT) of Estonia, and the Caradocian *Ch. alter* (BARRANDE) (cf. J. BARRANDE, 1887, Pl. 28 : II, fig. 16 etc., sub *Homocystites* BARRANDE) of Bohemia. Both species mentioned differ from the present form, however, the former i. a. in having all pectinirhombs disjunct, the latter i. a. in having no granulation of the test.

It is often difficult to refer isolated Cystoid plates to a definite species, or even genus. We find, for instance, that some of the plates with which we are now concerned have a certain resemblance to the isolated plates figured by J. BARRANDE (1887, Pl. 2, fig. 16-21), « dont nous ne pouvons pas reconnaître l'origine » (from the explanation of the figures), to the « plaquettes d'origine douteuse » of BARRANDE (1887, Pl. 14, fig. 24-33), and to the undetermined plates figured by M. THORAL (1935, Pl. 5, fig. 10-11). These examples refer to specimens from horizons widely apart, namely the Middle Cambrian of Bohemia, the Caradocian of Bohemia, and the Upper Cambrian of the Montagne Noire, respectively.

Summing up, the material available is too incomplete, in the author's opinion, to admit of a conclusive determination. On the other hand, actual data do not contradict an attribution to *Cheirocrinus constrictus* BATHER, or a closely related species.

The general character of *Ch. constrictus* BATHER, and its relations to other species of *Cheirocrinus*, was discussed thoroughly by F. A. BATHER (1913). So it is not necessary to comment further upon these questions.

Regional distribution. — Scotland, Girvan : Thraive Glen (*Ch. constrictus* BATHER). — Belgium, Sambre-et-Meuse : Fosse (*Ch.* cf. *constrictus* BATHER).

Stratigraphic range. — Ashgillian (Scotland : The Starfish Bed in the Drummuck Group. — Belgium : Fosse Shales).

Cheirocrinus dilatatus nov. sp.

Pl. I, fig. 9.

Derivation of name. — From Lat. *dilatare*, dilate, with reference to the shape of the axial ridges in the plates.

Holotype. — Louvain 5 (Pl. I, fig. 9).

Type locality. — Fosse, Sambre-et-Meuse.

Type stratum. — Fosse Shales (Ashgillian).

Material. — Of this species only one specimen is available, the holotype, consisting of an internal cast of an isolated thecal plate.

Diagnosis. — A species of *Cheirocrinus* with, at least partially, flattened plates, the ornament of which is made up of low radiate ridges dilating in a centrifugal direction; the only pectinirhomb observed is probably conjunct. (For natural reasons this is only a partial diagnosis).

Description. — The margin of the plate is not perfect so the exact outline is not known. However, it may have been roughly hexagonal. As orientated in our plate I, figure 9, the plate measures 13,2 mm in height and 10 mm in width.

The plate is vaulted only slightly, and the subcentral umbo does not project very much. There are five low axial ridges which have a width at the umbo of less than 1 mm but dilate in a centrifugal direction, to a varying degree in the several ridges. The greatest width, about 3 mm, is attained by the ridge to the left in our figure. Here, too, transverse rugae are discernible.

The character of the pore-rhomb cannot be decided quite safely from the internal mould, but that structure seems to have been conjunct rather than disjunct.

Discussion. — A development of the radial ridges similar to that of the present form has been described only in two other species of *Cheirocrinus*. These are *Ch. ornatus* Eichwald, of the East Baltic Provinces, and *Ch. holmi* Regnéll, of the Island of Öland, probably both of Lower Arenigian age (cf. G. Regnéll, 1945, pp. 70-71, and foot-note 4). In the species mentioned, the thecal plates are more strongly vaulted than in *Ch. dilatatus*. In *Ch. holmi* Regnéll only two axial ridges are dilated noteworthy distally. The pectinirhombs are conjunct in that species but disjunct in *Ch. ornatus* Eichwald.

Although one single thecal plate is of course a very narrow basis for the erection of a new species, the present writer feels that in this instance actual data are sufficient to warrant such a step.

Regional distribution. — Belgium, Sambre-et-Meuse : Fosse.

Stratigraphic range. — Ashgillian : Fosse Shales.

? Family **PLEUROCYSTITIDÆ** (Miller & Gurley, 1895, emend. Jaekel, 1899) Bassler, 1938.

? Genus PLEUROCYSTITES Billings, 1854.

After much hesitation the writer has tentatively placed the specimens recorded below in *Pleurocystites*. But it should be emphasized that there is not much evidence in favour of this decision. On the other hand, this seems to be the most plausible alternative.

Pleurocystites? sp. 1.

Pl. I, fig. 12-13.

Material. — Two external imprints of isolated thecal plates (Louvain 7*b* and *c*) have been thought to be conspecific, although showing certain obvious differences in ornamentation.

Description. — Specimen Louvain 7*b* (Pl. I, fig. 13*a*), described from a gutta-percha squeeze (Pl. I, fig. 13*b*) : The plate is irregularly subhexagonal in outline (in this and following specimens referred to *Pleurocystites* ? the correct orientation could not be settled but is arbitrary in our figures). Height 8,5 mm, width 4,6 mm.

The umbo has a lateral position, and the side to which it is approached is bent down very abruptly (to the left in Pl. I, fig. 13*b*). This side is arched gently.

The ornament of the plate surface is very coarse and distinctive. The umbonal margin of the deflected flank is bordered by a slightly raised stereom fold, from which four strong radial folds emerge. Between these main ridges there are a number of short but heavy accessory ridges, some of which are disintegrated into radially arranged pustules. The deflected side of the plate is devoid of ornament.

There are no traces of a pore-system.

Specimen Louvain 7*c* (Pl. I, fig. 12*a*) as studied on a gutta-percha squeeze (Pl. I, fig 12*b*) : The plate is roughly semi-lunar in outline. Height 8,3 mm, width 4,7 mm.

The main structural features are much the same as in the specimen Louvain 7*b*. The crest bordering on the deflected area (which slopes more gently in this specimen) is more pronounced, and so are the four radiate folds. There is no accessory ornament, however, nor are there any pores.

Remarks. — The present material cannot be identified with any species known to the writer. But, in searching for comparable forms, it seems to be reasonable to consider in the first hand species of *Pleurocystites* with a heavy

ornament. Among those, the author wishes to direct attention first and foremost to *Pl. quadratus* (BATHER), in which the « ornament of the antanal face consists of strong radiate ridges, and a few strong axial ridges both main and subsidiary. There are traces of concentric granulation » (F. A. BATHER, 1913, p. 483, § 515; further, p. 482, § 501). An examination of plate 6, fig. 69, in BATHER's work just quoted reveals that the « granulae to be traced » are in fact knobs or pustules very similar to those in our plate I, figure 13*b*. It should be observed that the deflected semi-lunar area of the plates now dealth with may have been occupied by a pectinirhomb.

Pleurocystites quadratus (BATHER) is an Ashgillian species from Girvan. No doubt the present material greatly resembles it. But caution bids us not to propose an identification, for there are other species of *Pleurocystites* which, by their coarse ornament, offer a certain similarity, e. g. the Maquoketa (Upper Ordovician) species *Pl. clermontensis* FOERSTE from Iowa (A. F. FOERSTE, 1924, Pl. 33, fig. 7). And, as pointed out already and as indicated by the mark of interrogation following the generic name, we cannot be sure that we are right in referring our specimens to *Pleurocystites*. This doubt is caused first and foremost by *Mimocystites* BARRANDE (Macrocystellidœ, Eocrinoidea), known from the Upper Tremadocian of the Montagne Noire (M. THORAL, 1935, pp. 110-115, Pl. 7, fig. 1-4) and from the Upper Llandeilian of Bohemia (J. BARRANDE, 1887, pp. 163-164, Pl. 28 : I, fig. 1-20; O. JAEKEL, 1899, p. 172, text-fig. 33). It has further been recorded from the Upper Ordovician of Portugal (J. F. N. DELGADO, 1908, p. 62) and Spain (B. M. MELÉNDEZ, 1944, pp. 58-61, Pl. 9, fig. 3-5; 1946, pp. 282-283; B. M. MELÉNDEZ & I. HEVIA DE MELÉNDEZ, 1947, pp. 14-15). There is no reason to enter upon a discussion of the species of *Mimocystites* but they seem to require some attention. It is, as a matter of fact, strange that one and the same species should appear, as has been proposed, in horizons as widely apart as the Tremadocian and the Ashgillian. In comparing our specimens with *Mimocystites*, we should think of *M. bohemicus* BARRANDE in the first place, especially as figured by O. JAEKEL (l. c.), However, the topography of the plates does not agree as closely as does that of *Pleurocystites quadratus* (BATHER).

There are a few more forms that, in a way, are reminiscent of the present one. Reference is made to « *Hemicosmites* » *rugatus* FORBES (cf. below) and to species of *Cheirocrinus* such as *Ch.* cf. *logani* (BILLINGS) as figured by G. T. TROEDSSON (1928, Pl. 23, fig. 17), both Upper Ordovician. There is, finally, some similarity between Louvain 7*c* and the undetermined plate from the Middle Cambrian of Bohemia figured by J. BARRANDE (1887, pl. 2, fig. 20-21), already referred to above in another connexion.

Regional distribution. — Belgium, Sambre-et-Meuse : Arville.

Stratigraphic range. — Ashgillian : Fosse Shales.

Pleurocystites? sp. 2.
Pl. I, fig. 10

Material. — One single fragment of an external imprint is available (Louvain 7*a*).

Remarks. — The writer is in doubt how to interpret this specimen. It represents a flattened plate with coarse axial ridges (three of which are visible) originating from a, probably, eccentric umbo. The plate is granulated all over the surface. The relation between the fragmentary plate and the fragmentary pore-rhomb (to the left in Pl. I, fig. 10*a*) is not clear, but, as far as can be inferred from the fossil, the pore seems to be in a primary position. The greatest total width is about 15 mm.

There is not much to be said about this specimen but that it was referred tentatively to *Pleurocystites* on account of a certain general resemblance to some figures illustrating specimens of that genus, namely in F. A. Bather (1913, Pl. 6, fig. 73 : *Pl. quadratus* (Bather), Ashgillian, Girvan) and G. W. Sinclair (1948, Pl. 42, fig. 3 : *Pl.* cf. *filitextus* Billings, Trenton, Quebec).

In this instance as well, *Cheirocrinus* might be advanced as an alternative. And it must be admitted that e. g. *Ch. granulatus* (Jaekel) from the Kukruse (probably equivalent to a lower part of the Caradocian) of Estonia (O. Jaekel, 1899, Pl. 11, fig. 4) is somewhat suggestive of our specimen.

Regional distribution. — Belgium, Sambre-et-Meuse : Arville.

Stratigraphic range. — Ashgillian : Fosse Shales.

Pleurocystites? sp. 3.
Pl. I, fig. 11.

Material. — One external imprint of an imperfect isolated thecal plate (Louvain 1).

Description. — The plate is large, flattened, polygonal in outline (probably irregularly hexagonal). There are at least six thread-like radiate ridges originating from a strongly eccentric umbo. Whether the axial furrows of the imprint represent axial ridges or are mere fissures is not quite clear. The plate surface exhibits a very faint concentric striation combined with concentrically arranged granulae.

Remarks. — In tentatively ascribing this specimen to *Pleurocystites*, the writer found it comparable in general type with the plates of certain species belonging there, or to the closely related *Dipleurocystis* Jaekel. It may suffice

to refer to *Pl.* cf. *filitextus* Billings (G. W. Sinclair, 1948, Pl. 42, fig. 2), a Trenton species of Quebec, and to *Dipleurocystis rugeri* (Salter) (F. A. Bather, 1913, Pl. 5, fig. 57) from the Ashgillian of Girvan.

Regional distribution. — Belgium, Sambre-et-Meuse : Vitrival.

Stratigraphic range. — Ashgillian : Fosse Shales.

Superfamily **HEMICOSMITIDA** (Jaekel, 1918) Regnéll, 1945.

? Family **HEMICOSMITIDÆ** Jaekel, 1918.

? Genus CORYLOCRINUS Koenen, 1886.

Corylocrinus? sp.

Pl. VI, fig. 8.

Material. — One single specimen is available, showing a cast of the internal face of an isolated thecal plate (Louvain 4*a*).

Description (largely from a gutta-percha squeeze, Pl. VI, fig 8*b*). — The plate is regularly hexagonal, measuring 9,3 mm in a transverse direction and inconsiderably more in a vertical direction. In external face, it probably slopes gently in all directions from a central umbo. The plate wall is very strong, attaining a thickness of about 1,5 mm.

There are two pairs of demi-rhombs. They are developed towards the plates that bordered on this plate in an oral and in an aboral direction respectively. The upper rhombs contain some ten pore-canals, the lower ones some fifteen. The pore-canals are fine and densely set. As is well known, nothing of these rhombs was visible on the external face of the plates but the pores at the proximal end of the canals. Thus the canals themselves can be studied only in plates showing the inner side. A broad bridge of stereom passes from the one lateral suture to the other, separating the two groups of demi-rhombs from each other. In the portion of the stereom bridge directed towards the adjacent right plate there are two pores with traces of their canals.

The occurrence of the transverse structure just described, which is found in all members of the Hemicosmitida (cf. O. Jaekel, 1899, p. 299, fig. 68), was discussed by F. A. Bather who proposed that, in life, the pore-canals were « filled with strands of stroma that held the plates together, permitting some flexible motion. Originally, it appears from traces that remain in some specimens, all the sutures were crossed by these strands, but as the theca increased in size greater rigidity was required. This was furnished by a deposit of stereom over the lateral sutures, such deposit filling up the triangle between the lateral margin and the umbo of the plate. Thus the stroma-strands were obliterated, and their pores gradually disappeared » (F. A. Bather, 1910, p. 48).

Discussion. — In considering the generic belonging of the present species, four genera (provided that the specimen does not represent a genus not yet described) must be taken into account, namely *Corylocrinus*, *Hemicosmites*, *Caryocrinites*, and *Oocystis*.

