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Phillipsastreids and Ptenophyllids (Rugosa) from the Givetian of Mauritania and Northwestern Spain

Marie COEN-AUBERT

DO Terre et Histoire de la Vie, Institut royal des Sciences naturelles de Belgique, rue Vautier 29, B-1000 Bruxelles, Belgium; E-mail: Marie.Coen-Aubert@naturalsciences.be.

ABSTRACT. *Acanthophyllum trompetti* n. sp., *Phillipsastrea hollardi* Coen-Aubert, 2002, *P.* cf. *hollardi* and *P. givetica* (Ivania in Zheltonogova & Ivania, 1960) occur in the Upper Givetian of the Mauritanian Adrar. *P. torreana* (Milne-Edwards & Haime, 1851), *P. kergarvanensis* Coen-Aubert & Plusquellec, 2007 and *P. sobolewi* (Rozkowska, 1956) have been identified in the Givetian of the Zemmour, also in Mauritania. Some of these species such as *P. givetica* and *P. torreana* are present in the Middle to Upper Givetian of Northwestern Spain together with *P. weyeri* Coen-Aubert, 2002 and *Scruttonia sotoi* n. sp. The specific name *Phillipsastrea givetica* is used herein for the Givetian colonies of Northwestern Spain which were previously assigned to *P. pradoana* (Haime in De Verneuil & Barrande, 1855). The investigated fauna is compared to that of the Tafilalt and the Ma'der in Morocco. All these different areas belong to the northern margin of Gondwana. However, there are also affinities with the Givetian phillipsastreids and ptenophyllids from Western and Eastern Europe and even with those from Western Siberia in Russia and Southern China.

KEYWORDS: Rugose corals, taxonomy, stratigraphy, Givetian, Gondwana.

1. Introduction

Up to now, the Givetian rugose coral fauna of Mauritania was nearly unknown. Of course, Sougy (1964) illustrated some of these fossils, but only in external views and with identifications without thin sections. The study of this paper is based on two collections. The first one was sampled in the early Sixties by Roland Trompette, in the Mauritanian Adrar situated in the central part of Mauritania (Fig. 1). It was sent to Professor Marius Lecompte of the Catholic University of Louvain in Belgium and it is now very well dated due to the investigation of conodonts and other fossil remains by Racheboeuf et al. (2001). The second much larger collection is that of Sougy (1964) gathered in the Zemmour, to the north of Mauritania, part of which was also given to M. Lecompte. From a stratigraphic point of view, these samples are not so well documented.

In the Mauritanian Adrar, the species *Acanthophyllum trompetti* n. sp. occurs in several localities and it is associated in one of them with a few colonies of *Phillipsastrea* D'Orbigny, 1849 identified as *P. hollardi* Coen-Aubert, 2002, *P.* cf. *hollardi* and *P. givetica* (Ivania in Zheltonogova & Ivania, 1960). So it was interesting to compare these taxa of *Phillipsastrea* with those present in the Zemmour, in Northwestern Spain and also in the Tafilalt and the Ma'der located in the southern part of Morocco (Fig. 1). Indeed, these Moroccan *Phillipsastrea* have been investigated in detail by Coen-Aubert (2002). Moreover, this author discussed already the problems related to the specific name *P. pradoana* (Haime in De Verneuil & Barrande, 1855) used in the Givetian of Northwestern Spain. These colonies are assigned herein to *P. givetica* on the basis among others of a third collection of rugose corals collected in the early Seventies by Hsienho Tsien, in the Province of Asturias. This material was stored in the Institute of Geology from the Catholic University of Louvain at Louvain-la-Neuve. It contains another taxon of massive phillipsastreid ascribed to *Scruttonia sotoi* n. sp. The Givetian of Asturias is very well known and dated by conodonts.

The Givetian stage is now formally subdivided into Lower, Middle and Upper Givetian. Its base is fixed at the lower boundary of the *Polygnathus hemiansatus* conodont Zone which is succeeded by the *P. varcus*, *Schmidtognathus hermanni* and *Klapperina disparilis* Zones. The start of the Frasnian occurs within the overlying Lower *Mesotaxis falsiovalis* Zone. However, this standard conodont zonation was refined by the alternative *Polygnathus* zonation introduced by Bultynck (1987). Indeed, the Lower-Middle Givetian boundary is defined at the base of the *P. rhenanus/P. varcus* Zone corresponding to the upper part of the Lower *P. varcus* Zone. As for the Upper Givetian, it starts at the base of the *Schmidtognathus hermanni* Zone which was previously named *S. hermanni-Polygnathus cristatus* Zone. The correlations between these different conodont zonations and the subdivisions of the Givetian have been well illustrated by Narkiewicz & Bultynck (2007, table 1) and Bultynck (2007, fig. 1).

2. Geological setting and localities

2.1. Mauritanian Adrar

Among the rugose corals collected by R. Trompette during the early Sixties, in the southeastern part of the Mauritanian Adrar, there are several solitary coralla of *Acanthophyllum trompetti*. These specimens come from samples TA970 of the eastern Mermedha section, TA995 of the western Mermedha section, TA1022 from the southern Mermedha section and TA1057 from the southern Tichillit el Gad section. In sample TA970 of

Figure 1. Geographic map of Southwestern Europe and Northwestern Africa showing the different areas concerned by this paper.

the eastern Mermedha section, there are also a few colonies of phillipsastreids represented by *Phillipsastrea hollardi*, *P.* cf. *hollardi* and *P. givetica*. Further information about this material has been given by R. Trompette to M. Lecompte, in a letter sent on 16 june 1966. All these geological sections, separated by less than 15 km, are close enough to each other to be located under the same geographical coordinates (19°15'N and 12°30'W).

Other fossiliferous samples with brachiopods, conodonts, ostracods and vertebrate microremains, also gathered by R. Trompette in the same area, have been investigated in detail by Racheboeuf et al. (2001). In figure 1 of that paper, there is a map with the location of the Mermedha syncline and the different outcrops, whereas figures 2, 3 and 4 of Racheboeuf et al. (2001) provide schematic lithostratigraphic columns of several sections, the position of the samples, the identified conodonts and brachiopods and finally stratigraphic correlations with the conodont zonation. By using all these data, Racheboeuf et al. (2001) arrived to the conclusion that sample TA995 of the western Mermedha section may be correlated with sample TA1022 of the southern Mermedha section and that both of them may be assigned to the *Schmidtognathus hermanni-Polygnathus cristatus* conodont Zone. Moreover, sample TA970 in the upper part of the eastern Mermedha section seems to be slightly younger and closer to the Givetian-Frasnian boundary. So it appears that the rugose corals from the Mauritanian Adrar studied herein can be referred with a strong probability to the Upper Givetian.

2.2. Zemmour in Mauritania

Among the rugose corals collected by Sougy (1964) to the north of Bir Moghreim (formerly Fort Trinquet) in the Zemmour, there are not many colonies of *Phillipsastrea*. As mentioned by Sougy (1964, p. 459), the first representatives of the genus occur in its unit 87 of the Givetian named as Lower Coral Beds. Indeed, a specimen of *P. sobolewi* (Rozkowska, 1956) has been identified in sample 5547D of this unit, in section E4 of Tighirt whose geographical coordinates are 25°51'N and 11°43'W; it is in the same context that has been found the colony of *Iowaphyllum* sp. from sample 5314 illustrated by Coen-Aubert & Lütte (1993, figs. 5b-c). In section E4, Sougy (1964, pp. 385-390) described a complete succession of the lower part of the Givetian from units 81 to 90, the latter named as Upper Coral Beds. However, the Eifelian-Givetian boundary is not placed with great precision. Indeed, Tourneur (1987, p. 53) noted that *Cabrieroceras crispiformis* present in unit 81 is known in the middle part of the *Tortodus kockelianus* conodont Zone, that is to say below the start of the Givetian defined at the base of the *Polygnathus hemiansatus* Zone.

In section E4 (Fig. 2), there are 105 m of marls (units 82 to 86) above unit 81. Then the Lower Coral Beds of unit 87 are 20 m thick and overlain by 83 m of marls with a few intercalations of limestone, up to the top of unit 90. The Givetian-Frasnian boundary was fixed by Sougy (1964) at the top of the Upper Coral Beds of this unit and correlated in table 36 of that publication, with the base of the Fromelennes Formation from France and Belgium, which of course still belongs to the Givetian, according to Bultynck et al. (2000) among others. The upper part of this succession is also exposed in section F5 of Aguelt Nebka and Amgli el Harra, located 23 km to the northeast of section E4 and studied in detail by Sougy (1964, pp. 381-385); its geographical coordinates are 26°N and 11°37'W. Upwards, section F6 of Amgli el Harra and Amgli Zguilma, in continuation with F5, has been investigated less carefully by Sougy (1964, pp. 489-492). A few metres above unit 90, samples 2389 and 2391 have provided respectively *Phillipsastrea sobolewi* and *P. torreana* (Milne-Edwards & Haime, 1851). From units 91 to 94 are observed mainly 51 m of siltstones with a key bed of oolitic limestone at the top. Then, there are 158 m of clays and siltstones with three intercalations of limestone containing some corals in units 96, 98 and 100. Samples 2392 with *P. torreana* and 2396 with *P. kergarvanensis* Coen-Aubert & Plusquellec, 2007 come from section F6 without much precision. Sample 2381c is located by J. Sougy, in a letter sent on 31 March 1992, above green clays with crinoids. Levels rich in crinoids have been mentioned by Sougy (1964, pp. 495 and 512) in units 97 and 99; so sample 2381C has probably been collected in units 98 or 100. Above unit 100,

