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Two new species of Temnophyllids (Rugosa) from the Upper Givetian of Belgium

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Abstract

Temnophyllum delmeri n. sp. , and *T. ramosum* n. sp. are described in detail and come from the Upper Givetian of Belgium. On the south side of the Dinant Synclinorium, *T. delmeri* is associated with *Sunophyllum beichuanense* HE, 1978 and *Wapitiphyllum laxum* (GÜRICH, 1896), at the top of the Mont d'Haurs Formation. It is also present in the Flohimont Member, the lower subdivision of the Fromelennes Formation. At the base of the overlying Moulin Boreux Member, there is a level of limestones rich in stringocephalids, diverse groups of tabulate corals and in rugose corals represented by *W. laxum*, *Temnophyllum ramosum*, *T. delmeri* and locally *Sunophyllum beichuanense*. Nearly all these fossils disappear higher in the Moulin Boreux Member. The same situation has been observed in the Philippeville Massif, on the north side of the Dinant Synclinorium and in the Vesdre Massif. As the base of the Flohimont Member lies at the top of the Lower *Polygnathus varcus* Zone and as the major part of this lithostratigraphic unit belongs to the *P. ansatus* Zone corresponding to the Middle *P. varcus* Zone, it is quite possible that the Taghanic Event occurs in Belgium just above the level of limestones with the last stringocephalids.

Key-words: Rugose corals, Givetian, Taxonomy, Taghanic Event.

Résumé

Temnophyllum delmeri n. sp. et *T. ramosum* n. sp. sont décrits en détail et proviennent du Givetien supérieur de la Belgique. Au bord sud du Synclinorium de Dinant, *T. delmeri* est associé à *Sunophyllum beichuanense* HE, 1978 et *Wapitiphyllum laxum* (GÜRICH, 1896), au sommet de la Formation du Mont d'Haurs. Il est aussi présent dans le Membre de Flohimont qui est la première subdivision de la Formation de Fromelennes. A la base du Membre sus-jacent du Moulin Boreux, il y a un niveau calcaire, riche en Stringocéphales, en divers groupes de Tabulés et en Rugueux représentés par *W. laxum*, *Temnophyllum ramosum*, *T. delmeri* et localement par *Sunophyllum beichuanense*. Presque tous ces fossiles disparaissent plus haut dans le Membre du Moulin Boreux. La même situation a été observée dans le Massif de Philippeville, au bord nord du Synclinorium de Dinant et dans le Massif de la Vesdre. Comme la base du Membre de Flohimont est datée du sommet de la Zone à *Polygnathus varcus* inférieure et que la majeure partie de cette unité lithostratigraphique appartient à la Zone à *P. ansatus* correspondant à la Zone à *P. varcus* moyenne, il est probable que l'événement Taghanic se situe en Belgique juste au-dessus du niveau calcaire contenant les derniers Stringocéphales.

Mots-clefs: Rugueux, Givetien, Taxinomie, Evénement Taghanic.

Introduction

After the papers of COEN-AUBERT (1999, 2000 and 2002) devoted to the highly diversified fauna of rugose corals from the Mont d'Haurs Formation, on the south side of the Dinant Synclinorium, it seems interesting to continue these investigations in the overlying Fromelennes Formation that is the last stratigraphic unit of the Givetian (Fig. 7). Two new species of *Temnophyllum* WALTHER, 1929, namely *T. delmeri* n. sp. and *T. ramosum* n. sp., have been collected at the transition between the Mont d'Haurs and Fromelennes Formations. They are associated with *Wapitiphyllum laxum* (GÜRICH, 1896) and *Sunophyllum beichuanense* HE, 1978 which have been revised by COEN-AUBERT, 1999. Higher in the Fromelennes Formation, the rugose corals are rare and fragmentary up to the beds rich in *Disphyllum virgatum* (HINDE, 1890) that occur at the top of the lithostratigraphic unit. This species has been studied by COEN-AUBERT (1989) and is refigured herein.

In addition to the area between Frasnes and Ave-et-Auffe (Fig. 1), several sections have been sampled at Philippeville, in the Philippeville Massif, at Erquelinnes and Gerpinnes, on the north side of the Dinant Synclinorium and also close to Verviers and Membach, in the Vesdre Massif. In the latter two structural units, the Givetian facies are rather different as the Mont d'Haurs and Fromelennes Formations pass laterally into the Névremont and Le Roux Formations.

Conodonts have only been found in the lower and upper parts of the Fromelennes Formation subdivided into three members which are in ascending order the Flohimont, Moulin Boreux and Fort Hulobiet Members. According to BULTYNCK & DEJONGHE (2002, p. 52) and BULTYNCK & GOUWY (2002), the basal layers of the Fromelennes Formation belong to the *Polygnathus rhenanus*/*P. varcus* Zone which corresponds to the upper part of the Lower *P. varcus* Zone whereas the major part of the Flohimont Member is assigned to the *P. ansatus* Zone equivalent to the Middle *P. varcus* Zone. Below the base of the Frasnian, the Lower *Mesotaxis falsiovalis* Zone has been recognized in the Fort Hulobiet Member.

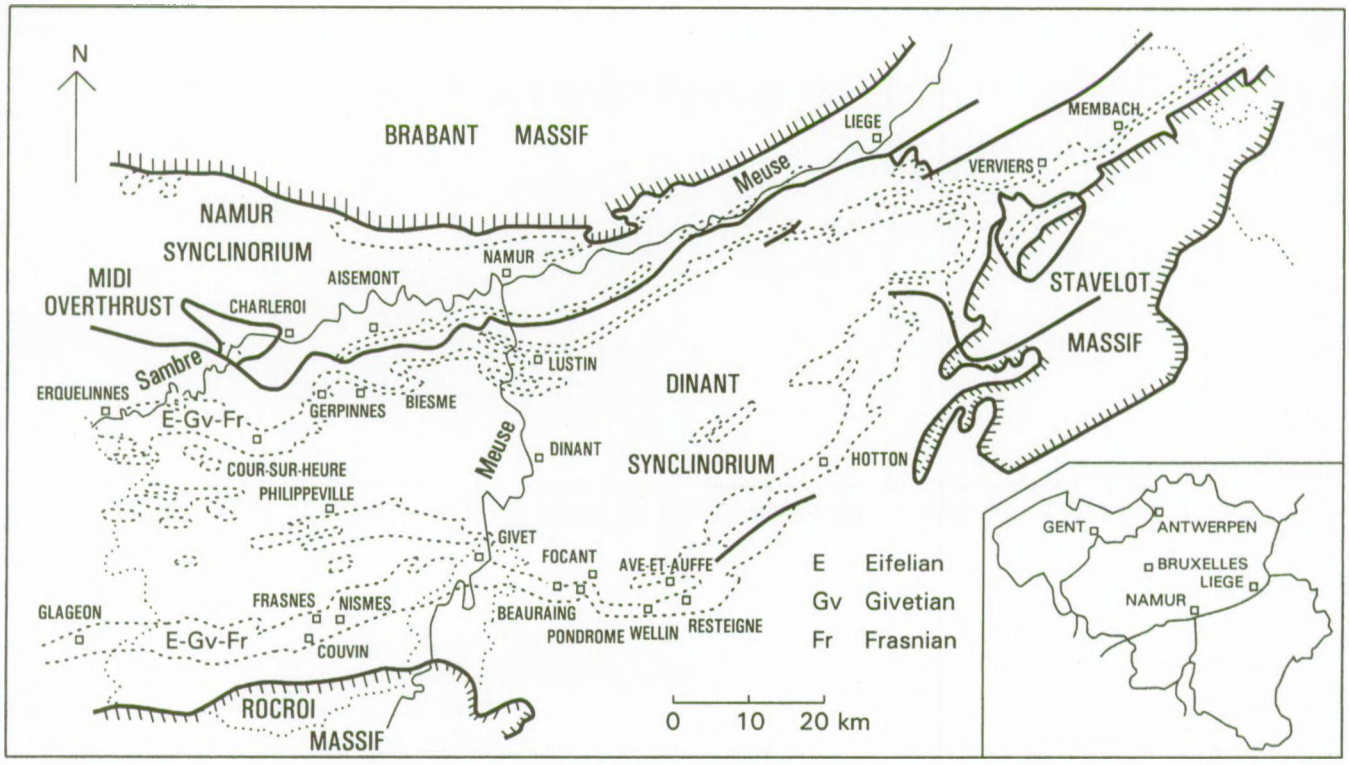

Fig. 1 — Geological setting and locality map in the southern part of Belgium.

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 two new species and the figured colony of *Disphyllum virgatum* are also stored in the collections of the Institut royal des Sciences naturelles de Belgique (IRScNB).

Description of the outcrops

NEPTUNE OR ADUGEOIR CAVES AT FRASNES (Couvin MC-1980-5; Figs. 2 and 3)

The most complete section investigated at the transition between the Mont d'Haurs and Fromelennes Formation, on the south side of the Dinant Synclinorium, is that of the Neptune or Adugeoir Caves along the north bank of the Eau Noire river at Frasnes. It has been briefly described by COEN & COEN-AUBERT (1971, p. 15) and BIRENHEIDE *et al.* (1991, p. 19).

