Stromatoporoids from the latest reefal episode in the Devonian (late Frasnian) of the Cantabrian Mountains (NW Spain)

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Abstract: In the Palaeozoic series of the Cantabrian Mountains, reefal carbonates occur first in the Devonian of the Asturian-Leonese Domain. In this period seven reefal episodes of different importance, starting from the Early Devonian to the Late Devonian were developed. The latest of these Devonian reefal episodes is very local and took place in the late Frasnian during deposition of the Crémenes Limestone.

About 80 stromatoporoid samples were collected from three sections located on the southern slope of the Cantabrian Mountains, where only a few species occur. The specimens here described are assigned to *Stictostroma saginatum*, *Stictostroma*? sp., *Clathrocoilona spissa*, *Clathrocoilona* cf. *inconstans*, *Clathrocoilona* sp. and *Stachyodes australe*. None of these species had previously been reported from the Cantabrian Mountains. Most stromatoporoids show laminar growth forms, in some cases with well-developed mamelons. This type of morphology is possibly a response to palaeoenvironmental conditions. Numerous associations with other organisms such as bryozoans (fistuliporids), algae (*Sphaerocodium* sp.), laminar tabulates (alveolitids) and worms (*Spirorbis* sp.) are present.

Finally, the stromatoporoids of the Crémenes Limestone are compared with other stromatoporoid faunas from reefal levels of similar age from the Boulonnais (northern France), Namur and Dinant Synclinoria in the Ardennes (Belgiun), and Kerman and Esfahan areas (Iran) showing four common species (*S. saginatum*, *C. spissa*, *C. inconstans* and *S. australe*).

Key words: Stromatoporoids, systematic remarks, reefal deposits, Crémenes Limestone, late Frasnian, Cantabrian Mountains

Contents

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1. INTRODUCTION

In the Iberian Massif, LOTZE (1945) and JULIVERT et al. (1972) have distinguished several zones with characteristic stratigraphical, structural and palaeogeographical features. One of these zones, the Cantabrian Zone (Fig. 1A), is found in the northeast of the Iberian Massif, which represents the westernmost part of the European Hercynian belt.

In the Cantabrian Zone the Devonian is widely represented, and has been divided stratigraphically into two different facies domains (Fig. 1A): the Asturian-Leonese Domain and the Palentine Domain (BROUWER, 1964). In this Zone reefal carbonates occur first in the Devonian and are well developed in the Asturian-Leonese Domain. In this Domain a succession of alternating terrigenous and carbonate sediments with varied reefal development was deposited on a shallow marine platform. In some of these carbonate units important reefal deposits are found. The type of fauna and the occurrence of carbonate facies, including reefal ones, indicate tropical latitudes in the Cantabrian Zone during the Devonian. Due to the episodic input of terrigenous sediments the reefal growth was periodically inhibited. This change of sedimentary regime determined the development of up to seven reefal episodes of different importance (Fig. 2) starting from the Early Devonian (Pragian) to the Late Devonian (late Frasnian). The most widespread reef facies occurred at the end of the Early Devonian (late Emsian) and Middle Devonian (Givetian), although some reefal episodes of minor importance were developed at slightly older and younger stratigraphic levels (MÉNDEZ-BEDIA et al., 1994). Stromatoporoids and tabulate and rugose corals were the most prominent members of the reef community.

This work focuses on the latest reefal phase, which took place during the Late Devonian (late Frasnian) within the Nocedo Formation (upper Givetian-Frasnian, southern slope of the Cantabrian Zone). Studies of the distribution of stromatoporoids in upper Frasnian rocks (ZUKALOVA, 1971; KAZMIERCZAK, 1971; STEARN, 1975, 1987; COCKBAIN, 1989; MISTIAEN, 1994, 2002; among others) indicate that the diversity of the stromatoporoids had declined by this time. The aim of this work is to describe this low diversity assemblage of stromatoporoids occurring in deposits, below the Frasnian/Famennian boundary, and to explore the significance of the cosmopolitan character of this fauna. Moreover, some systematic issues are highlighted and outstanding features concerning the growth morphology of these builders are made in relation to their palaeoecology.

For this purpose about 80 specimens of stromatoporoids were collected from several sections on the southern slope of the Cantabrian Mountains.

