

Description of a few rugose corals from the Givetian Terres d'Haus Formation in Belgium

by Marie COEN-AUBERT

COEN-AUBERT, M., 2003. – Description of a few rugose corals from the Givetian Terres d'Haus Formation in Belgium. *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre*, 73: 11-27, 3 pls., 7 figs., Bruxelles-Brussel, March 31, 2003. – ISSN 0374-6291.

Abstract

Disphyllum mcleani n. sp., *Tennophyllum wellinense* n. sp. and *Pseudozaphrentis zamkowae* (WRZOLEK, 1993) are described in detail and come from the Givetian Terres d'Haus Formation, on the south side of the Dinant Synclinorium. This subdivision belongs to the top of the *Polygnathus hemiansatus* Zone and to the Lower *P. varcus* Zone. *Tennophyllum wellinense* is present at the base of the lithostratigraphic unit together with *Argutastrea quadrigemina* (GOLDFUSS, 1826) refigured herein. *Disphyllum mcleani* and *Pseudozaphrentis zamkowae* have only been observed very sparsely, respectively in the middle and upper parts of the Terres d'Haus Formation. At its top occur already a few species characteristic of the lower part of the overlying Mont d'Haus Formation. The area located between Beauraing and Resteigne to the east of Givet is compared to that more eastern of Hotton where the Terres d'Haus Formation is thicker and richer in coral beds.

Key-words: Rugose corals, Givetian, Taxonomy, Stratigraphy, Belgium.

Résumé

Disphyllum mcleani n. sp., *Tennophyllum wellinense* n. sp. et *Pseudozaphrentis zamkowae* (WRZOLEK, 1993) sont décrits en détail et proviennent de la Formation givetienne des Terres d'Haus, au bord sud du Synclinorium de Dinant. Celle-ci appartient au sommet de la Zone à *Polygnathus hemiansatus* et à la Zone à *P. varcus* inférieure. *Tennophyllum wellinense* est présent à la base de l'unité lithostratigraphique où il est associé à *Argutastrea quadrigemina* (GOLDFUSS, 1826) refiguré dans ce travail. *Disphyllum mcleani* et *Pseudozaphrentis zamkowae* n'ont été observés que très sporadiquement, respectivement dans les parties moyenne et supérieure de la Formation des Terres d'Haus. Au sommet de celle-ci apparaissent déjà quelques espèces caractéristiques de la partie inférieure de la Formation sus-jacente du Mont d'Haus. La région située entre Beauraing et Resteigne à l'est de Givet est comparée à celle plus orientale de Hotton où la Formation des Terres d'Haus est plus épaisse et plus riche en niveaux coralliens.

Mots-clefs: Rugueux, Givetien, Taxinomie, Stratigraphie, Belgique.

Introduction

Normally, the Givetian Terres d'Haus Formation, as it was defined on the south side of the Dinant Synclinorium

by BULTYNCK *et al.* (1991, p. 53), is rather poor in rugose corals which are restricted to a few levels. This is especially the case in the area between Beauraing and Resteigne located to the east of Givet (Fig. 1) where several sections have been sampled and studied by the author. However, some specimens come also from Hotton situated in the southeastern part of the Dinant Synclinorium. At this locality, the different lithostratigraphic units of the Middle Devonian are much thicker than between Beauraing and Resteigne and the coral layers are more numerous within the Terres d'Haus Formation.

According to BULTYNCK *et al.* (2000) and BULTYNCK & DEJONGHE (2002), the lower part of the Terres d'Haus Formation belongs probably to the top of the *Polygnathus hemiansatus* conodont Zone whereas the rest of the lithostratigraphic unit lies in the *P. timorensis* Zone introduced by BULTYNCK (1987) and corresponding to the lower part of the Lower *P. varcus* Zone. It must also be mentioned that the Givetian on the south side of the Dinant Synclinorium is represented, in ascending order, by the upper part of the Hanonet Formation, the Trois-Fontaines, Terres d'Haus, Mont d'Haus and Fromellenes Formations.

Three species occurring in the Terres d'Haus Formation are described herein: *Disphyllum mcleani* n. sp., *Tennophyllum wellinense* n. sp. and *Pseudozaphrentis zamkowae* (WRZOLEK, 1993). As for *Argutastrea quadrigemina* (GOLDFUSS, 1826) which is very common in the lower part of the lithostratigraphic unit, it was revised by COEN-AUBERT (1980) and COEN-AUBERT & LÜTTE (1990) and is illustrated herein. Moreover, several taxa already present at the top of the Terres d'Haus Formation, but more abundant in the lower part of the Mont d'Haus Formation, have been investigated by COEN-AUBERT (1999, 2000 and 2002).

The main part of the material was collected by the author *in situ*, during geological surveys made bed by bed. This sampling is supplemented by a few old thin sections referred in this paper to the "Old collection from the Institut royal des Sciences naturelles de Belgique". The types of the new species and the figured specimens are also stored in the collections of the Institut royal des Sciences naturelles de Belgique (IRScNB).

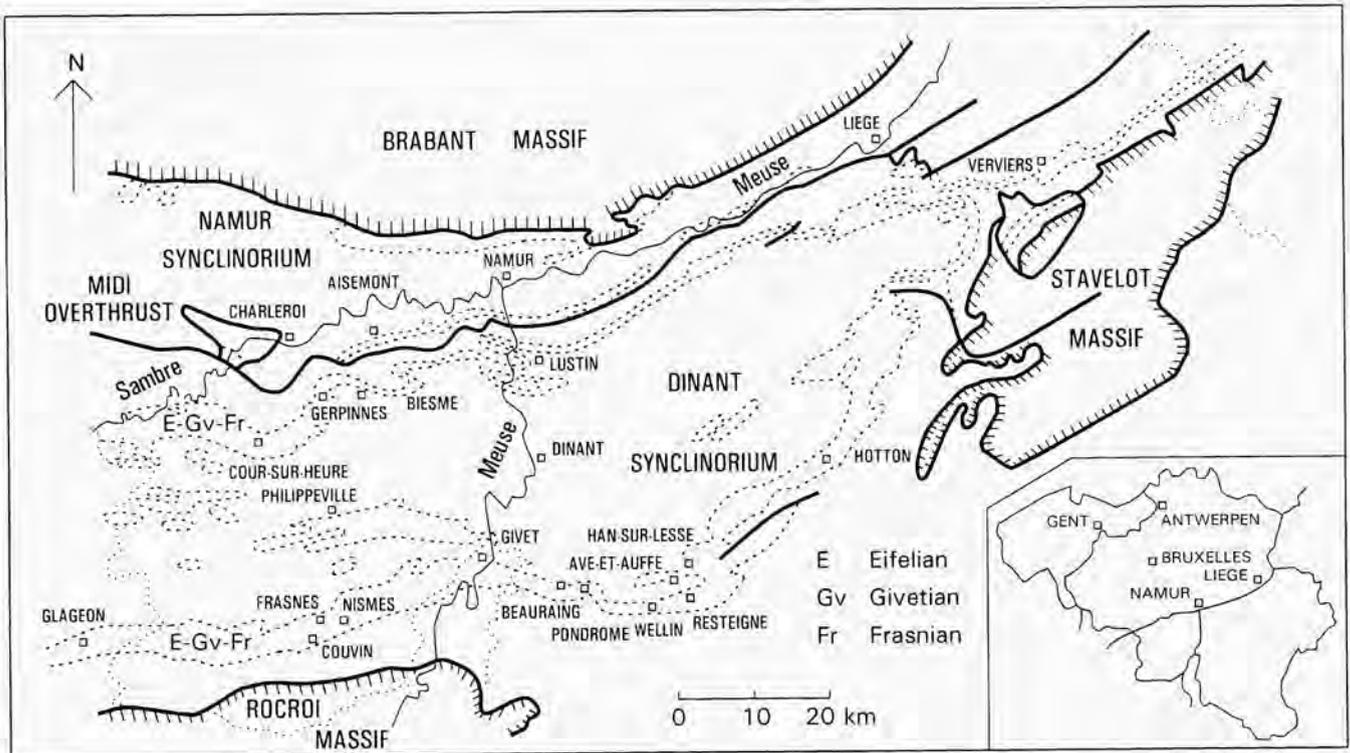


Fig. 1 — Geological setting and locality map in the southern part of Belgium.

Description of the outcrops

RESTEIGNE QUARRY (Wellin MC-1974-95; Fig. 2)

The most continuous and complete section investigated in the Terres d'Haus Formation is that of the disused quarry of Resteigne. It has already been described by COEN-AUBERT *et al.* (1986, p. 249) and BIRENHEIDE *et al.* (1991, p. 10) and the rugose coral fauna at the transition to the overlying Mont d'Haus Formation has been studied by COEN-AUBERT (1999, 2000 and 2002).

Below the Terres d'Haus Formation, the upper part of the Trois-Fontaines Formation is mainly represented by lagoonal limestones with several beds of laminites; however, one colony of *Argutastrea quadrigemina* has been found in this restricted environment. The Terres d'Haus Formation is 75 m thick and is mostly characterized by well-bedded dark and bioclastic limestones which may also be argillaceous. The lithostratigraphic unit starts with a coralliferous biostrome of more or less 3 m thickness that has been described in detail by PREAT *et al.* (1984, p. 238). It contains abundant specimens of *A. quadrigemina*, *Pachyfavosites polymorphus*, *Thamnopora cervicornis*, *Hillaepora spicata* as well as some solitary coralla of *Temnophyllum wellinense*. A bed rich in *Disphyllum mcleani* occurs 22.5 m above the base of the Terres d'Haus Formation. This species has been assigned to *D. geinitzi* LANG & SMITH, 1935 by BIRENHEIDE *et al.* (1991). Between 15 and 18 m higher, a few colonies of *Argutastrea quadrigemina* are associated with diverse tabulate corals. Then, corals are rather rare in the following 20 m except near the top of this sequence where several coralla of *Pseudozaphrentis zamkowae* have been

collected. The upper 14 m of the Terres d'Haus Formation are represented by coarsely crinoidal limestones which serve as basement for the reefal limestones from the lower part of the Mont d'Haus Formation. *Spinophyllum spongiosum* (SCHLÜTER, 1889) and *Acanthophyllum simplex* (WALTHER, 1929) are already present at the top of the Terres d'Haus Formation.