It is hardly possible to show definitely that the plate Louvain 4*a* belongs to a species of *Corylocrinus*. Yet, by elimination, we find this alternative to be the most probable one.

On the whole, the outline of the individual plates does not vary very much throughout the Hemicosmitidae and Caryocrinitidae, as far as the writer's experience goes. As a rule only a few thecal plates are hexagonal in outline (see also O. JAEKEL, 1899, p. 294, fig. 65; F. A. BATHER, 1900, p. 68, fig. 36 : 3-4, 6; M. DREYFUSS, 1939, p. 126, fig. 2; JAEKEL's figures are a little more diagrammatic than are BATHER's).

In *Hemicosmites* truly hexagonal plates are found only in the *L*-circlet (mediolateralia of JAEKEL, radialia of BATHER; cf. G. REGNÉLL, 1945, pp. 61, 98). They do not form regular hexagons, however, but taper in an oral direction in consequence of the general shape of the theca. Nor does the great number of *LL* (9) admit of a great width of any of the individual plates. Further, the upper pore-rhombs are weakly developed, at least as a rule, as in most related genera (sometimes the upper pore-rhombs of the *LL* are lacking altogether). *IL* 5 is roughly hexagonal but has a curved incision in its left upper corner bordering on the periproct. The various species of *Hemicosmites* have not been described in sufficient detail to enable us to judge of the occurrence of genuinely hexagonal plates in the *IL*-circlet, nor is there much actual material available to the writer. It is of interest to note, however, that in *H. verrucosus* EICHWALD, from strata in the region of the Ordovician-Silurian boundary in Estonia, one *IL*-plate (probably *IL* 2, which, moreover, is hexagonal in *Corylocrinus* and *Oocystis*) is hexagonal in outline (see E. EICHWALD, 1860, Pl. 32, fig. 3). In fig. 6 of the plate just quoted EICHWALD figures a hexagonal plate, both in external and internal view. It is said to represent *H. porosus* EICHWALD. O. JAEKEL (1899, p. 310) suggests, rightly as it seems, that *H. porosus* EICHWALD should be identified with *H. verrucosus* EICHWALD. The plate figured by EICHWALD greatly resembles the present one, but his plate is not as wide and there are three and four pores respectively in the lateral portions of the stereom bridge. An isolated plate of *Hemicosmites* sp. figured by A. VOLBORTH (1846, Pl. 9, fig. 17*a-b*) shows fairly well developed lateral demi-rhombs. An imprint of the inner surface of an isolated plate belonging to a Middle Ordovician *Hemicosmites* from the Urals was figured by N. N. YAKOVLEV (1937, Pl. 1, fig. 8), but unfortunately the figure is not quite clear.

In the *L*-circlet of *Caryocrinites* there are no hexagonal plates, because the brachiole-facets are embraced by the adoral margin of these plates. Of the *ILL*, *IL* 2 and *IL* 5 are hexagonal. The former plate is better represented in the

diagrams communicated by J. HALL (1852, Pl. 49, fig. 1*y*; plate *IL* 2 is no. 5) and O. JAEKEL (1899, p. 294, fig. 65 B) than in those of F. A. BATHER (1900, p. 68, fig. 36 : 4) and M. DREYFUSS (1939, p. 126, fig. 2 B), where the aboral suture is almost straight. In the Swedish Ashgillian *C. septentrionalis* REGNÉLL and in all specimens of the Middle Silurian *C. ornatus* SAY examined by the writer, the sutures between *B* 2 and *IL* 2 on the one hand and *IL* 2 and *B* 3 on the other form a very definite angle. *IL* 2 is much broader in the material of *Caryocrinites* examined by the writer than in the diagrammatic representations published. It is in fact an almost regular hexagon, which in the holotype of *C. septentrionalis* REGNÉLL is of about the same size-order as the plate under discussion. Therefore, we cannot exclude the possibility that the genus *Caryocrinites* is represented in the Upper Ordovician deposits of Belgium, especially in view of the fact that the genus has been proved to occur in broadly equivalent strata of North Europe (REGNÉLL, 1948, p. 35). The reason why the writer has preferred not to designate the Belgian form as *Caryocrinites* ? sp. (a reason which is indeed quite open to criticism) is that in *Caryocrinites* the apices of the pore-rhombs generally seem to meet more or less in the umbo of the *ILL*, so that we are inclined to infer that no place is left for such a broad bridge of stereom as that developed in our specimen. Actually, however, as appears from HALL's figures (1852, Pl. 49, fig. 1*s*, 1*t*) and from K. A. ZITTEL (1879), text-fig. 295*c*, p. 419; reproduced in K. A. ZITTEL & F. BROILI, 1924, text-fig. 339*c*, p. 215, and in K. A. ZITTEL & C. R. EASTMAN, 1913, text-fig. 240*c*, p. 153), the stereom bridge on the internal plate surface of *Caryocrinites* is astonishingly broad. In fact is seems to represent — along the vertical axis — up to 15 per cent of the total height of the plate (cf. yet G. STEINMANN & L. DÖDERLEIN, 1890, text-fig. 179 C, p. 183; reproduced in G. STEINMANN, 1903, text-fig. 270 C, p. 196, where the stereom bridge is not as broad as indicated in the figures quoted just above; it is also pierced by numerous transverse pore-canals). This means that the plate wall is pierced obliquely by the pore-canals in the umbonal region, as is also evident from a figure communicated by O. JAEKEL (1899, text-fig. 23*i*, p. 109). However, in the specimen Louvain 4*a* the stereom bridge is still broader, covering some 20 per cent of the total height of the plate. *IL* 5 of *Caryocrinites* is a good deal higher than broad and may not have any bearing on this discussion.

In *Oocystis* DREYFUSS, 1939, *IL* 2 and *IL* 5 are likewise hexagonal, but, in conformity with all plates of the *IL*- and *L*-circlets, they are remarkably elongate (M. DREYFUSS, 1939, p. 126, fig. 2 : E, yet perhaps less obviously in the Pl.-figs. than in the diagram), and thus do not resemble our specimen very much. M. DREYFUSS (1939, Pl. 12, fig. 4) also gives a figure of the internal face of an isolated plate of *Oocystis major* DREYFUSS. As far as can be made out from this figure, the pore-rhombs nearly meet in the umbonal region.

Hemicosmites and *Oocystis* having been eliminated definitely and *Cary-*

ocrinites with some hesitation, *Corylocrinus* KOENEN, 1886, only remains. Let us see how conditions are in that genus. It should be observed that, in accordance with O. JAEKEL (1899, p. 311) and F. A. BATHER (1910, p. 39), *Juglandocrinus* KOENEN, 1886, is taken as a synonym of *Corylocrinus*. M. DREYFUSS (1939) thinks *Juglandocrinus* to be a valid genus.

Diagrams of the theca of *Corylocrinus* have been published by A. VON KOENEN (1886, Pl. 9), O. JAEKEL (1899, p. 294, fig. 65 B, repeated p. 312, fig. 75), F. A. BATHER (1900, p. 68, fig. 36 : 6; 1910, p. 43, diagram 1), M. DREYFUSS (1939, p. 126, fig. 2 : C-D), and by N. N. YAKOVLEV (1940, p. 765). The writer has not endeavoured to present a complete list.

In *Corylocrinus* the hexagonal plates are also confined to the *IL*-circlet. And *IL* 2 (*ant. II* of BATHER, 1910) and *IL* 5 (*post. II* of BATHER, 1910) are again hexagonal, in this all authors agree ([4]). The diagrams most true to nature with regard to the outline of the individual plates are probably those of A. VON KOENEN (1886), referring to *C. europœus* (QUENSTEDT, 1874) (syn. *C. pyriformis* KOENEN, 1866, fide M. DREYFUSS, 1939, p. 124) and *C. crassus* (KOENEN, 1886), of F. A. BATHER (1910), referring to *C. carnicus* BATHER, and of N. N. YAKOVLEV (1940), referring to *C. olii* YAKOVLEV. All the species are Upper Ordovician, originating from France, the Carnic Alps, and the Urals. The best description that we have of a species of *Corylocrinus* is BATHER's of 1910, where the properties of the individual plates are recorded most carefully. To some this way of describing may seem pedantic and of little use and merit. In the writer's opinion, however, it is very creditable that an author takes the pain of making an adequate and exhaustive description of the material treated by him. It may seem to be nonsensical, but really it is essential, especially for the identification of isolated or fragmentary skeletal parts.

IL 5 (post. *II*) is said by F. A. BATHER (1910, p. 45) to be a hexagon which, though bilaterally symmetrical, widens considerably above. There is also a noticeable difference in height and width of the plate. In these respects it does not agree with the plate now under consideration. *IL* 2 (ant. *II*), on the other hand, is almost a regular hexagon (F. A. BATHER, 1910, p. 44; cf. also this detail in the diagram on p. 43). Thus, in shape, it is very close to the specimen Louvain 4*a*.

It might be objected to our tentative determination that pores occur sparsely in the thecal plates of *Corylocrinus*, as far as can be inferred from published data, whereas in our specimen there is quite a number of them. Yet N. N. YAKOVLEV (1940, p. 765) mentions that the pore-rhombs of the *LL* are

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([4]) The diagram given by N. N. YAKOVLEV (1940, p. 765) shows that in *C. ollii* YAKOVLEV not only *IL* 2 and *IL* 5 are hexagonal but also the anal plate intercalated between *IL* 5 and *IL* 1, and *IL* 4. This is due to the fact that the ventral margin of *B* 1 and *B* 4 is not more or less straigt, as in other *Corylocrinus*, but shaped like an inverted W.

disposed just as in *Hemicosmites*, which indicates that this is also true of the pores of the *ILL*. Moreover, A. von Koenen (1886, Pl. 8, fig. 1*a*) gives a figure of *C. europæus* in which two upper and two lower pore-rhombs are clearly recognizable in the hexagonal *IL* 5. The apices of the rhombs do not seem to meet in the umbo but to be separated by a solid area, as is the case in our specimen.

On the evidence of the above discussion, the writer does not find it unreasonable to designate our specimen as *Corylocrinus*? sp., although it should be emphasized once more that the *Caryocrinites* alternative cannot be left out of account.

A few words must be said, finally, about the structure in the upper right of our Pl. VI, fig. 8*a*. The author does not believe that it has any connexion with the plate but cannot give a definite opinion of its nature. In the Echinoderms, structure recalling this one are found in several groups (Hydrophoridea Rhombifera : *Cystoblastus*, ambulacral fields; Blastoidea : ambulacra; Carpoidea : *Dendrocystites*, brachioles; Edrioasteroidea : *Astrocystites* a. o., ambulacra).

Regional distribution. — Belgium, Sambre-et-Meuse : Les Tombes.

Stratigraphic range. — Ashgillian : Fosse Shales.

Incertæ familiæ.

Gen. and spec. indet. 1.

Pl. II, fig. 1.

Material. — The single specimen available is an imprint of an isolated thecal plate (Louvain 4*b*).

Description. — The plate is heptagonal in outline, measuring 12,5 mm in height and 11 mm in width. It should be observed that in our figures the specimen is probably turned upside down; it was orientated originally in this way for a direct comparison with the so-called *Hemicosmites rugatus* Forbes as figured by J. W. Salter (1866, Pl. 20 fig. 12, upper figure). There are seven strong radiate ridges along which rows of pores are just traceable. The plate surface between the ridges is here and there somewhat crumpled.

Discussion. — This specimen belongs either to the Hemicosmitidae or to the Caryocrinitidae but it does not seem to be possible to determine it as to genus. It very likely represents an *IL*-plate. There is a certain similarity between this plate and the Welsh Ashgillian *Oocystis rugatus* (Forbes) (see E. Forbes, 1848, Pl. 20, fig. 2-5, sub *Hemicosmites pyriformis* Buch; J. W. Salter, 1866, Pl. 20, fig. 12, sub *Hemicosmites rugatus* Forbes; M. Dreyfuss, 1939, p. 129, Pl. 10, fig. 2-4). Whether this a superficial similarity or an expression of true relationship is dubious. Thanks to the courtesy of

Dr. C. J. STUBBLEFIELD, London, the present writer has had an opportunity to look over the material of British Cystoids — including several of E. FORBES's original specimens — kept in the Geological Survey and Museum in London. Too much importance must not, of course, be attached to the notes made at a cursory examination of the material without consulting any literature but FORBES's monograph (1848). Yet, in the conception of *Hemicosmites rugatus* FORBES, the writer stated afterwards a very great accordance with the views held by O. JAEKEL (1899, pp. 314-315). Thus *Hemicosmites rugatus-pyriformis* was found to comprise forms referable partly to *Hemicosmites*, partly to *Cheirocrinus*. The following notes were made on three isolated plates, casts of which were figured by E. FORBES (1848, Pl. 20, fig. 3-5) :

Geol. Surv. Mus. 7422 (probably original of fig. 3) : looks like a genuine *Hemicosmites*.

Geol. Surv. Mus. 21055 (original of fig. 4) : according to the accompanying label » cf. *Juglandocrinus crassus* KOENEN (*Hemicosmites pyriformis* FORBES, *non* BUCH) ». The figure is inadequate but the specimen may admit of a definite determination which was not made. Cf. A. VON KOENEN (1886, pp. 251, 254) and M. DREYFUSS (1939, p. 124).

Geol. Surv. Mus. 69903 (original of fig. 5) : might rather be a *Cheirocrinus*. Cf. O. JAEKEL (1899, p. 315).

M. DREYFUSS (1939, pp. 129-130) transferred the Welsh *Hemicosmites rugatus-pyriformis* to *Oocystis*.

Regional distribution. — Belgium, Sambre-et-Meuse : Les Tombes.

Stratigraphic range. — Ashgillian : Fosse Shales.

SUPERFAMILY CARYOCYSTITIDA (JAEKEL, 1918) REGNÉLL, 1945.

FAMILY CARYOCYSTITIDÆ (JAEKEL, 1918) REGNÉLL, 1945.

Genus HELIOCRINITES EICHWALD, 1840.