At the top of the Mont d'Haurs Formation, there are 6 m of dark limestones containing sparse to abundant reef-building organisms: massive and dendroid stromatoporoids, massive and platy alveolitids, thamnoporids, massive, fasciculate and solitary rugose corals with among them several coralla of *Temnophyllum delmeri* at the top of this sequence. Then the Flohimont Member of the Fromelennes Formation is represented by:

– 7 m: argillaceous limestones with brachiopods including cyrtospiriferids and a few corals: *T. delmeri*, *Cystiphylloides*, thamnoporids, massive, platy and ramose alveolitids.
– 6 m: thin-bedded and fine limestone, slightly argillaceous in the lower part, weakly crinoidal in the upper part.
– 3 m shales becoming calcareous at the top.

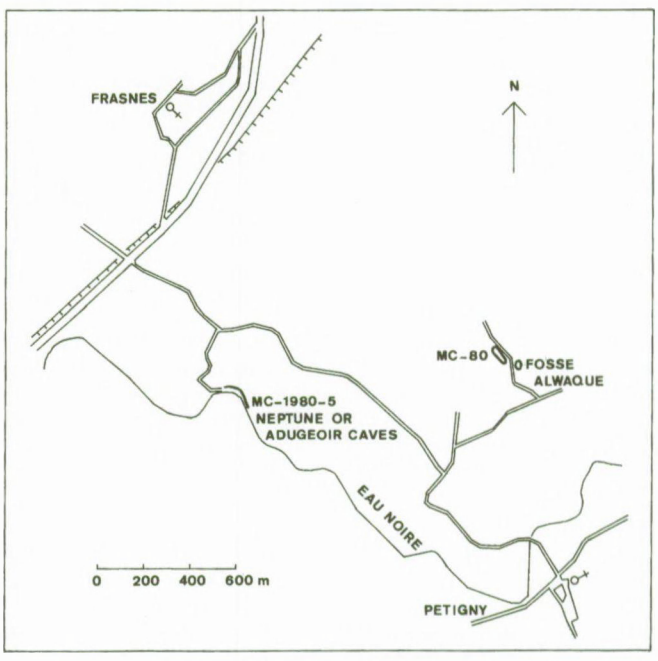

Fig. 2 — Location of the outcrops investigated at Frasnes and Petigny.

– 1.9 m: thin-bedded and fine limestone with a few gastropods.
– 5.4 m alternation of shales, argillaceous or fine dolomite and laminated or dolomitic limestone.

The Moulin Boreux Member starts with 3 m of fine limestone containing bioclasts at the base and numerous amphiporids in its upper part. Then, 10.5 m of mostly biostromal and locally dolomitic limestones are exposed before reaching the exit of the tourist cave. Their highly diversified fauna is characterized by massive and dendroid stromatoporoids, alveolitids, scolioporids, thamnoporids, solitary to fasciculate rugose corals belonging to *Temnophyllum ramosum*, associated with a few stringocephalids at the base.

EXCAVATION LOCATED TO THE NORTH OF PETIGNY
(Couvin MC-80; Figs. 2 and 3)

The preceding outcrop is completed by the less continuous section of Petigny lying 1 km to the east. This complex of two holes has been pointed out to the author by COEN and has been mentioned by MARION & BARCHY (1999, p. 37). In the southern excavation called Fosse Alwaque, the upper part of the Mont d'Haurs Formation is badly exposed whereas its top has probably collapsed at the southern end of the northern excavation (outcrop Couvin MC-80).

Above an unexposed area with a thickness of 5.5 m, the Flohimont Member is represented by 19.5 m of thin-bedded and dark limestones interrupted by several gaps. They contain some crinoids, brachiopods or gastropods and also a few corals at the base. Debris of yellow shales have been observed in the main hiatus, rather high in this sequence. The Moulin Boreux Member starts with 5.75 m of dolomitic limestones more or less rich in corals: *Temnophyllum ramosum*, *T. delmeri* and thamnoporids accompanied by massive and dendroid stromatoporoids. After 2.85 m of fine and dolomitic limestones, the section ends with 7 m of still dolomitic limestones that often contain massive and dendroid stromatoporoids.

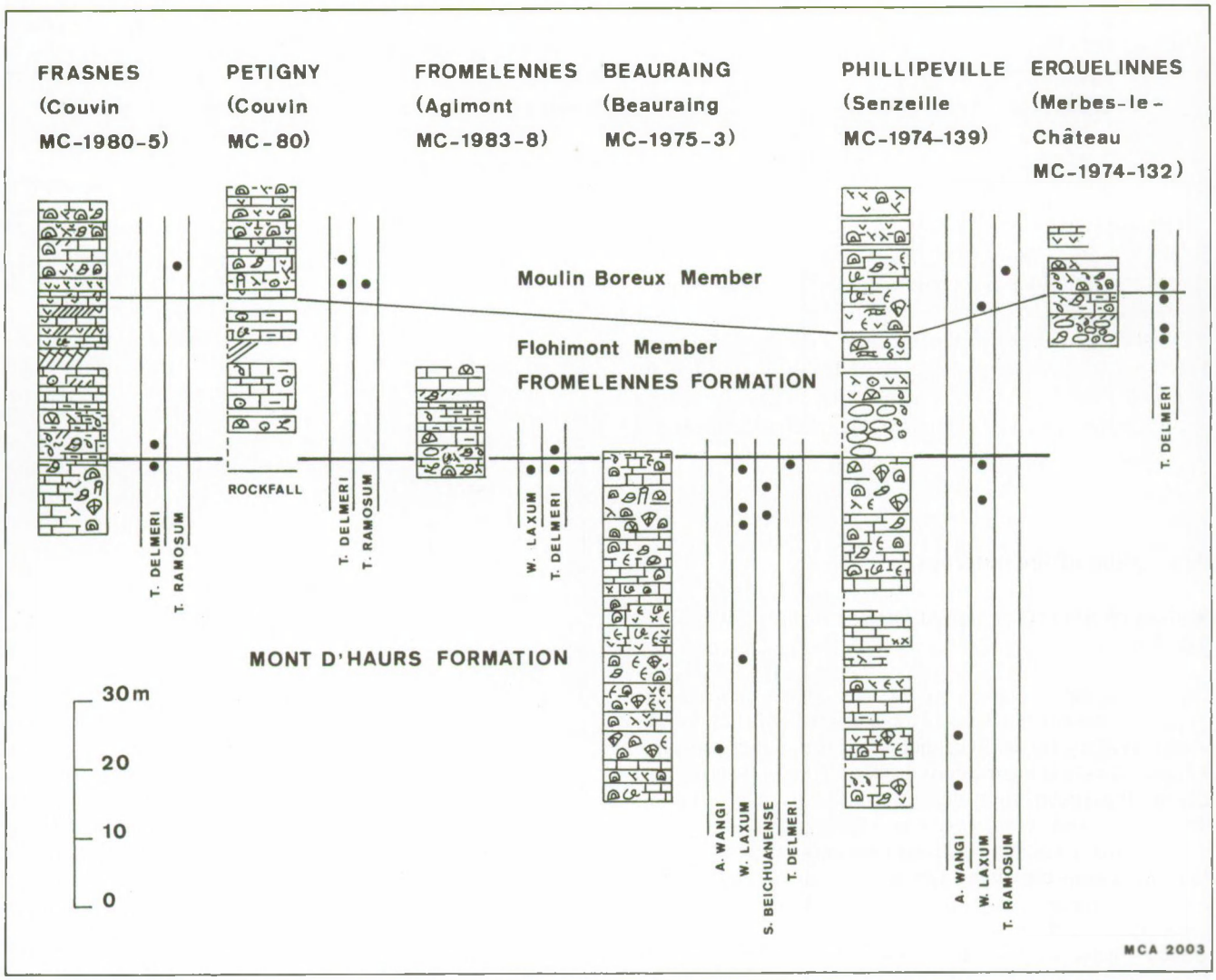

Fig. 3 — Comparative logs of the transition between the Mont d'Haurs and Fromelennes Formations at Frasnes, Petigny, Fromelennes, Beauraing, Philippeville and Erquelinnes with the distribution of the rugose corals. (For explanation of conventional signs, see Fig. 4).