LES LIMITES QUARRIES AT AVE-AUFFE (Wellin MC-1983-12 and MC-1988-6; Fig. 2)

By looking at the different sections exposed in the active Les Limites quarries at Ave-et-Auffe, it is also possible to have a complete succession in the Terres d'Haus Formation that is 61 m thick at this locality. The lithostratigraphic unit was briefly described by BIRENHEIDE *et al.* (1991, pp. 11-13) and the two outcrops were located on a map by COEN-AUBERT (1999, fig. 2). In the southern quarry (Wellin MC-1983-14) also partly studied by COEN-AUBERT (1998, p. 9), one can see the top of the Hanonet Formation, the Trois-Fontaines Formation and the lower part of the Terres d'Haus Formation whereas the northern quarry (Wellin MC-1988-6) investigated by COEN-AUBERT (1999, 2000 and 2002) is excavated in the upper part of the Terres d'Haus Formation and in the Mont d'Haus Formation. However, this situation has slightly changed since my detailed geological surveys made ten years ago. The top of the Trois-Fontaines Formation is represented by laminites, lagoonal facies and bioclastic limestones where *Argutastrea quadrigemina* is present. As mentioned by BIRENHEIDE *et al.* (1991), it is possible to survey two sections in the lower part of the Terres d'Haus Formation: one at the entry to

the southern quarry and the other one at its working face. In this latter exposure, the Terres d'Haus Formation starts very normally with a biostrome rich in *A. quadrigemina* that reaches a thickness of 4.5 m. The same biostrome crops out at the entry to the quarry where a bedding plane shows at its base and over a great distance a few scattered corals and several patch reefs. These patch reefs consist mostly of rather big colonies of *A. quadrigemina*; in some places however, there are numerous branches of *Thamnopora cervicornis*.

The top of the bed with *Disphyllum mcleani* is observed 25 m above the base of the Terres d'Haus Formation. The following

24 m are represented by dark, well-bedded limestones which are sometimes nodular or argillaceous and which contain locally fragments of crinoids and brachiopods, gastropods and rare corals; indeed, only one corallum of *Pseudozaphrentis zamkowae* has been collected in this sequence. As in Resteigne, the Terres d'Haus Formation ends with nearly 12 m of coarsely crinoidal limestones with a few stromatoporoids and corals. At the top of the lithostratigraphic unit occur *Spinophyllum spongiosum*, *Acanthophyllum simplex* and *Sociophyllum wedekindi* COEN-AUBERT, 1999 that are more characteristic of the lower part of the Mont d'Haus Formation.

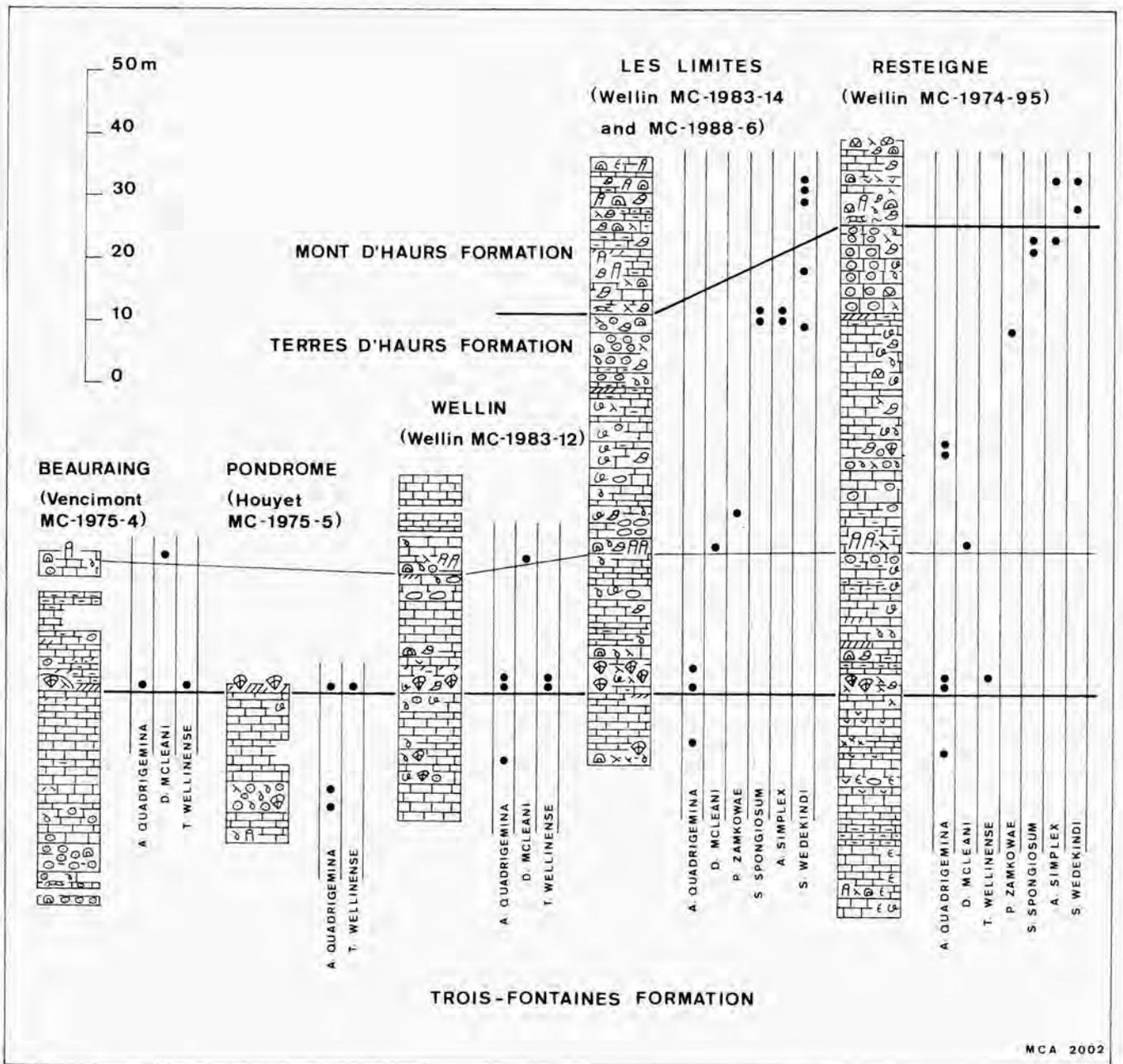


Fig. 2 — Comparative logs of the Terres d'Haus Formation at Beauraing, Pondrôme, Wellin, Les Limites at Ave-et-Auffe and Resteigne with the distribution of the rugose corals. (For explanation of conventional signs, see Fig. 3).

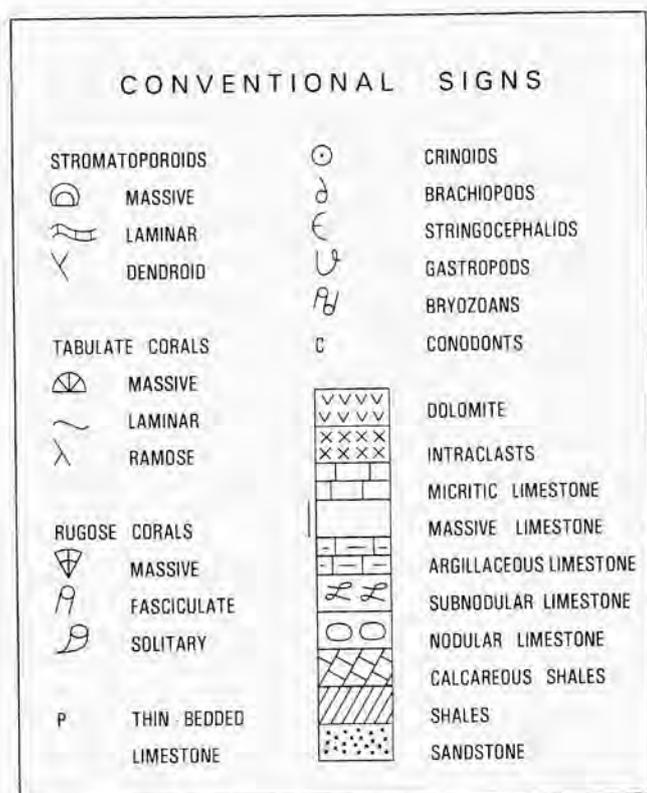


Fig. 3 — Explanation of conventional signs used in Figs. 2 and 7.

FOND DES VAUX WEST QUARRY AT WELLIN
(Wellin MC-1983-12; Fig. 2)

To the north of the village of Wellin, there are two active quarries named Fond des Vaux East (Wellin MC-1983-9) and Fond des Vaux West (Wellin MC-1983-12) where is exposed a complete succession from the top of the Hanonet Formation to the base of the Terres d'HOURS Formation. They have been investigated among others by COEN-AUBERT (1990 and 1998). Only the Fond des Vaux West quarry is described herein as it shows a greater thickness of the Terres d'HOURS Formation with interesting rugose corals.