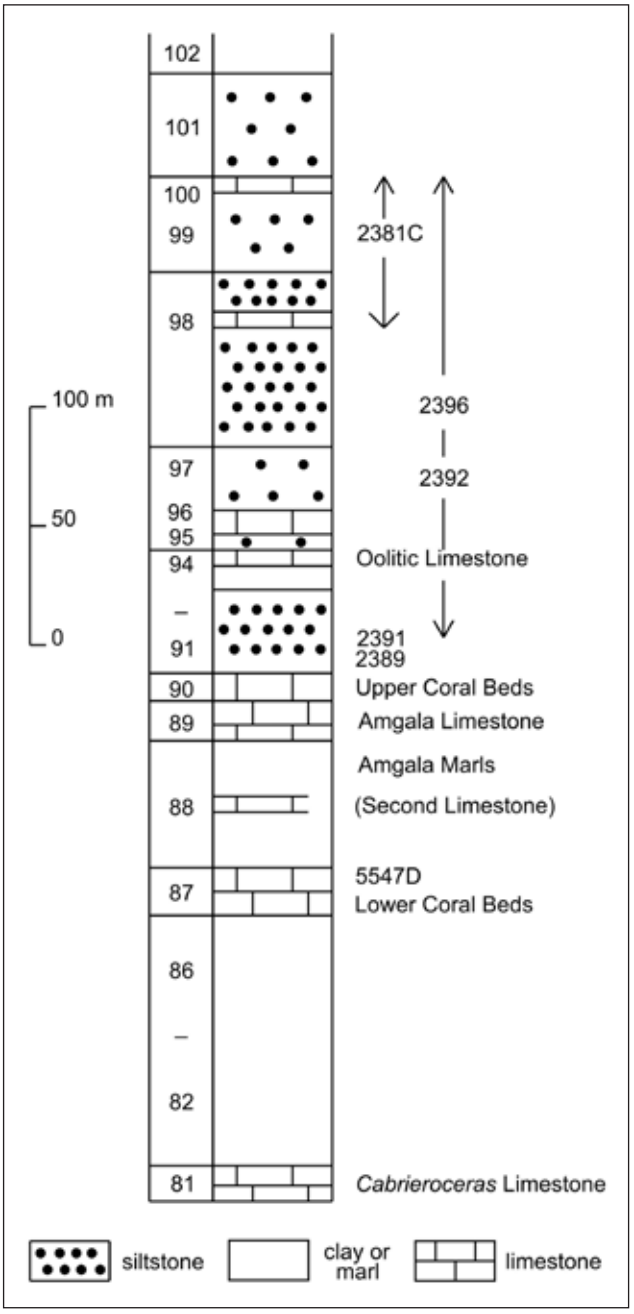

Figure 2. Schematic lithologic column for the Givetian of the Zemmour based on sections E4, F5 and F6 described by Sougy (1964); explanations in the text.

section F6 is first characterized by 43 m of clays and siltstones with brachiopods (unit 101) and then by 100 m of silty clays with rare fossils (unit 102). Brachiopods are present throughout section F6 up to unit 101; but they do not allow to recognize the Givetian-Frasnian boundary. For a few other samples belonging to the collection of Sougy (1964) and mentioned in this paper, there is no adequate information on locality and stratigraphy.

Dumestre & Illing (1967, fig. 2) and Wendt & Kaufmann (2006, fig. 2) compared and correlated the Givetian succession of the Zemmour described by Sougy (1964) with that exposed about 100 km to the north, close to Smara in the northern part of Western Sahara. In this area, the Givetian is characterized by the superimposition of six reef cycles. The second reef cycle appears well above the Lower coral beds of the Zemmour whereas the third reef cycle is developed laterally to the Upper coral beds. Then the key bed of oolitic limestone serves as basement for the fourth reef cycle. Upwards, the fifth and sixth reef cycles are often restricted to coral beds. Dumestre & Illing (1967, p. 336) noted the occurrence of *Phillipsastrea* in the second and third reef cycles of Smara. As for Wendt & Kaufmann (2006, p. 347), they mentioned several species of the genus in the fourth and

sixth reef cycles, but they did not figure them in thin sections. By this comparison, it is clear that all the colonies of *Phillipsastrea* sampled by Sougy (1964) in the Zemmour are Givetian in age and that most of them come from the middle and upper parts of the stage.

2.3. Asturias in Spain

The colonies of phillipsastreids collected by H.H. Tsien during the early Seventies, in the Givetian of Asturias, on the northern side of the Cantabrian Mountains, come from the coastal localities of Candas, Carranques and Perlora lying to the northwest of Oviedo. According to S. Garcia-Lopez and E. Fernandez-Martinez (written communications), Candas corresponds to the section of Peran whereas Carranques and Perlora correspond to different places of the section of Carranques Beach. These two sections are exposed respectively in the northwestern and southeastern limbs of the Perlora Syncline; they have both been located with precision and investigated by Fernandez et al. (1995, pp. 55-59). Peran is the stratotype of the Candas Formation and has been described by Garcia-Alcade et al. (1979, pp. 8-11) and Garcia-Lopez (1986, pp. 285-288). The Candas Formation is 189 m thick and consists of limestones, argillaceous limestones, marls, shales and occasional thin sandstones beds with several reefal episodes. Colonies of phillipsastreids are observed nearly throughout the Candas Formation, from about 25 m above its base; however, biostromes with *Disphyllum* characterize mostly the top of the lithostratigraphic unit. *Scruttonia sotoi* has been identified in the three localities of Candas, Carranques and Perlora sampled by H.H. Tsien; in the latter outcrop, it is accompanied by *Phillipsastrea givetica* and there is also one colony of *Kuangxiastraea* Yu & Kuang, 1982.

The conodonts of the Candas Formation have been studied in detail at Peran, by Garcia-Lopez et al. (2002) who recognized the Lower, Middle and Upper *Polygnathus varcus* Zones, the *Schmidtognathus hermanni-Polygnathus cristatus* Zone and finally the Lower *Mesotaxis falsiovalis* Zone at the top of the lithostratigraphic unit with *Ancyrodella binodosa* and *A. pristina*. That is to say that the uppermost part of the Candas Formation is very close to the base of the Frasnian. Typical Frasnian conodonts occur in the overlying Pineres Formation with among others *A. rotundiloba*. At the base of the Candas Formation at Peran, the identification of *Polygnathus rhenanus* indicates the *P. rhenanus/P. varcus* Zone corresponding to the upper part of the Lower *P. varcus* Zone. In conclusion, the main part of the Candas Formation belongs to the Middle and Upper Givetian whereas its top is basal Frasnian.

On the southern side of the Cantabrian Mountains, in the Leon Province, the Portilla Formation is laterally equivalent to the Candas Formation and shows the same facies. Colonies of phillipsastreids occur also in the Portilla Formation. Its conodonts have been investigated by Garcia-Lopez & Sanz-Lopez (2002) who identified the Lower, Middle and Upper *Polygnathus varcus* Zones and the *Schmidtognathus hermanni-Polygnathus cristatus* Zones. The base of the Portilla Formation is still Lower Givetian in age and slightly older than that of the Candas Formation as it contains the *Polygnathus timorensis* Zone corresponding to the lower part of the Lower *Polygnathus varcus* Zone. The overlying Nocedo Formation is Frasnian and starts in the Upper *Mesotaxis falsiovalis* Zone

2.4. Tafilalt in Morocco

One specimen of *Phillipsastrea givetica* has been identified among the numerous platy colonies of *P. weyeri* Coen-Aubert, 2002 and *P. tafilaltensis* Coen-Aubert, 2002 which constitute the small Upper Givetian reefal lens of Amessoui, in the Tafilalt, described by Coen-Aubert (2002 and 2005). According to this author, *P. weyeri* and *P. tafilaltensis* are also common in the Middle and Upper Givetian of the Ma'der where they are associated with *P. hollardi*.

3. Systematic Palaeontology

The types of the new species and the figured specimens are stored in the collection of Palaeontology from the Institut royal des Sciences naturelles de Belgique at Brussels (IRScNB).

Family Ptenophyllidae Wedekind, 1923

Genus *Acanthophyllum* Dybowski, 1873

Type species. By subsequent designation of Schlüter (1889, p. 38), *Cyathophyllum heterophyllum* Milne-Edwards & Haime, 1851.

Diagnosis. Large solitary rugose corals. Septa of two orders, rarely discontinuous at the periphery, thin to more or less dilated throughout their length. Major septa, sometimes thicker in the outer or in the inner part of the dissepimentarium, carinate in the tabularium and reaching usually the axis of the corallum. Minor septa traversing the entire dissepimentarium. Wide dissepimentarium composed of numerous rows of inclined dissepiments which are occasionally subhorizontal at the periphery. Tabulae incomplete and closely spaced, forming concave floors.

Acanthophyllum trompetti n.sp.
(Plate 1A-B; Plate 2A-E)

Derivation of name. The species is dedicated to Roland Trompette, a distinguished French geologist who collected during the Sixties all the material from the Mauritanian Adrar available for this study.

Holotype. IRScNB a12835 (= Plate 1A-B). Specimen TA1022 I collected during the early Sixties by R. Trompette in the Mauritanian Adrar.

Type locality and horizon. Sample TA1022 of Mermedha, southern section in the Mauritanian Adrar. Upper Givetian, probably *Schmidtognathus hermanni-Polygnathus cristatus* conodont Zone according to Racheboeuf et al. (2001).

Material. 16 specimens with 30 thin sections. Sampling of R. Trompette from the Mauritanian Adrar: Mermedha, eastern section TA970 III; Mermedha, western section TA995 I, II, III, MAU 6, MAU 7 and MAU 8; Mermedha, southern section TA1022 I, II, III, V, MAU 12 and MAU 13; Tichillit el Gad, southern section, TA1057 I, III and IV.

Diagnosis. A species of *Acanthophyllum* with 72 to 88 septa at a diameter of 17 mm to 30 mm. Septa slightly dilated in the dissepimentarium and sometimes thinning in the tabularium. Major septa reaching the axis of the corallum or leaving an open space in the centre of the tabularium.

Description. The material consists of conical or sometimes cylindrical coralla with a conical tip. Their height varies between 2.5 cm and 8 cm, but often reaches at least 4 cm. Longitudinal ribs are frequent. One specimen is compressed laterally whereas the calices of a few other ones are more or less deeply excavated and bordered by inclined or steep sides. The outer wall is rarely preserved and the coralla may be abraded at the periphery. Two of them are locally encrusted by chaetetids and thin laminar stromatoporoids

The septa are non-carinate; however, a few vepreculae are observed in a rather young stage. The septa are slightly dilated in the dissepimentarium with occasionally the major ones thicker than the minor ones. The septa may be dilated throughout their length; but they may be also thinner, thicker or less thick in the tabularium. In two specimens, a stereoplasmic thickening occurs locally against the wall or on a layer of dissepiments.

The major septa reach the axis of the corallum or leave an open space in the centre of the tabularium. Their axial ends are sometimes rhopaloid, forked, curved, twisting in a whorl, forming pseudofossulae or breaking into fragments. Some stereoplasma is present in the tabularium of rather young stages, between the septa or at its centre. The minor septa traverse the entire dissepimentarium and are rarely shorter; in some cases, they are hardly projecting into the tabularium or they are contratingent.

The dissepimentarium consists of 7 to 16 and even only 4 rows of small inclined dissepiments which are rarely horizontal at the periphery. The tabulae are closely spaced and they are frequently incomplete and intersecting laterally with few traces of septa disrupting them; they are occasionally vesicular. The base of the corallum is full of stereoplasma formed by contiguous septa; stereoplasmic thickenings occur also locally on some tabulae.