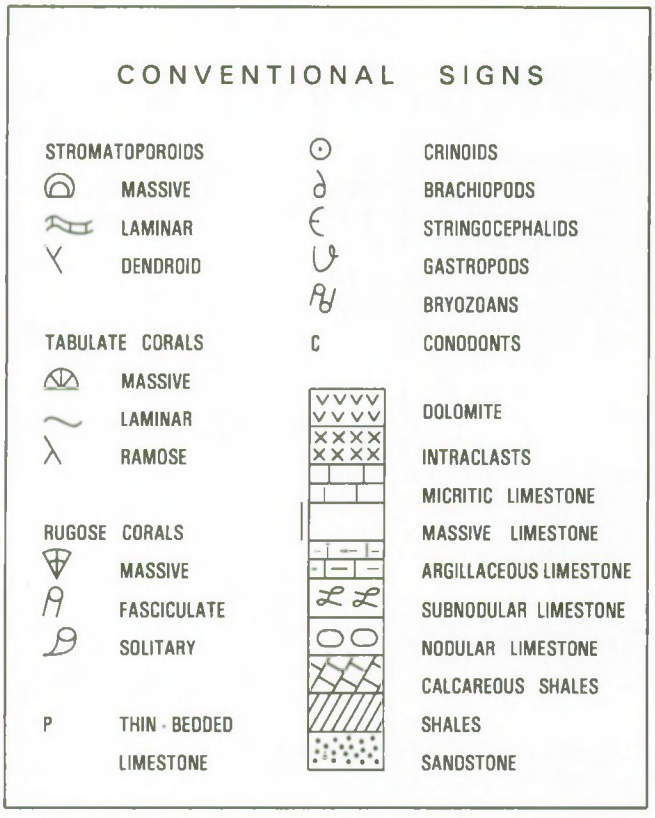

Fig. 4 — Explanation of conventional signs used in Figs. 3 and 6.

ROAD SECTION AT FROMELENNES (Agimont MC-1983-8; Fig. 3)

Fromelennes is a French locality lying 2.5 km to the southeast of Givet and is of course the stratotype of the Fromelennes Formation. It has been described among others by COEN & COEN-AUBERT (1971, p. 14), BULTYNCK *et al.* (1991, p. 61) and BULTYNCK & DEJONGHE (2002, p. 51). The material investigated in this work concerns only the transition between the Mont d'Haurs and Fromelennes Formations that crops out along the road from Fromelennes to Flohimont. This section corresponds to point 1 located on a map by BULTYNCK *et al.* (1991, p. 63).

At the top of the Mont d'Haurs Formation, there are 2.7 m of fine and dark limestones, locally subnodular or argillaceous in their lower part where various reef-building organisms occur: massive stromatoporoids, alveolitids, thamnoporids, scolioporids, caliaporids, auloporids and rugose corals represented by colonies of *Wapitiphyllum laxum* and fragmentary solitary coralla of *Temnophyllum delmeri*. In their upper part, these limestones become bioclastic and shelly first with brachiopods, then with gastropods. The Flohimont Member is represented at the base of the Fromelennes Formation by about 13 m of limestones, argillaceous in their lower part where there are several levels rich in brachiopods including cyrtospiriferids. A few corals are present throughout this sequence: massive, platy and ramose alveolitids, thamnoporids and solitary rugose corals represented by *T. delmeri* at the base.

The conodonts of this section have been revised by BULTYNCK *et al.* (2001, p. 30). According to these authors and to BULTYNCK & DEJONGHE (2002), the basal layers of the Fromelennes Formation belong to the *Polygnathus rhenanus/P. varcus* Zone corresponding to the upper part of the Lower *P. varcus* Zone whereas *P. ansatus* has been found about 9 m above the base of the Flohimont Member indicating the *P. ansatus* Zone which corresponds to the Middle *P. varcus* Zone.

In the area of Fromelennes and Givet, the upper part of the Flohimont Member is characterized by an alternation of argillaceous limestones and shales that is 16 m thick. The Moulin Boreux Member reaches a thickness of 82 m and consists of lagoonal limestones and biostromes with massive and dendroid stromatoporoids accompanied by scolioporids. The Fort Hulobiet Member is represented by 24 m of calcareous shales and shelly or more argillaceous limestones with several beds rich in *Disphyllum virgatum* in their upper part.

BEAURAING, AVE-ET-AUFFE AND FOCANT

The Mont d'Haurs Formation is exposed in the second quarry excavated to the south of Beauraing, along the road to Winenne (Beauraing MC-1975-3; Fig. 3). The fauna of its upper part, which is 92 m thick and which contains sparse to locally more numerous stromatoporoids and corals, has been investigated by COEN-AUBERT (1999, p. 29, figs. 3 and 5). *Argutastrea wangi* (TSIEN, 1978) occurs 43 m below the top of the Mont d'Haurs Formation whereas *Wapitiphyllum laxum* and *Sunophyllum beichuanense* are abundant in the last 11.5 m of the lithostratigraphic unit. Several coralla of *Temnophyllum delmeri* have also been collect just below the base of the Fromelennes Formation which is only represented in this outcrop by 1 m of argillaceous limestones with crinoids, atrypids and stringocephalids.

In the northern Les Limites quarry at Ave-et-Auffe (Wellin MC-1988-6), only one corallum of *T. delmeri* has been found 8 m below the end of the section described by COEN-AUBERT (1999, p. 27, figs. 2 and 3), close to the top of the Mont d'Haurs Formation which is also rich in colonies of *Wapitiphyllum laxum* and *Sunophyllum beichuanense*.

A few coralla of *Temnophyllum ramosum* have been observed between 3190 m and 3192 m in the bottom of the Focant borehole (Houyet 185W407) located in the Famenne depression. Indeed, the Fort Hulobiet and Moulin Boreux Members of the Fromelennes Formation have been intersected in this hole between 3071 m and 3208 m without reaching the Flohimont Member. According to BOULVAIN & COEN-AUBERT (1997, p. 49), the base of the Moulin Boreux Member is characterized by dark and often subnodular limestones which contain diverse fossils between 3187 m and 3196.5 m: stringocephalids, massive and dendroid stromatoporoids, thamnoporids, scolioporids caliaporids, fragments of *T. ramosum*, *Wapitiphyllum laxum* and *Sunophyllum beichuanense*. It needs also to be noted that the Fromelennes Formation has a very particular look in the borehole of Focant due to the occurrence of anhydrite pseudomorphs at different levels.

ROAD SECTION AT PHILIPPEVILLE (Senzeille MC-1974-139; Fig. 3)

In the Philippeville Massif, the upper part of the Mont d'Haurs Formation and the Fromelennes Formation have been investigated in detail by COEN (1978, p. 24) to the south of Philippeville, along the road Charleroi-Couvin and just to the south of the railway bridge. This section has also been figured by COEN-AUBERT (1977, fig. 1) and has been mentioned by COEN-AUBERT (1999, p. 31). *Argutastrea wangi* is present locally between 40 m and 48 m below the base of the Fromelennes Formation whereas *Wapitiphyllum laxum* is abundant in the topmost 8 m of the Mont d'Haurs Formation.

The Flohimont Member starts with 8 m of nodular limestones rich in brachiopods including cyrtospiriferids and in conodonts including *Icriodus eslaensis* and *I. latecarinatus*. It ends with 10 m of more or less argillaceous and dolomitic limestones containing brachiopods, tabular stromatoporoids, alveolitids, thamnoporids, auloporids and bryozoa. At the base of the Moulin Boreux Member, there are 14 m of limestones with various fossils represented by stringocephalids, gastropods, massive, tabular and dendroid stromatoporoids, thamnoporids, *Wapitiphyllum laxum* and solitary coralla of *Temnophyllum ramosum*. The rest of the Moulin Boreux Member is 46 m thick and is often dolomitic in its lower part; it is characterized by numerous levels with massive and dendroid stromatoporoids accompanied by scolioporids. The Fort Hulobiet Member is reduced to a thickness of 14 m and is not very well exposed.

RAILWAY SECTION AT ERQUELINNES (Merbes-le-Château MC-1974-132; Figs. 3 and 5)

In the western part from the north side of the Dinant Synclinorium, the railway section between Erquelinnes and Solre-sur-Sambre has been described previously by BEUGNIES *et al.* (1962, p. 207). The layers are dipping to the north and the outcrop investigated in the Fromelennes Formation starts to the north of the road bridge where the upper part of the Flohimont Member is characterized by 7.5 m of nodular or argillaceous limestones rich in crinoids and brachiopods including cyrtospiriferids and atrypids with a few corals: massive, platy and ramose alveolitids, thamnoporids and solitary coralla of *Temnophyllum delmeri*. At the base of the Moulin Boreux Member, there are 3.25 m of limestones still containing atrypids, but also a lot of reef-building organisms represented by massive and laminar stromatoporoids, massive and platy alveolitids, thamnoporids, scolioporids and *T. delmeri* associated with bryozoa. After 3 m of limestones poorly accessible, the section ends with a few beds of fine limestone and dolomite badly exposed.

DISUSED RAILWAY SECTION AT GERPINNES (Nalinnes MC-1975-2; Fig. 6)

The disused railway section of Gerpinnes has been recently located on a map and investigated by COEN-AUBERT (2000, p. 9, figs. 5 and 6) who described in detail the Névremont Formation. At the top of this lithostratigraphic unit, there are limestones with massive stromatoporoids capped by 11 m of nodular or argillaceous limestones. Then, the Le Roux Formation consists of:

- 12.5 m: shales becoming calcareous at the top.
- 5 m: fine and dark limestones locally argillaceous or dolomitic, containing crinoids and intraclasts.
- 5.5 m: fine and dark limestones locally dolomitic with a few minor shaly interbeds at the base; occurrence of solitary coralla of *Temnophyllum delmeri*, poorly developed colonies of *T. ramosum*, thamnoporids, scolioporids and stringocephalids.
- 12.2 m: fine dolomite with a few beds of fine limestone in the upper part.
- 8 m: fine and dark limestone locally dolomitic, interbedded with three levels rich in scolioporids, massive and dendroid stromatoporoids accompanied by a few solitary rugose corals.