Once more, the upper part of the Trois-Fontaines Formation is characterized by lagoonal limestones with laminites and some colonies of *Argutastrea quadrigemina*. At the base of the Terres d'HOURS Formation, the coralliferous biostrome is nearly 3 m thick and contains numerous specimens of the same species and *Temnophyllum wellinense*. Three m higher, there is a bed with some stringocephalids, massive stromatoporoids, rugose and tabulate corals which occurs at the same position in the Resteigne and Les Limites quarries. Between 19 m and 22 m above the base of the Terres d'HOURS Formation, a level of bioclastic limestone contains a few massive stromatoporoids, alveolitids, thamnoporids, massive and solitary rugose corals as well as some colonies of *Disphyllum mcleani* at the top. Above this level crop out 12.5 m of well-bedded and dark limestones that are fine or bioclastic.

OLD QUARRY AT BEAURAING
(Vencimont MC-1975-4; Figs. 2 and 4)

This small excavation is open in the wood, above the road from

Beauraing to Winenne and is lying to the south of Beauraing quarry (Beauraing MC-1975-3) where COEN-AUBERT (1999, 2000 and 2002) described the Mont d'HOURS Formation. This old quarry with nearly vertical layers has been investigated by PEL (1975, p. 84) and also by PREAT and TOURNEUR during the eighties.

At the base of the quarry, there are about 10 m of crinoidal limestone with a few massive and laminar stromatoporoids, thamnoporids, massive rugose corals, fragments of solitary rugose corals and brachiopods. This facies recalls the coarsely crinoidal and locally reefal limestones observed, among others, by COEN-AUBERT (1990 and 1998) at the base of the Trois-Fontaines Formation between Wellin and Resteigne. In the old quarry of Beauraing, the rest of the Trois-Fontaines Formation is represented by 24.5 m of fine and well-bedded limestones; some brachiopods and crinoids are present near the base of this sequence and some laminites near its top.

Then, the Terres d'HOURS Formation starts with about 0.5 m of shales and argillaceous limestones containing a few brachiopods, crinoids, tabulate and rugose corals. However, at the base and at the top of this level, there are two bedding planes showing several patch reefs which are mostly made up of colonies of *Argutastrea quadrigemina*. In one big patch reef, the core consists of massive rugose corals and is enclosed by numerous branches of *Thamnopora* lying more or less horizontally. Some coralla of *Temnophyllum wellinense* and *Pachyfavosites polymorphus* occur also at this level. Above the patch reefs are exposed 22 m of argillaceous and bioclastic limestones locally discontinuous. At the top of the quarry appear a few massive stromatoporoids, favositids, alveolitids and colonies of *Disphyllum mcleani*.

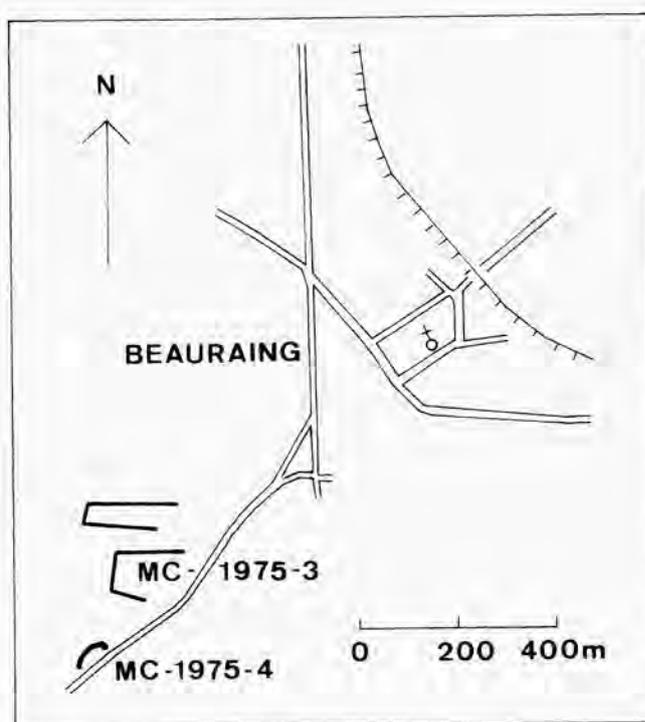


Fig. 4 — Location of the old quarry Vencimont MC-1975-4 at Beauraing.

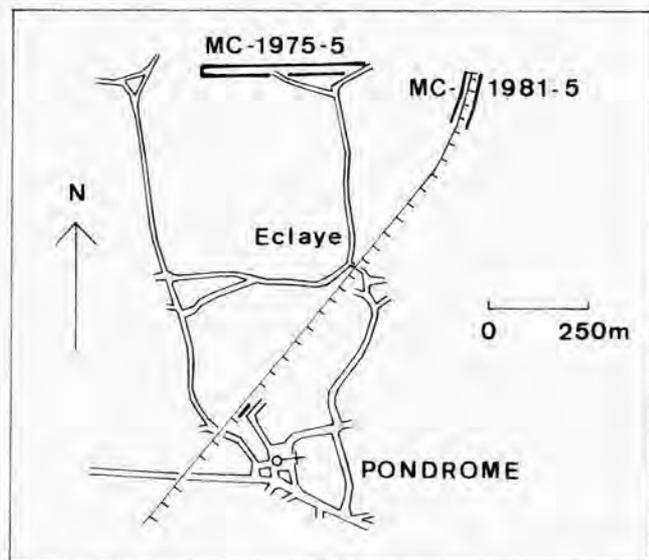


Fig. 5 — Location of Eclaye quarry at Pondrôme.

ECLAYE QUARRY AT PONDROME
(Houyet MC-1975-5; Figs. 2 and 5)

This old quarry is excavated over a distance of 400 m, along the strike of the layers which are vertical to slightly overturned. The outcrop is situated very close to the railway section of Pondrôme (Houyet MC-1981-5) where the coarsely crinoidal and reefal limestones from the base of the Trois-Fontaines Formation have been investigated at its northern end by COEN-AUBERT (1997 and 1998). As for Eclaye quarry, it was described by COEN-AUBERT *et al.* (1986, p. 252).

In the southern part of the excavation, the upper part of the Trois-Fontaines Formation consists of:

- 4.85 m: fine and dark limestone with a few brachiopods, *Pachyfavosites* and fasciculate rugose corals present near the base.
- 4.85 m: crinoidal limestone often rich in atrypids; occurrence of two coralliferous beds with *Argutastrea quadrigemina*, *Pachyfavosites* and *Thamnopora*.
- 14.5 m: well-bedded and fine limestone, locally bioclastic, laminated or showing birdseyes.

The base of the Terres d'Haus Formation is represented by shales and argillaceous or bioclastic limestones with again two levels of patch reefs composed of colonies of *Argutastrea quadrigemina*, *Pachyfavosites polymorphus* and *Thamnopora cervicornis* accompanied by rare coralla of *Temnophyllum wellinense*.

HAMPTEAU QUARRY AT HOTTON (Hotton MC-33; Figs. 6 and 7)

The disused quarry of Hampteau is located 1.5 km to the south-east of Hotton, along the road to La Roche. It shows a complete succession from the upper part of the Hanonet Formation to the base of the Mont d'Haus Formation. This outcrop has been described in detail by PEL (1965). Until now, the fauna of this large and interesting excavation has only been partly investigated.

The transition between the Trois-Fontaines and Terres d'Haus Formations is exposed just to the north of a strongly and complicated folded zone. So the top of the Trois-Fontaines Formation is represented by:

- 4 m: fine and bedded limestone:

- 8 m: bioclastic limestone containing crinoids, brachiopods including stringocephalids, massive stromatoporoids, thamnoporids, massive, fasciculate and solitary rugose corals with among them *Argutastrea quadrigemina*. This level is disrupted by several small faults.
- 7.5 m: fine limestone; occurrence of some dendroid stromatoporoids at the base and of some thamnoporids at the top where numerous brachiopods form a coquina bed.
- 8.7 m: fine and bedded limestone with laminites and a few fragments of solitary rugose corals in the middle.

It is possible to study the Terres d'Haus Formation along the northern wall of the quarry and also near its north entry where there are several small sections within the lithostratigraphic unit. However, prominent bedding planes allow the correlation of these different geological sections.

At the base of the Terres d'Haus Formation, the facies changes sharply with 2.5 m of argillaceous limestone very rich in corals in its upper part: *A. quadrigemina*, *Favosites*, *Pachyfavosites*, *Thamnopora* and *Hillaepora* accompanied by some brachiopods and fragmented solitary rugose corals. For the rest, the general look of the Terres d'Haus Formation is very different at Hotton from that known in the area between Beauraing and Resteigne. Indeed, the lower 79 m of the lithostratigraphic unit consist of fine or bioclastic limestones, locally argillaceous or interbedded with thin layers of shales and characterized by:

- several beds of laminites;
- several coquina beds due to numerous brachiopods including stringocephalids and sometimes atrypids;
- several beds with abundant and various corals associated locally with a few massive stromatoporoids. In addition to the tabulate corals observed at the base of the Terres d'Haus Formation, there are also scolioporids, massive, platy and ramose alveolitids. Massive rugose corals are mostly represented by *Argutastrea quadrigemina* whereas some colonies of *Disphyllum meleani* have been collected between 28 m and 40 m above the Trois-Fontaines Formation. Only one corallum of *Pseudozaphrentis zamkowae* has been found about 14 m below the top of this sequence of 79 m.