There are 72 to 88 septa per corallum; this number is restricted to 60 in a rather young stage. The diameter of the corallum ranges from 13.5 mm to 30 mm. The width of the tabularium varies between 10 mm or even 8.5 mm and 16 mm.

Discussion. Acanthophyllum trompetti is related to *A. simplex* (Walther, 1929) introduced in the Givetian Schwelm Formation from the Bergisches Land in Germany. The latter species has been revised by Coen-Aubert (2000) and synonymized by this author with *A. concavum* (Walther, 1929) from the same area in Germany. *A. simplex* occurs in Belgium, across the boundary between the Lower and the Middle Givetian. It has also been observed by Coen-Aubert (2002 and 2005) in the Middle and Upper Givetian from the Tafilalt and the Ma'der in Morocco. *A. simplex* is distinguished from *A. trompetti* by slightly fewer septa which are more dilated throughout their length and reach the centre of the tabularium. However, *A. trompetti* resembles more the material described as *A. concavum simplex* by May & Becker (1996, p. 215) and coming from the Upper Givetian of the Northern Sauerland in Germany. Indeed, the 56 to 80 septa of these specimens, though they are also extending to the axis of the corallum, are less thickened in the dissepimentarium and are thinning in the tabularium. The same characteristics are more or less present in the samples from the Upper Givetian of Western Yunnan in China assigned to *A. concavum* by Wang (1994, p. 399).

Distribution. The species is only known in the Upper Givetian of the Mauritanian Adrar.

Family Phillipsastreidae Roemer, 1883

Genus *Phillipsastrea* D'Orbigny, 1849

1849 *Phillipsastrea* D'Orbigny: 12.
1851 *Smithia* Milne-Edwards & Haime: 171.
1855 *Medusaephyllum* Roemer: 33.
1881 *Pseudoacervularia* Schlüter: 84.

Type species. By subsequent designation of Milne-Edwards & Haime (1850, p. lxxi), *Astrea hennahi* Lonsdale, 1840.

Diagnosis. Massive rugose corals, astreoid, thamnasterioid or even pseudocerioid. Septa of two orders, slightly carinate or non-carinate, spindle-shaped dilated in the inner part of the dissepimentarium. Major septa reaching the axis of the corallites or leaving an open space in the centre of the tabularium. Minor septa traversing the entire dissepimentarium. Dissepimentarium composed of several rows of globose dissepiments arranged in horizontal layers; at its inner margin, horseshoe dissepiments varying from intermittent, as in the type species, to a continuous pipe completely surrounding the tabularium. Narrow symmetrical fans of septal trabeculae centred over the horseshoe dissepiments. Tabulae incomplete, sometimes complete or compound.

***Phiilipsastrea hollardi* Coen-Aubert, 2002**
(Plate 1E-F)

* v 2002 *Phiilipsastrea hollardi* n. sp.; Coen-Aubert: 29, pl. 3, figs. 1-6.
2005 *Phillipsastrea hollardi* Coen-Aubert; Wrzolek: fig. 10, 1.

Holotype. Specimen IRScNB a11238 (= MA246) stored in the Collection of Palaeontology from the Institut royal des Sciences naturelles de Belgique at Brussels, Belgium. Top of the Taboumakhlouf South section in the Ma'der, Morocco. Middle Givetian, Upper *Polygnathus varcus* conodont Zone. Pl. 3, figs. 1-2 in Coen-Aubert (2002).

Material. 1 specimen with 3 thin sections. Sampling of R. Trompette from the Mauritanian Adrar: Mermedha, eastern section TA970 I.

Diagnosis. A thamnasterioid species of *Phillipsastrea* with 22 to 26 major septa at tabularial diameters of 1.6 mm to 2.5 mm. Major septa thin or thick in the tabularium where they leave an open space in the centre or outline an axial structure. Horseshoe dissepiments weakly developed.

Description. The only colony available is tabular with an area of 12 cm x 17 cm and a height of 7 cm; the small calices are excavated and raised over the corallum surface. The corallites are connected by confluent septa and very locally by a weak zigzagged pseudotheca.

The non-carinate septa are slender or rather thickened at the periphery. They are spindle-shaped dilated in the inner part of the dissepimentarium where they are occasionally contiguous. The septa become thinner or remain more or less thick in the tabularium. The horseshoe dissepiments sometimes coated with stereome may be conspicuous in transverse section. The major septa reach the axis of the corallites or leave a small open space in the centre of the tabularium. Their axial ends are forming occasionally pseudofossulae or a more or less complete pseudoaulos; they are also fusing partially in the centre of some corallites where there is sometimes a small deposit of stereoplasma. The minor septa traverse the entire dissepimentarium.

The dissepimentarium consists of a few rows of globose dissepiments arranged in horizontal layers or locally inclined towards the peripheral part of the corallites. Small horseshoe dissepiments are frequently present at the border of the tabularium. The tabulae are incomplete and intersecting laterally.

There are 22 to 26 septa per corallite. The width of the tabularium ranges from 2.1 mm to 2.9 mm whereas the diameter of the corallites varies between 5.7 mm and 8.7 mm.

Discussion. With the exception of more numerous horseshoe dissepiments, the Mauritanian colony is similar to the Givetian material of *Phillipsastrea hollardi* collected in the Ma'der, Morocco by Coen-Aubert (2002). A specimen of *P. hollardi* from the Upper Givetian locality of Aït Ou Amar, also in the Ma'der, has been illustrated by Wrzolek (2005, fig. 10, 1). From the same outcrop, Wrzolek (2005, figs. 10, 2-3) figured respectively *P. weyeri* and *P. tafilaltensis*. In my opinion, the colony identified by Wrzolek (2005, fig. 10, 2) as *P. weyeri* is typical of *P. tafilaltensis* which is separated from *P. hollardi* by a slightly more astreoid aspect, the weaker dilation of the septa in the inner dissepimentarium and a rather wide open space in the centre of the tabularium without any trace of axial structure. *P. weyeri* differs from *P. tafilaltensis* and *P. hollardi* by carinate septa reaching the axis of the corallites and by greater septal number and diameter of the tabularium.

An extreme representative of *P. jachowiczi* Wrzolek, 2005 coming from the Upper Givetian of the Holy Cross Mountains in Poland and illustrated by Wrzolek (2005, fig. 7, 3) resembles *P. hollardi*. Indeed, this sample is thamnasterioid and characterized by septa strongly dilated in the dissepimentarium and still thick in the tabularium. Normally, *P. jacowiczi* is more or less astreoid with septa rather slender in the main part of the dissepimentarium, only spindle-shaped dilated at the border of the tabularium and becoming thin slightly beyond their entry into it.

Distribution. The species is known in the Upper Givetian from the Mauritanian Adrar as well as in the Middle and Upper Givetian from the Ma'der in Morocco.

***Phillipsastrea* cf. *hollardi* Coen-Aubert, 2002**
(Plate 1C-D)

Material. 1 specimen with 3 thin sections. Sampling of R. Trompette from the Mauritanian Adrar: Mermedha, eastern section TA970 MAU2.

Description. The only colony available is platy and fragmentary with an area of 9 cm x 11 cm and a height of 3,5 cm. The corallites

are connected by confluent septa and sometimes by a weak pseudotheca.

The septa are non-carinate and locally discontinuous at the periphery. They are slender or slightly thickened in the main part of the dissepimentarium. In some corallites, the septa are spindle-shaped dilated at the border of the tabularium where they may be contiguous; they become thin or more or less thick somewhat beyond their entry into the tabularium. In other corallites, the septa are slender or weakly dilated throughout their length. The horseshoe dissepiments are rarely conspicuous in transverse section.

The major septa leave a small open space in the centre of the tabularium or reach more or less the axis of the corallites where there are occasionally pseudofossulae, short fragments of septa or a weak deposit of stereoplasma. The minor septa traverse the entire dissepimentarium or even enter into the tabularium where they may be contratingent.

The dissepimentarium consists of a few rows of globose dissepiments arranged in horizontal layers or inclined towards the peripheral part of the corallites. Small horseshoe dissepiments are rather often present at the border of the tabularium. The tabulae are concave, more or less convex or incomplete and intersecting laterally.

There are 26 to 30 or only 20 septa per corallite. The width of the tabularium ranges from 3.1 or even 2.5 mm to 4.3 mm whereas the diameter of the corallites varies between 9 mm and 12 mm.

Discussion. The colony described herein differs from *Phillipsastrea hollardi* by greater diameters of the tabularia and corallites and by septa which may be slender in the main part of the dissepimentarium or even throughout their length in some corallites. It has some affinities with *P. rozkowskae* Fedorowski, 2003 coming from the Middle to Upper Frasnian of the Holy Cross Mountains in Poland and based on the material of Rozkowska (1953) assigned to *P.* cf. *macouni* Smith, 1945. However, the new species of Fedorowski (2003), different from *P. rozkowskae* Scrutton, 1968, is separated from *P.* cf. *hollardi* by septa rather thick in the peripheral part of the dissepimentarium and often leaving an open space in the centre of the tabularium.

Distribution. The form is only known in the Upper Givetian of the Mauritanian Adrar.

***Phillipsastrea givetica* (Ivania in Zheltonogova & Ivania, 1960)**
(Plate 2F; Plate 3A-B)

* 1960 *Pachyphyllum giveticum* Ivania sp. nov.; Zheltonogova & Ivania: 407, pl. D-57, fig. 1.
1965 *Pachyphyllum giveticum* Ivania; Ivania: 119, pl. 101, figs. 437-438.
v 1967 *Pseudoacervularia* cf. *pradoana* (Haime 1855); Pickett: pl. 3, fig. 12, pl. 4, fig. 16.
1994 *Medusaephyllum pradoanum* (Haime, 1855); Fernandez-Martinez et al.: figs. 3.13-14.
v 2002 *Phillipsastrea* cf. *pradoana* (Haime, 1855) sensu Pickett (1967); Coen-Aubert: 28, 31, pl. 4, figs. 5-6.
2005 *Phillipsastrea givetica*; Wrzolek: table 4.
non 2005 *Phillipsastrea "pradoana"*; Wrzolek: fig. 9, 1.
2005 *Phillipsastrea torreana* (Milne-Edwards & Haime, 1851); Wrzolek: fig. 9, 2.