After a gap of about 7.5 m crop out the shales of the Nismes Formation. The same succession has been observed by BULTYNCK *et al.* (1991, p. 78) at Biesme lying 5 km to the east of Gerpinnes where the total thickness of the Le Roux Formation is 40 m.

VESDRE MASSIF (Fig. 6)

In the Vesdre Massif, the transition between the Névremont and Le Roux Formations is well exposed at the locality Les Surdents situated to the east of Verviers and investigated by COEN & COEN-AUBERT (1971, p. 8) and COEN-AUBERT (1974, p. 70). At the outcrop Limbourg MC-1974-38 corresponding to point 6 of COEN-AUBERT (1974, fig. 17), the upper part of the Névremont Formation is represented by 16.5 m of dolomitic limestones containing bioclasts, stromatoporoids and corals including *Wapitiphyllum laxum* close to the base of this sequence. The Le Roux Formation starts with 4.5 m of fine sandstone locally dolomitic or calcareous. Then, there are about 8 m of limestones which are better exposed along the other side of the Vesdre river, at the outcrop Limbourg MC-1974-39 corresponding to point 7 of COEN-AUBERT (1974). These limestones are rich in stringocephalids, massive and dendroid stromatoporoids, alveolitids, scolioporids, caliaporids, *W. laxum*, *T. delmeri* and *T. ramosum*. After 0.2 m of shales, the rest of the Le Roux Formation is characterized in the area of Les Surdents by 34 m of fine dolomite interbedded in their lower part with two thin levels of limestone containing massive and dendroid stromatoporoids, scolioporids and a few solitary rugose corals.

One corallum of *T. ramosum* has been found at Membach lying about 10 km to the east of Verviers. This occurrence concerns the outcrop Limbourg MC-1974-25 corresponding to point 4 of COEN-AUBERT (1974, fig. 19) and showing the transition in the middle part of the Le Roux Formation, between the limestones with stringocephalids accompanied by diverse reef-building organisms and the fine dolomites. A complete succession of this lithostratigraphic unit has been intersected by the boreholes Membach 2 and 3 described by COEN-AUBERT *et al.* (1986). More especially, *Argutastrea wangi* has been observed in the upper part of the Névremont Formation drilled in the bottom of the borehole 2. In this drillhole, the Le Roux Formation starts with 5 m of shales overlain by 13.5 m of sandy dolomites. The succeeding 21.5 m of limestones contain stringocaphalids, massive and dendroid stromatoporoids, caliaporids, scolioporids and some colonies of *Wapitiphyllum laxum*. After 10 m of fine dolomite, the Le Roux Formation ends with 32 m of limestones with several dolomitic intercalations in their lower part. It should also be mentioned that the conodonts *Icriodus latecarinatus*, *I. eslaensis* and *Polygnatus pseudofoliatus* have been collected at the base of the Le Roux Formation, in the borehole Membach 3, by COEN-AUBERT *et al.* (1986, p. 31).

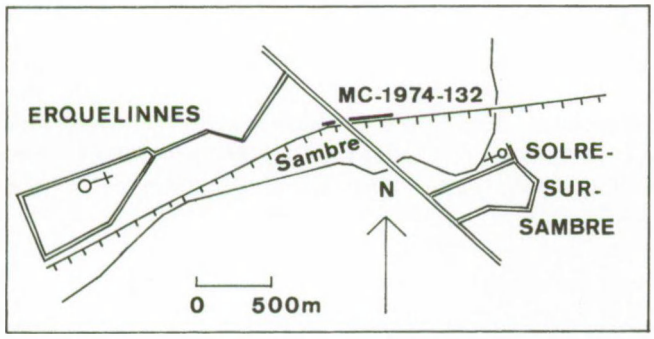

Fig. 5 — Location of the railway section at Erquelinnes.

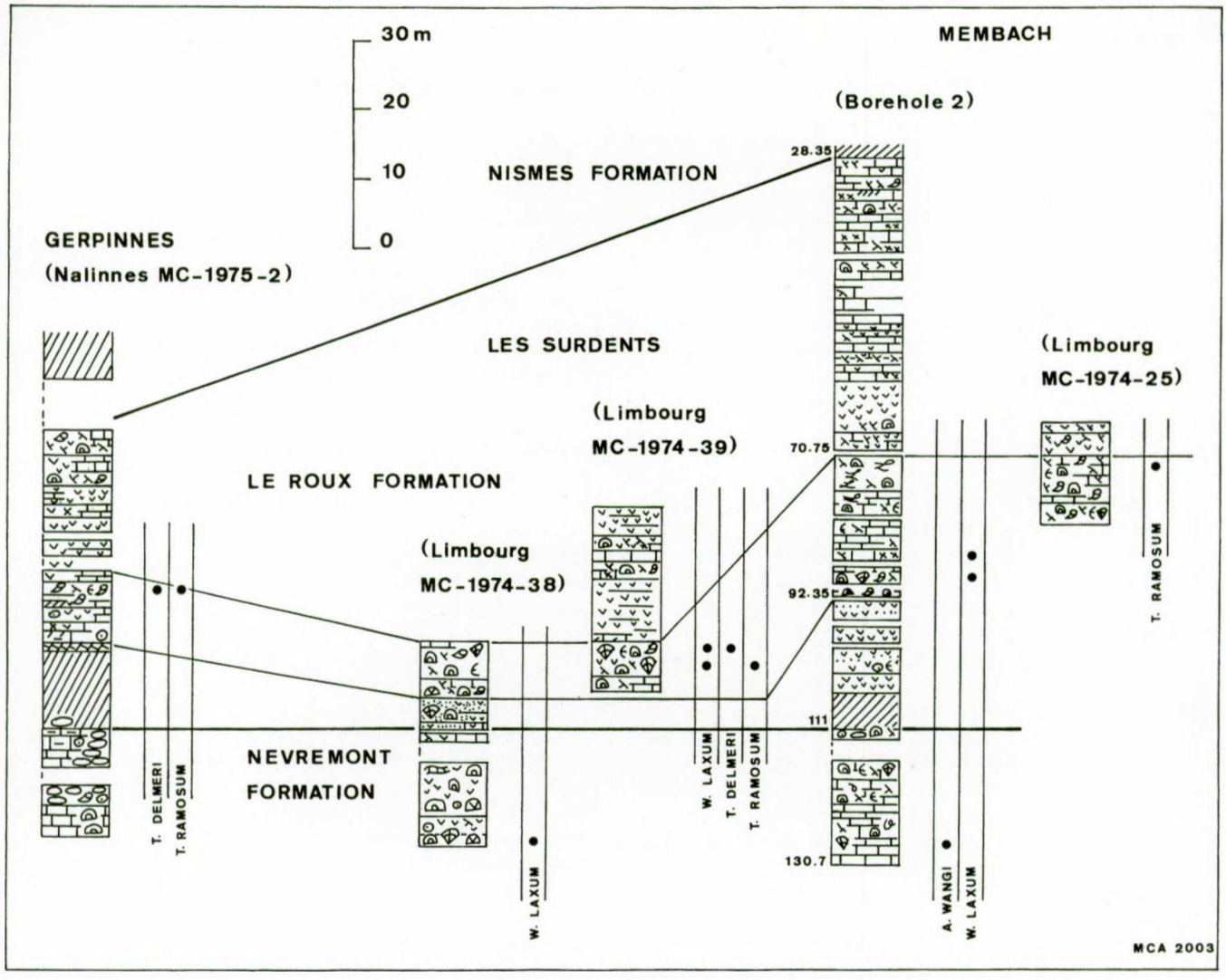

Fig. 6 — Comparative logs of the Le Roux Formation at Gerpinnes, Les Surdents and Membach with the distribution of the rugose corals. (For explanation of conventional signs, see Fig. 4).