In the succeeding 27.5 m, the section is more or less discontinuous and the limestone becomes argillaceous or sometimes nodular; brachiopods are often present and are accompanied by some crinoids and rare solitary rugose corals.

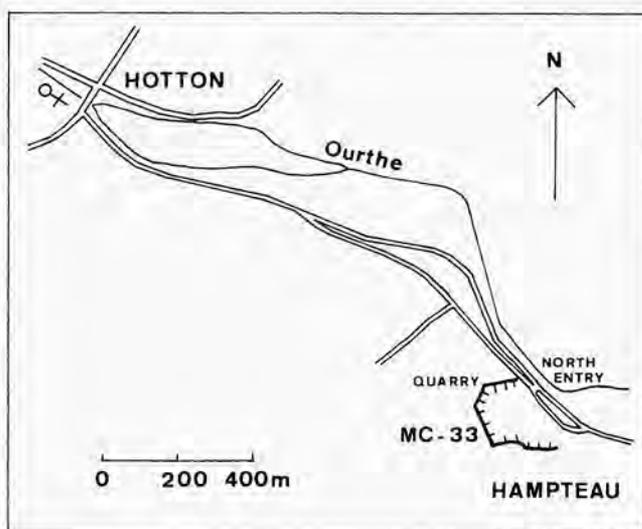


Fig. 6 — Location of Hampteau quarry at Hotton.

After a lack of outcrop that is nearly 4 m thick, the Mont d'Hours Formation starts in the northeast corner of the quarry, with 1.2 m of argillaceous and bioclastic limestone which contains rather abundant corals: heliolitids, ramose alveolitids, colonies of *Thamnophyllum*, solitary coralla of *Cystiphylloides* and *Spinophyllum blacourti* (ROHART, 1988). Then, the Mont d'Hours Formation is exposed along the road to Hotton.

Facies variations and stratigraphic distribution of the rugose corals

In the area between Beauraing and Resteigne (Fig. 2), it is easy to establish correlations between the different sections investigated in the Terres d'Hours Formation. At the base of the lithostratigraphic unit, there are everywhere accumulations of corals forming a thin biostrome or small patch reefs. The fauna of this level is highly characteristic with abundant specimens of *Argutastrea quadrigemina*, *Pachyfavosites polymorphus*, *Thamnopora cervicornis* and *Hillaepora spicata* as it was already mentioned by BULTYNCK *et al.* (1991, p. 54). There are also some solitary coralla of *Temnophyllum wellinense* which are more common at Wellin. *Argutastrea quadrigemina* is already present in the upper part of the underlying Trois-Fontaines Formation. Between 22 m and 25 m above the base of the Terres d'Hours Formation occurs a bed rich in *Disphyllum mcleani* at Beauraing, Wellin, Les Limites quarries and Resteigne. In the latter locality, two other layers with colonies of *Argutastrea quadrigemina* have been observed about 15 m higher. Also at Resteigne, several solitary coralla of *Pseudozaphrentis zamkowae* have been collected near the top of 61 m of fine or more frequently bioclastic limestones which constitute the main part of the Terres d'Hours Formation. Then, the lithostratigraphic unit ends in the two complete sections of Resteigne and Les Limites quarries by coarsely crinoidal limestones containing a few reef building organisms at their top. Among them, the rugose corals are represented by *Sociophyllum wedekindi*, *Acanthophyllum simplex* and *Spinophyllum spongiosum* that are also found in the overlying Mont d'Hours Formation.

At Hotton, the Terres d'Hours Formation reaches a thickness of about 110 m and is much more developed than in the area between Beauraing and Resteigne. Furthermore, the facies are rather different. In the lower 79 m exposed at Hampteau quarry, there is an alternation of laminites, coquina beds and bioclastic limestones including several layers rich in corals. Normally, the laminites and coquina beds with stringocephalids are characteristic of the upper part from the Trois-Fontaines Formation where the few reefal levels are thicker and often contain massive stromatoporoids. As for the corals of the Terres d'Hours Formation, they are certainly not so frequent between Resteigne and Beauraing. However, the distribution of the rugose corals is the same in both areas. Indeed, *Argutastrea quadrigemina* has been collected at the base and rather high in this sequence of 79 m from Hotton whereas *Disphyllum mcleani* has been found in two thin beds from its middle part; moreover, *Pseudozaphrentis zamkowae* has been recognized not very far from its top. The upper part of the Terres d'Hours Formation is represented at Hotton by argillaceous limestones with abundant brachiopods. This argillaceous facies is nearly lacking at Resteigne and Les Limites quarries, but occurs in the upper part of the lithostratigraphic unit at Givet where it corresponds to the eighth and ninth major sedimentary phases described by ERRERA *et al.*

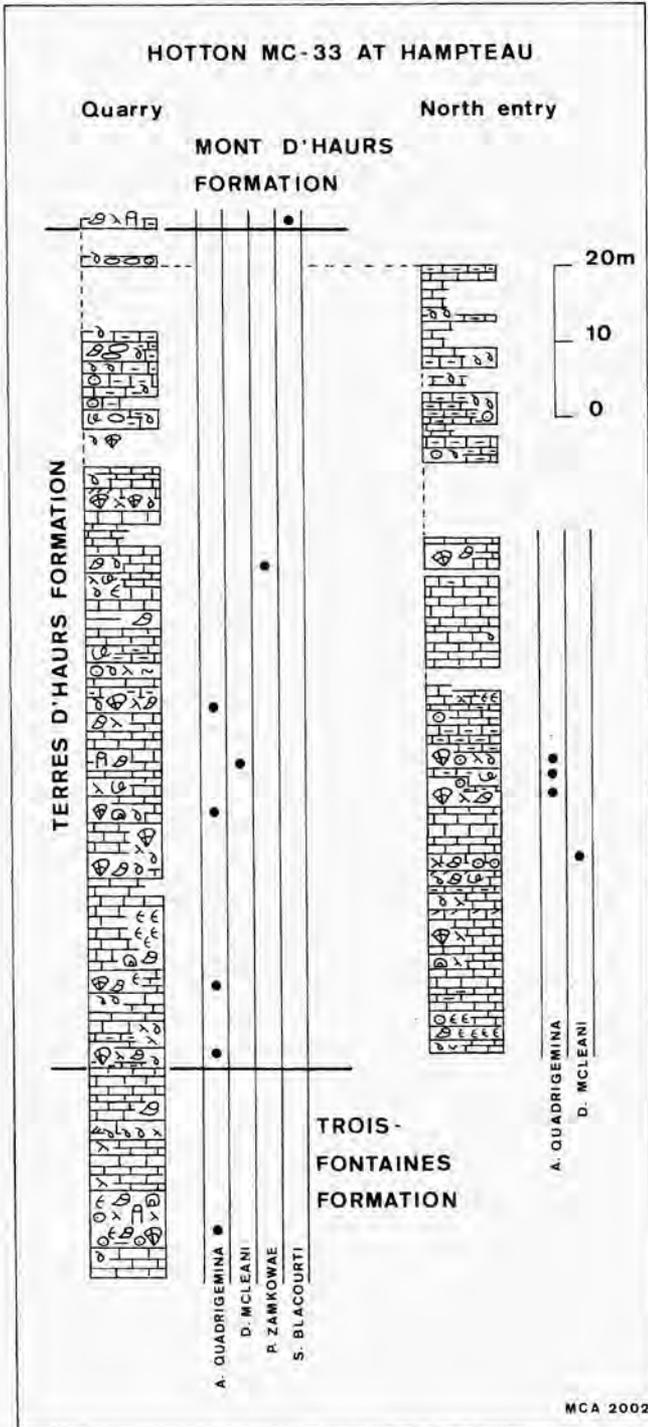


Fig. 7 — Comparative logs of the Terres d'Hours Formation at Hampteau quarry near Hotton with the distribution of the rugose corals. (For explanation of conventional signs, see Fig. 3).

(1972, p. 44) and figured by BULTYNCK (1987, fig. 2). At the base of the Mont d'Haus Formation appear again at Hotton diverse tabulate and rugose corals including *Spinyphyllum blacourti* that was recorded in the lower part of the lithostratigraphic unit by COEN-AUBERT (2002).

Systematic Palaeontology

Family DISPHYLLIDAE HILL, 1939
Genus *Disphyllum* DE FROMENTEL, 1861

= *Pantophyllum* LAKHOV, 1982

Type species

By subsequent designation of LANG & SMITH (1934, p. 80), *Cyathophyllum caespitosum* GOLDFUSS, 1826.

DIAGNOSIS

Fasciculate rugose corals. Septa of two orders, occasionally carinate, more or less dilated in the dissepimentarium and thin in the tabularium. 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, often arranged in horizontal layers in its outer part and inclined towards the axis of the corallites in its inner part. Tabulae usually incomplete or compound.

Disphyllum mcleani n. sp.

Plate 1, Figures 1-6, Plate 2, Figures 2-5

- v 1970 *Disphyllum geinitzi* Lang et Smith, 1935 - TSIEN, p. 167, fig. 7.
- v 1991 *Disphyllum geinitzi* Lang & Smith, 1935 - BIRENHEIDE *et al.*, pp. 9, 10 and 13.

Derivatio nominis

The species is dedicated to ROSS MCLEAN, a distinguished Canadian specialist of Silurian and Devonian rugose corals.

Holotype

IRScNB a11929 (= Pl. 1, Figs. 3, 4). Specimen Wellin MC-1983-14-A624 collected by COEN-AUBERT in 1987, 24 m above the base at the Terres d'Haus Formation.