2. GEOGRAPHIC AND STRATIGRAPHIC SETTING

The latest Devonian reefal episode known in the Cantabrian Zone has a local character and crops out in the southern part of this Zone, restricted to the Esla Nappe of the Fold and Nappe Province (Fig. 1A, B). This reefal episode consists of both reefal and biostro-

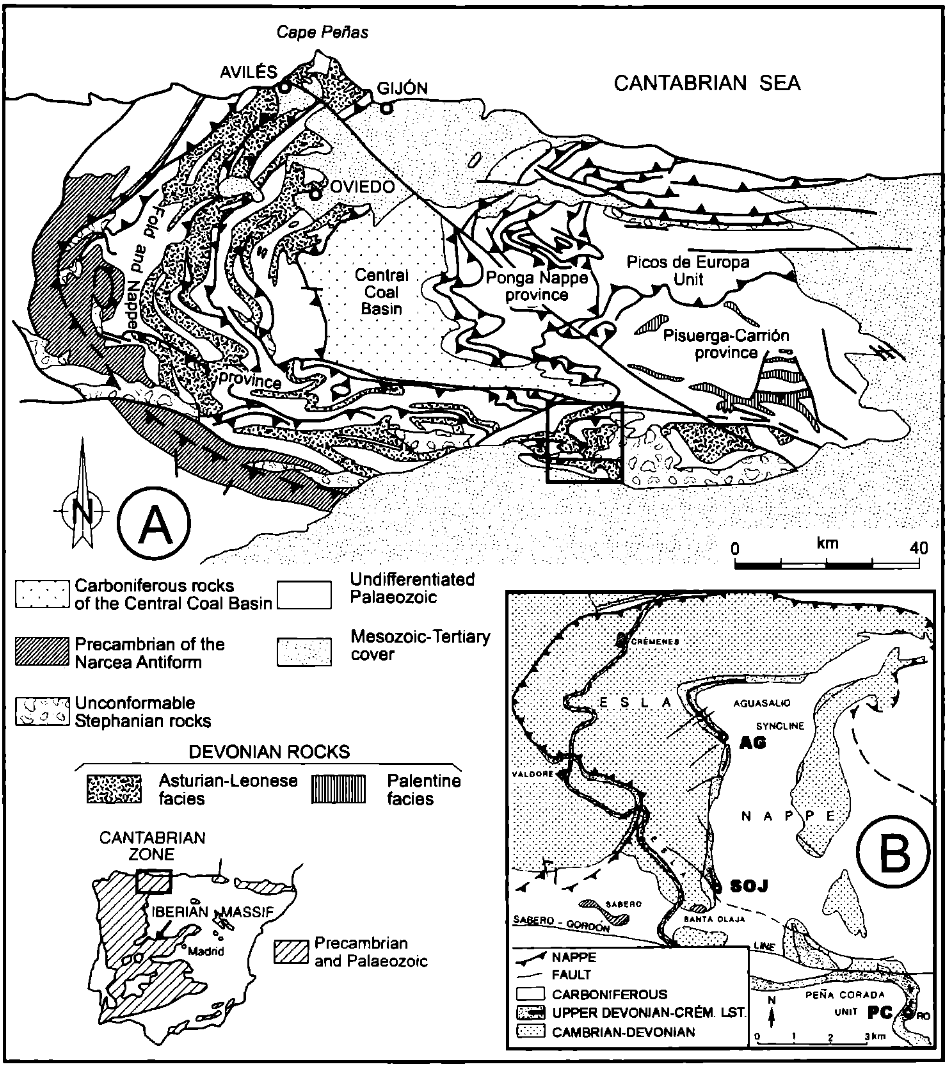


Fig. 1: (A) Geological sketch map of the Cantabrian Zone showing the distribution of Devonian outcrops with Asturian-Leonese and Palentine facies and the location of the studied area (sources: Brouwer, 1967; García-López, 2002; Julivert et al., 1983).
(B) Outcrop map of the studied area and position of the sections (from Loevezijn et al., 1986).