Stratigraphic distribution of the rugose corals

On the south side of the Dinant Synclinorium and in the Philippeville Massif (Fig. 7), there are many similarities between the rugose coral fauna from the upper part of the Mont d'Haurs Formation and the base of the Fromelennes Formation. *Argutastrea wangi* is sparsely present in the Mont d'Haurs Formation, but does not reach its upper boundary. *Wapitiphyllum laxum* is particularly abundant close to the top of this lithostratigraphic unit where it is accompanied by *Sunophyllum beichuanense* and *Temnophyllum delmeri*. *T. delmeri* occurs also at the base of the argillaceous Flohimont Member of the Fromelennes Formation. In the lower part of the overlying Moulin Boreux Member, there are about 8 m to 14 m of limestones containing massive and dendroid stromatoporoids, various corals and the last stringocephalids of the Givetian stage in Belgium. The rugose corals are represented by *T. ramosum*, *T. delmeri* and *Wapitiphyllum laxum*. These massive colonies are frequent at Philippeville, but have also been observed in the Focant borehole, together with fragments of *Sunophyllum beichuanense* and at Glageon, to the west of Frasnes in France, where they have been mentioned by COEN-AUBERT (1999, p. 31). As for the tabulate corals from the base of the Moulin Boreux Member, they are highly diversified with numerous specimens of alveolitids, scolioporids, thamnoporids and caliaporids. This fauna has been partly investigated by COEN-AUBERT *et al.* (1986) and TOURNEUR (1989). Higher in the Moulin Boreux Member, the environment is more restricted and the biostromal beds are characterized by massive and dendroid stromatoporoids associated only with scolioporids and rare debris of solitary rugose corals. At the top of the Fort Hulobiet Member, there are argillaceous limestones with fasciculate colonies of *Disphyllum virgatum* accompanied by alveolitids and thamno-

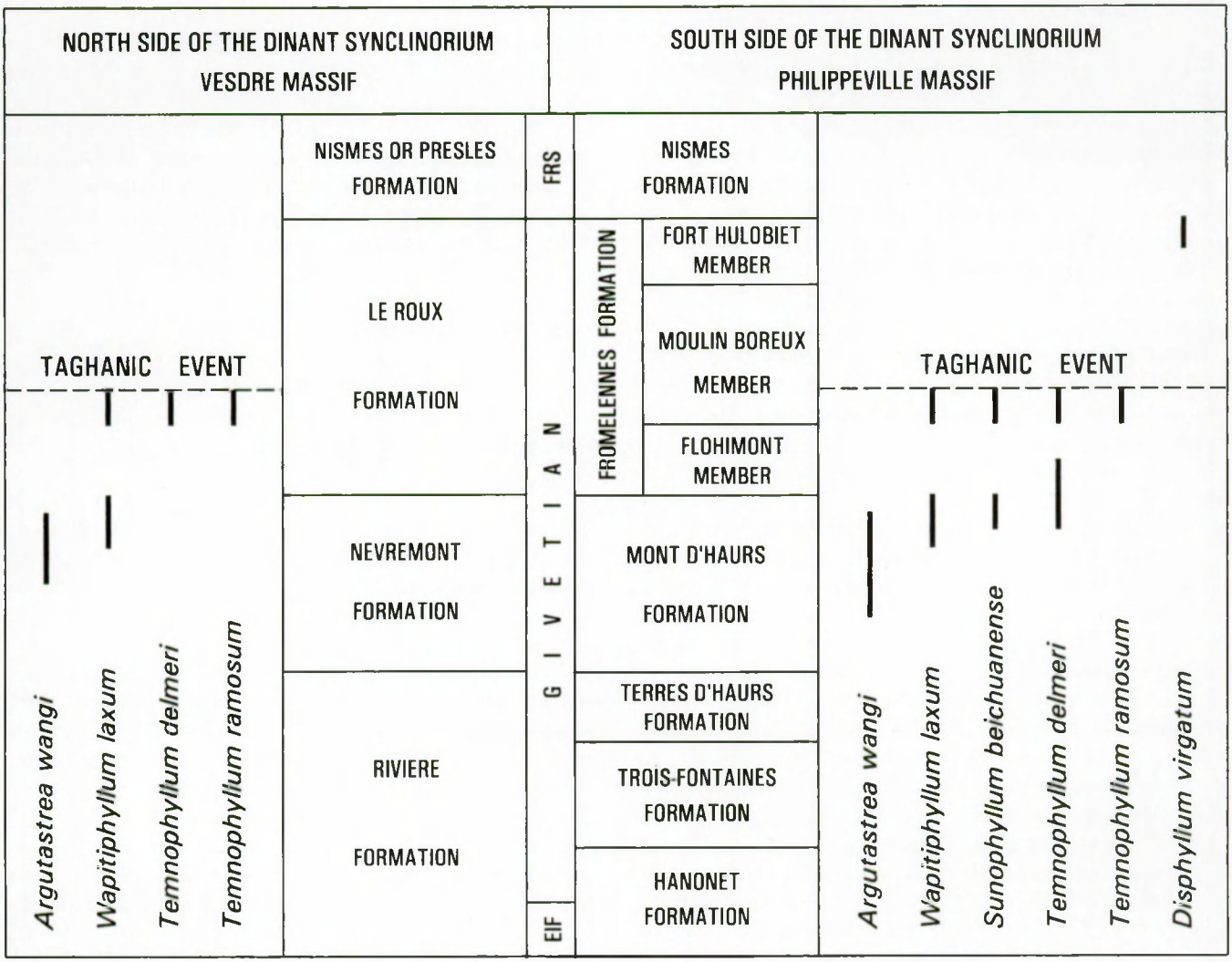

Fig. 7 — Stratigraphic distribution of the rugose corals investigated in the upper part of the Givetian on the south and north sides of the Dinant Synclinorium as well as in the Philippeville and Vesdre Massifs, with the possible occurrence of the Taghanic Event.

porids. These two group of tabulate corals as well as the disphyllids are again widespread in the Frasnian of Belgium.

The same situation occurs among the northern facies which are rather different. At Erquelinnes lying at the western end from the north side of the Dinant Synclinorium, the Givetian deposits are still more or less similar to those from the south side of the same synclinorium though the Fort Hulobiet Member is no more recognizable at the top of the stage. At Gerpinnes located 29 km to the northeast of Erquelinnes and in the Vesdre Massif, the Mont d'Haurs and Fromelennes Formations pass laterally into the Névremont and Le Roux Formations. *Argutastrea wangi* and *Wapitiphyllum laxum* occur in the upper part of the Névremont Formation. At the base of the Le Roux Formation, there are shales and sandstones locally dolomitic. These terrigenous sediments are overlain by a level of limestone which is rich in the Vesdre Massif in stringocephalids, the same various tabulate corals as at the base of the Moulin Boreux Member and rugose corals represented by *W. laxum*, *Temnophyllum ramosum* and *T. delmeri*. The latter two species have been found at Gerpinnes where this level of limestone is also developed. The rest of the Le Roux Formation consists of fine dolomites and limestones with a few biostromal beds where the reef-building organisms are mostly restricted to stromatoporoids and scolioporids.

The correlations between the Le Roux and Fromelennes Formations are confirmed by the occurrence of *Polygnathus pseudofoliatus*, *Icriodus latecarinatus* and *I. eslaensis* at the base of the first lithostratigraphic unit, in the boreholes of Membach. Indeed, these three species of conodonts are also present together at the base of the Fromelennes Formation, according to BULTYNCK *et al.* (2001, p. 32).

Occurrence of the Taghanic Event in Belgium

There is a continuity among the faunas of rugose and tabulate corals, at the transition between the Mont d'Haurs and Fromelennes Formations and the northern time-equivalent Névremont and Le Roux Formations, despite important changes of facies. Indeed, the base of the Fromelennes Formation corresponds to a significant transgression marked by the argillaceous sediments of the Flohimont Member which pass laterally into the shales and sandstones from the base of the Le Roux Formation, in a more littoral situation. This sea level rise has been mentioned among others by BULTYNCK & GOUWY (2002, p. 142). Above these terrigenous deposits, there are in all the sections investigated several metres of limestones with the last stringocephalids of Belgium as well as diverse rugose and tabulate corals which are for most of them already present in the upper part of the Mont d'Haurs Formation. Higher in the Moulin Boreux Member and in the Le Roux Formation, nearly all of them disappear. Indeed, the tabulate corals are reduced to the group of the scolioporids, even if they are abundant, and the rugose corals are only represented by rare fragments of solitary coralla which are difficult to collect and to identify. At the top of the Fromelennes Formation, the reappearance of disphyllids, alveolitids and thamnoporids announces the fauna of the Frasnian stage.

Of course, there is a sharp change of the environment above the level with the last stringocephalids. These restricted facies have been described in the Fromelennes Formation, by BOULVAIN & PREAT (1987) and PREAT & CARLIEZ (1996). But quite similar facies occur also in the Lower Givetian Trois-Fontaines Formation investigated among others by CASIER & PREAT (1991). However, there is no significant change in the distribution of the rugose and tabulate corals throughout the Trois-Fontaines Formation. For instance, COEN-AUBERT (2003) reported the abundance of *Argutastrea quadrigemina* (GOLDFUSS, 1826), *Pachyfavosites polymorphus* and *Hillaepora spicata* at the base of the open marine facies from the overlying Terres d'Haurs Formation, but these three species occur already rather low in the Trois-Fontaines Formation according to BULTYNCK *et al.* (1991, p. 56).