Locus typicus

Southern Les Limites quarry at Ave-et-Auffe located in figure 2 of COEN-AUBERT (1999). Map sheet Wellin IGNB 59/6, Lambert coordinates: x = 205.175 and y = 87.5, south side of the Dinant Synclinorium, Belgium.

Stratum typicum

Middle part of the Terres d'Haus Formation, Early Givetian.

Material and localities

Twenty-seven colonies with 50 thin sections. Personal sam-

pling: Wellin MC-1974-95-L85, Z815, Z816, Z817, Z819, Z820, Z821 and Z822; Wellin MC-1983-14-A146, A147, A148, A149, A150, A623, A624 and A625; Wellin MC-1983-12-A187, A188, A189, and A190; Vencimont MC-1975-4-A477; Hotton MC-33-B623, B624, B627 and B642. Old collection from the Institut royal des Sciences naturelles de Belgique: Durbuy 7779-Gib-11670; Seloignes 8259-Gib-11505.

DIAGNOSIS

A species of *Disphyllum* with 36 to 44 septa at a diameter of 4.5 mm to 8.5 mm. Major septa slightly dilated in the dissepimentarium and leaving an open space in the centre of the tabularium. Narrow dissepimentarium with 0 to 3 rows of small globose dissepiments. Incomplete tabulae with broad axial flat-topped tabellae.

DESCRIPTION

The material consists of fragments of fasciculate colonies whose height varies between 2.5 cm and 12 cm; the largest piece reaches an area of 13 cm x 8 cm. The thin outer wall is often preserved. It is characterized by a dark median line when the cylindrical corallites are locally in contact and it is occasionally encrusted by a thin laminar stromatoporoid in one specimen. Axial quadripartite and sometimes tripartite offsets occur in many colonies.

The septa are normally non-carinate; however, a few small knobby or spinose carinae are present in some specimens. The septa are slightly dilated in the narrow dissepimentarium and become thin in the tabularium or beyond their entry into it; they are rarely dilated or slender throughout their length. Very locally, a thin stereoplasmic thickening affects a layer of dissepiments.

The major septa leave a more or less extensive open space in the centre of the tabularium; they rarely reach the axis of the corallites. Sometimes, their axial ends are discontinuous or fusing to form pseudofossulae or a plane of bilateral symmetry. The minor septa traverse the entire dissepiments or even enter into the tabularium where they may be contratingent. Occasionally, they are more or less short, reduced to spines, lacking or divided into isolated fragments.

The dissepimentarium consists of 0 to 3 or 4 rows of small inclined dissepiments which are often arranged in horizontal layers at the periphery. The tabulae are mostly incomplete and intersecting laterally with broad axial flat-topped tabellae; sometimes, they are also horizontal, concave or convex.

There are 32 to 46 septa per corallite. The diameter of the corallites ranges from 4 mm to 10.5 mm. The width of the tabularium varies commonly between 4 mm and 6.5 mm and more generally between 3 mm and 7.2 mm.

DISCUSSION

Disphyllum mcleani has been identified as *D. geinitzi* by TSIEN (1970) and BIRENHEIDE *et al.* (1991). However, the latter species, which comes from the Givetian of the Bergisches Land in Germany and which has been figured by LANG & SMITH (1935, pl. 36, figs. 1-3) and BIRENHEIDE

(1969, pl. 3, fig. 8, pl. 5, fig. 13), is different in having slightly larger corallites with broad complete tabulae. *D. geinitzi* has been chosen by LAKHOV (1982) as type species of *Pantophyllum* LAKHOV, 1982 without further revision. As it was stated recently by SCHRÖDER (1998, p. 41) and ROHART (1999, p. 51), the genus *Pantophyllum* is not well defined and is very likely a synonym of *Disphyllum* DE FROMENTEL, 1861.

The colonies collected in the Givetian Rodert Formation from the Eifel Hills in Germany and described as *Disphyllum* sp. by BIRENHEIDE & LÜTTE (1990 p. 11) are closely related to *D. mcleani*. Moreover, they are characterized by axial quadripartite offsets just as in the new species. Such a quadripartite budding also occurs in the Givetian material from the Cürten Formation of the Eifel Hills assigned to *D. caespitosum* (GOLDFUSS, 1826) by SCHRÖDER (1998, p. 41). But, these specimens differ from *D. mcleani* by longer major septa and by a weak stereoplastic thickening in the dissepimentarium. This feature is not present in the lectotype of *D. caespitosum* revised by BIRENHEIDE (1969, p. 38) and coming from the Givetian of the Bergisches Land; *D. caespitosum* is in fact the type species of *Disphyllum*. An axial quadripartite increase is very frequent in the cerioid taxon *Argutastrea quadrigemina* investigated among others in the Givetian of Belgium and Germany by COEN-AUBERT (1980) and COEN-AUBERT & LÜTTE (1990). Except for this budding, *A. quadrigemina* and *Disphyllum mcleani* have nothing in common. More especially, *Argutastrea quadrigemina* (Pl. 2, fig. 1, pl. 3, figs. 1, 2) has a normally developed dissepimentarium and major septa that often reach the centre of the tabularium. In the Belgian Givetian, *Disphyllum mcleani* is succeeded by *D. semenoffi* COEN-AUBERT, 2000 at the base of the Mont d'Hairs Formation. Though the two species have rather thin septa in the dissepimentarium, the latter is easily distinguished from the former by larger corallites with more septa and dissepiments.

There are several similarities between *D. mcleani* and *D. lemaitreae* BRICE, 1970 from the Frasnian of Afghanistan which is separated from the new taxon by inclined dissepiments and by a greater number of septa. *D. karolinae* GALLE, 1985 from the Frasnian of Moravia in the Czech Republic differs from *D. mcleani* by some stereoplastic thickenings occurring between the septa in the dissepimentarium. Finally, *Peneckiella metalinae* SORAUF, 1972 from the Frasnian of Washington in the USA and *P. xizangensis* LIAO, 1982 in Wu *et al.* (1982, p. 119) from the Frasnian of Tibet in China resemble also *Disphyllum mcleani*. However, both of these species have very few dissepiments which are not typically peneckielloid. Additionally, *Peneckiella metalinae* is characterized by smaller corallites than *Disphyllum mcleani*.

GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCE

The species is only known in the Early Givetian of Belgium. The material sampled by the author comes from the middle part of the Terres d'Hairs Formation at Beauraing, Wellin, Resteigne, Ave-et-Auffe and Hotton, on the south side of the Dinant Synclinorium.

Genus *Temnophyllum* WALTHER, 1929

Type species

By subsequent designation of LANG *et al.* (1940, p. 132), *Temnophyllum latum* WALTHER, 1929.

DIAGNOSIS

Solitary rugose corals. Septa of two orders, non-carinate or sometimes faintly carinate. Both orders of septa frequently in lateral contact in the outer part of the dissepimentarium so as to form a wide peripheral stereozone which is complete or partial. Septa more or less dilated in the inner part of the dissepimentarium and thin in the tabularium. Major septa reaching the axis of the corallum 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, often arranged in horizontal layers in its outer part and inclined towards the axis of the corallum in its inner part. Tabulae usually incomplete.

Temnophyllum wellinense n. sp.

Plate 1, Figures 7-12, Plate 2, Figures 6-10

Derivatio nominis

Latin adjective: wellinensis, e, referring to Wellin, the type locality of the new species.

Holotype

IRScNB a11935 (= pl. 1, Figs. 10-12). Specimen Wellin MC-1983-12-A111A collected by COEN-AUBERT in 1983, 1.5 m above the base of the Terres d'Hairs Formation.

Locus typicus

Active quarry Fond des Vaux West at Wellin located in figure 2 of COEN-AUBERT (1999). Map sheet Wellin IGNB 59/6, Lambert coordinates: x = 203.525 and y = 87.2, south side of the Dinant Synclinorium.

Stratum typicum

Base of the Terres d'Hairs Formation, Early Givetian.

Material and localities

Twenty-six specimens with 37 thin sections. Personal sampling: Wellin MC-1974-95-Z39, Z770, Z772, Z779 and Z782; Wellin MC-1983-12-A111A, A111B, A111C, A111E, A111F, A111G, A111I, A111K, A111M, A111N, A111O, A111P, A111R, A113, A154, A155, A177, A179 and A180; Houyet MC-1975-5-Z205; Vencimont MC-1975-4-Z259.

DIAGNOSIS

A species of *Temnophyllum* with 54 to 62 septa at a diameter of 12 mm to 16 mm. Narrow and incomplete stereozone developed against the outer wall or within the dissepimentarium. Major septa leaving a more or less extensive open space in the centre of the tabularium. Rather few rows of dissepiments often inclined towards the axis of the corallum.

DESCRIPTION

The material consists of conical, cylindrical and sometimes ceratoid or trochoid coralla which are complete or fragmentary with frequent longitudinal ribs. Their height varies between 1 cm and 4.5 cm. Two specimens are affected by rejuvenescence and two others have a deep and steep sided calice. The outer wall is not very well preserved and is rarely encrusted by thin laminar stromatopoids or auloporids.

The septa are normally non-carinate though some small spinose and knobby carinae occur in a few samples. They are dilated in the dissepimentarium and become thinner or less thick in the tabularium or beyond their entry into it. Occasionally, the major septa are dilated throughout their length. A deposit of stereoplasma is present against the outer wall or within the dissepimentarium, but this zone of thickening is always narrow and often discontinuous.