The species of *Heliocrinites* were divided by F. A. BATHER (1906, p. 18) into two groups : one which may be called *Plicata* (group *a* of BATHER), with marked axial folds, and another which may be called *Planata* (group *b* of BATHER), with axial folds slight or undeveloped. There are a few forms, however, which hold a fairly intermediate position between these groups.

In the material available from the Upper Ordovician rocks of Belgium there are only two specimens representing the Plicata, whereas the rest of the rather restricted material belongs to the Planata. The former will be dealt with first.

Heliocrinites cf. **helmhackeri** (BARRANDE, 1887).

Pl. II, fig. 2.

Cf. *Orocystites Helmhackeri* BARR. — J. BARRANDE, 1887, p. 170, pl. 7-8.
Cf. *Orycystis Helmhackeri*, BARR. — E. HAECKEL, 1896, p. 57, fig. 4.
Cf. *Caryocystites Helmhackeri*, BARRANDE. — O. JAEKEL, 1899, p. 330, pl. 9, fig. 7.
Cf. *Orocystis Helmhackeri.* — F. A. BATHER, 1900, p. 54, fig. 16.
Cf. *Heliocrinus Helmackeri.* — F. A. BATHER, *1906*, p. 18.
Cf. *Orocystites Helmackeri*, BARR. — J. F. N. DELGADO, *1908*, p. 62.
Cf. *Orocystis helmhackeri.* — KIRK, *1911*, p. 10.
Cf. *Cariocystites Helmhackeri* (BARR,) [ex parte]. — B. v. FREYBERG, *1923*, p. 264.
Cf. *Caryocystites helmhackeri* JAEKEL. — W. RÖPKE, 1933, pp. 40-46, fig. 1-2.
Cf. *Heliocrinites helmhackeri.* — G. REGNÉLL, *1945*, p. 119, foot-note 31.

Holotype of *H. helmhackeri.* — Not designated; a lectotype must be chosen among the specimens in the BARRANDE Collection, Praha.

Type locality. — Kladno, Bohemia.

Type stratum. — « Bande Dd 4 » of BARRANDE (Caradocian).

Material. — One fragmentary and imperfect internal cast (Louvain 2), measuring 24 × 18 mm.

Description. — The specimen is so imperfect that nothing can be said about the general outline of the theca and the number of thecal plates, nor about the character of the ambulacral area and the thecal openings. The structure of the test of course also remains unknown.

The plates of the theca are pentagonal — heptagonal and have a diameter of up to 5 mm. High folds radiate from the strongly pointed umbo of a plate to join the respective umbos of adjacent plates. Between the folds there are deeply depressed triangular areas.

It is true that the pores are not very clearly visible, but, in the writer's opinion, clearly enough to let us establish that pores are developed not only in the folds but in the interstitial triangular areas as well.

Discussion. — The present specimen of *Heliocrinites* was identified with *H. helmhackeri* (BARRANDE) on the evidence of two facts, namely the nature of the axial folds and the distribution of the pores, as far as can be recognized, almost all over the theca.

There are a few other species which greatly resemble the present specimen with regard to the development of the axial folds. One is *Heliocrinites stellatus* REGNÉLL, 1945, from strata on the Ordovician-Silurian boundary in Sweden (G. REGNÉLL, 1945, p. 133, Pl. 6, fig. 11), the other one is *H. rouvillei* (KOENEN, 1886) as figured by M. DREYFUSS (1939, Pl. 10, fig. 5; Pl. 11, fig. 3-6), from the

Caradocian and Ashgillian of France and Algeria (cf. A. LAMBERT, H. TERMIER & G. TERMIER, 1948, p. 824). Figures of *H. rouvillei* (KOENEN) have been given by A. VON KOENEN (1886, Pl. 8, fig. 4*a-b*), O. JAEKEL (1899, pl. 10, fig. 5), and M. DREYFUSS (1939, Pl. 10, fig. 5). KOENEN's and JAEKEL's figures have been suggested to apply to diffcrent forms, quite correctly as it seems. Now, the specimen figured by M. DREYFUSS is not very similar to any one of those published previously. There is no reason to comment further upon the delimitation and relationship of *H. rouvillei* (KOENEN), but it may be said that its affinities to *Heliocrinites balticus* (EICHWALD) may not be so close as thinks M. DREYFUSS (1939, pp. 122-123). See also G. REGNÉLL (1948, p. 137).

Heliocrinites balticus (EICHWALD) should also be considered (see e. g. R. F. HECKER, 1923, Pl. 2, fig. 7). But the peculiar pore-system traced in our specimen seems to be found solely in *H. helmhackeri* (BARRANDE). The reason why the writer does not venture to propose an unreserved identification is that the special development of the projecting peristomal and periproctal areas in *H. helmhackeri* (BARRANDE) cannot be controlled in the specimen available.

As regards the various opinions set forth regarding *H. helmhackeri thuringiæ* (JAEKEL, 1899) and the generic rank of *Orocystites* BARRANDE, 1887, cf. G. REGNÉLL (1945, p. 119, foot-note 31).

H. helmhackeri (BARRANDE) has been recorded from Bohemia, div. Dd 4 (Caradocian) and from the Upper Ordovician of Portugal (J. F. N. DELGADO, 1908, p. 62; unconfirmed statement). *H. helmhackeri thuringiæ* (JAEKEL) is known from Thuringia (B. VON FREYBERG, 1923). It occurs in the so-called « Lederschiefer » which — according to R. & E. RICHTER (1927, p. 80) — must be correlated with the Zdice Beds of Bohemia and the Ashgillian of Great Britain.

Regional distribution. — Belgium, Sambre-et-Meuse : Les Tombes (see also just above).

Stratigraphic range. — Ashgillian : Fosse Shales.

Heliocrinites sp., of the group Plicata.
Pl. III, fig. 7.

Material. — One poorly preserved internal cast (I.R.Sc.N.B. 5*b*).

Description. — The outline and orientation of the flattened and crushed theca cannot be made out. In its present state of preservation the theca measures 44,5 mm × 40 mm.

The few plates that can be recognized are hexagonal and measure about 6 mm, or less. The radial folds passing from the umbo of one plate to those of the surrounding ones are not as high as in the preceding species. The pore-canals were lodged in the folds.

Remarks. — On the label written by C. Malaise accompanying this specimen, it is referred to as « *Sphæronites punctatus*, Forbes ». That name covers an obscure conception. On examining the original specimen (Geol. Surv. Mus. London 7433) figured by E. Forbes (1848, Pl. 22, fig. 2*a*), from Rhiwlas, Bala, the writer arrived at the opinion that it can hardly be determined generically. Some other specimens kept along with it would perhaps indicate *Sphæronites*. Anyhow, the Belgian form may have nothing in common with the Welsh species. And probably it would not be wise to go any further than to say that the specimen under discussion may have some affinity to the form group of *Heliocrinites balticus* (Eichwald) in the Middle and Upper Ordovician deposits of the East Baltic area.

Regional distribution. — Belgium, Brabant : Grand-Manil (Lefèvre Quarry).

Stratigraphic range. — Upper Caradocian : Gembloux Shales.

Heliocrinites malaisei nov. sp.

Pl. II, fig. 3-7.

Sphæronites stelluliferus, Salt. [ex parte]. — C. Malaise, 1873*a*, p. 106, pl. 6, fig. 9 (non fig. 8).

Derivation of name. — The species is named in memory of the late Professor C. Malaise.

Holotype. — I.R.Sc.N.B. 8. This is the specimen figured by C. Malaise in his paper just quoted, or, more correctly, the specimen a squeeze of which or an image of which was figured by C. Malaise (cf. his figure with our plate II, figure 6*b;* the sutures are not indicated correctly throughout in Malaise's figure).

Type locality. — Grand-Manil (Lefèvre Quarry), Brabant.

Type stratum. — Bluish grey greywacke of the Gembloux Shales (Upper Caradocian).

Material. — Besides the holotype, which is a fragmentary external imprint, there are some twenty moulds and imprints, generally very imperfect (I.R.Sc.N.B. 2, two specimens; 3*a-c*; 5; 7, seven specimens; 11; Liège 5647; 8169 Louvain 8*a-b*).

Diagnosis. — A species of *Heliocrinites* (the group Planata) with theca relatively large; thecal plates of moderate or large size, not axially folded; rhomb-ridges very distinct, about 7 to 5 mm, the median ones generally coming close to the umbonal centre. [Thecal openings unknown.]

Description. — The general shape of the theca, which does not appear from the holotype, is ovoid (Pl. II, figs. 5 and 7). The specimens mentioned measure 35 × 31 mm and 57,5 × 38,5 mm, but they are broader than in the natural state owing to compression. The preserved portion of the holotype, which must have been a big specimen, measures 50 × 37 mm.

The number of thecal plates can be estimated at 40-50. The individual plates are fairly irregular in shape. They are often pentagonal but also hexagonal and heptagonal. In the holotype the largest plate measures 13 × 13 mm and the smallest one 8,5 × 7,5 mm. In most other specimens the plates are somewhat smaller still. They are not axially folded.

The rhomb-ridges are distinct and coarse. The number of ridges in a pore-rhomb varies, of course, according to the length of the suture crossed by the rhomb. In some cases (as in the rhomb in the lower middle of figs. 6*a-b* of Pl. II) there are only two ridges, but this is an exception. On an average there are seven rhomb-ridges to 5 mm. The median ridges practically reach the centre of the umbo leaving no, or a very small, smooth umbonal area.

None of the thecal openings is to be seen in any specimen available.

Discussion. — Of the species of *Heliocrinites* hitherto described, only *H. qualus* (Bather, 1906) shows a close affinity to *H. malaisei*. A comparison between the holotypes of the two species will prove this (see our Pl. II, fig. 6*b*, and F. A. Bather, 1906, Pl. 1, fig. 6-8). In general type they are very similar but differ in that *H. qualus* (Bather) is still more robust both with regard to the size of the theca and the plates. According to F. A. Bather (1906, pp. 22, 23) about ten rhomb-ridges go to 10 mm. He remarks that to this statement there is an occasional exception : « in a few plates of hexagonal or heptagonal outline, one or two of the sides are much shorter than the others, and, while a longer side has, for instance, 10 or 11 well defined ridges crossing it, the shorter side, 3 mm long, is traversed by only two or three rather stouter ridges, which are the more conspicuous because they interfere with the regularity of the concentric triangular ornament. Probably no particular importance is to be attached to this, and, in this specimen at any rate, the rhomb-ridges nowhere form quite a regular series of concentric triangles » (F. A. Bather, 1906, pp. 23-24). This observation is quoted here because the same feature occurs in *H. malaisei*.

H. qualus (Bather) has been found in Llandeilian strata of the Northern Shan States (F. A. Bather, 1906) and in Yunnan (F. R. C. Reed, 1917, p. 16).

Finally, a few words may be said about *Sphæronites stelluliferus* Salter, the name attached by C. Malaise to the present species. The writer is inclined to believe that the specimen (Geol. Surv. Mus. London 7428) figured by J. W. Salter (1866, Pl. 20, fig. 6) is an *Echinosphærites*, but can give no definite opinion about it (cf. O. Jaekel, 1899, p. 337). Moreover, all the specimens kept along with the original specimen do not seem to be congeneric.

Regional distribution. — Belgium, Brabant : Grand-Manil (17 fragments from the Lefèvre Quarry; 4 without close indication of origin).

Stratigraphic range. — Upper Caradocian : Gembloux Shales.

FAMILY **ECHINOSPHÆRITIDÆ** NEUMAYR, 1889, emend. JAEKEL, 1918.

Genus ECHINOSPHÆRITES WAHLENBERG, 1818.

Echinosphærites barrandei belgicus JAEKEL, 1899.
Pl. III, fig. 1-4 (-6 ?).

Sphæronites stelluliferus, SALT. [ex parte]. — C. MALAISE, 1873*a*, p. 106, pl. 6, fig. 8 (non fig. 9).
Echinosphærites belgicus n. sp. — O. JAEKEL, 1899, p. 337.

Holotype. — Specimen in the collections of the University Breslau referred to by O. JAEKEL (1899, p. 337).

Type locality. — Gembloux (information of exact locality wanting), Brabant.

Type stratum. — Gembloux Shales (Upper Caradocian).

Material. — Only six specimens — all more or less imperfect and mostly internal casts — could be referred unreservedly to this species [I.R.Sc.N.B. 1 (the specimen figured by C. MALAISE, 1873*a*, Pl. 6, fig. 8, our Pl. III, fig. 1), 3*d*, 6*a-b*, 10; Liège 8170].

Diagnosis. — A species of *Echinosphærites* with very large theca (height up to 160 mm, width up to 140 mm, according to O. JAEKEL), more or less ovoid; thecal plates numerous, measuring up to 8 mm in diameter; tangential pore-canals fine, probably about ten to 5 mm, reaching almost the very centre of the plates (5).

Remarks on the diagnosis. — O. JAEKEL (1899, p. 337) gave no diagnosis of the new species *E. belgicus* erected by him but only stated that the theca and its plates are nearly twice the size of the corresponding elements in the preceding species, which is *E. barrandei* JAEKEL (Syn. *E. infaustus* BARRANDE, 1887, ex parte, Pl. 22). He also remarked that *E. belgicus* should perhaps be classified as a variety of *E. barrandei*. As to the species last mentioned, the theca is said to merge into a stem composed of relatively high hexagonal

(5) In this it seems to differ from *E. barrandei barrandei* JAEKEL, in which the pore-canals as a rule leave a smooth area at the plate-centre, as far as can be inferred from J. BARRANDE's (1887) figures in his Pl. 22.

plates. Our material does not admit of either confirmation or denial of this statement. Further, according to O. JAEKEL, the anal aperture is located in the equatorial zone of the theca. This is not the case in the material at the writer's disposal, in which the periproct is situated almost on the ventral surface of the theca, not far from the peristome. And it should be emphasized that O. JAEKEL did not say expressly that the features mentioned are peculiar to *E. belgicus* as well.