So it is quite possible that the Taghanic Event occurs in Belgium just above the level of limestones with the last stringocephalids. As the *Polygnathus ansatus* conodont Zone has been recognized by BULTYNCK *et al.* (2001), about 9 m above the base of the Flohimont Member at Fromelennes, BULTYNCK & GOUWY (2002) conclude that the Taghanic Onlap is most likely younger than the transgression observed at the base of the Fromelennes Formation. Unfortunately, there are nearly no conodonts in the Moulin Boreux Member, on the south side of the Dinant Synclinorium. It needs also to be mentioned that ABOUSSALAM & BECKER (2001) have documented a complex sequence of sedimentary events and faunal changes within an extended Givetian Taghanic Event Interval or Taghanic Biocrisis covering the *P. ansatus* and the overlying *P. semialternans* Zones. Therefore, regional factors may influence the precise timing of extinction in different groups of fossils. As for the rugose corals, SCRUTTON (1988, p. 76) and OLIVER (1990) have listed the various families and genera which became extinct during the Late Givetian, due to the Taghanic Event. More generally, it should be necessary to investigate more in detail the Belgian brachiopods, stromatoporoids and tabulate corals from the lower part of the Fromelennes and Le Roux Formations to validate the interpretation proposed herein.

Systematic Palaeontology

Family DISPHYLLIDAE HILL, 1939
Genus *Temnophyllum* WALTHER, 1929

= *Alaiophyllum* GORIANOV, 1961

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

DIAGNOSIS
Solitary to weakly fasciculate 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.

DISCUSSION
The type species of *Alaiophyllum* GORIANOV, 1961 is *A. jarushevskyi* GORIANOV, 1961 from the Givetian of Tien Shan in Kirghizistan. The type material of this taxon illustrated by GORIANOV, (1961, pl. 8) and PEDDER (1973, figs. 32, 33, pl. 11, figs. 1, 3, 5 and 6) shows among other data a wide peripheral stereozone where the septa are contiguous and whose coarse trabeculae lying more or less horizontally obscure most of the dissepimentarium. So it resembles *Temnophyllum latum* WALTHER, 1929, type species of *Temnophyllum* WALTHER, 1929 and *T. majus* WALTHER, 1929. Both species are from the Givetian of the Sauerland in Germany and have been revised recently by COEN-AUBERT (2002). According to GORIANOV (1961), *Alaiophyllum jarushevskyi* is weakly fasciculate, but this feature does not appear in his figures and the mode of budding was not described by the author as already noted by PEDDER (1973, p. 96).

Alaiophyllum was placed in synonymy with *Temnophyllum* by PICKETT (1967, p. 28). It was thought to be close to *Temnophyllum* or possibly its synonym by BIRENHEIDE (1978, p. 85), HILL (1981, p. F266) and

BIRENHEIDE & LIAO (1985, p. 239). And it was regarded as a subgenus of *Temnophyllum* by BIRENHEIDE (1998, p. 175). On the other hand, *Alaiophyllum* was retained by MCLEAN (1993, p. 115) though considered as a rare genus mainly represented by its type species. It was used by PEDDER (1963 and 1973) for two new species from the Givetian of the Northwest territories in Canada: *A. mackenziense* PEDDER, 1963 and *A. goryanovi* PEDDER, 1973. However, *A. mackenziense* was transferred to the genus *Grypophyllum* WEDEKIND, 1922 by PEDDER (1973, p. 107) and *Alaiophyllum goryanovi* to the genus *Chostophyllum* PEDDER, 1982 by PEDDER (1982, p. 570).

Several of the authors mentioned herein claim that another diagnostic character of *Alaiophyllum jarushevskyi* is the occurrence of a wide open space in the centre of the tabularium. But the holotype of *Pexiphyllum altum* WALTHER, 1929 from the Givetian-Frasnian boundary in the Sauerland, that was figured by BIRENHEIDE & LIAO (1985, pl. 7, fig. 39) and assigned to *Alaiophyllum*, has rather long major septa which may reach the axis of the corallum. Later, the same specimen reillustrated by LIAO (1996, pl. 1, fig. 4) was referred to *Temnophyllum*. Of course, it is quite possible that the length of the major septa has not much generic significance. Therefore, the type material of *Alaiophyllum jarushevskyi* as currently known needs some revision and precision to discuss further whether it is suitable to separate it from *Temnophyllum*.

Temnophyllum delmeri n. sp.

Plate 1, Figures 4-10, Plate 2, Figures 5-7

v 1974 *Temnophyllum* sp. – COEN-AUBERT, pl. 1, fig. 5.

Derivatio nominis

The species is dedicated to André DELMER, former Director of the Geological Survey of Belgium.

Holotype

IRScNB a11981 (= Pl. 1, Figs. 4, 5). Specimen Beauraing MC-1975-3-21 collected by COEN-AUBERT in 1975, at the top of the Mont d'Haurs Formation.

Locus typicus

Second quarry excavated to the south of Beauraing, along the road to Winenne and located in figure 5 of COEN-AUBERT (1999). Map sheet Beauraing IGNB 58/4, Lambert coordinates: x = 191.625 and y = 89.375, south side of the Dinant Synclinorium, Belgium.

Stratum typicum

Top of the Mont d'Haurs Formation, middle part of the Givetian.

Material and localities

Forty specimens with 58 thin sections. Personal sampling: Couvin MC-1980-5-Y94, Y95, Z44, Z45, Z512, B351 and B352; Couvin MC-80-D176 and D179; Agimont MC-1983-8-Z947, Z948, Z949, Z950, Z953 and Z966; Beauraing MC-1975-3-18, 19, 21, 22, 26, 27, and 27A; Wellin MC-1988-6-A760; Merbes-le-Château MC-1974-132-R20, R21, R22, R24, R34, A167, A172, A174, A175 and A177; Nalinnes MC-1975-2-5; Limbourg MC-1974-39-884. Old collection from the Institut royal des Sciences naturelles de Belgique: Senzeille 6848-Gid-12629; Surice 51e-Gi-5205, 5321, 5371 and 5444.

DIAGNOSIS

A species of *Temnophyllum* with 56 to 66 septa at a diameter of 12 mm to 21 mm. Narrow and incomplete stereozone developed within the dissepimentarium or sometimes against the outer wall. Minor septa long, occasionally discontinuous at their inner ends. Dissepiments often inclined towards the axis of the corallum.

DESCRIPTION

The material consists of conical, cylindrical, trochoid or ceratoid coralla which are frequently fragmentary and are occasionally eroded at the periphery. Their height varies between 1 cm and 6 cm. The outer wall is not often well preserved and is sometimes encrusted by thin laminar stromatoporoids or even by auloporids.

The septa are non-carinate or bear a few small spinose or knobbly carinae. They are dilated in the dissepimentarium and become more or less thinner in the tabularium or beyond their entry into it. In several cases, the septa remain rather thick in the tabularium or are dilated throughout their length. In rare coralla, they are locally thinner or even segmented at the periphery. Discontinuous rings of stereoplasma are present within the dissepimentarium; this deposit is normally weak and occasionally stronger. A stereoplasmic thickening occurs also locally against the outer wall; again, this peripheral stereozone is wider in a few specimens.

The major septa reach the axis of the corallum or leave an open space in the centre of the tabularium. Their inner ends may be rhopaloid or dilated with sometimes a deposit of stereoplasma, discontinuous, curved, forked or fusing to form pseudofossulae. In rare coralla, one longer septum intersects the centre of the tabularium. The minor septa traverse the entire dissepimentarium or even enter into the tabularium where they are occasionally contratingent. Sometimes, they are more or less short or discontinuous at their axial ends.

The dissepimentarium consists of 3 to 9 or even 2 to 11 rows of small inclined dissepiments which are often arranged in horizontal layers at the periphery. The dissepiments are locally obscured by some spots of coarse trabeculae. The tabulae are incomplete and intersecting laterally: their axial parts are horizontal or flat-topped in a few specimens.

There are 48 to 70 septa per corallum. The diameter of the corallum ranges from 9 mm to 30 mm. The width of the tabularium varies commonly between 7 mm and 12 mm and more generally between 6 mm and 13.5 mm.

DISCUSSION

There are many similarities between *Temnophyllum delmeri* and *T. wellinense* COEN-AUBERT, 2003 described

from the base of the Terres d'Haurs Formation, on the south side of the Dinant Synclinorium. However, the latter species is distinguished from the former:
- by somewhat smaller coralla with slightly fewer septa;
- by major septa leaving normally an extensive open space in the centre of the tabularium;
- by a narrower dissepimentarium;
- by an incomplete stereozone more often developed against the outer wall.

Another taxon very close to *T. delmeri* is *T. wangchengpoense* (YU & LIAO, 1974 *in* YU *et al.*, 1974) from the Frasnian of the Guizhou Province in China. It was assigned to the genus *Pseudozaphrentis* SUN, 1958 by YU & LIAO, (1974, p. 231) and revised by LIAO (1977, p. 45) and LIAO & BIRENHEIDE (1989, p. 89). However, it differs from *Temnophyllum delmeri* by septa rather thin at the periphery, by a wide open space in the centre of the tabularium and by minor septa sometimes shorter with herringbone dissepiments. *T. dushanense* (LIAO, 1977) associated with *T. wangchengpoense* and also referred to the genus *Pseudozaphrentis* by LIAO (1977, p. 46) is characterized by a narrower dissepimentarium.