The major septa leave a more or less extensive open space in the centre of the tabularium; they rarely reach the axis of the corallum. Their axial ends may be rhopaloid, divided into isolated fragments or fusing to form pseudo-fossulae. Moreover, there is a closed fossula in two specimens. The minor septa traverse the entire dissepimentarium or even enter into the tabularium where they are sometimes contratingent. Occasionally, they are slightly shorter, restricted to the outer part of the dissepimentarium or discontinuous at their inner ends.

The dissepimentarium consists of 2 to 8 rows of small inclined dissepiments with are rather frequently arranged in horizontal layers at the periphery. Locally, the outer part of the dissepimentarium is obscured by some stereoplasma. The tabulae are incomplete and intersecting laterally.

There are 50 to 66 septa per corallum. The diameter of the corallum ranges from 9 mm to 21 mm. The width of the tabularium varies commonly between 7 mm and 10 mm and more generally between 5.8 mm and 11 mm.

DISCUSSION

Temnophyllum wellinense is probably related to *T. imperfectum* COEN-AUBERT, 2002 described mainly from the lower part of the Mont d'Haus Formation, on the south side of the Dinant Synclinorium. However, the latter species is easily distinguished from the former:

- by slightly larger coralla;
- by an incomplete stereozone which is much better developed in the outer part of the dissepimentarium;
- by longer major septa that may reach the centre of the tabularium;
- by more numerous dissepiments systematically arranged in horizontal layers at the periphery.

T. wellinense resembles the material from the Givetian of the Holy Cross Mountains in Poland assigned to *T. occidentale* HILL & JELL, 1970 by WRZOLEK (1993, p. 233). This is especially the case for the specimens figured by WRZOLEK (1993, figs. 10D, F and H), showing some stereoplasmic thickening. Such a peripheral stereozone is not always present in the type material of HILL &

JELL (1970, p. 59) coming from the Givetian of the Canning Basin in Australia. Moreover, this sampling is characterized by more dissepiments which are horizontal in the outer part of the dissepimentarium. There are also some similarities between *T. wellinense* and the smaller coralla collected in the Givetian Loogh and Cürten Formations of the Eifel Hills and referred to *Glossophyllum* sp. cf. *schoupppei* LÜTTE, 1990 by SCHRÖDER (1998, p. 34). In fact, there is no stereozone in the type material of *G. schoupppei* illustrated by LÜTTE (1990, figs. 20-23). *G. multifossulatum* KETTNEROVA, 1932 from the Givetian of Moravia in the Czech Republic is rather close to *Temnophyllum wellinense*, but differs from it by a narrower dissepimentarium.

Finally, *T. lenzi* PEDDER, 1972 from the Upper Givetian of the Northwest Territories in Canada has several features in common with *T. wellinense* although it is separated from it by minor septa of more variable length.

GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCE

The species is only known in the Early Givetian of Belgium. The material sampled by the author comes from the base of the Terres d'Haus Formation at Beauraing, Pondrôme, Wellin and Resteigne, on the south side of the Dinant Synclinorium.

Genus *Pseudozaphrentis* SUN, 1958*Type species*

By original designation, *Pseudozaphrentis difficile* SUN, 1955 in WANG *et al.* (1955).

DIAGNOSIS

Solitary rugose corals. Septa of two orders, non-carinate or faintly carinate, irregularly dilated in the dissepimentarium and thin the tabularium. Major septa leaving an open space in the centre of the tabularium. Minor septa variable in length and occasionally replaced by dissepiments in herringbone pattern. Dissepimentarium composed of several rows of inclined dissepiments, sometimes arranged in horizontal layers at the periphery. Tabulae incomplete.

DISCUSSION

The genus *Pseudozaphrentis* SUN, 1958 has been discussed by COEN-AUBERT (1995, p. 164) who described a few coralla of its type species *P. difficilis* SUN, 1955 from the Upper Frasnian of the Hunan Province in China. More or less at the same time, MCLEAN (1993, p. 111) considered *Pseudozaphrentis* as synonymous with *Temnophyllum* WALTHER, 1929 like HILL (1981, p. F269) whereas ZHEN & JELL (1996, p. 79) regarded it as a synonym of *Paracanthus* MERRIAM, 1973 and a subgenus of *Temnophyllum*. On the contrary, *Pseudozaphrentis* was retained with a separate status by LIAO (1996, p. 65) and SCHRÖDER & SALERNO (2001, p. 118). As it was mentioned by COEN-AUBERT (1995), *Temnophyllum* is easily distinguished from *Pseudozaphrentis* by a wide peripheral stereozone, by long minor septa traversing the entire

dissepimentarium and by dissepiments arranged in horizontal layers at the periphery. The type species of *Paracanthus* is *P. richardsoni* (MEEK, 1867) which comes from the Givetian of the Northwest Territories in Canada and which has been investigated by PEDDER (1972, p. 701) and McLEAN (1993, p. 111). Among other features, it shows some stereoplasmic thickening in the dissepimentarium and was assigned to *Temnophyllum* by both authors.

***Pseudozaphrentis zamkowae* (WRZOLEK, 1993)**

Plate 3, Figures 3-12

- * 1993 *Temnophyllum zamkowae* n. sp. - WRZOLEK, p. 235, fig. 12.
 1993 *Temnophyllum menyouense* Hill & Jell 1970 - WRZOLEK, p. 234, fig. 11.

Holotype

Fig. 12A, B in WRZOLEK (1993). Specimen GIUS 402 JS 03 stored in the Department of Earth Sciences from the Silesian University at Sosnowiec, Poland. Late Givetian (set A) of Jazwica quarry lying to the south of Bolechowice village, Holy Cross Mountains, Poland.

Material and localities

Fourteen specimens with 23 thin sections. Personal sampling: Wellin MC-1974-95-Z827, Z828, Z829, Z830, Z831, Z832, Z834, Z836, Z837, Z838, Z839 and Z840; Wellin MC-1983-14-A621; Hotton MC-33-B636.

DIAGNOSIS

A species of *Pseudozaphrentis* with 50 to 60 septa at a diameter of 13 mm to 20 mm. Septa slightly dilated and carinate in the dissepimentarium. Minor septa rather long.

DESCRIPTION

The material consists of conical and ceratoid coralla which are complete or fragmentary with frequent longitudinal ribs. Their height varies between 1 cm and 5 cm, but reaches 10 cm in one specimen. Another sample shows a lateral offset and a deep calice bordered by a flat platform. The outer wall is not very well preserved.

The septa are non-carinate or bear some spinose and more rarely knobby carinae. They are slightly dilated in the dissepimentarium or sometimes throughout their length. The septa become slender in the tabularium or beyond their entry into it. Occasionally also, they are thinning gradually or only at their axial ends. In very few specimens, a stereoplasmic thickening affects locally a layer of dissepiments.

The major septa leave a more or less extensive open space in the centre of the tabularium; in rare cases, their axial ends are divided into isolated fragments. The minor septa traverse all or nearly all the dissepimentarium or even enter into the tabularium where they may be contracting. Sometimes, they are more or less shorter or discontinuous especially in the inner dissepimentarium where appear some herringbone dissepiments.

The dissepimentarium consists of 3 to 10 rows of small

inclined dissepiments which are occasionally arranged in horizontal layers at the periphery. The tabulae are incomplete and intersecting laterally; their axial parts are often horizontal or flat-topped and are rarely concave.

There are 50 to 60 septa per corallum. The diameter of the corallum ranges from 11 mm to 22 mm. The width of the tabularium varies between 6.4 mm and 10.5 mm.

DISCUSSION

The Belgian material shows the same variability and is similar to that of WRZOLEK (1993) assigned to *Pseudozaphrentis zamkowae* and *Temnophyllum menyouense*, HILL & JELL, 1970. According to WRZOLEK (1993), there are intermediate forms between the two species that occur together in the Upper Givetian of the Holy Cross Mountains in Poland. *T. menyouense* has been defined by HILL & JELL (1970, p. 60) in the Late Givetian or Early Frasnian from the Canning Basin in Western Australia. Its type specimens differ from *Pseudozaphrentis zamkowae* by a smaller open space in the centre of the tabularium, by a wider dissepimentarium and by slightly more septa. The coralla from the Frasnian of the Holy Cross Mountains ascribed to *Temnophyllum menyouense* by ROZKOWSKA (1979, p. 32) are different as they present some stereoplasmic thickening at the periphery. *T. menyouense* has been referred by WRIGHT *et al.* (1990, p. 234) to the genus *Piceaphyllum* ROZKOWSKA, 1979 whose type species is *Neostriophyllum pronini* SOSHKINA, 1951 from the Frasnian of the Urals in Russia. But this taxon as figured by SOSHKINA (1951, pl. 10 and 1952, pl. 26, fig. 89) is characterized by long major septa reaching the centre of the tabularium and by numerous dissepiments more or less arranged in horizontal layers near the outer wall. So the genus *Piceaphyllum* cannot be used for *Temnophyllum menyouense* and *Pseudozaphrentis zamkowae*. In fact *P. zamkowae* is distinguished from *P. difficilis*, type species of the genus, by smaller coralla with fewer septa and dissepiments and by minor septa better developed.