Description. — *E. barrandei belgicus* JAEKEL is the biggest species known of *Echinosphærites*. The theca is more or less ovoid. In the specimen figured in Pl. III, fig. 3*a*, the transverse axis seems to be the long axis (which cannot be decided safely, however, because the dorsal part of the theca is entirely wanting); in the specimen figured in Pl. III, fig. 1, the condition is reversed.

Measurements of the thecae just referred to :

Specimen No.	Long axis mm	Short axis mm
I.R.Sc.N.B. 3*d* (incomplete)	115	90+
Liège 8170	114	90
I.R.Sc.N.B. 10	86	60
I.R.Sc.N.B. 1 (incomplete and crushed) .	80+	52,5

The theca is composed of numerous plates, estimated at about 300 in specimen I.R.Sc.N.B. 1 (Pl. III, fig. 1). They are polygonal, with 4 to 6 sides, having a greatest diameter of generally 6,5-8 mm.

If recognizable, the pores of the thecal plates are represented by casts of the pores directed perpendicularly to the plate surface, whereas the tangential pore-canals can be traced only in specimens I.R.Sc.N.B. 6*a* and *b*, which are unique in our material in so far as they show — very poorly, it is true — an external imprint of the test. The pore-ridges are very fine (about 10 to 5 mm) and seem to leave practically no smooth area at the umbonal centre.

The ambulacral area, which is not known, was located on a chimney-like peristomal projection, the base of which is present in specimen I.R.Sc.N.B. 3*d* (Pl. III, fig. 3*a*, *p*). It reached a considerable height, as shown by a squeeze taken from I.R.Sc.N.B. 6*a*. This squeeze measures 22 mm in length.

The anal pyramid is preserved in a very good cast in specimen I.R.Sc.N.B. 3*d* (Pl. III, fig. 3*a*, *a*, 3*b*). It is pentagonal and measures 15 × 9 mm (the theca has suffered from compression caused by a tolerably lateral pressure, which explains the variation in diameter of the anal pyramid when measured in different directions). In this specimen the centre of the anal opening lies 24 mm behind the base of the vertical axis of the peristome. The pyramid is

rather flat. Its valvulves have on their inside a median swell which has mainly the same shape as the valvule itself but tapers in a centripetal direction into a neck, so that a more or less wedge-shaped space is created at each radial margin of the valvules (these thinner margins are of course represented by elevations in the cast). The swells may have served for the fixation of the muscles effecting the retraction of the anal valvules.

The gonopore is not visible in any specimen.

Discussion. — In his monograph on the Bohemian Old Paleozoic Pelmatozoans J. BARRANDE (1887) described a form of *Echinosphærites* for which he proposed the name *E. infaustus*. An examination of BARRANDE's figures shows that some rather heterogeneous forms are included in this conception, which caused O. JAEKEL (1899, p. 337) to divide *E. infaustus* BARRANDE into two species, a smaller one retaining the old name, and a bigger one, for which he proposed the name *E. barrandei*. They differ also with regard to the development of the stem ([6]). The theca of *E. barrandei* JAEKEL is said to be about 80 mm high and 70 mm wide, the thecal plates having a diameter of 3-4 mm.

A form of *Echinosphærites* from the Upper Ordovician of Gembloux, differing from *E. barrandei* JAEKEL in that the theca and its plates are about twice the size of the theca and the plates in the species last mentioned, was recognized by O. JAEKEL (1899, p. 337) as a separate species, *E. belgicus*. But, as indicated above, O. JAEKEL was aware of the possibility that *E. belgicus* JAEKEL should be considered a variety — or rather a subspecies — of *E. barrandei* JAEKEL.

On the evidence of the present material, the writer found the latter interpretation to be correct. For there is no absolute correlation between the size of the theca and the size of the plates, as demonstrated by the specimen figured in our plate III, fig. 1, in which the largest thecal plates are nearly as big (7 mm) as the largest plates (8 mm) in the very big specimen in plate III, fig. 3*a*. So it is appropriate to refer the small-plated specimens of this form-group to *Echinosphærites barrandei barrandei* JAEKEL and the large-plated ones to *Echinosphærites barrandei belgicus* JAEKEL.

In the above description and discussion no attention has been paid to certain specimens in our material, in which the diameter of the thecal plates, and, especially, the size of the theca is much inferior to the maximum size of the plates and the theca given in the diagnosis of *E. barrandei belgicus* (I.R.Sc.N.B. 4*a-b;* 15*a-d;* see our Pl. III, fig. 5). They are irregularly ovoid, more or less tapering towards the base of the theca. The smallest of these specimens (I.R.Sc.N.B. 4*b*) measures only 25 mm in height, but the largest plates have a

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([6]) F. A. BATHER (1906, p. 15) recommended that the genus *Arachnocystites* NEUMAYR, 1889 (with the single species *infaustus* BARRANDE), characterized by well developed stem and brachioles, should not be rejected.

diameter of 4,5 mm (in I.R.Sc.N.B. 15 *a* : 5,5 mm), thus more than in *E. barrandei barrandei* JAEKEL and more than in *E. infaustus* BARRANDE. Since the small thecae with, relatively, large plates are connected by fairly intermediate forms with the big thecae with large plates, the writer prefers to call the small specimens *E. barrandei belgicus* JAEKEL ?, with the implication that the small specimens probably represent young individuals.

The small specimens might also belong to « *Sphæronites* » *arachnoideus* FORBES, 1848. The present writer had an opportunity to make sure that the original specimen (Geol. Surv. Mus. London 7405) of E. FORBES (1848, Pl. 22, fig. 4*a;* copied by J. W. SALTER, 1866, Pl. 20, fig. 8), which is a very poorly preserved internal cast, is a true *Echinosphærites,* this interpretation being corroborated by the evidence of the accompanying specimens. This form, from the Caradocian of Wales, has large plates, as stated by FORBES (1848, p. 518), and a small theca. However, the writer does not wish to identify the doubtful Belgian *Echinosphærites* with *E. arachnoideus* (FORBES) until that species has been better investigated (cf. O. JAEKEL, 1899, p. 337). It may be mentioned that C. MALAISE (1873 *a*, p. 106) referred to « *Echinosphærites arachinoideus*, FORBES » [sic !] in commenting upon the Belgian forms figured by himself.

The fragmentary specimen reproduced in Pl. III, fig. 6, cannot either be referred to *E. barrandei belgicus* JAEKEL without hesitation, owing to the poor state of preservation. Casts of the pore-canals are visible only where these traverse the plate sutures.

The largest specimens of *Echinosphærites barrandei belgicus* JAEKEL are far bigger than any other known *Echinosphærites.* Of those coming next in size, *E. barrandei barrandei* JAEKEL, from stage Dd4 (Caradocian) of Bohemia, has already been discussed. The two other species with a large theca, *E. grandis* JAEKEL, 1899 (prob. syn. *E. pogrebowi* HECKER, 1923), and *E.* sp. REGNÉLL, 1945, p. 152, from the Caradocian of the Baltic area, agree fairly closely with *E. barrandei belgicus* JAEKEL with regard to the size of the plates and the character of the pore-canals. But the former is almost spheroidal (with a practically smooth epithek, moreover) and the latter is pyriform. It is insufficiently known, however.

Regional distribution. — Belgium, Brabant : Grand-Manil (Lefèvre Quarry) (7); the specimens I.R.Sc.N.B. 15*a-d*, referred to *E. barrandei belgicus* JAEKEL ?, were collected at Fauquez (the old quarry NW of Fauquez Castle) (8).

Stratigraphic range. — Upper Caradocian : Gembloux Shales.

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(7) Specimen Liège 8170 has only the designation « Grand-Manil ».

(8) Specimen I.R.Sc.N.B. 1 (Pl. III, fig. 1) is accompanied by four labels, one printed and three in hand-writing. On one of those (C. MALAISE scrips. ?), the locality is given at Fauquez, which may be wrong since in the explanation of his Pl. 6, fig. 8, C. MALAISE (1873 *a*, p. 121) states that the specimen originates from Grand-Manil.

Echinosphærites sp.
Pl. V, fig. 8.

Remarks. — As appears from the figure, this specimen (Louvain 9*b*) is only a small fragment showing the internal cast of some few plates. It differs from the ordinary state of preservation in that it does not show the inner wall of the stereothek but of the innermost layer of the epithek, with concentrically arranged undulating lines, as described by O. Jaekel (1899, pp. 73-74), and figured by J. Barrande (1887, Pl. 16, fig. 26-28). Fragments of the pore-canals are also visible.

The plates are big, the largest being 8 mm, and irregular in outline. It is possible that this form belongs to *Echinosphærites barrandei belgicus* Jaekel, but since it is not determinable and, besides, originates from a higher horizon than do all specimens of the species mentioned, it may be better not to try to attach a specific name to it.

Under this heading may be included properly another specimen (I.R.Sc.N.B. 27*a*) of *Echinosphærites*, a poorly preserved internal cast with large plates (6 mm) in which, however, the rhombic arrangement of the pore-canals is clearly visible.

Regional distribution. — Belgium, Brabant : Rebecq (I.R.Sc.N.B. 27*a*); Sambre-et-Meuse : Presles (Louvain 9*b*).

Stratigraphic range. — Ashgillian : Fosse Shales.

Order DIPLOPORITA J. Müller, 1854, emend. Bather, 1906.

Superfamily **SPHÆRONITIDA** (Jaekel, 1918) Regnéll, 1945.

Family **SPHÆRONITIDÆ** Neumayr, 1889.

Genus HAPLOSPHÆRONIS Jaekel, 1926.

Haplosphæronis proiciens nov. sp.
Pl. IV, fig. 1-7; Pl. V, fig. 1-7; Pl. VI, fig. 9.

Derivation of name. — From Lat. *proicere*, protrude, with reference to the protruding peristome.

Holotype. — I.R.Sc.N.B. 13*a* (Pl. IV, fig. 3).

Type locality. — Old quarry NW of Fauquez Castle, Brabant.

Type stratum. — Gembloux Shales, Upper Caradocian.

Material. — This is the species represented most abundantly in the material of Belgian Cystoids at the writer's disposal. Besides the holotype — an internal cast of a specimen compressed obliquely from the sides — there are about 75 isolated specimens or rock-specimens containing this species (I.R.Sc. N.B. 4*c-f*, 12*a-b*, 13*a-f*, 14*a-d*, 16*a-d*, 17*a-d*, 18*c*, 18*g-o*, 19*a-k*, 20*a*, 21*a-c*, 22, 23*a-g*, 24*a-b*, 25*b-d*, 26*a-b*, 27*b-e*, 28*a-d*, 30; Liège F 2001*a-b;* Maredsous 181, I: 183*a-b;* Coll. RONCART 542). Most of them are more or less fragmentary internal casts or imprints.

Diagnosis. — A species of *Haplosphæronis* in which the peristome is well elevated over the ambulacral area; ambulacral fans of 4-5 branches.

Description. — There is no specimen available which has not suffered from distortion or compression in one way or the other. In consequence, the thecae vary a good deal in outline. For instance, the specimen in plate IV, figure 3 (the holotype) has been compressed mainly in a transversal direction, and the specimens in plate IV, figures 2 and 5, more or less along the vertical axis. This is also true of the specimen in plate V, figure 7, whereas those in plate V, figures 4-5, have been subject to pressure acting in an antero-posterior direction. This, of course, explains the differences in the outline of the theca in oral view. Anyhow, it may be assumed that the theca was mitre-like. In recognition of the secondary deformation of the specimens, the following measurements are of but restricted value to give an idea of the shape and dimensions of the theca in this species.

Specimen No.	Height	Greatest diam.
	mm	mm
I.R.Sc.N.B. 13*a* (holotype)	26	23,5
I.R.Sc.N.B. 16*b*	23,5	21
I.R.Sc.N.B. 19*c*	20,5	21,5
I.R.Sc.N.B. 13*b*	20	29,5
I.R.Sc.N.B. 30	19	14
I.R.Sc.N.B. 12*b*	14	24,5
Liège F 2001*b*	11	7,5

Very little, in fact almost nothing, of the construction of the thecal skeleton is to be seen in this unfavourably preserved material. No sutures appear in the internal casts, nor, with the exception of some not clearly defined traces in

I.R.Sc.N.B. 14*d*, in the external imprints. But the arrangement of the pores makes it appear very likely that the theca was composed of two circlets of large plates as postulated in the diagnosis of the genus *Haplosphæronis* (cf. Pl. IV, fig. 7*a*).

The theca is covered all over with diplopores. In the internal moulds the pores are represented by small spikes, being casts of the pore-canals. The length of these spikes was measured in the specimen figured in plate V, figure 7, which is still partially embedded in the rock It is about 0,5 mm, a measurement that indicates also, in consequence, the thickness of the test. The pores are of course best studied in the external imprints (Pl. IV, fig. 4, 6, 7*a-b*) and, first and foremost, in squeezes taken from those (Pl. IV, fig. 7*c*). The two pores making a pair are surrounded by the raised rim of an elongate, very frequently dumb-bell-shaped, peripore. The longest of these are 0,9 mm. The number of peripores is very great. Their long axis is generally tolerably parallel with the lateral margins of the plates. They are more or less transverse in definite zones only, undoubtly indicating the course of the sutures, analogously to the condition in congeneric forms (cf. O. JAEKEL, 1926, p. 20; G. REGNÉLL, 1945, p. 173).

The ambulacral area is subpentagonal, best demonstrated in the specimen in plate V, figure 5*b*. Traces of the ambulacral grooves are found in exceptional cases only, in external imprints (Pl. IV, fig. 4, 7*a-c*). The main grooves with their branches extending over the peristome are not visible, only part of the fans into which they branch. As far as can be made out from the specimen in plate IV, figure 7, these fans contain four or five grooves. Accordingly, the number of brachioles was 20-25.

No hydropore can be detected.

The mouth opened in a peristome well elevated over the surface of the ambulacral area (Pl. IV, fig. 3, *p;* Pl. V, fig. 5*a*, *p*).

The anal opening is close behind the peristome. It is covered by a fairly high anal pyramid (Pl. V, fig. 4*a*, *a*) with a diameter about equal to that of the peristome (both 0,4 mm in the holotype). In cases where the individual valvules of the pyramid are traceable in the internal casts, their number appears to be about seven.