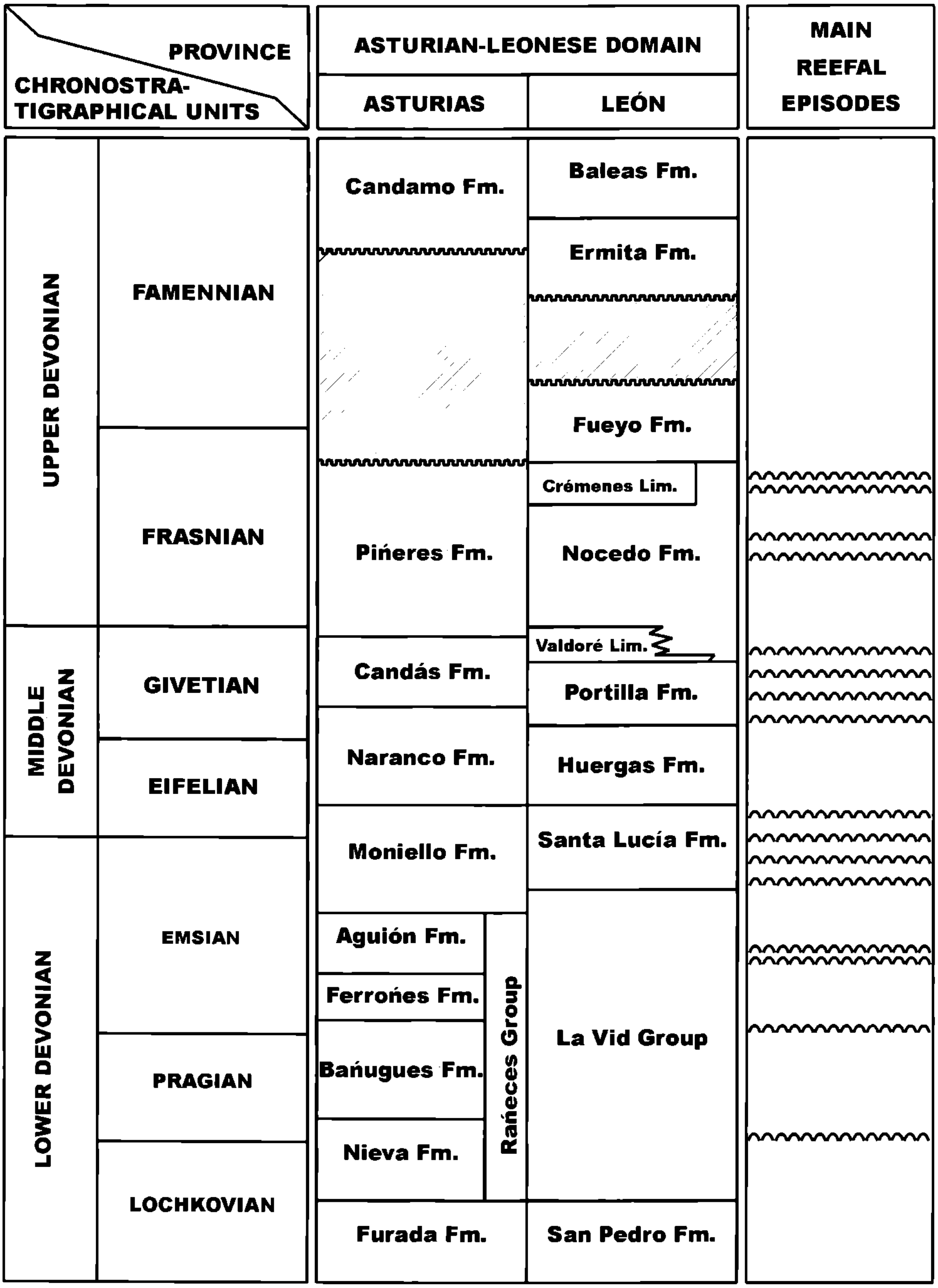


Fig. 2: Devonian lithostratigraphic units of the Cantabrian Zone and main reefal episodes (modified from Fernández et al., 1997).

mal deposits and occurs within the Crémenes Limestone (Westbroek, 1964), a 15–20 m thick calcareous unit (Fig. 2) that lies in the upper part of the siliciclastic Nocedo Formation (upper Givetian-Frasnian). The Crémenes Limestone is made of stromatoporoid-coral boundstones, nodular argillaceous limestones and bioclastic grainstones, packstones, wackestones and mudstones. It yielded a rich fauna of different organisms such as tabulate and rugose corals (*Hexagonaria* among others), stromatoporoids, receptaculitids, brachiopods, bryozoans, trilobites (asteropygids), ostracods, crinoids, homoctenids, gastropods, bivalves, serpulids and conodonts.

In the valley of the River Esla (León province), three sections with levels yielding the stromatoporoids under study were selected (Fig. 1B). These levels, at outcrop scale, have to be considered as biostromes due to the absence of a significant relief. From north to south, these sections are: Aguasalio syncline (AG), Santa Olaja de la Varga (SOJ) and the eastern part of the Peña Corada unit (PC).