Three species described in the genus *Mictrophyllum* LANG & SMITH, 1939 resemble *Pseudozaphrentis zamkowae* in transverse section: *M. duesterbergense* LÜTTE, 1990 from the Givetian Rodert and Kerpen Formations of the Eifel Hills in Germany, *M. schlueteri* BIRENHEIDE & LÜTTE, 1990 from the Kerpen Formation of the same area and *M. intermedium* LIAO, 1977 from the Frasnian of the Guizhou Province in China. All three of them have horizontal dissepiments in the outer part of the dissepimentarium and have also more septa than *Pseudozaphrentis zamkowae*. *Mictrophyllum duesterbergense* has the same size as the latter taxon whereas *M. schlueteri* is slightly larger. Moreover, the holotype of the second species has been compared by COEN-AUBERT (2002, p. 17) with *Spinophyllum blacourti* present in the Mont d'Hairs Formation of Belgium whereas its paratypes are closer to *Pseudozaphrentis zamkowae*. As the septa of *Mictrophyllum duesterbergense*, *M. schlueteri* and *M. intermedium* are faintly dilated in the dissepimentarium, they cannot be assigned to *Mictrophyllum* which is char-

acterized by slender septa throughout their length. This genus has been discussed recently by McLEAN (1993, p. 116) and LIAO (1996, p. 65). Thin septa occur in *Charactophyllum batchaticum* IVANIA, 1965 from the Givetian of the Kuznetsk Basin in Russia though its transverse section is more or less like that of *Pseudozaphrentis zamkowsae*. However, the former species investigated by IVANIA (1965, p. 101) is also separated from the latter by dissepiments arranged in horizontal layers at the periphery and by compound tabulae with axial flat-topped tabellae.

GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCE

The material sampled by the author comes from the upper

part of the Terres d'Haus Formation at Resteigne, Avelin and Hotton, on the south side of the Dinant Synclinorium.

Outside Belgium, *Pseudozaphrentis zamkowsae* is known only from the Upper Givetian of the Holy Cross Mountains in Poland.

Acknowledgements

W.A. OLIVER, Jr. (Washington, D.C.) and B. MISTIAEN (Lille) kindly reviewed the manuscript. The thin sections were prepared by R. CREMERS (IRScNB) and by the Laboratory of E. POTY (Liège). The photos were printed by W. MISEUR (IRScNB). I am most grateful to all these persons.

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Marie COEN-AUBERT

Département de Paléontologie

Section des Invertébrés fossiles

Institut royal des Sciences naturelles de Belgique

rue Vautier 29, B-1000 Bruxelles, Belgium

E-mail: Marie.Coen-Aubert@naturalsciences.be

Typescript submitted June 28, 2002

Revised typescript received October 11, 2002

Explanation of Plates

All specimens are figured at magnification x 3.

PLATE 1

Disphyllum mcleani n. sp.

- Figs. 1, 2 — Paratype. IRScNB a11930. Wellin MC-1983-14-A148. Transverse and longitudinal sections.
 Figs. 3, 4 — Holotype. IRScNB a11929. Wellin MC-1983-14-A624. Transverse and longitudinal sections.
 Fig. 5 — Paratype. IRScNB a11931. Hotton MC-33-B642. Transverse section.
 Fig. 6 — Paratype. IRScNB a11932. Hotton MC-33-B623. Transverse section.

Temnophyllum wellinense n. sp.

- Fig. 7 — Paratype. IRScNB a11936. Wellin MC-1983-12-A180. Transverse section.
 Figs. 8, 9 — Paratype. IRScNB a11937. Wellin MC-1983-12-A111C. Transverse and longitudinal sections.
 Figs. 10-12 — Holotype. IRScNB a11935. Wellin MC-1983-12-A111A. Transverse and longitudinal sections.

PLATE 2

Argutastrea quadrigemina (GOLDFUSS, 1826)

- Fig. 1 — IRScNB a11941. Vencimont MC-1975-4-5. Transverse section.

Disphyllum mcleani n. sp.

- Fig. 2 — Paratype. IRScNB a11933. Wellin MC-1974-95-L85. Transverse section.
 Figs. 3-5 — Paratype. IRScNB a11934. Vencimont MC-1975-4-A477. Transverse and longitudinal sections.

Temnophyllum wellinense n. sp.

- Figs. 6, 7 — Paratype. IRScNB a11938. Wellin MC-1974-95-Z770. Transverse and longitudinal sections.
 Figs. 8, 9 — Paratype. IRScNB a11939. Wellin MC-1983-12-A177. Transverse and longitudinal sections.
 Fig. 10 — Paratype. IRScNB a11940. Wellin MC-1983-12-A154. Transverse section.

PLATE 3

Argutastrea quadrigemina (GOLDFUSS, 1826)

- Figs. 1-2 — IRScNB a11942. Houyet MC-1975-5-1. Transverse and longitudinal sections.

Pseudozaphrentis zamkowsae (WRZOLEK, 1993)

- Figs. 3, 4 — IRScNB a11943. Wellin MC-1974-95-Z830. Transverse and longitudinal sections.
Figs. 5, 6 — IRScNB a11944. Wellin MC-1974-95-Z834. Transverse and longitudinal sections.
Figs. 7, 8 — IRScNB a11945. Wellin MC-1974-95-Z828. Transverse and longitudinal sections.
Fig. 9 — IRScNB a11946. Wellin MC-1974-95-Z827. Transverse section.
Figs. 10-12 — IRScNB a11947. Wellin MC-1974-95-Z829. Transverse and longitudinal sections.