At the upper left side of the periproct a cast of the gonopore is visible in all internal moulds of the ventral pole (Pl. V, fig. 1-3, *pr*; 4 *b*; 5 *b*-7, *pr*). It is remarkable that also part of the duct passing between the periproct and the peristome and along the right side of the base of the peristome is represented by a ridge (see the figures just referred to). By this duct the gametes passed from the gonad in the axial sinus (cf. O. JAEKEL, 1899, p. 141; T. GISLÉN, 1924, p. 222) to the gonopore by which they were let out. As far as the writer is aware, the only record in the literature of the duct mentioned is in a fairly obscure figure of *Aristocystites sinicus* (SUN), given by Y. C. SUN (1936, Pl. 1, fig. 1*c*).

Haplosphæronis proiciens was attached to the sea-floor, or to objects resting on it, by a broad base surface shaped like a shallow cup (Pl. IV, fig. 5). In order to augment the adhesive power of the theca, the margins of the base are more or less dentale (Pl. IV, fig. 1-3, 5).

Discussion. — There cannot be any doubt that the species now described is a typical *Haplosphæronis*. The state of preservation of this species is very far from that in which the Swedish *H. oblonga* (Angelin) is found, a fact which in a way renders a comparison difficult. But a close examination reveals that the two forms are indeed so intimately connected that it is even difficult to indicate any points of difference. On the other hand, it is hardly possible to demonstrate conclusively that the two forms are identical. For that reason, the writer prefers to consider the Belgian form as a species apart from the Swedish one, referring in the above diagnosis to the divergent character of the peristome, which is little prominent in *H. oblonga* (Angelin), and the number of brachioles in each fan, which seems never to extend four in the Swedish species.

It might be objected that the composition of the thecal skeleton characteristic of *Haplosphæronis* has not been proved in the present species. But there are two features corroborating the assumption that the theca consists of a restricted number of large plates, as is the case in *Haplosphæronis*. The first of these arguments is the disposition of the diplopores emphasized above. The second — less decisive, it is true — is that the internal moulds always represent pratically the entire theca and not fragments of it. This indicates that the theca was made up of a few firmly connected elements rather than of a great number of minor plates. In *Craterina* Barrande (syn. *Codiacystis* Jaekel), which must also be considered in discussing the Belgian form, the theca contained many smaller plates. These were regularly disjointed after the death of the animal, so that among a great number of individuals almost always only the lower part of the theca is found (O. Jaekel, 1899, p. 399).

Craterina Barrande, an emended diagnosis of wich was given recently by J. Chauvel (1941, p. 98), differs further from the present form in the shape of the peripores, which are shorter and not dumb-bell-shaped, and in the character of its base surface, which is shaped like the bottom of a bottle.

Calix Rouault differs by the shape of the peripores (oval, but shorter than in *Haplosphæronis*), by its elongate theca, and by the very different skeletization and the pustules present in some thecal plates.

Aristocystites Barrande and allied genera differ, inter alia, by the quite divergent development of the ambulacral area and the character of the thecal pores.

As we have seen, the peripores in the genera mentioned do not agree closely in shape with the peripores of the Belgian form now under discussion. A far

better agreement, and in fact a very good one, is obvious in the case of « *Caryocystites* » *litchi* FORBES, 1848 (syn. *Sphæronites litchii*, J. W. SALTER, 1866, p. 286; ? *Eucystis litschi* [sic !], O. JAEKEL, 1899, p. 406; *Eucystis* ? *litchi*, G. REGNÉLL, 1948, p. 33), from the Caradocian of Wales. As observed by J. W. SALTER (1866, p. 286), this conception comprises two different forms. According to the brief notes on the original material made by the present writer, the original specimen (Geol. Surv. Mus. London 7431) of E. FORBES (1848, Pl. 21, fig. 2*c*), copied by J. W. SALTER (1866, Pl. 20, fig. 4) and pointed out by him as the true « *Sphæronites* » *litchi*, is hardly determinable, whereas the specimens associated with it strongly recall *Haplosphæronis*. However, to judge from the figures, the species is many-plated, unlike *Haplosphæronis*. The original (Geol. Surv. Mus. London 1430) of the specimen figured in plate 21, fig. 2*b*, of E. FORBES (1848) copied by J. W. SALTER (1866. Pl. 20, fig. 3), seems to belong to *Sphæronites* but requires further attentation.

In conclusion, it seems to be legitimate to classify this Belgian form as a separate species of *Haplosphæronis*. This genus is distributed mainly in Scandinavia where it ranges from the lower Caradocian into the Ashgillian.

On the labels accompanying specimens of *Haplosphæronis proiciens* collected and determined by C. MALAISE, the species is generally referred to either as « *Sphæronites punctatus* FORBES », or « *Echinosphærites munitus* [or *minutus* !] FORBES ».

Regional distribution. — Belgium, Brabant: The old quarry NW of Fauquez Castle (8 specimens), Fauquez (39 specimens), Grand-Manil (4 specimens), Rebecq (11 specimens), Rebecq-Rognon (6 specimens), Ronquières (7 specimens).

Stratigraphic range. — Upper Caradocian: Gembloux Shales.

Incerti ordinis.

Genn. and spp. indet. 2-5.

Pl. VI, fig. 1-6.

The state of preservation of the fossils mentioned under this heading — all of them internal casts except that in plate VI, figure 5 — does not admit of a conclusive determination, not even as to order.

The plating of the specimens (Gen. and sp. indet. 2) in plate VI, figures 1-2 (Louvain 6*a* and 9 *a*), with elongate plates in the aboral region, would rather indicate a member of the Echinosphaeritidae. On the other hand, pore-rhombs can hardly be restituted out of the few and, as it seems, irregularly distributed pores. The small specimens originate from Ashgillian strata, that in plate VI, figure 1, from Le Roux, and that in plate VI, figure 2, from Presles.

In the compressed theca of the specimen (Gen. and sp. indet. 3) in plate VI, figure 6 (I.R.Sc.N.B. 9*a*) sutures do not come out at all. It is not possible

either to clarify them by means of refracting liquids, since that method, of course, does not work when the test itself is absent. The pores are distributed all over the surface. The light semilunar spot near the upper margin of the theca seems to be the base of the peristome. Close behind it is another spot which may represent the base of the periproct. If this is so, the specimen belongs to the Sphaeronitidae. It originates from the Caradocian of Grand-Manil. It should be remarked that the square excavations in the thecal surface are spaces vacant after weathered out crystals of pyrites.

The specimens (Gen. and sp. indet. 4) figured in plate VI, figures 3-4, also seem to suggest a species of the Sphaeronitidae (I.R.Sc.N.B. 18*a* and *b*). The theca seems to have been sessile by its bare surface (in a way, the specimen in Pl. VI, fig. 3, reminds of *Aristocystites bohemicus* BARRANDE figured by J. CHAUVEL, 1941, p. 55, fig. 17). The pores are disposed all over the plates. Both specimens are from the Gembloux Shales at Fauquez. There are three more specimens from Fauquez (I.R.Sc.N.B. 18*d-f*), one from Rebecq (Liège 8172), and two from Grand-Manil (Louvain 3*a* and *b*), which may be conspecific with those figured in plate VI, figures 3-4.

The last species to be recorded in this connexion (Gen. and sp. indet. 5) is that reproduced in plate VI, fig. 5 (I.R.Sc.N.B. 12*c*). This is unique in that part of the test is preserved. The pores are sparser than in the preceding form and the construction of the theca more regular. In general appearance it has something in common with *Glyptosphærites* MÜLLER. But, of course, nothing indicates that it belongs to that genus. Horizon and finding place are the Upper Caradocian at Fauquez. It is possible that two specimens (Ec. 5415, Ec. 5416) in the Swedish Museum of Natural History, Stockholm, belong to the same species.

STEM FRAGMENTS OF PELMATOZOA.

Our knowledge of isolated columnals — and Pelmatozoan stems on the whole — is still very inadequate, at least where the Old Paleozoic forms are concerned. It would not be much use, therefore, to try to refer the stem-fragments present in our material to a definite species. It is even doubtful wheter they are Crinoids or other Pelmatozoa, but probability speaks in favour of the former interpretation, for they almost all derive from the Gembloux Shales, in which no stalked Hydrophoridea seem to appear.

Columnals are found fairly frequently. They are of two kinds, referred to below as « type A » and « type B ». A few words will be said about them.

Type A.

Pl. V, fig. 9-10.

This type is represented *inter alia* in specimens I.R.Sc.N.B. 23*h* and 29, Liège F 2110, and Maredsous I : 102. It is pentagonal in outline. There is a fairly wide central lumen and five radial (or interradial) lumina. The articular face is coarsely striated. The greatest diameter is 6,5 mm, the height of the columnal hardly exceeds 1 mm.

Type A is somewhat similar to « *Pentacrinus* » *lobatus* Eichwald (1860, Pl. 31, fig. 25) from the Orthoceratite limestone of the East Baltic area.

The fossil is present from the following localities of Brabant : Grand-Manil, Rebecq-Rognon, Ronquières. It is figured by C. Malaise (1873*a*, Pl. 6, fig. 11).

Type B.

Pl. VI, fig. 7-8*a*.

This one is more common than type A. Specimens are present, i. a., in I.R.Sc.N.B. 16*e*; I.R.Sc.N.B. 25*a*, *e*, *f;* I.R.Sc.N.B. 26*c;* Louvain 4*a*. It is circular with a more or less pentagonal lumen and radially striated articular face. Diameter about 2 mm, thickness less than 1 mm.

Columnals similar to type B are most common among the Crinoids and may have no diagnostic value, at least not for the present.

It has been recorded from the following localities in Brabant : Fauquez and Rebecq, and in Sambre-et-Meuse : Les Tombes.

A specimen, referred to as « Crinoid », from Grand-Manil, is figured by C. Malaise (1873*a*, Pl. 6, fig. 10).

7. GENERAL REMARKS AND CONCLUSIONS.

By the investigation now performed, the Cystoid fauna of the Upper Ordovician of Belgium has turned out to be much more varied than could be inferred from the scanty information hitherto available. The fauna — including Pelmatozoan columnals — as known now is summarized in the following table, in which is also shown the stratigraphic range of the several species met with in the Upper Ordovocian series of strata of Brabant and Sambre-et-Meuse.

The rather unfavourable state of preservation of the fossils and the fragmentary material available of many forms has necessarily in many cases allowed of but an approximate generic or specific determination. Yet the picture thus gained is clear enough to disclose some general features.

The conception that the Gembloux Shales of Brabant and the Fosse Shales of Sambre-et-Meuse represent different divisions in the stratigraphic sequence is well corroborated by the evidence of the fauna recorded in the table below.

In fact we find that, out of twenty species, only two are common to the two areas, namely *Echinosphærites* sp., a designation which may cover different species, and a type of Pelmatozoan columnal which has little stratigraphic significance.

SPECIES	Upper Caradocian Brabant	Ashgillian Sambre-et-Meuse
Cheirocrinus cf. *constrictus* BATHER	–	+
Cheirocrinus dilatatus n. sp.	–	+
Pleurocystites ? sp. 1	–	+
Pleurocystites ? sp. 2	–	+
Pleurocystites ? sp. 3	–	+
Corylocrinus ? sp.	–	+
Gen. & sp. indet. 1 (Hemicosmitidæ or Caryocrinitidæ	–	+
Heliocrinites cf. *helmhackeri* (BARRANDE)	–	+
Heliocrinites sp. (of the group Plicata)	+	–
Heliocrinites malaisei n. sp.	+	–
Echinosphærites barrandei belgicus JAEKEL	+	–
Echinosphærites barrandei belgicus JAEKEL ?	+	–
Echinosphærites sp.	+	+
Haplosphæronis proiciens n. sp.	+	–
Gen. & sp. indet. 2	–	+
Gen. & sp. indet. 3	+	–
Gen. & sp. indet. 4	+	–
Gen. & sp. indet. 5	+	–
Pelmatozoan columnals, type A	+	–
Pelmatozoan columnals, type B	+	+

As regards the number of species, there are eleven in both Brabant and Sambre-et-Meuse. But as constituents of the fauna as a whole the Cystoids play a far more important role in the Upper Caradocian of Brabant, first and foremost by *Heliocrinites malaisei* nov. sp., *Echinosphærites barrandei belgicus* JAEKEL, and, especially, *Haplosphæronis proiciens* nov. sp. It is noticeable, further, that the Glyptocystitida and Hemicosmitida are confined to the Ashgillian section of the Belgian series of strata.

The following list shows the distribution of species at the several localities that have yielded Cystoids.

1. Upper Caradocian of Brabant.

F a u q u e z, old quarry N of : *Echinosphærites barrandei belgicus* JAEKEL ? : *Haplosphæronis proiciens* nov. sp.

Fauquez, without close localization : *Haplosphæronis proiciens* nov. sp.; Gen. and sp. indet. 4; Gen. and sp. indet. 5; Pelmatozoan columnals, type B.

Grand-Manil, Lefèvre Quarry : *Heliocrinites* sp. (of the group Plicata); *Heliocrinites malaisei* nov. sp.; *Echinosphærites barrandei belgicus* JAEKEL.

Graud-Manil, without close localization : *Heliocrinites malaisei* nov. sp.; *Echinosphærites barrandei belgicus* JAEKEL; *Haplosphæronis proiciens* nov. sp.; Gen. and sp. indet. 3; Gen. and sp. indet. 4 ?; Pelmatozoan columnals, type A; Pelmatozoan columnals, type B.

Rebecq-Rognon : *Haplosphæronis proiciens* nov. sp.; Pelmatozoan columnals, type A.

Rebecq, without close localization : *Echinosphærites* sp.; *Haplosphæronis proiciens* nov. sp.; Gen. and sp. indet. 4 ?; Pelmatozoan columnals, type B.

Ronquières : *Haplosphæronis proiciens* nov. sp.; Pelmatozoan columnals, type A

2. Ashgillian of Sambre-et-Meuse.

Arville : *Pleurocystites* ? sp. 1; *Pleurocystites* ? sp. 2.