Holotype. Specimen N° 1-26A-22 stored in the Palaeontological Museum of the State University of Tomsk, Russia. Upper Givetian Chielev Beds from the Tyutyo river in the southeast part of the Gornyi Altai, Russia. Pl. D-57, fig. 1 in Zheltonogova & Ivania (1960) and pl. 101, figs. 437-438 in Ivania (1965).

Material. 6 specimens with 16 thin sections from Morocco, Mauritania and the Cantabrian Mountains in Spain. Personal sampling: Amessoui MA136. Sampling of R. Trompette from the Mauritanian Adrar: Mermedha, eastern section TA970 MAU1. Sampling of R. Birenheide from the Leon Province: Santa Olaja de la Varga to the east of Sabero PRA2 and SMF 18879b-c; the latter colony is stored in the Forschungsinstitut Senckenberg at Frankfurt am Main, Germany. Sampling of H.H. Tsien and Y. Plusquellec from Asturias: Perlora 404 (l. 12081) and the colony of Peran close to Candas with the thin sections B37676, B37677 and B37678 which is stored in the collections of the Laboratoire de Paléontologie de l'UFR Sciences et Techniques, University of Bretagne Occidentale at Brest, France.

Diagnosis. An astreoid species of *Phillipsastrea* with 32 to 36 septa at tabularial diameters of 2.5 mm to 3.6 mm. Septa spindle-shaped dilated in the inner part of the dissepimentarium. Horseshoe dissepiments well developed.

Description. The material consists of platy and tabular colonies whose height reaches 3 cm to 6 cm; the largest piece has an area of 9 cm x 11 cm. In some specimens, the small calices are excavated and raised above the corallum surface. The corallites often polygonal in shape are separated by a rather weak zigzagged pseudotheca; they are locally connected by confluent septa.

The septa are non-carinate or bear a few small spinose and knobbly carinae. They are slender or slightly thickened at the periphery and they are spindle-shaped dilated in the inner part of the dissepimentarium or only in the area of the horseshoe dissepiments which is often coated with stereome on both sides, in the Mauritanian colony. The septa become thin or in some corallites less thick in the tabularium or somewhat beyond their entry into it. The major septa leave an open space in the centre of the tabularium and reach occasionally the axis of the corallites where they may fuse partially or form pseudofossulae; in the Moroccan colony, a few trabeculae and small fragments of septa are present there. The minor septa traverse the entire dissepimentarium; they are rarely shorter or hardly projecting into the tabularium.

The dissepimentarium consists of several rows of globose dissepiments arranged in horizontal layers or sometimes inclined towards the pseudotheca of the corallites. A continuous pipe of horseshoe dissepiments frequently occurs at the border of the tabularium with locally one row of inner dissepiments. Some symmetrical, tight fans of septal trabeculae are centred over the horseshoe dissepiments. The tabulae are incomplete and intersecting laterally, often with a flat-topped axial part; they may be also horizonal or convex.

There are 28 to 36 septa per corallite. The width of the tabularium ranges from 2.2 mm or even 1.9 mm to 3.8 mm whereas the diameter of the corallites varies between 5.3 mm and 11 mm.

Discussion. The material investigated herein is similar to the holotype of *Phillipsastrea givetica* which is the only colony figured by Zheltonogova & Ivania (1960) and Ivania (1965); in this specimen however, the major septa reach more often the axis of the corallites and the septal number is slightly greater. According to these two Russian papers, the diameter of the tabularium varies between 3.5 mm and 10 mm. However, it is clear from their illustrations of *P. givetica* that the tabularia are much smaller. The same observation has been made by Schröder (2004, p. 626) and by Wrzolek (2005, table 4) who mentions a mean value of 2.77 mm to 2.80 mm for the tabularial diameter of *P. givetica*.

Among our sampling of the species appears the Spanish colony identified as *Pseudoacervularia* cf. *pradoana* by Pickett (1967) and figured also by Coen-Aubert (2002). This specimen and the one determined as *Medusaephyllum pradoanum* by Fernandez-Martinez et al. (1994) and collected in the Givetian of Asturias are now assigned to *Phillipsastrea givetica*. As for the holotype of *Acervularia pradoana* coming probably from the Pragian or the Emsian of the Sierra Morena in Spain, it has been revised by Coen-Aubert (2002, p. 33) and provisionally referred to the genus *Argutastrea* Crickmay, 1960. Concerning the Spanish material illustrated by Wrzolek (2005, fig. 9), it seems to me that the colony sampled in the Candas Formation of Peran in Asturias and identified by the author as *Phillipsastrea torreana* should be assigned to *P. givetica* whereas the colony sampled in the Portilla Formation of Beberino in the Leon Province and identified by the author as *P. "pradoana"* should be assigned to *P. torreana*. Indeed, *P. torreana*, which is described below and

whose lectotype has been studied by Coen-Aubert (2002), differs from *P. givetica* by the stronger dilation of the septa in the inner part of the dissepimentarium, fewer septa and narrower tabularia.

P. givetica resembles *P. monticola* Reed, 1922 from the Frasnian of Chitral in Pakistan; however, the latter species is separated from the former by a more thamnasterioid aspect, the weaker thickening of the septa at the border of the tabularium, a few more septa and larger tabularia. Several of these features characterize also *P. orientalis* Smith, 1929 in Reed (1929) from Burma or the Union of Myanmar whose Eifelian or Frasnian age has been discussed by Coen-Aubert & Plusquellec (2007, p. 68).

Distribution. The species is known in the Upper Givetian from the Gornyi Altai in Russia, the Tafilalt in Morocco and the Mauritanian Adrar. The Spanish Givetian material comes from the Candas Formation in Asturias and the Portilla Formation in the Leon Province.

***Phillipsastrea torreana* (Milne-Edwards & Haime, 1851)**
(Plate 3C-E)

v * 1851 *Syringophyllum? torreanum*; Milne-Edwards & Haime: 452.
non 1950 *Phillipsastrea torreana*; Almela & Revilla: pl. 3, fig. 4.
1950 *Phillipsastrea torreana* Edw. Haime var. *minuta* nov. var.; Almela & Revilla: 16, pl. 3, fig. 5.
non 1950 *Phillipsastrea torreana*; Termier & Termier: 103, pl. 50, fig. 19.
v 2002 *Phillipsastrea torreana* (Milne-Edwards & Haime, 1851); Coen-Aubert: 30, pl. 4, figs. 1-2.
non 2005 *Phillipsastrea torreana*; Wrzolek: fig. 9, 2.
2005 *Phillipsastrea "pradoana"*; Wrzolek: fig. 9, 1.
? 2006 *Phillipsastrea torreana torreana* (Milne-Edwards & Haime, 1851); May: 156.
2006 *Phillipsastrea torreana minuta* Almela & Revilla, 1950; May: 157, figs. 2D-F.

Remark. A more complete list of synonymy about the references before 1950 has been provided by Coen-Aubert (2002).

Lectotype. Specimen MNHN, LP S 12093 chosen by Coen-Aubert (2002) and stored in the Milne-Edwards collection from the Institut de Paléontologie, Muséum national d'Histoire naturelle at Paris, France. Probably lower part of the Givetian Portilla Formation from Sabero, Leon in the Cantabrian Mountains, Spain. Pl. 4, figs. 1-2 in Coen-Aubert (2002).

Material. 4 specimens with 9 thin sections. Sampling of J. Sougy from the Zemmour in Mauritania: Zemmour 2391 I (l. 8191); 2392 I (l. 7165); 2441 I (l. 7190) and III (l. 7191).

Diagnosis. An astreoid species of *Phillipsastrea* with 22 to 28 septa at tabularial diameters of 2.1 mm to 2.7 mm. Septa strongly spindle-shaped dilated in the inner part of the dissepimentarium. Horseshoe dissepiments well developed at the border of the tabularium.

Description. The material consists of platy and sheet-like colonies which are sometimes fragmentary. Their height varies between 0.5 cm and 5 cm whereas the largest piece has an area of 14 cm x 16 cm. The small calices are excavated and typically raised above the corallum surface. The corallites frequently polygonal in shape are separated by a weak zigzagged pseudotheca; locally, they are connected by confluent septa.

The septa are non-carinate or bear rarely some small spinose carinae. They are usually rather slender at the periphery and strongly dilated in the inner part of the dissepimentarium where they are occasionally contiguous. The septa become thin or sometimes less thick in the tabularium or beyond their entry into it. In transverse section, the pipe of the horseshoe dissepiments is often conspicuous and may be coated with stereome on both sides.

The major septa reach the axis of the corallites or leave a small open space in the centre of the tabularium. In some corallites, their axial ends are fusing partially or are bearing a few spinose carinae whereas a few trabeculae or small fragments of septa are present close to the axis of some other ones. The minor septa traverse the entire dissepimentarium.

The dissepimentarium consists of 2 to 8 rows of small globose dissepiments arranged in horizontal layers or inclined towards the pseudotheca of the corallites. Small horseshoe dissepiments frequently occur at the border of the tabularium. In one colony, there is locally one row of inner dissepiments. Some symmetrical, tight fans of septal trabeculae are centred over the horseshoe dissepiments. The tabulae are incomplete and intersecting laterally, occasionally with a flat-topped axial part; they may be also horizontal or convex.

There are 22 to 30 septa per corallite. The width of the tabularium ranges from 2 mm to 2.8 mm. The diameter of the corallites varies commonly between 5.5 mm and 8 mm and more generally between 5.1 mm and 9 mm.

Discussion. The variability of *Phillipsastrea torreana* is much better known since the description of its lectotype made by Coen-Aubert (2002). Indeed, there are now several colonies assigned to the species which come from Mauritania, but also from its type area, the Leon Province in Spain, according to the references of Wrzolek (2005) and May (2006). Qualitatively, the major septa of *P. torreana* reach the axis of the corallites or leave an open space in the centre of the tabularium. Quantitatively, it seems obvious that *P. torreana minuta* Almela & Revilla , 1950, also from the Leon Province and investigated by May (2006), is synonymous with *P. torreana* as suggested by Soto (2007). Indeed, in the lectotype of *P. torreana minuta* figured by May (2006), the diameter of the tabularium varies between 1.8 mm and 2.2 mm and there are usually 24 septa, but sometimes only 18 to 20 septa. As mentioned above, in the discussion of *P. givetica*, the differences between this species and *P. torreana* are very clear. As for the specimen from the Leon Province attributed by Almela & Revilla (1950) to *P. torreana*, it has been sectioned and determined by May (2006) as *Radiastraea arachne* Stumm, 1937; it is assigned herein to the new species *Scruttonia sotoi*.

Distribution. The species is known in the Givetian Portilla Formation from the Cantabrian Mountains in Spain and probably in the Middle to Upper Givetian from the Zemmour in Mauritania.