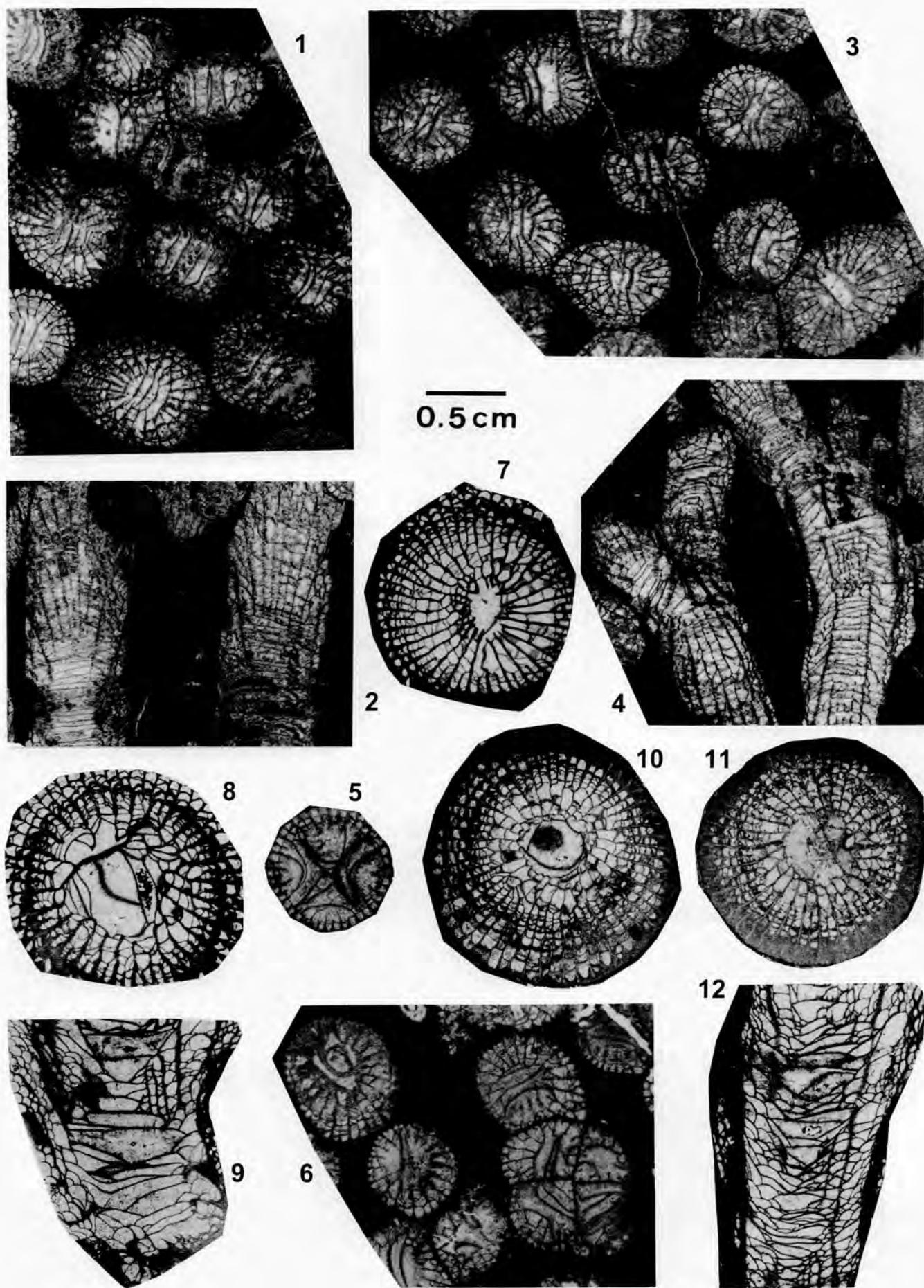
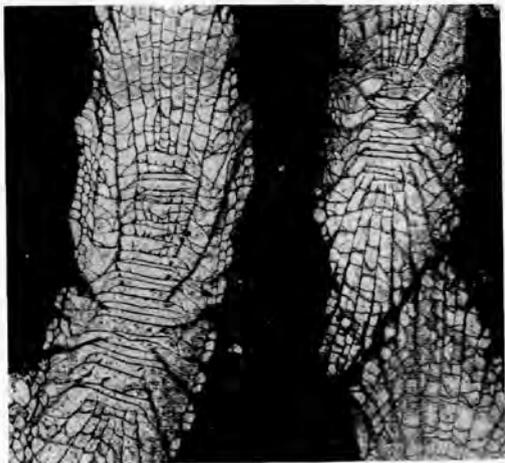
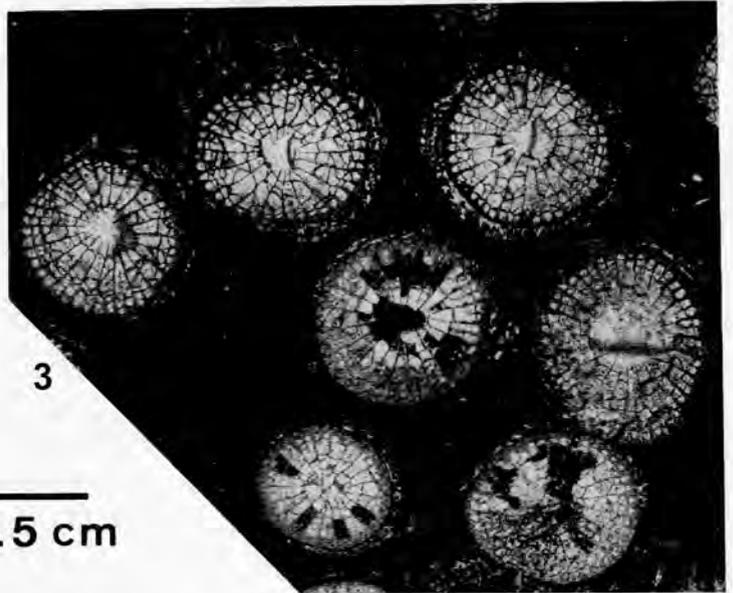
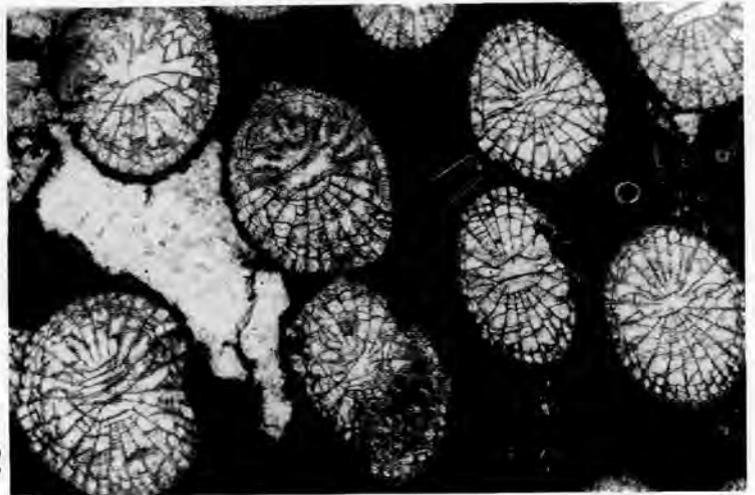
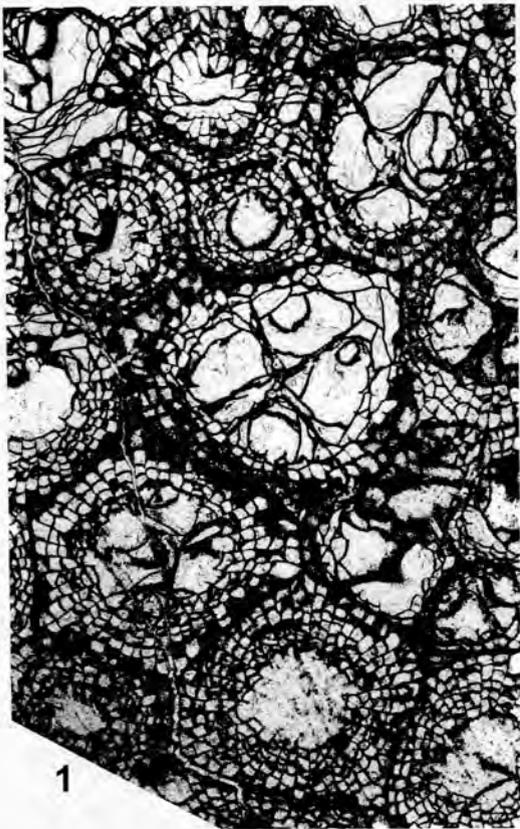
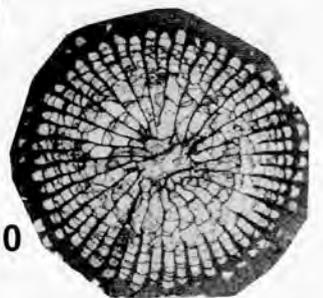
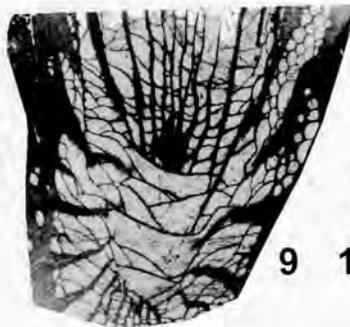
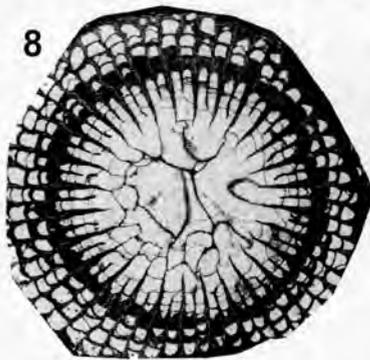
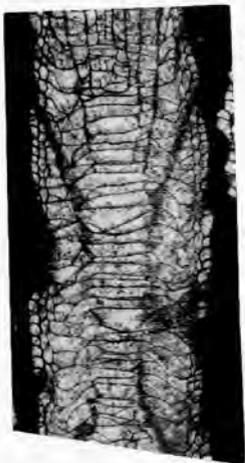


PLATE 1



0.5 cm



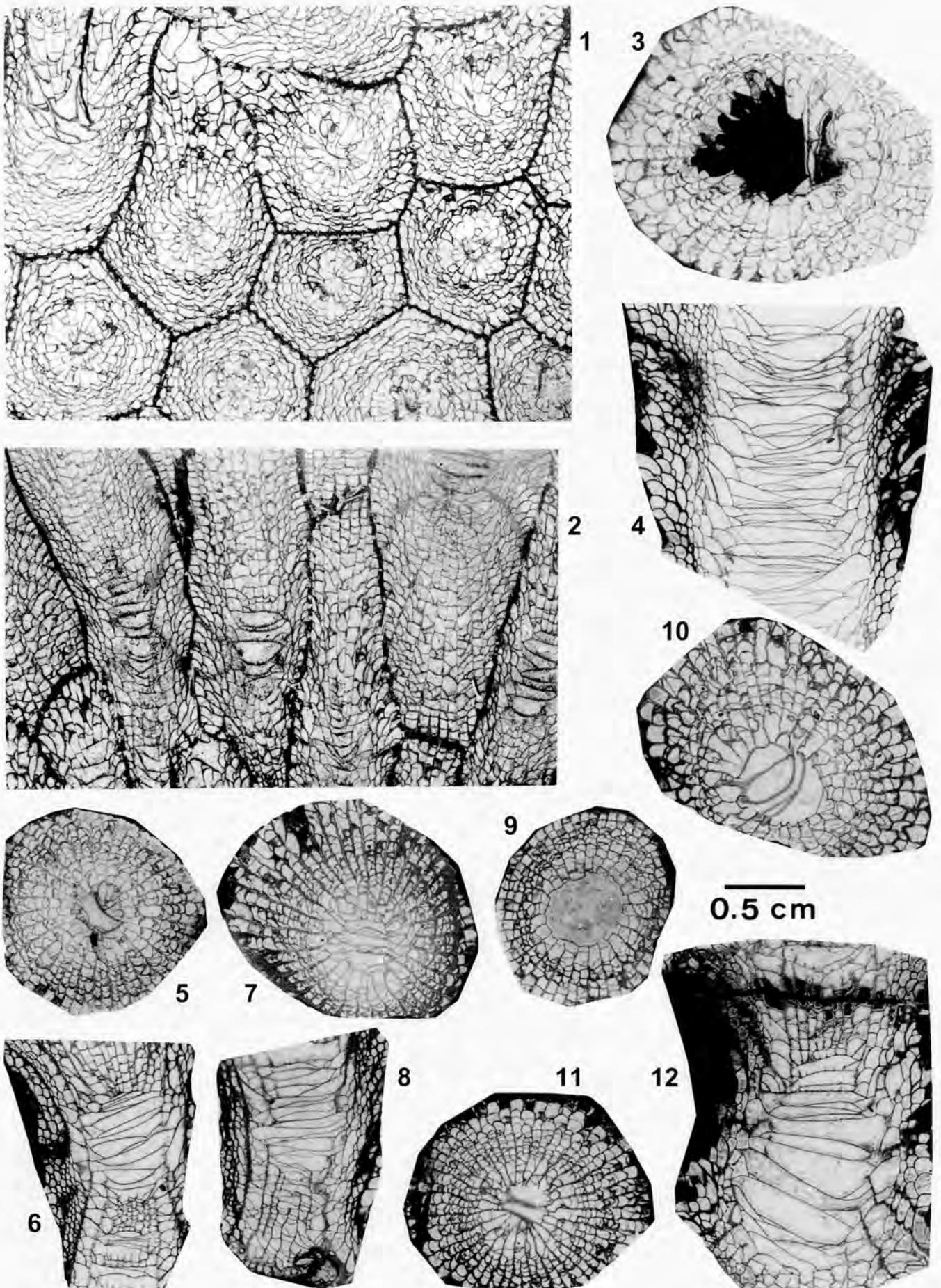


PLATE 3