Temnophyllum verum ROZKOWSKA, 1979 from the Frasnian of the Holy Cross Mountains in Poland resembles also *T. delmeri*, but unfortunately, its holotype is partially eroded at the periphery. Finally, some coralla recorded in the Givetian of the Northwest Territories in Canada and ascribed to *T. richardsoni* (MEEK, 1867) and *T. lenzi* PEDDER, 1972 by SMITH (1945, pl. 5, fig. 11) and PEDDER (1972, figs. 3 and 6) have some features in common with *T. delmeri*. However, their type specimens seem to be different: lack of peripheral stereozone in the crushed lectotype of *T. richardsoni* illustrated by PEDDER (1972, pl. 1, figs. 1, 3 and 6) and probably also in the small transverse section of the holotype of *T. lenzi* figured by LENZ (1961, pl. 3, fig. 6).

GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCE

The species is only known in the upper part of the Givetian from Belgium and Fromelennes in France. The material sampled by the author at Frasnes, Fromelennes, Beauraing and Ave-et-Auffe, on the south side of the Dinant Synclinorium comes from the top of the Mont d'Haurs Formation and the base of the Flohimont Member of the Fromelennes Formation. In the same area, a few coralla have been found at Petigny, at the base of the overlying Moulin Boreux Member. The species has also been collected at Erquelinnes and Gerpinnes, on the north side of the Dinant Synclinorium and at Les Surdents, in the Vesdre Massif. The first occurrence is from the lower part of the Fromelennes Formation whereas the two others belong to the lower part of the Le Roux Formation.

Temnophyllum ramosum n. sp.

Plate 1, Figures 1-3, Plate 2, Figures 1-4

Derivatio nominis

From *ramosus* (latin) = branching, referring to the weakly fasciculate look of the species.

Holotype

IRScNB a11988 (= Pl. 2, Figs. 1, 2). Specimen Couvin MC-1980-5-Z755 collected by COEN-AUBERT in 1981, at the base of the Moulin Boreux Member of the Fromelennes Formation.

Locus typicus

Neptune Caves (Couvin MC-1980-5; Fig. 2) located 1250 m to the southeast of Frasnes. Map sheet Couvin IGNB 57/8, Lambert coordinates: x = 160.35 and y = 83.825, south side of the Dinant Synclinorium, Belgium.

Stratum typicum

Base of the Moulin Boreux Member, Fromelennes Formation, upper part of the Givetian.

Material and localities

Twenty specimens with 25 thin sections. Personal sampling with that of COEN and GRAULICH: Couvin MC-1980-5-Z72, Z752, Z753, Z754 and Z755; Couvin MC-80-D172, D174, D175 and D176; Focant borehole Houyet 185W407 at 3190 m, 3191 m and 3192 m; Senzeille MC-1974-139-714A and 714C; Nalinnes MC-1975-2-5, 6 and 7; Limbourg MC-1974-25-F58; Limbourg MC-1974-39-T13. Old collection from the Institut royal des Sciences naturelles de Belgique: Surice 51c-F1-5468.

DIAGNOSIS

A solitary to weakly fasciculate species of *Temnophyllum* with 42 to 52 septa at a diameter of 7 mm to 16 mm. More or less complete stereozone developed against the outer wall. Minor septa traversing the entire dissepimentarium, occasionally slightly shorter. Dissepiments often inclined towards the axis of the corallites.

DESCRIPTION

The material consists of sections or fragments of cylindrical corallites whose height varies between 2 cm and 4 cm. Some corallites show longitudinal ribs, are grouped by two or three or form small fasciculate colonies; the largest piece reaches an area of 9 x 3 cm. Several colonial samples have corallites with 2 to 5 axial offsets. The outer wall is often preserved and may be encrusted by thin laminar stromatoporoids or even by algae. A dark median line is present when the corallites or the offsets are contiguous.

A more or less wide and continuous stereozone occurs normally against the outer wall; locally, there are also some stereoplasmic thickenings between the septa in the outer part of the dissepimentarium. Beyond the stereozone, the septa are non-carinate or bear a few small spinose or knobbly carinae in some specimens. They are dilated in the dissepimentarium and become thin in the tabularium or beyond their entry into it. Occasionally however, the septa remain rather thick in the tabularium or are dilated throughout their length.

The major septa reach the axis of the corallites or leave a small open space in the centre of the tabularium which

is more extensive in a few specimens. The inner ends of the major septa may be rhopaloid, curved, divided into isolated fragments or fusing to form pseudofossulae. The minor septa traverse the entire dissepimentarium or even enter in the tabularium where they are sometimes contratingent. Occasionally, they are more or less short or discontinuous, especially in the inner dissepimentarium.

The dissepimentarium consists of 2 to 6 or up to 8 rows of small inclined dissepiments which are rarely horizontal at the periphery. Its outer part is often obscured by stereoplasma. The tabulae are incomplete and intersecting laterally. Their axial parts are rather frequently flat-topped; they are horizontal or concave in very few corallites.

There are 38 to 56 septa per corallite. The diameter of the corallites ranges from 5 mm to 19 mm. The width of the tabularium varies commonly between 3.3 mm and 9 mm, but may reach 10 mm or 11 mm.

DISCUSSION

Temnophyllum ramosum is readily distinguished from *T. delmeri* by a strong peripheral stereozone and by fewer septa for a slightly smaller size. The same quantitative differences concern *T. imperfectum* COEN-AUBERT, 2002 described mainly from the lower part of the Mont d'Haurs Formation, on the south side of the Dinant Synclinorium. The latter species is also separated from *T. ramosum*:

- by a narrower and incomplete outer stereozone;
- by minor septa traversing systematically the entire dissepimentarium;
- by dissepiments arranged in horizontal layers at the periphery.

T. ramosum resembles *T.* sp. from the Upper Givetian of the Bergisches Land in Germany figured by BIRENHEIDE (1990, pl. 4, fig. 11). But, this corallum is cut at the level of the calice and shows some horizontal dissepiments close to the outer wall. The new species is also related to *T. (Alaiophyllum)* cf. *altum* investigated by BIRENHEIDE (1998, p. 175) in the Upper Givetian of the borehole Viersen 1001 near Krefeld although this German specimen is characterized by an incomplete stereozone and by more septa. On the other hand, the holotype of *Temnophyllum altum* is different as its peripheral stereozone invests nearly the entire dissepimentarium so that the minor septa project only locally beyond it. BIRENHEIDE (1998) compares also the material of Viersen with *T. waltheri* YOH, 1937 from the Givetian of the Guangxi Province in China, which is a complicated species. Indeed, its holotype as illustrated by YOH (1937, pl. 7, fig. 1) has several features in common with *T. ramosum* though it has a greater number of septa. As for the two paratypes from YOH (1937, pl. 7, figs. 2, 3), the first one probably belongs to the genus *Spinophyllum* WEDEKIND, 1922 as suggested by BIRENHEIDE & LIAO (1985, p. 243) whereas the second one is close to *Temnophyllum majus* according to COEN-AUBERT (2002, p. 13).

T. ramosum is rather strange as it is represented by isolated cylindrical corallites sometimes associated in a small cluster and by weakly fasciculate colonies. At the top of the Fromelennes Formation, in the Fort Hulobiet Member from the south side of the Dinant Synclinorium, there is a typically colonial species which is *Disphyllum virgatum*. The latter taxon has been investigated by TSIEN (1970, p. 166) and COEN-AUBERT (1989, p. 100) and is refigured herein (Pl. 2, figs. 8, 9). It differs from *Temnophyllum ramosum*:

- by smaller corallites with slightly fewer septa;
- by stereoplasmic thickenings present within the dissepimentarium;
- by a narrower dissepimentarium with mostly horizontal layers of dissepiments.

Normally, the species referred to the genus *Disphyllum* DE FROMENTEL, 1861 are not characterized by a well developed stereozone against the outer wall. Such peripheral thickenings occur in *Temnophyllum imperfectum*, *T. majus* and *T. latum* which are very close to *T. ramosum*, especially in transverse sections. They are also present in the fasciculate genus *Lyrielasma* HILL, 1939 whose type species is *L. chapmani* PEDDER, 1967 from the Pragian of Victoria in Australia. But *Lyrielasma* is a ptenophyllid with elongate dissepiments which are very different from the small and often inclined dissepiments of *T. ramosum*.

GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCE

The species is only known in the upper part of the Givetian from Belgium. The material sampled by the author at Frasnes, Petigny and Focant, on the south side of the Dinant Synclinorium and at Philippeville, in the Philippeville Massif comes from the base of the Moulin Boreux Member of the Fromelennes Formation. Some specimens have also been collected in the lower part of the Le Roux Formation at Gerpinnes, on the north side of the Dinant Synclinorium and at Les Surdents and Membach, in the Vesdre Massif.

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Explanation of Plates

All specimens are figured at magnification x 3.

PLATE 1

Temnophyllum ramosum n. sp.

Figs. 1-3 — Paratype. IRScNB a11989. Couvin MC-80-D172. Transverse and longitudinal sections.

Temnophyllum delmeri n. sp.