***Phillipsastrea kergarvanensis* Coen-Aubert & Plusquellec, 2007**
(Plate 3F-G; Plate 4A-B; Plate 5B-C)

v * 2007 *Phillipsastrea kergarvanensis* n. sp.; Coen-Aubert & Plusquellec: 66, pl. 1, figs. 1-6, pl. 2, figs. 1-6.

Holotype. Specimen LPB 15187 and thin sections B39097-B39098 stored in the collections of the Laboratoire de Paléontologie de l'UFR Sciences et Techniques, University of Bretagne Occidentale at Brest, France. Upper Givetian of Kergarvan (outcrop KE 19-27) in Plougastel-Daoulas (Rade de Brest), Armorican Massif, France. Pl. 1, figs. 1-2 in Coen-Aubert & Plusquellec (2007).

Material. 4 specimens with 9 thin sections. Sampling of J. Sougy from the Zemmour in Mauritania: Zemmour 2381C MAU3 and l. 9142; 2396 IV (l. 7166) and I (l. 7167).

Diagnosis. An astreoid species of *Phillipsastrea* with 28 to 36 septa at tabularial diameters of 2.5 mm to 4 mm. Septa more or less spindle-shaped dilated in the inner part of the dissepimentarium. Major septa rather long, reaching sometimes the axis of the corallites. Horseshoe dissepiments variably developed.

Description. The fragmentary platy colonies of outcrop 2381C reaches an area of 9 x 5 cm and a height of 4 cm; some excavated calices have been observed. In the whole material, the corallites often polygonal in shape are separated by a weak zigzagged epitheca, but they may be also connected by confluent septa.

The septa are usually non-carinate. They are frequently slender at the periphery and more or less dilated in the inner dissepimentarium where they are locally contiguous in one

specimen. The septa become thin or less thick slightly beyond their entry into the tabularium. The horseshoe dissepiments are occasionally conspicuous in transverse section; they are rarely coated with stereome.

The major septa reach the axis of the corallites or leave a small open space in the centre of the tabularium. Their axial ends are sometimes rhopaloid, wavy, bearing a few small spinose carinae, fusing to form pseudofossulae or divided into isolated fragments. The minor septa traverse the entire dissepimentarium.

The dissepimentarium consists of several rows of globose dissepiments arranged in horizontal layers. Small horseshoe dissepiments are more or less present at the border of the tabularium with locally 1 to 3 rows of inner dissepiments. Some symmetrical, tight fans of septal trabeculae are centred over the horseshoe dissepiments. The tabulae are incomplete and intersecting laterally; their axial parts are often flat-topped and occasionally convex.

There are 28 to 36 septa per corallite. The width of the tabularium ranges from 2.6 mm to 3.8 mm. The diameter of the corallites varies commonly between 7.5 mm and 11.5 mm and more generally between 6.9 m and 12.5 mm.

Discussion. There are only minor differences with the Armorican material of *Phillipsastrea kergarvanensis*. Indeed, the major septa of the colonies from the Zemmour reach more often the axis of the corallites and their small horseshoe dissepiments are slightly more frequent. *P. kergarvanensis* is easily distinguished from *P. torreana* by greater septal number and diameters of the tabularia and corallites, by the weaker spindle-shaped dilation of the septa and by the occurrence of a few inner dissepiments. It is separated from *P. givetica* by the last feature and by slightly larger tabularia and corallites. As mentioned by Coen-Aubert & Plusquellec (2007, p. 68), the specimens from the Upper Givetian to the Lower Frasnian of Chitral in Pakistan identified by Schröder (2004, p. 625) as *P.* cf. *orientalis* are very close to *P. kergarvanensis*.

Distribution. The species is known in the Upper Givetian from the Armorican Massif in France and probably in the Middle to Upper Givetian from the Zemmour in Mauritania.

***Phillipsastrea sobolewi* (Rozkowska, 1956)**
(Pl. 4C-D; Plate 5A)

* 1956 *Pachyphyllum sobolewi* n. sp.; Rozkowska: 317, figs. 37-39.
2003 *Phillipsastrea sobolewi* (Rozkowska, 1956); Fedorowski: 106, pl. 48, fig. 2.
2005 *Phillipsastrea sobolewi* (Rozkowska, 1956); Wrzolek: 176, fig. 8.

Holotype. Specimen Tc 5/18 stored in the Department of Geology from the University of Poznan, Poland. Area of Skaly and Wlochy in the northern part of the Holy Cross Mountains, Poland. Middle Givetian Pokrzywianka beds, Middle to Upper *Polygnathus varcus* conodont Zone according to Wrzolek (2005). Figs. 37-39 in Rozkowska (1956) and pl. 48, fig 2 in Fedorowski (2003).

Material. 5 specimens with 12 thin sections. Sampling of J. Sougy from the Zemmour in Mauritania: Zemmour 2389 XII (l. 7109) and XI (l. 7164); 2427 II (l. 7172); 2443 VI (l. 7192); 5547D (l. 9174).

Diagnosis. An astreoid to thamnasterioid species of *Phillipsastrea* with 36 to 44 septa at tabularial diameters of 3.5 mm to 5 mm. Septa slender to more or less spindle-shaped dilated in the inner part of the dissepimentarium. Major septa rather long, leaving a small open space in the centre of the tabularium. Several series of inner dissepiments adjacent to the horseshoe dissepiments.

Description. The material consists of platy colonies whose height varies between 2 cm and 5 cm; the largest piece reaches an area of 10 cm x 5.5 cm. In some specimens, the large calices are excavated and raised above the corallum surface. The corallites are connected by confluent septa or by a weak zigzagged pseudotheca.

The septa are non-carinate or bear a few small spinose carinae. They are usually slender at the periphery and more or less dilated in the inner part of the dissepimentarium; they are sometimes slender throughout their length. The septa become thin or remain rather thick in the tabularium. In transverse section, the horseshoe dissepiments are only apparent occasionally in one sample.

The major septa leave an open space in the centre of the tabularium; in some cases, they nearly reach the axis of the corallites. Their axial ends may be slightly carinate, divided into isolated fragments or fusing to form pseudofossulae. The minor septa traverse all or occasionally nearly all or half the dissepimentarium; they may be discontinuous at their inner ends or hardly entering into the tabularium where they are locally contratingent.

The dissepimentarium consists of several rows of globose dissepiments arranged in horizontal layers or sometimes inclined towards the peripheral part of the corallites. Horseshoe or more or less specialized dissepiments occur close to the border of the tabularium from which they are often separated by 1 to 6 rows of inner dissepiments. Some symmetrical, tight fans of septal trabeculae are centred over the horseshoe dissepiments. The tabulae are incomplete and intersecting laterally, with occasionally a flat-topped or convex axial part; they are rarely horizontal or convex.

There are 34 to 44 septa per corallite. The width of the tabularium ranges from 2.5 mm to 6.5 mm. The diameter of the corallites varies commonly between 10 mm and 16 mm and more generally between 9 mm and 18 mm.

Discussion. The material from the Zemmour resembles more frequently the topotypes of *Phillipsastrea sobolewi* figured by Wrzolek (2005) than its holotype illustrated by Rozkowska (1956) and Fedorowski (2003). In this specimen indeed, the septa are rather slender throughout their length whereas they are more or less spindle-shaped dilated in the colonies investigated by Wrzolek (2005). The same situation concerning the inner thickening of the septa has been observed by Coen-Aubert & Plusquellec (2007) among their large Armorican sampling of *P. kergarvanensis*. For the rest, *P. sobolewi* differs from the latter species by greater septal number and diameters of the tabularia and corallites, by septa more often confluent between the corallites, by the weaker dilation of the septa, by a small open space in the centre of the tabularium, by more inner dissepiments and sometimes by shorter minor septa.

The colony from the Givetian of Smara in the Western Sahara, identified as *P.* n. sp. aff. *irregularis* (Webster & Fenton in Fenton & Fenton, 1924) by Schröder & Werner (2000, pls. 1-2), is very similar to *P. sobolewi*. It is more difficult to be sure about the very fragmentary specimen from the same place determined as *P.* ex gr. *irregularis* by May (2008, pl. 1, figs. E-F). In any case, *P. irregularis* from the Frasnian of Iowa in USA revised by McLean (1994, pl. 7, figs. 1 and 3) and Sorauf (1998, pl. 47, figs. 1-3) is different by the dilation of the septa restricted to the pipe of the horseshoe dissepiments and by major septa reaching the axis of some corallites. *P. chenouensis* (Semenoff-Tian-Chansky, 1961) occurring close to the Givetian-Frasnian boundary, in the north of Algeria, has nearly the same quantitative data as *P. sobolewi*, but is separated from it by its thamnasterioid aspect. The same feature characterizes *P. beneharnica* Joseph & Tsien, 1975 from the Lower Givetian of the Pyrenees in France whose septa also bear small carinae and are weakly spindle-shaped dilated.

Distribution. The species is known in the Middle Givetian from the Holy Cross Mountains in Poland and in the Givetian from the Zemmour in Mauritania.

Genus *Scruttonia* Tcherepnina, 1974

Type species. By original designation, *Smithia bowerbanki* Milne-Edwards & Haime, 1851.

Diagnosis. Massive rugose corals, thamnasterioid to astreoid at times. Septa of two orders, carinate or non-carinate, dilated in the dissepimentarium and sometimes thicker in its inner part, thin in the tabularium. Major septa extending nearly to the axis of the

corallites. Minor septa traversing the entire dissepimentarium. Dissepimentarium composed of several rows of globose dissepiments arranged in horizontal layers. Tabulae complete or incomplete, occasionally compound.

Scruttonia sotoi n. sp.
(Pl. 4E-G; Plate 5D-G)

1950 *Phillipsastrea torreana*; Almela & Revilla: pl. 3, fig. 4.
2006 *Radiastraea arachne* Stumm, 1937; May: 153, figs. 2A-C.

Derivation of name. The species is dedicated to Francisco Soto, a distinguished Spanish specialist of Devonian rugose corals who knows very well the different Givetian levels with phillipsastreids of the Cantabrian Mountains.

Holotype. IRScNB a12850 (= Pl. 5D-E). Specimen Candas T6 (l. 12140) collected by H.H. Tsien during the early Seventies in Asturias.

Type locality and horizon. Middle to Upper Givetian Candas Formation from Peran close to Candas in Asturias, Northern Spain.

Material. 4 specimens with 7 thin sections. Sampling of H.H. Tsien in Asturias: Candas T6 (l. 12140); Carranques T11 I and II (l. 12150); Perlora 33a II (l. 10279).