Fosse : *Cheirocrinus* cf. *constrictus* BATHER; *Cheirocrinus dilatatus* nov. sp.

Le Roux : Gen. and sp. indet. 2.

Les Tombes : *Corylocrinus* ? sp.; Gen. and sp. indet. 1 (Hemicosmitidæ or Caryocrinitidæ); *Heliocrinites* cf. *helmhackeri* (RARRANDE); Pelmatozoan columnals, type B.

Presles : *Echinosphærites* sp.; Gen. and sp. indet. 2.

Vitrival : *Pleurocystites* ? sp. 3.

A comparison between foreign Cystoid faunas and the Caradocian Cystoid fauna of Brabant, on the one hand, and the Ashgillian Cystoid fauna of Sambre-et-Meuse, on the other, admits of interesting conclusions.

The relations of the Caradocian Cystoid fauna of Belgium are mainly with more or less contemporary easterly and North European faunas. Of the forms specifically determined, *Heliocrinites malaisei* nov. sp. has affinities with *H. qualus* (BATHER) from the Llandeilian of the Far East, *Echinosphærites barrandei belgicus* JAEKEL with *E. barrandei barrandei* JAEKEL from the Caradocian of Bohemia, and *Haplosphæronis proiciens* nov. sp. with congeneric forms in the Lower Caradocian-Ashgillian of Scandinavia. *Heliocrinites* sp., further, is related to the East Baltic *H. balticus* (EICHWALD). These facts suggest that the Cystoids of the Belgian Upper Caradocian beds are immigrants from the East and North East. There may have existed a certain connexion with the Welsh area as well, as indicated by the contingent relationship between

the forms designated above as *Echinosphærites barrandei belgicus* JAEKEL ? and « *Sphæronites* » *arachnoideus* FORBES, and between *Haplosphæronis proiciens* nov. sp. and « *Sphæronites* » *litchi* (FORBES). But the Welsh forms are not closely known as yet.

Turning to the Ashgillian forms, we find that an easterly influence can be traced here, too. *Corylocrinus* is represented in the Urals and the Carnic Alps but also in Languedoc and Portugal. *Heliocrinites helmhackeri* (BARRANDE) originates from the Caradocian of Bohemia but has also been reported from Portugal. *H. helmhackeri thuringiæ* (JAEKEL) appears in the Ashgillian of Thuringia. *Cheirocrinus dilatatus* nov. sp., finally, seems to be a derivate from geologically older species in the Baltic area. In case the doubtful *Corylocrinus* is in reality a *Caryocrinites* this would also suggest Baltic affinities.

Cheirocrinus cf. *constrictus* BATHER and the questionable species of *Pleurocystites* affirm a faunal communication in Ashgillian time between Belgium and Girvan and, further, North America. The similarity to the Girvan fauna is also accentuated by the absence of (probably) all Diploporites and the very scarce occurrence of *Heliocrinites* and *Echinosphærites* (cf. F. A. BATHER, 1913, p. 494, § 559).

Whether there is an affinity between our Gen. and sp. indet. 1 and the Welsh *Oocystis rugatus* (FORBES) — possibly known from Languedoc and the Pyrenees as well — requires further investigation.

Summing up, we may look upon the assemblage of Upper Ordovician Cystoids of Belgium as a mixed fauna, the Belgian area having acted as a station on the migration route from Bohemia and North Europe to Girvan and Wales on the one hand, and, on the other hand, as a basin within the reach of the westerly Girvan elements. The Bohemian affinity of the Girvan fauna was emphasized already by F. A. BATHER (1913, p. 495, § 561 et seq.).

The connexion with contemporary French and Mediterranean Cystoid faunas is, on the whole, remarkably weak. However, a few genera are common to Belgium and the Upper Ordovician of Algeria recently discovered (A. LAMBERT, H. TERMIER & G. TERMIER, 1948, p. 824).

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* *

A c k n o w l e d g m e n t. — This investigation was carried out in the Paleozoological Department of the Swedish Museum of Natural History, Stockholm. For technical aid in the preparation of photographs and plates, and of guttapercha and plasteline squeezes, the writer is indebted to the skilled staff of that Institution. All figures have been retouched in order to intensify sutures and other features.

The manuscript was finished in January, 1950.

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9. INDEX OF GENERA AND SPECIES.

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EXPLANATION OF PLATE I.

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FIG. 1-8. — *Cheirocrinus* cf. *constrictus* BATHER 10

Isolated thecal plates (×5). — Sambre-et-Meuse : Fosse.

1. Internal cast (Maredsous I : 72*b*).
2. Internal cast (Louvain 10*c*).
3. Internal cast (Maredsous I : 72*a*).
4. Internal cast (Louvain 10*e*).

5*a*. External imprint (Louvain 10*b*).

5*b*. Gutta-percha squeeze of the same.

6. External imprint (Louvain 10*a*).
7. External imprint (Maredsous I : 72*c*).
8. Internal cast (Louvain 10*d*).

FIG. 9. — *Cheirocrinus dilatatus* nov. sp. 13

Internal cast of isolated thecal plate, holotype (Louvain 5) (×3). — Sambre-et-Meuse : Fosse.

FIG. 10. — *Pleurocystites* ? sp. 2 16

Imperfect isolated thecal plate (Louvain 7*a*) (×3). — Sambre-et-Meuse : Arville.

10*a*. External imprint.

10*b*. Plasteline squeeze of the same.

FIG. 11. — *Pleurocystites* ? sp. 3 16

External imprint of imperfect isolated thecal plate (Louvain 1) (×3). — Sambre-et-Meuse : Vitrival.

FIG. 12-13. — *Pleurocystites* ? sp. 1 14

Isolated thecal plates (×5). — Sambre-et-Meuse : Arville.

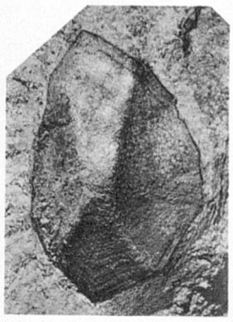
12*a*. External imprint (Louvain 7*c*).

12*b*. Gutta-percha squeeze of the same.

13*a*. External imprint (Louvain 7*b*).

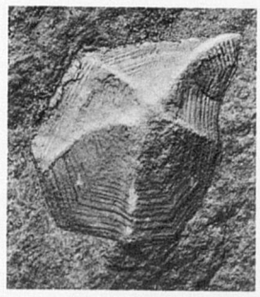
13*b*. Gutta-percha squeeze of the same.

Phot. G. AHL. Ret. S. EKBLOM.



1 x 5

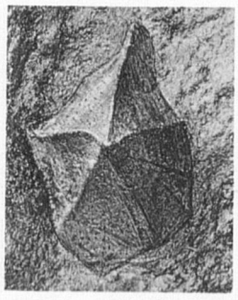
2 x 5



3 x 5

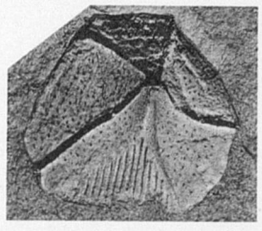
4 x 5

5 a x 5



5 b x 5

Fig. 1 - 8. - *Cheirocrinus* cf. *constrictus* BATHER.



6 x 5

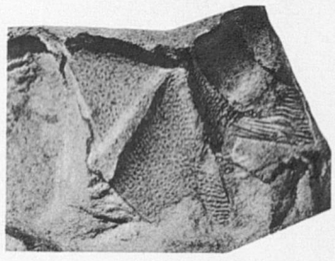
7 x 5

8 x 5

9 x 3

Fig. 9. - *Cheirocrinus dilatatus* n. sp.

10 a x 3



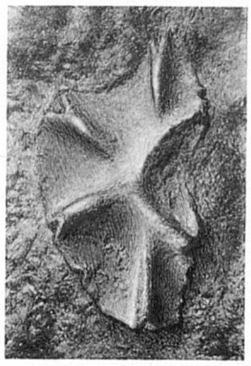
10 b x 3

Fig. 10. - *Pleurocystites?* sp. 2.

11 x 3

Fig. 11. - *Pleurocystites?* sp. 3.

12 a x 5



12 b x 5

13 a x 5

13 b x 5

Fig. 12 - 13. - *Pleurocystites?* sp. 1.

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Phototypie A. Dohmen, Bruxelles

EXPLANATION OF PLATE II.

Phot. G. AHL. Ret. S. EKBLOM.

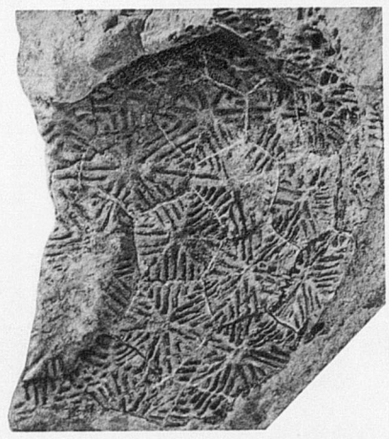
1 a x 3

1 b x 3

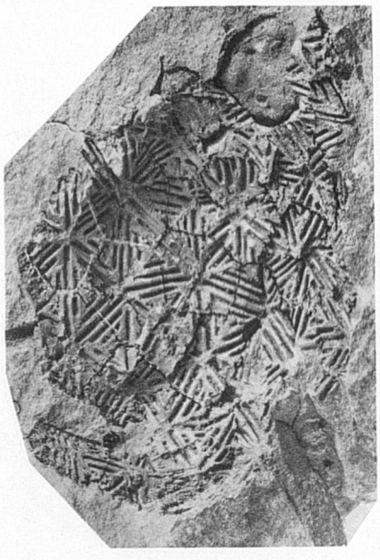
Fig. 1. - Gen. & sp. indet. 1.

2 x 2

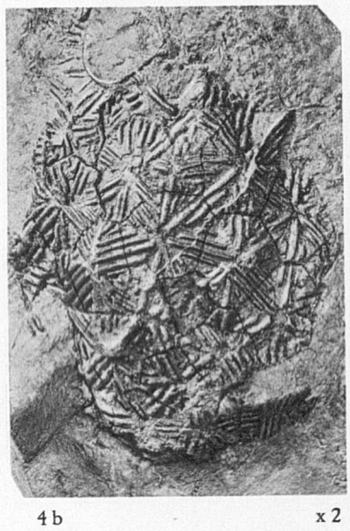
Fig. 2. - *Heliocrinites* cf. *helmhackeri* (BARRANDE).



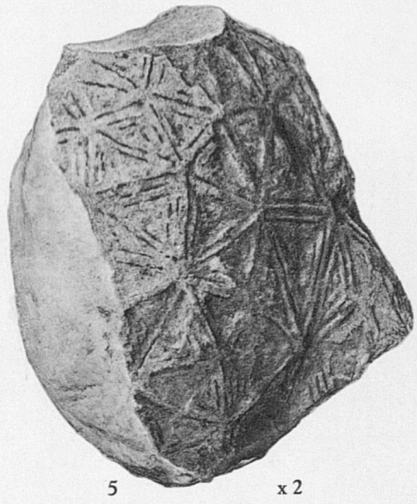
3 x 2



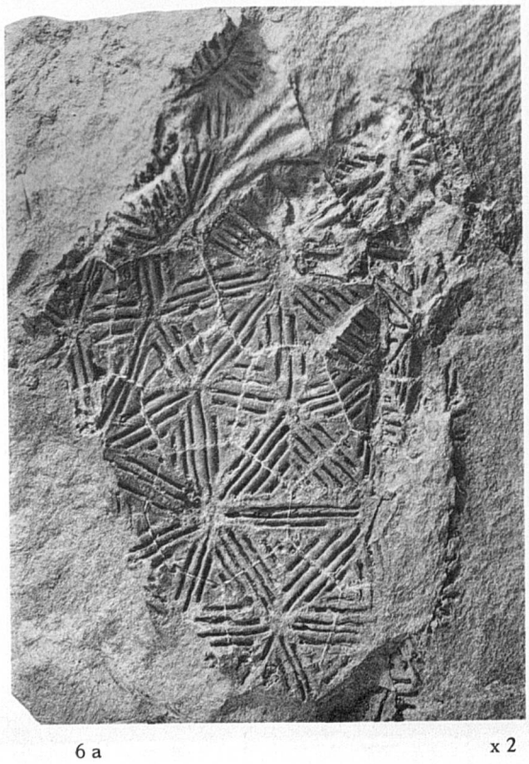
4 a x 2



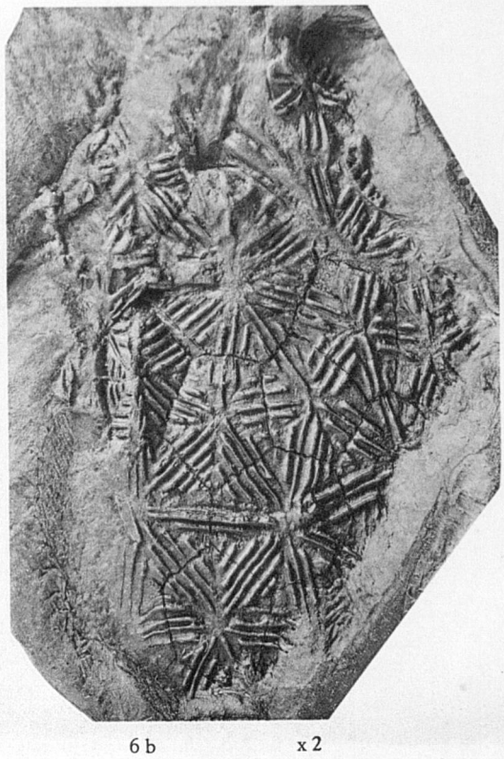
4 b x 2



5 x 2



6 a x 2



6 b x 2

7 x 1,2

Fig. 3 - 7. - *Heliocrinites malaisei* n. sp.

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Phototypie A. Dohmen, Bruxelles

EXPLANATION OF PLATE III.

Page.