The age of the Crémenes Limestone was a matter of confusion (Westbroek, op. cit.; Loevezijn, 1986, 1989; Loevezijn et al., 1986) and assigned both to the late Frasnian or early Famennian. This was due to the fact that conodonts are neither abundant nor characteristic elements, and the brachiopod identification was mistaken or imprecise. The lower part of the limestone was assigned by Loevezijn et al. (op. cit.) to the Lower and Middle *P. triangularis* Zones, early Famennian in age, mainly based on the occurrence of the tentaculite *Homoctenus ultimus ultimus* and the brachiopod *Cyrtiopsis sencelia*. Later on Loevezijn (1989) assigned the Crémenes Limestone, without new faunal data, to the Upper to Uppermost *Ancyrognathus gigas* Zone or even to the *A. gigas* to *P. triangularis* Zones. In this formation, according to García-Alcalde (1996, 1998), above the main interval containing reefal fauna, abundant and different brachiopods are found; the same fauna is recognized in other localities, even in the northern side of the Cantabrian Zone (Asturias province), however the terrigenous supply inhibited the reefal growth in those localities. The brachiopod association present in the Crémenes Limestone indicates a Frasnian age, taking into account the abundance of atrypids and douvellinids. Although the occurrence in this association of elements shows Famennian affinities, the majority of brachiopod fauna points to a late Frasnian age. Following this point of view, the Crémenes Limestone would not be higher than *Palmatolepis hassi* or *P. jamieae Zones* on the basis of the brachiopods.

According to Loevezijn et al. (1986) and within a general transgressive sequence, the Crémenes Limestone was developed at the platform edge with relatively high-energy water and well oxygenated bottom conditions. The reefal and biotromal intervals, formed over crinoidal deposits as a stabilized substratum, consist, from base to top, of mainly laminar stromatoporoid and coral boundstone with low content of argillaceous material and argillaceous nodular boundstone in which laminar stromatoporoids and branching corals (rugose and tabulate) are the dominant organisms.

3. LOCATION OF THE STROMATOPOROID SAMPLES

In the studied sections, two parts can be distinguished in the Crémenes Limestone. The lower part, which is between 7 and, at least, 17 m thick in the Santa Olaja de la Varga section due to tectonic deformation, consists of several thin biostromal intervals (from

0.5 to 3.5 m thick). The upper part is about 6–15 m thick and is made of cross-bedded bioclastic grainstones. The biostromal intervals of the lower part consist mostly of branching coral bafflestones and laminar stromatoporoid and tabulate coral bindstones.

In the Aguasalio syncline, 21 samples from the lower part of the section were studied. Most of them were collected from a biostromal level made of alveolitid and laminar stromatoporoid bindstone with a wackestone matrix. This biostromal layer (about 3.5 m thick) is overlain by the cross-bedded skeletal grainstone unit (15 m thick).

In the Peña Corada section, there are several levels yielding stromatoporoids from where nine samples were collected. The beds with more abundant stromatoporoids are directly overlain by the grainstones of the 6-m-thick upper part of the Crémenes Limestone. The biostromal levels consist of alveolitid and stromatoporoid bindstones, rarely framestones, from 1.8 to 0.5 m thick, with a wackestone-packstone matrix. In general, and from a sedimentological point of view, this is the succession with the highest mud content.

In the Santa Olaja de la Varga section, 42 samples were collected from all the biostromal levels of the lower part of the Crémenes Limestone. The stromatoporoid-bearing levels are mostly made of alveolitid-laminar stromatoporoid bindstones and branching tabulate and rugose coral bafflestones. The occurrence of cycles consisting of thamnoporid bafflestones changing upwards into laminar stromatoporoid bindstones is common. Towards the top of the section a few stromatoporoid and alveolitid framestones are found.

4. MAJOR FEATURES OF THE STROMATOPOROID FAUNA

The most common growth form of the stromatoporoids building the biostromal deposits in the Crémenes Limestone is laminar, commonly very thin (usually 1 cm, but ranging from 1 mm to 4 cm thick), very often showing well-developed mamelons. A few tabular growth shapes occur. In many cases, several laminar skeletons are intergrown and interbedded with sediment layers. This laminar morphology can be related to a not very favorable environment for the stromatoporoid growth, since sediment in which the stromatoporoids occur is mud-rich suggesting a muddy water environment. This type of growth form is also common in other stromatoporoids collected in the Boulonnais (northern France), the Ardennes (Belgium), and Kerman and Esfahan provinces (eastern and central Iran respectively).