Diagnosis. A non-carinate species of *Scruttonia* with 30 to 36 septa at tabularial diameters of 2.4 mm to 3.6 mm. Tabulae often compound with flat-topped axial parts

Description. The material consists of platy colonies whose height varies between 1.5 cm and 3.5 cm; the largest piece has an area of 6.5 cm x 5 cm. One specimen is developed on a thin mamillated laminar stromatoporoid; in another one, there are two small lateral offsets. The corallites are normally connected by confluent septa; very locally appears a weak zigzagged pseudotheca.

The septa are non-carinate though rare small carinae are present in two colonies. The septa are slightly dilated in the dissepimentarium and they become thin beyond their entry into the tabularium. They may be also slender at the periphery or show a weak thickening at the inner border of the dissepimentarium.

The major septa reach the axis of the corallites or leave a small open space in the centre of some of them; their axial ends are sometimes forming pseudofossulae, a plane of bilateral symmetry or even fusing partially. The minor septa traverse the entire dissepimentarium; they are rarely shorter or hardly projecting into the tabularium where they may be contratingent.

The dissepimentarium consists of several rows of globose dissepiments arranged in horizontal layers; locally, there is one inner row of inclined dissepiments. The tabulae are incomplete and intersecting laterally, often with a flat-topped axial part; in rare cases, they are horizontal or concave.

There are 28 to 38 septa per corallite. The width of the tabularium ranges from 2 mm to 4 mm. The distances between the centres of adjacent corallites vary commonly between 5.3 mm and 8.7 mm and more generally between 4 mm and 11.5 mm.

Discussion. Scruttonia sotoi is a particular species of the genus as it is nearly devoid of carinae. On the basis of its quantitative data, it resembles some more or less carinate taxa of *Scruttonia* such as *S. balconi* Coen-Aubert, 1980 and *S. boloniensis* (Milne-Edwards & Haime, 1851) as revised by Rohart (1982), which come respectively from the Middle Frasnian of the Ardenne in Belgium and the Boulonnais in France. By the same features, the new species is related to *Radiastraea zinzilbania* (Erina in Kim et al., 1978, pl. 33, fig. 1) from the Emsian of Uzbekistan and to *R. norrisi* Pedder, 1980 from the Late Eifelian of Northwestern Canada. Other taxa of *Radiastraea* Stumm,1937, also from the Late Eifelian of Northwestern Canada, such as *R. verrili* (Meek,1867) and *R. tapetiformis* (Crickmay, 1960) are similarly characterized by septa carinate and dilated in the dissepimentarium. According to McLean (2010, p.79), they are not typical of *Radiastraea*. Indeed, its type species *R. arachne* Stumm, 1937 from the Emsian of Nevada in USA has very thin septa throughout their length with rare and weak carinae; its holotype has been well reillustrated by Oliver (1976, pl. 66, figs. 1-4) and Hill (1981, fig. 175, 2). It was to *R. arachne* that May (2006) referred the colony of the Leon Province attributed to *Phillipsastrea torreana* by Almela & Revilla (1950). As discussed by Soto (2007) and Wrzolek (2007), this specimen is certainly distinct from *R. arachne*; in my opinion, it is similar to *Scruttonia sotoi*. Its age has been considered as Emsian to Lower Eifelian by May (2006) whereas Soto (2007) attributed such phillipsastreids to the Givetian Portilla Formation, which seems most probable for me.

Qualitatively, it is easy to distinguish *S. sotoi* from *Phillipsastrea weyeri* which is abundant in the Middle and Upper Givetian of the Tafilalt and the Ma'der in Morocco. Indeed, the latter species is characterized by carinate and spindle-shaped dilated septa as well as by the occurrence of some horseshoe dissepiments.

Distribution. The material of *Scruttonia sotoi* comes from the Middle to Upper Givetian Candas Formation of Asturias in Spain. The new species occurs also in the same country, probably in the Givetian Portilla Formation of the Leon Province.

4. Palaeobiogeographic conclusions

The mainly Middle to Upper Givetian fauna of *Phillipsastrea* investigated herein is situated at the northwestern margin of Gondwana, according among others to Coen-Aubert & Plusquellec (2007, fig. 3). As a whole, this assemblage is much diversified, but its specific variation is not so wide in each particular area (Fig. 3). The most important collection comes from the Tafilalt and the Ma'der, in the southern part of Morocco and has been gathered by Coen-Aubert (2002 and 2005). *P. weyeri* and *P. tafilaltensis* are abundant in these two areas; they are associated with *P. hollardi* in the Ma'der and with rare specimens of *P. givetica* in the Tafilalt. *P. hollardi* and *P. givetica* occur also in the Mauritanian Adrar, together with *P.* cf. *hollardi*. From the Zemmour in Mauritania have been identified *P. torreana*, *P.kergarvanensis* and *P. sobolewi*. The Spanish material of the Asturias and Leon Provinces in the Cantabrian Mountains comprises *P. givetica*, *P. torreana*, *Scruttonia sotoi* and also *P. weyeri*. Indeed, I have

	MAURITANIAN ADRAR	ZEMMOUR	ASTURIAS AND LEON PROVINCES	MA'DER	TAFILALT
Phillipsastrea hollardi	x			x	
Phillipsastrea cf. *hollardi*	x				
Phillipsastrea givetica	x		x		x
Phillipsastrea torreana		x	x		
Phillipsastrea kergarvanensis		x			
Phillipsastrea sobolewi		x			
Phillipsastrea weyeri			x	x	x
Phillipsastrea tafilaltensis				x	x
Scruttonia sotoi			x		
Acanthophyllum trompetti	x				
Acantophyllum simplex				x	x

Figure 3. Distribution of the Givetian phillipsastreids and ptenophyllids identified in the different areas from Mauritania, Spain and Morocco investigated in this paper.

observed one colony of this species collected by Y. Plusquellec in the Candas Formation at Peran (thin sections B37679 and B37680 stored at Brest). And I have seen another one in the Milne-Edwards collection stored at Paris (thin sections EH2); this specimen was labelled as *Acervularia roemeri* De Verneuil & Haime, 1850 and comes from Puerto de las Volcas, close to Pola de Gordon in the Leon Province.

Besides the affinities between the taxa of *Phillipsastrea* occurring in the different areas considered by this paper, *P. kergarvanensis* is known in the Armorican Massif, France also belonging to North Gondwana. On the contrary, *P. sobolewi* has been introduced in the Holy Cross Mountains, Poland and *P. givetica* in the Gornyi Altai situated in the southeastern part of Western Siberia, Russia. As for the ptenophyllids, *Acanthophyllum trompetti* defined in the Mauritanian Adrar shows some similarities with Upper Givetian coralla from the Northern Sauerland in Germany and the Western Yunnan in China as well as with *A. simplex*. This species is widespread in the Middle and Upper Givetian of the Tafilalt and the Ma'der and it is also present in the Givetian of several countries from Western Europe such as Belgium, Germany, France and Great Britain.

In conclusion, the Givetian fauna of phillipsastreids and ptenophyllids studied in Mauritania is basically North Gondwanan. But it is also related to that of Western and Eastern Europe and even to that of Western Siberia and Southern China. The same situation was observed by Coen-Aubert (2005) for more various Middle and Upper Givetian rugose corals of the Tafilalt and the Ma'der in Morocco.

From a taxonomic point of view, the specific name *Phillipsastrea givetica* is now used for the Spanish colonies which were previously assigned to *P. pradoana* and *P.* cf. *pradoana*. The sample from the Leon Province determined by May (2006) as *Radiastraea arachne* is included in the synonymy of the new species *Scruttonia sotoi*. In fact, the genus *Scruttonia* is more characteristic of the Frasnian. However, specimens from the Upper Givetian of the Sauerland in Germany have been ascribed by Schröder (2005, pp. 82-86) to *S.* cf. *sanctacrucensis* (Rozkowska, 1953) and *Scruttonia* sp.

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Through the kindness of Dominique Laduron and Francis Tourneur, the rugose coral collections of Roland Trompette from the Mauritanian Adrar, Jean Sougy from the Zemmour and Hsienho Tsien from Asturias, which were previously stored in the Institute of Geology at Louvain-la-Neuve, have been moved to the Collection of Palaeontology from the Institut royal des Sciences naturelles de Belgique at Brussels. Yves Plusquellec, Rudi Birenheide and Pierre Semenoff-Tian-Chansky lent me a few colonies from respectively the collections of the University of Bretagne Occidentale at Brest, the Forschungsinstitut at Frankfurt am Main and the Muséum national d'Histoire naturelle at Paris. Jean Sougy gave me during the years 1991 and 1992 stratigraphic information about several samples from the Zemmour. Esperanza Fernandez-Martinez (Leon) and Susana Garcia-Lopez (Oviedo) provided me very interesting precision about the localities of Asturias. This paper contributes to IGCP 596 on Mid-Paleozoic climate and biodiversity. Denise Brice and Ross McLean kindly reviewed the manuscript. Some recent thin sections were made by the Laboratory of Eddy Poty (Liège) whereas the photographs were prepared by Wilfried Miseur; Adriano Vandersypen helped me for one figure. I am most grateful to all these persons.