Figs. 4, 5 — Holotype. IRScNB a11981. Beauraing MC-1975-3-21. Transverse and longitudinal sections.
Figs. 6, 7 — Paratype. IRScNB a11982. Beauraing MC-1975-3-18. Transverse and longitudinal sections.
Figs. 8, 9 — Paratype. IRScNB a11983. Merbes-le Château MC-1974-132-A175. Transverse and longitudinal sections.
Fig. 10 — Paratype. IRScNB a11984. Agimont MC-1983-8-Z966. Transverse section.

PLATE 2

Temnophyllum ramosum n. sp.

Figs. 1, 2 — Holotype. IRScNB a11988. Couvin MC-1980-5-Z755. Transverse and longitudinal sections.
Fig. 3 — Paratype. IRScNB a11990. Senzeille MC-1974-139-714C. Transverse section.
Fig. 4 — Paratype. IRScNB a11991. Focant borehole Houyet 185W407 at 3191 m. Transverse section.

Temnophyllum delmeri n. sp.

Fig. 5 — Paratype. IRScNB a11985. Merbes-le Château MC-1974-132-A174. Transverse section.
Fig. 6 — Paratype. IRScNB a11986. Couvin MC-1980-5-B351. Transverse section.
Fig. 7 — Paratype. IRScNB a11987. Agimont MC-1983-8-Z947. Transverse section.

Disphyllum virgatum (HINDE, 1890)

Figs. 8, 9 — IRScNB a11992. Olloy-sur-Viroin MC-1984-2-A210. Transverse and longitudinal sections.

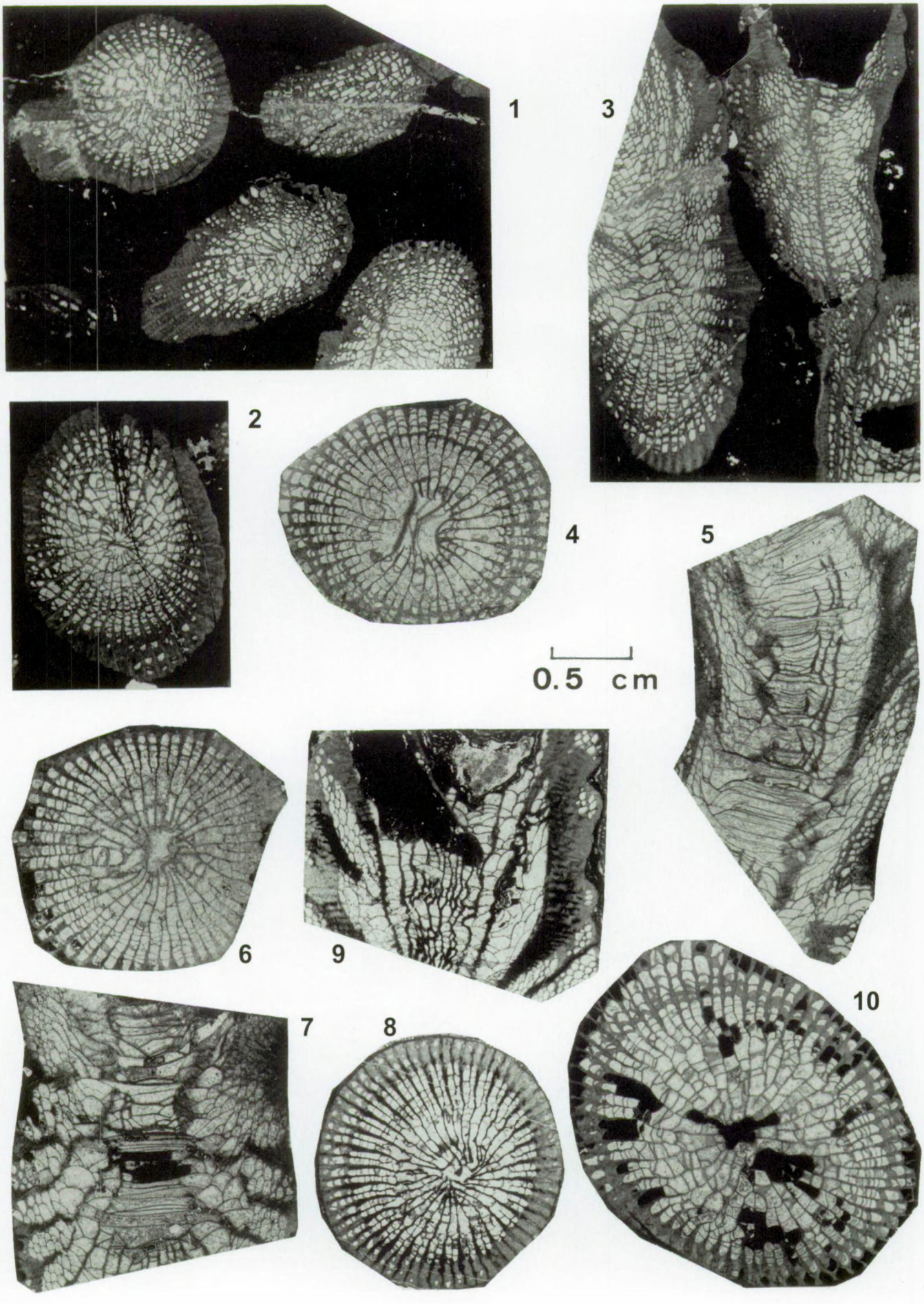

PLATE 1

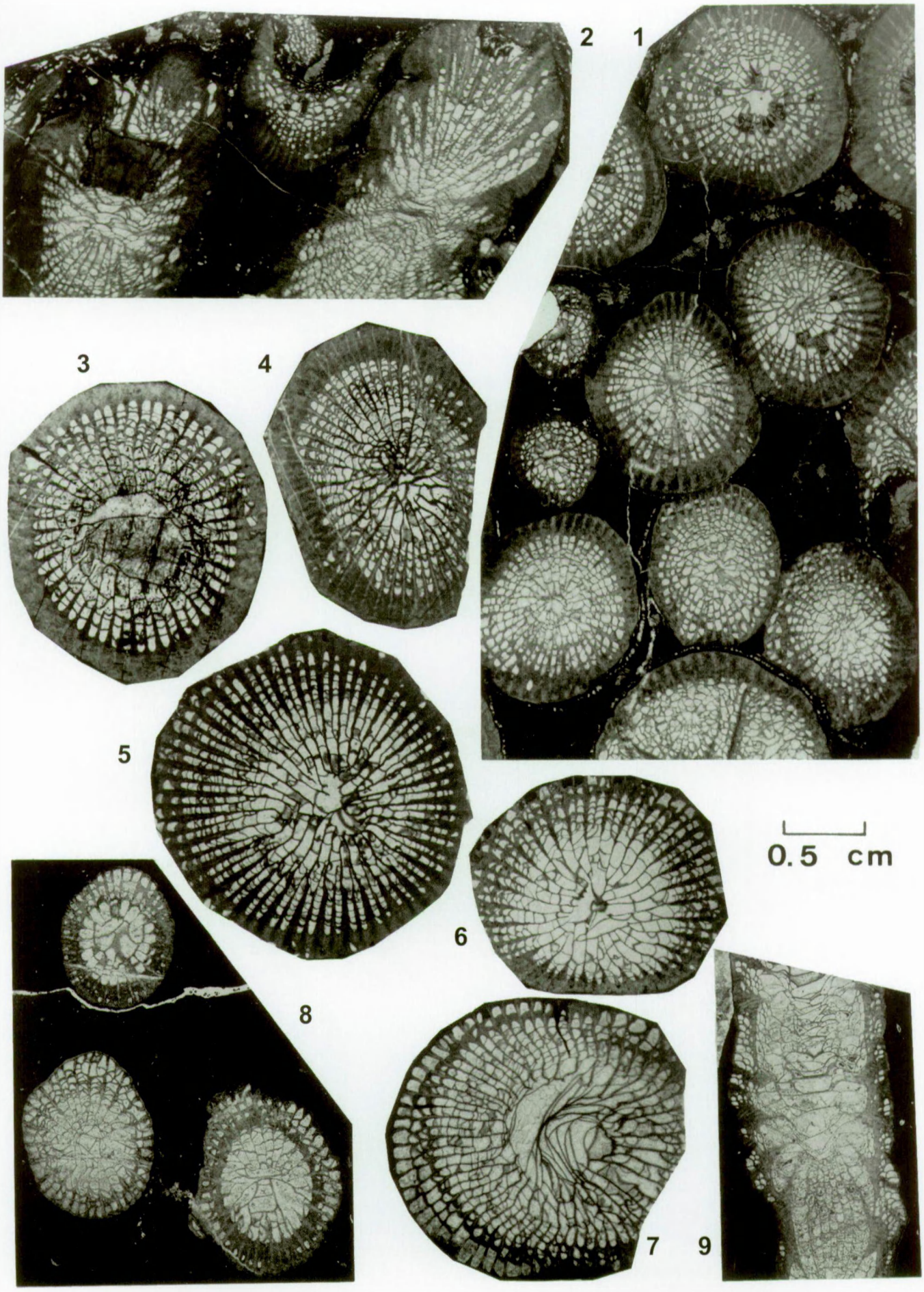

PLATE 2