FIG. 1-4. — *Echinosphærites barrandei belgicus* JAEKEL 27

Brabant : Grand-Manil.

1. Internal cast of fairly complete theca (I.R.Sc.N.B. 1). Nat. size. Lefèvre Quarry. This is the specimen figured by C. MALAISE (1873*a*, Pl. 6, fig. 8, sub *Sphæronites stelluliferus* SALTER).
2. Internal cast of fairly complete specimen (Liège 8170 (nat. size).
3*a*. Internal cast of imperfect specimen (I.R.Sc.N.B. 3*d*) (nat. size). Lefèvre Quarry.
3*b*. The anal pyramid of the same (×3).
4. Internal cast of imperfect specimen (I.R.Sc.N.B. 10) (nat size).

FIG. 5-6. — *Echinosphærites barrandei belgicus* JAEKEL ? 30

Brabant.

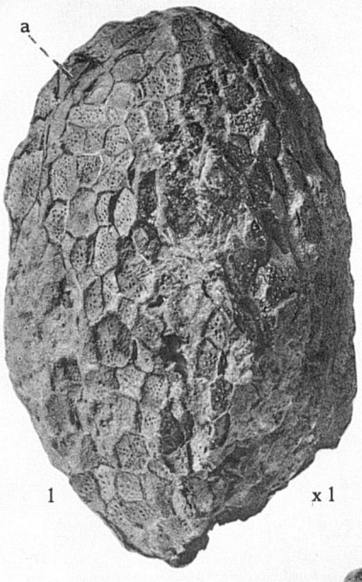
5. Internal cast of imperfect theca, showing the aboral part (I.R.Sc.N.B. 15*a*) (nat. size). Fauquez (old quarry NW of Fauquez Castle).
6. Internal cast of small fragment, probably from the aboral part of the theca (I.R.Sc.N.B. 9*b*) (×2). Grand-Manil.

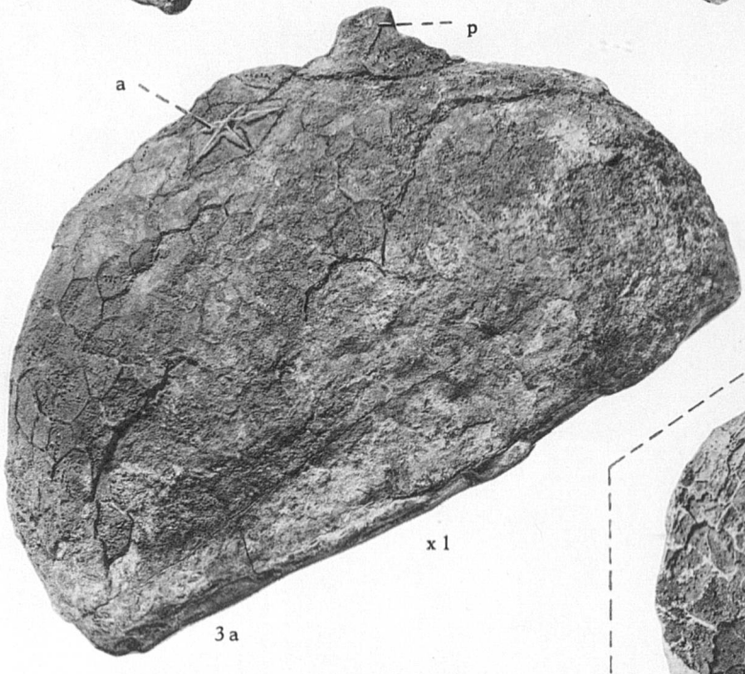
FIG. 7. — *Heliocrinites* sp., of the group Plicata 24

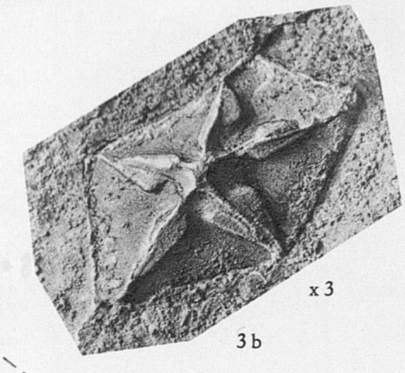
Internal cast (I.R.Sc.N.B. 5*b*) (×1,2). — Brabant : Grand-Manil.

(*a*, periproct; *p*, peristome.)

Phot. G. AHL. Ret. S. EKBLOM.







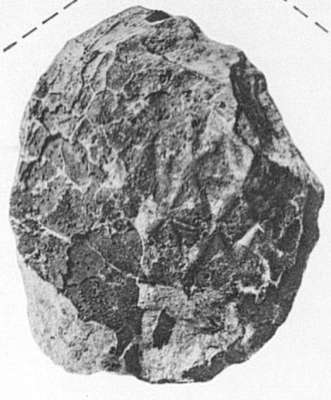
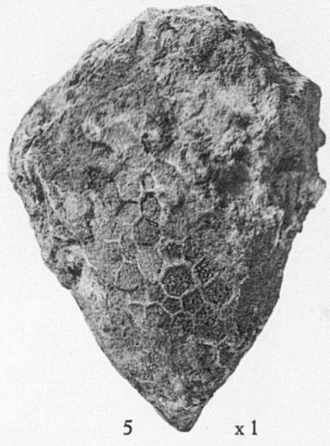


Fig. 7. - *Heliocrinites* sp.



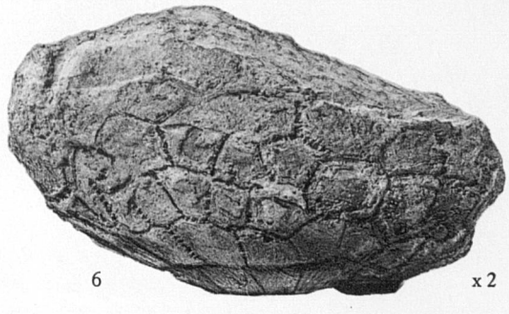


Fig. 1 - 4. - *Echinosphaerites barrandei belgicus* JAEKEL.

Fig. 5 - 6. - *Echinosphaerites barrandei belgicus* JAEKEL ?

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Phototypie A. Dohmen, Bruxelles

EXPLANATION OF PLATE IV.

Brabant.

1. Internal cast of crushed theca, in anterior view (I.R.Sc.N.B. 16*b*) (×2). Fauquez.
2. Internal cast of crushed specimen (the oral region bent forwards) in anterior view (I.R.Sc.N.B. 13*b*) (×2). Fauquez.
3. Internal cast of complete theca, in left lateral view, holotype (I.R.Sc.N.B. 13*a*) (×2). Fauquez (old quarry NW of Fauquez Castle).
4. External imprint (Maredsous I : 83*a*) (×5). Fauquez (old quarry NW of Fauquez Castle).
5. Internal cast of somewhat deformed theca, in dorso-anterior view (I.R.Sc.N.B.) 12*b*) (×2). Fauquez (old quarry NW of Fauquez Castle).
6. External imprint (I.R.Sc.N.B. 23*a*) (×5). Ronquières.

7*a*. External imprint (I.R.Sc.N.B. 21*a*) (×2). Fauquez.

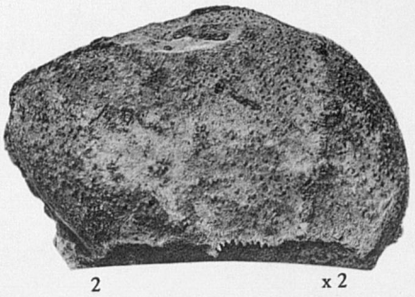
7*b*. Detail of the same (×10).

7*c*. Gutta-percha squeeze of the portion shown in fig. 7*b* (×10).

(*amb*, fans of ambulacral furrows.)

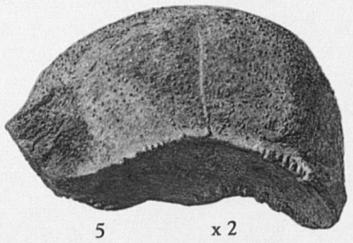
Phot. G. AHL. Ret. S. EKBLOM.

1 x 2



2 x 2

3 x 2



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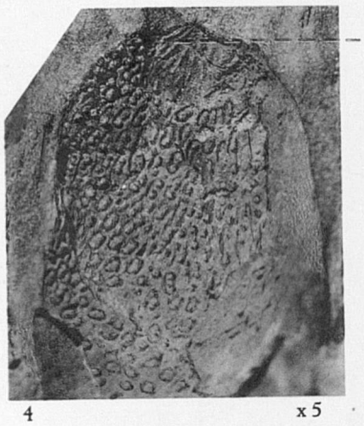

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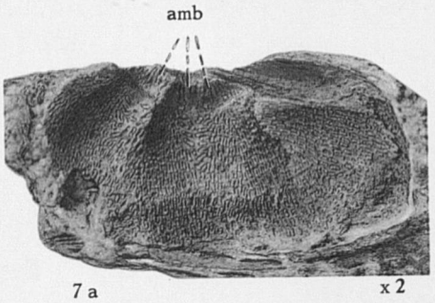
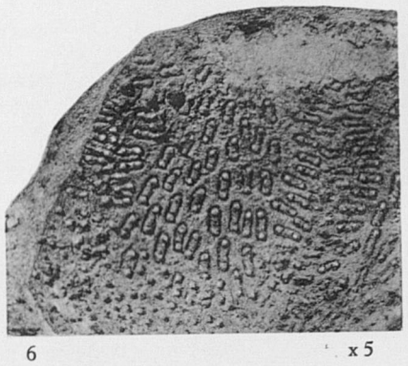


7 a x 2



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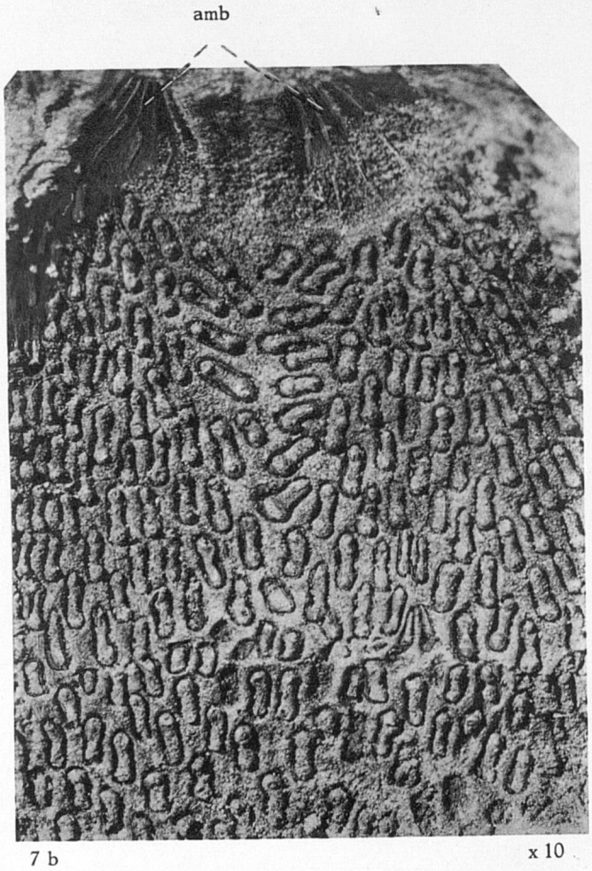
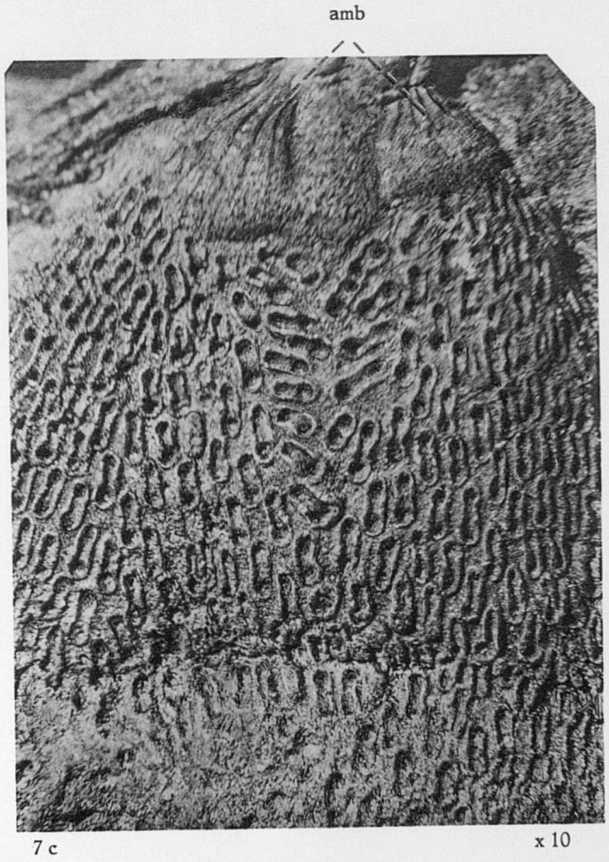


7 b x 10



7 c x 10

Fig. 1 - 7. - *Haplosphaeronis proiciens* n. sp.

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Phototypie A. Dohmen, Bruxelles

EXPLANATION OF PLATE V.

Page

FIG. 1-7. — *Haplosphæronis proiciens* nov. sp. 31

Internal casts. — Brabant.

1. Apical part of the theca (I.R.Sc.N.B. 18*c*) (×5). Fauquez.
2. As the preceding (I.R.Sc.N.B. 13*f*) (×5). Fauquez (old quarry NW of Fauquez Castle).
3. As the preceding (I.R.Sc.N.B. 12*a*) (×5). Fauquez (old quarry NW of Fauquez Castle).

4*a*. Imperfect theca, in posterior view (Liège 2001*b*) (×5). Rebecq-Rognon.

4*b*. The same, oral view (×5).

5*a* Somewhat deformed theca, in posterior view (I.R.Sc.N.B. 30) (×5). Rebecq-Rognon.

5*b*. The same, oral view (×5).