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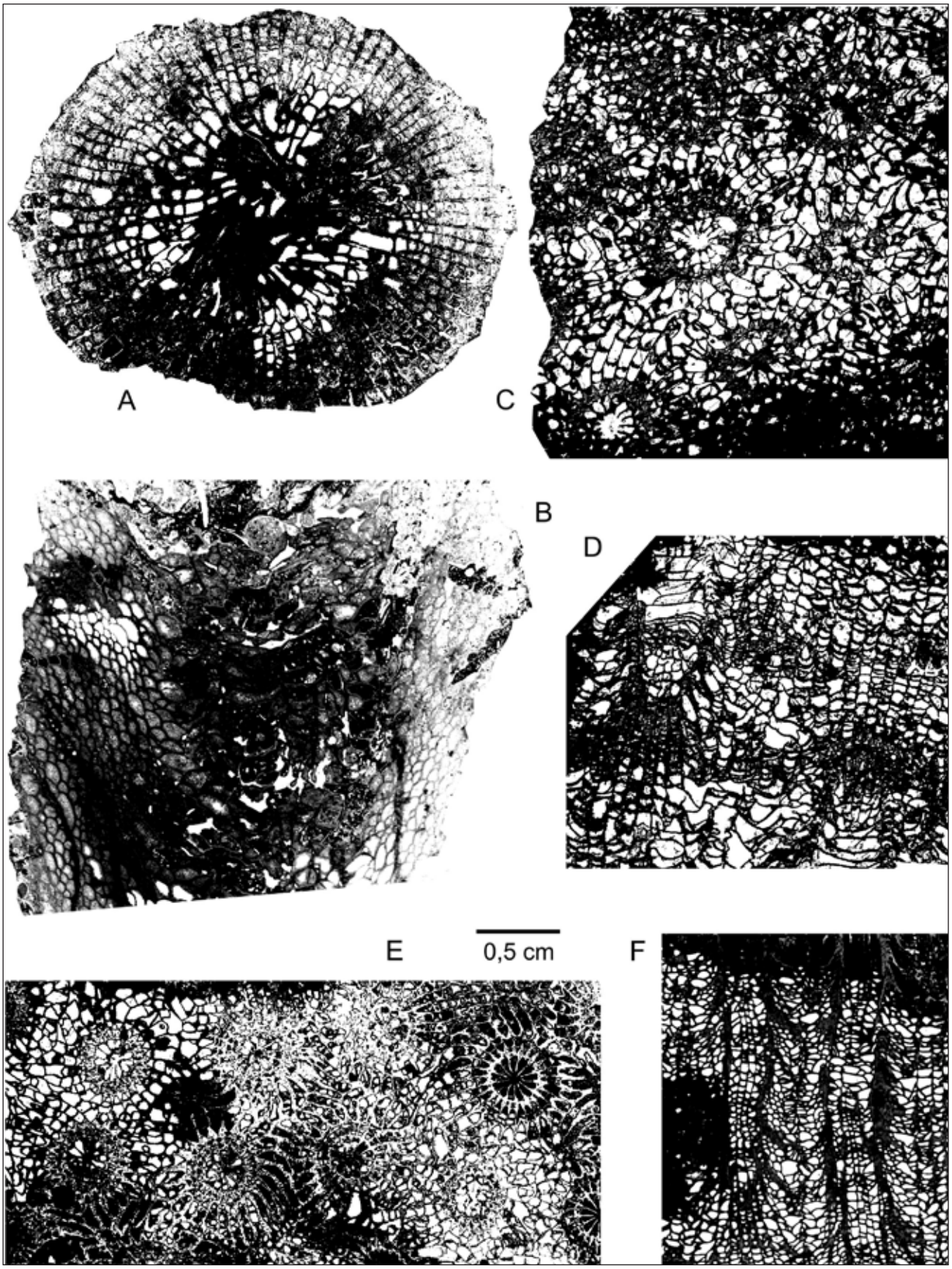

Plate 1. A-B: *Acanthophyllum trompetti* n. sp. Holotype, IRScNB a12835, Mauritanian Adrar, Mermedha, southern section TA1022 I; transverse and longitudinal sections. C-D: *Phillipsastrea* cf. *hollardi* Coen-Aubert, 2002. IRScNB a12840, Mauritanian Adrar, Mermedha, eastern section TA970 MAU2; transverse and longitudinal sections. E-F: *Phillipsastrea hollardi* Coen-Aubert, 2002. IRScNB a12839, Mauritanian Adrar, Mermedha, eastern section TA970 I; transverse and longitudinal sections. Magnification x 3.

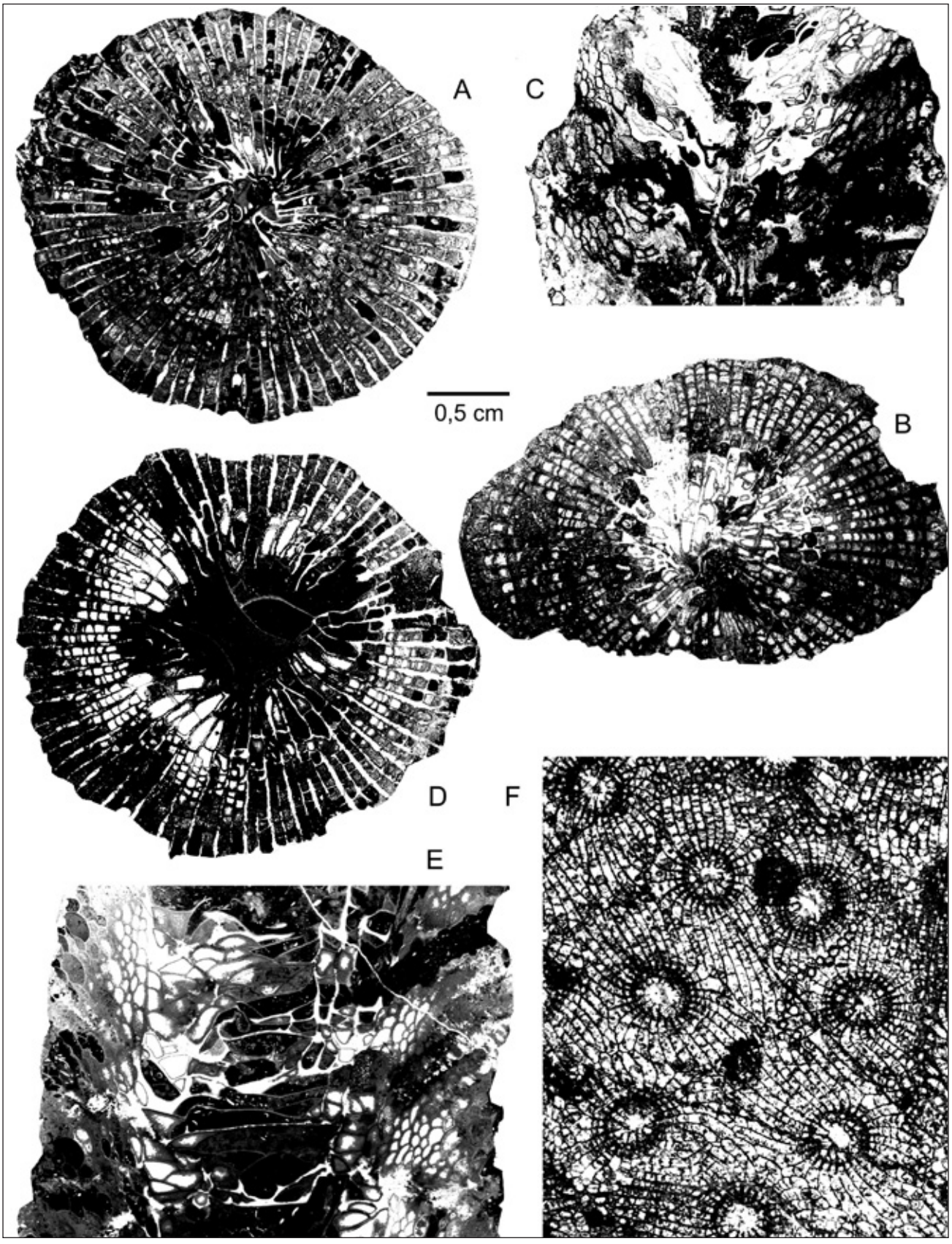

Plate 2. A-E: *Acanthophyllum trompetti* n. sp. A: Paratype, IRScNB a12836, Mauritanian Adrar, Mermedha, western section TA995 MAU6; transverse section. B-C: Paratype, IRScNB a12837, Mauritanian Adrar, Tichillit el Gad, southern section TA1057 III; transverse and longitudinal sections. D-E: Paratype, IRScNB a12838, Mauritanian Adrar, Mermedha, western section TA995 I; transverse and longitudinal sections. F: *Phillipsastrea givetica* (Ivania in Zheltonogova & Ivania, 1960). IRScNB a12841, Asturias, Perlora 404 (l. 12081); transverse and longitudinal sections. Magnification x 3.

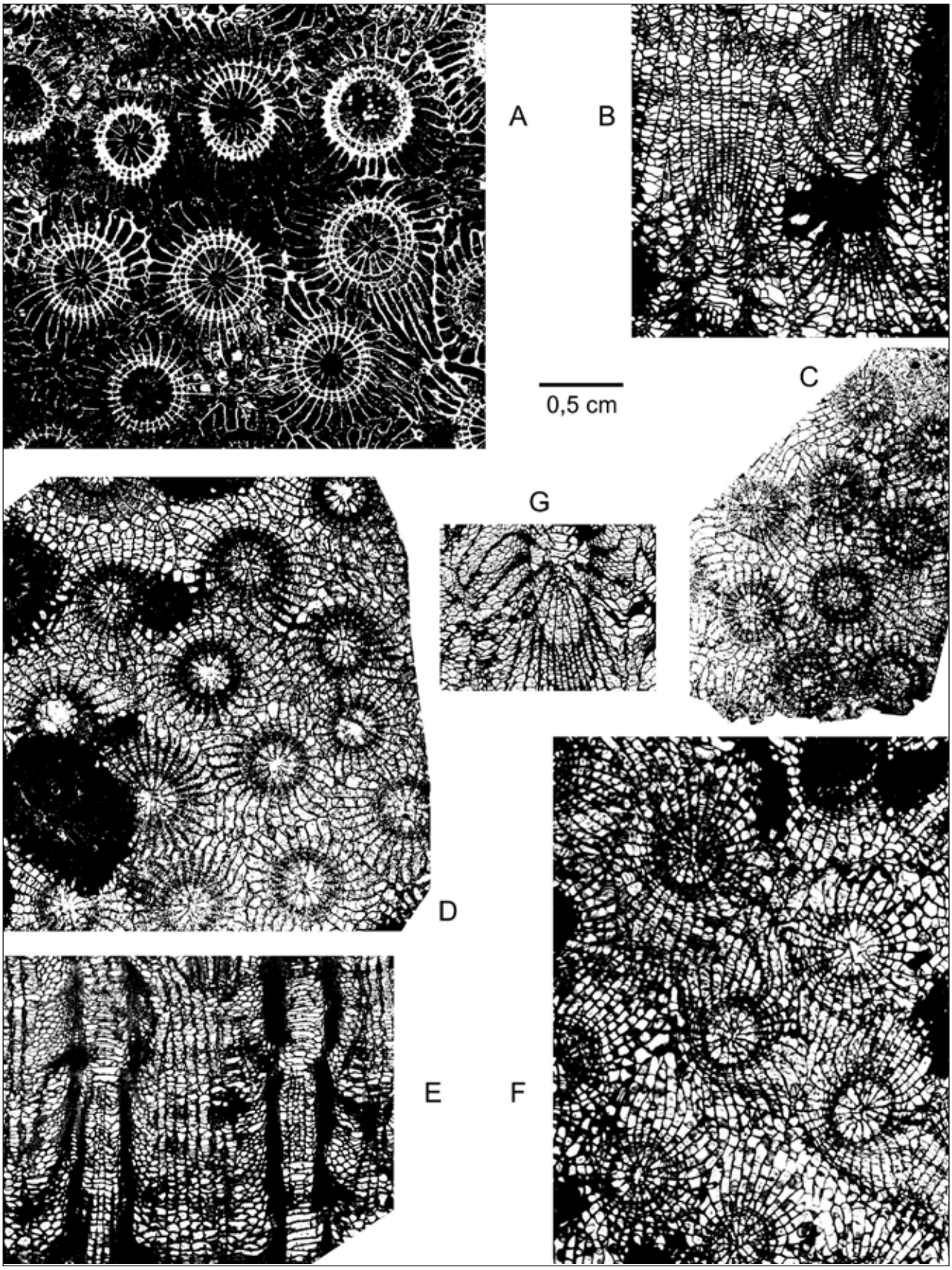

Plate 3. A-B: *Phillipsastrea givetica* (Ivania in Zheltonogova & Ivania, 1960). IRScNB a12842, Mauritanian Adrar, Mermedha, eastern section TA970 MAU1; transverse and longitudinal sections. C-E: *Phillipsastrea torreana* (Milne-Edwards & Haime, 1851). C: IRScNB a12843, Zemmour 2441 III (l. 7191); transverse section. D-E: IRScNB a12844, Zemmour 2392 I (l. 7165); transverse and longitudinal sections. F-G: *Phillipsastrea kergarvanensis* Coen-Aubert & Plusquellec, 2007. IRScNB a12845, Zemmour 2396 I (l. 7167); transverse and longitudinal sections. Magnification x 3.