6. Apical part of distorted specimen (I.R.Sc.N.B. 13*e*) (×5). Fauquez (old quarry NW of Fauquez Castle).
7. Compressed theca, in oral view (I.R.Sc.N.B. 16*a*) (×2). Fauquez.

FIG. 8. — *Echinosphærites* sp. 31

Internal cast of fragmentary specimen (Louvain 9*b*) (×3). — Sambre-et-Meuse : Presles.

FIG. 9-10. — Pelmatozoan stem, type A. × 5 37

Brabant.

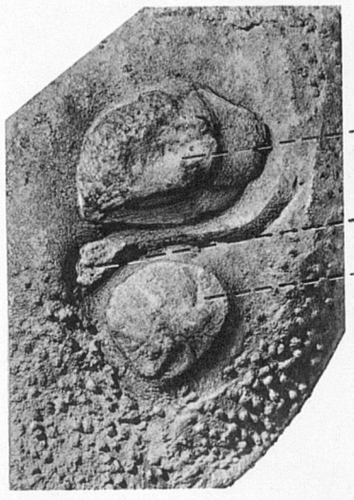
9. Internal cast, showing articular surface of a columnal, with its lumina, and part of the inner wall of the stem, with columnal joints (I.R.Sc.N.B. 23*h*). Ronquières.

10*a*. Cast of articular surface of columnal (I.R.Sc.N.B. 29). Rebecq-Rognon.

10*b*. Gutta-percha squeeze of the same.

(*a*, periproct; *p*, peristome; *pr*, gonopore.)

Phot. G. AHL. Ret. S. EKBLOM.



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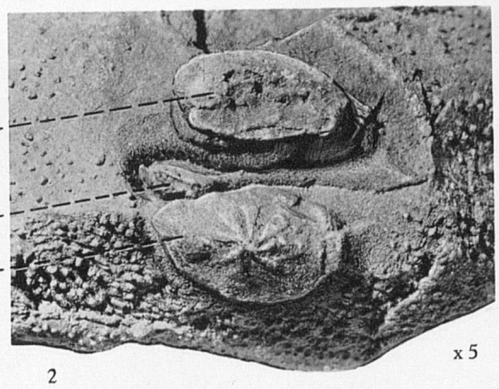
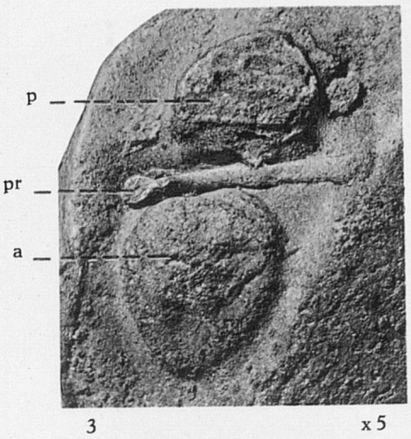
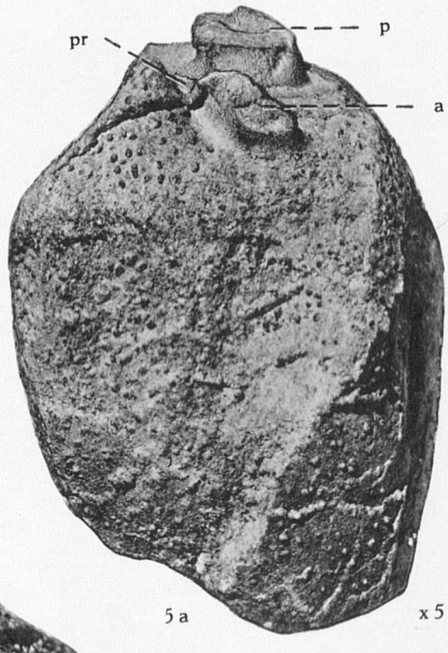


2 x 5

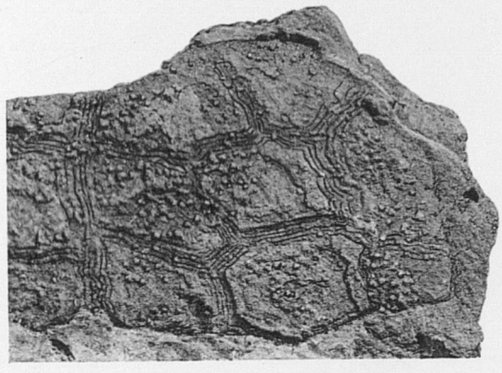


3 x 5



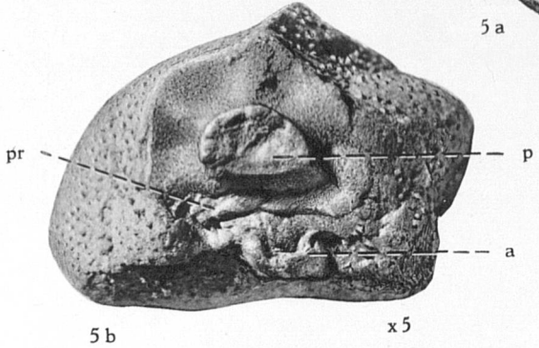
5 a x 5

4 a x 5

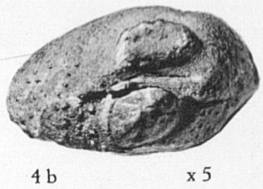


8 x 3

Fig. 8. - *Echinosphaerites* sp.

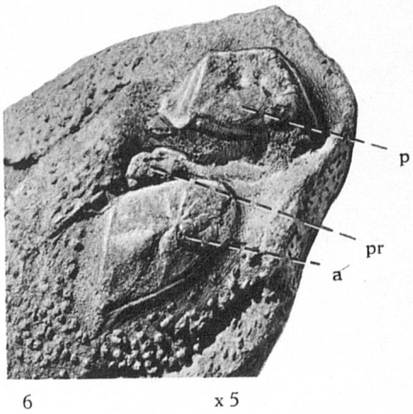


5 b x 5

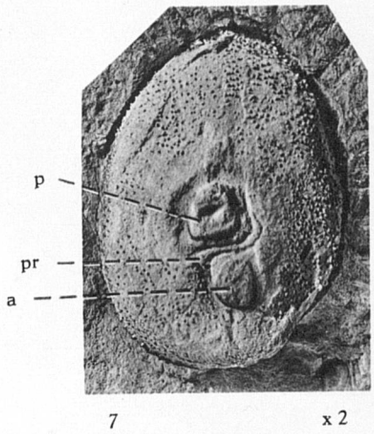


4 b x 5

9 x 5



6 x 5



7 x 2

Fig. 1 - 7. - *Haplosphaeronis proiciens* n. sp.

10 a x 5

10 b x 5

Fig. 9 - 10. - Pelmatozoan stem, type A.

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Phototypie A. Dohmen, Bruxelles

EXPLANATION OF PLATE VI.

Page.

FIG. 1-2. — Gen. and sp. indet. 2 35

Internal casts (×3). — Sambre-et-Meuse.

1. Fragmentary theca, in aboral view (Louvain 6*a*). Le Roux.
2. Theca in lateral view (Louvain 9*a*). Presles.

FIG. 3-4. — Gen. and sp. indet. 4 36

Internal casts of imperfect specimens (×2). — Brabant : Fauquez.

3. Imperfect theca, in lateral view (I.R.Sc.N.B. 18*a*).
4. As the preceding (I.R.Sc.N.B. 18*b*).

FIG. 5. — Gen. and sp. indet. 5 36

Imperfect theca with part of the test preserved (I.R.Sc.N.B. 12*c*). — Brabant : Fauquez.

5*a*. Theca in lateral view (×2).

5*b*. Detail from the right side of the theca (×5).

FIG. 6. — Gen. and sp. indet. 3 35

Internal cast of imperfect theca (I.R.Sc.N.B. 9*a*) (×2). — Brabant : Grand-Manil.

FIG. 7. — Pelmatozoan stem, type B. 37

Internal cast of articular surface of columnal (I.R.Sc.N.B. 25*a*) (×5). — Brabant : Rebecq.

FIG. 8. — *Corylocrinus*? sp. 17

Isolated thecal plate (Louvain 4*a*) (×5). — Sambre-et-Meuse : Les Tombes.

8*a*. Internal cast. To the left Pelmatozoan columnals, type B (p. 37).

8*b*. Gutta-percha squeeze of the same.

FIG. 9. — Specimen (I.R.Sc.N.B. 22) of Gembloux Shale bearing various fossils (i. a. *Haplosphæronis proiciens* nov. sp.) (nat. size)..... 10

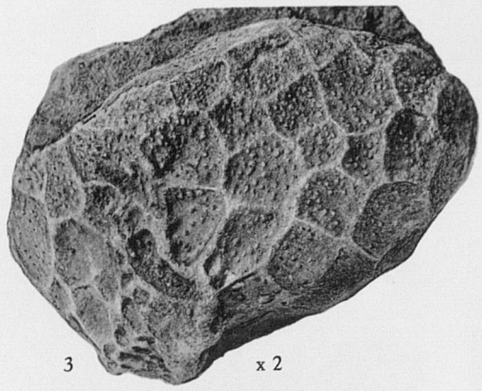
Brabant : Fauquez. Coll. C. MALAISE.

Phot. G. AHL. Ret. S. EKBLOM.

1 x 3

2 x 3

Fig. 1 - 2. - Gen. & sp. indet. 2.



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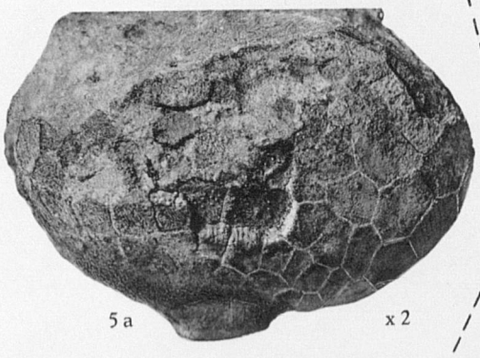
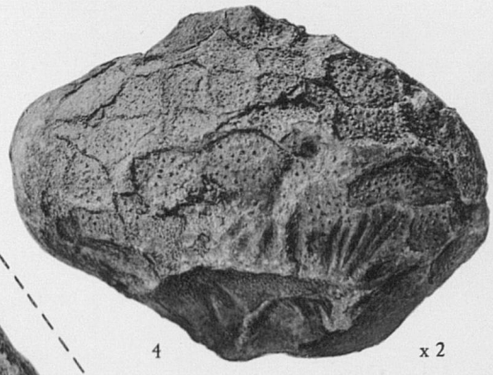


5 a x 2

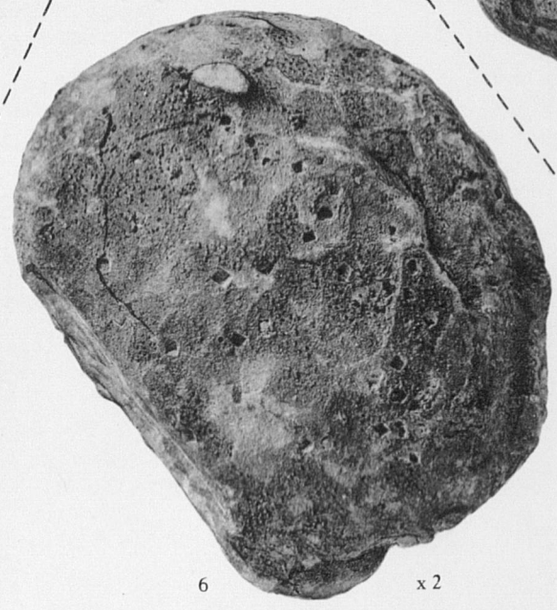


4 x 2

Fig. 3. - 4. - Gen. & sp. indet. 4.

5 b x 5

Fig. 5. - Gen. & sp. indet. 5.

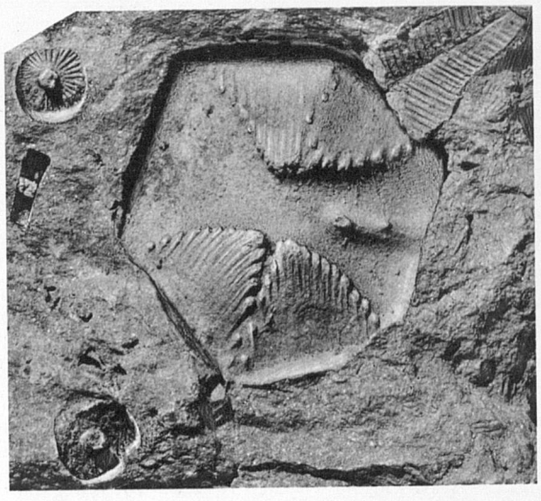


6 x 2

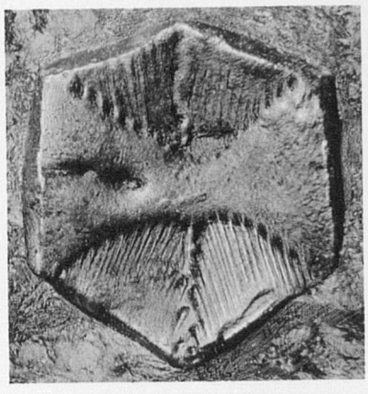
Fig. 6. - Gen. & sp. indet. 3.

7 x 5

Fig. 7. - Pelmatozoan stem, type B.

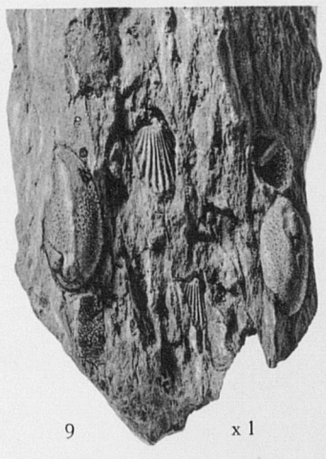


8 a x 5



8 b x 5

Fig. 8. - *Corylocrinus ?* sp.



9 x 1

Fig. 9. - Specimen of Gembloux Shale.

G. REGNÉLL. — Caradocian-Ashgillian Cystoid Fauna.

Phototypie A. Dohmen, Bruxelles