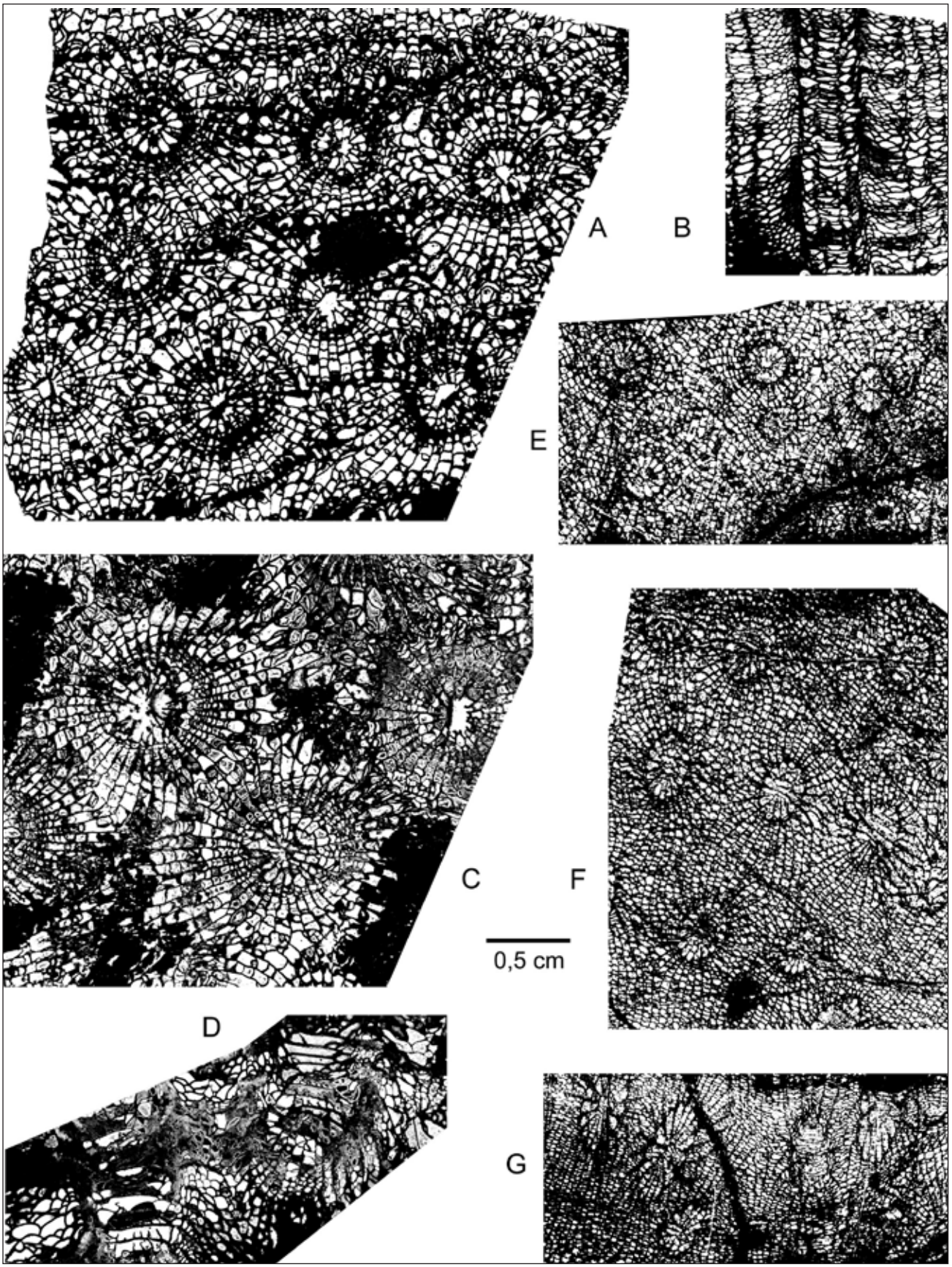

Plate 4. A-B: *Phillipsastrea kergarvanensis* Coen-Aubert & Plusquellec, 2007. IRScNB a12846, Zemmour 2381C MAU3; transverse and longitudinal sections. C-D: *Phillipsastrea sobolewi* (Rozkowska, 1956). IRScNB a12848, Zemmour 2389 XI (l. 7164); transverse and longitudinal sections. E-G: *Scruttonia sotoi* n. sp. E: Paratype, IRScNB a12851, Asturias, Carranques T11 I (l. 12150); transverse section. F-G: Paratype, IRScNB a12852, Asturias, Carranques T11 II (l. 12150); transverse and longitudinal sections. Magnification x 3.

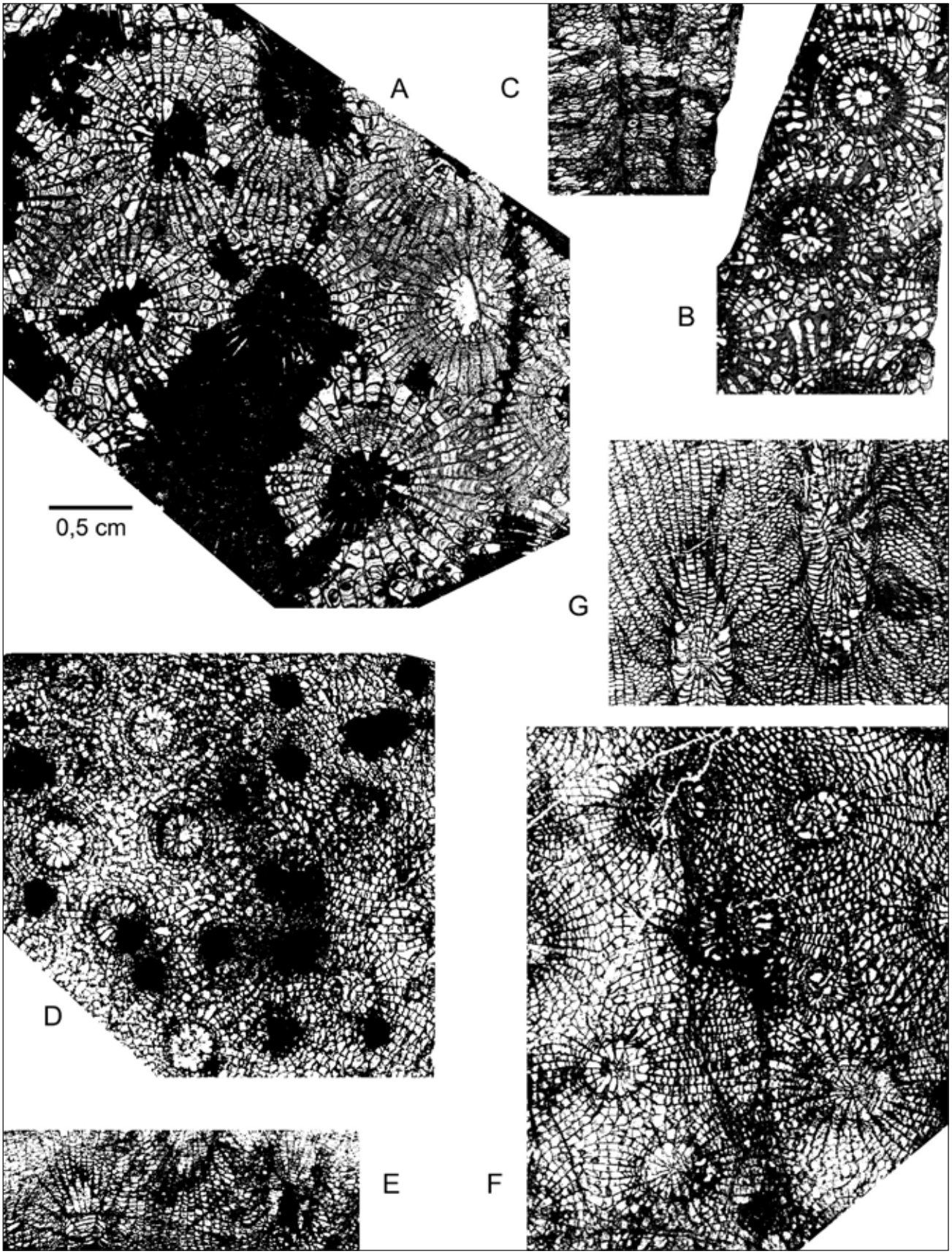

Plate 5. A: *Phillipsastrea sobolewi* (Rozkowska, 1956). IRScNB a12849. Zemmour 2427 II (l. 7172); transverse section. B-C: *Phillipsastrea kergarvanensis* Coen-Aubert & Plusquellec, 2007. IRScNB a12847, Zemmour 2381C l. 9142; transverse and longitudinal sections. D-G: *Scruttonia sotoi* n. sp. D-E: Holotype, IRScNB a12850, Asturias, Candas T6 (l. 12140); transverse and longitudinal sections. F-G: Paratype, IRScNB a12853, Asturias, Perlora 33a II (l. 10279); transverse and longitudinal sections. Magnification x 3.