Numerous associations with other organisms such as bryozoans (fistuliporids), algae (*Sphaerocodium* sp., *Girvanella* sp.), laminar tabulates (alveolitids) and worms (*Spirorbis* sp.) are present. These encrusting and boring organisms used stromatoporoid upper and lower surfaces as hard substrates. The relationship between these organisms will be the aim of a future work.

This is a preliminary study of the species identified in the Crémenes Limestone, thus only the most outstanding features that differentiate them are indicated. The following species have been identified: *Stictostroma saginatum* (Lecompte, 1951), *Stictostroma*? sp., *Clathrocoilona spissa* (Lecompte, 1951), *C.* cf. *inconstans* Stearn, 1962, *Clathrocoilona* sp. and *Stachyodes australe* (Wray, 1967).

Stictostroma saginatum (LECOMPTE, 1951)
(Pl. 1, Figs. 1–5)

Material: 19 specimens (12 from the Aguasalio syncline, 4 from the Peña Corada unit and 3 from Santa Olaja de la Varga).

All of them are of very small laminar shapes, generally only a few mm thick. The thickest is 15 mm high. Some are slightly undulated, but others present some more accentuated undulations with well-developed mamelons (3 to 4 mm wide, 2 mm high). In many cases, several laminar specimens are anastomosed and interbedded with sediment layers, or intergrown with other thin stromatoporoids (the same or other species), tabulate corals, bryozoans and algae layers (*Sphaerocodium* sp. or *Girvanella* sp.). Some skeletons show other boring or fixed organisms such as worms (*Spirorbis* sp.). In some cases, amygdaloid-shaped sparite areas (one to several cm large and a few mm up to 10 mm high) with geopetal structure occur. In some other specimens several laminar sheets can be irregularly superposed with sediment between the layers, presenting a massive-like shape.

By thickness, shape and density of laminae (15 to 30 in 5 mm, mean 20–25) and pillars (14 to 25 in 5 mm, mean 18 to 20), the specimens correspond closely to *Stictostroma saginatum* (LECOMPTE, 1951), but astrorhizal canals (300 to 450 µm large) are a little less developed. As emphasized by LECOMPTE (1951), this species shows large skeletal variation. The microstructure is characterized by the presence of some dark (or light) microlaminae and in some places ordinicellular microstructure is visible. Some specimens, especially one from the Peña Corada unit with large geopetal structure and superposed laminar sheets, are similar to some forms of *Stictostroma saginatum* present at the top of some mud-mounds ("récifs de marbre rouge") in the Ardennes.

LECOMPTE's type material of *Stictostroma saginatum* comes from the upper Frasnian ("Assise de Frasnes") in the Dinant Synclinorium, Belgium. The species has also been reported from other Frasnian localities (Fig. 3a, b).

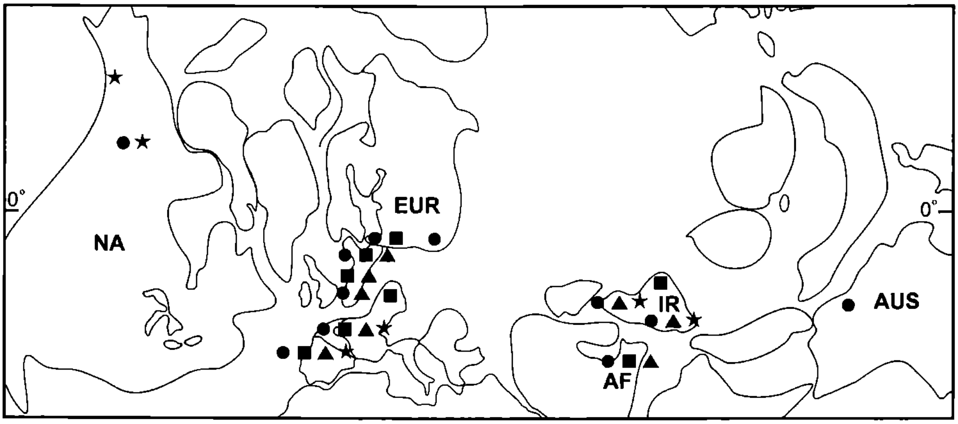
Stictostroma? sp.
(Pl. 1, Figs. 6–9)

Material: 29 specimens (4 from the Peña Corada unit and 25 from Santa Olaja de la Varga).

Specimens are generally laminar and several mm thick but the thickest can reach up to 5 or 6 cm. Some specimens are associated with fistuliporid bryozoans or alveolitid tabulate corals. Laminae are slightly or largely undulated, in relation to the well-developed astrorhizal canals.

The most typical specimens present a regular or slightly undulated skeletal structure with well-differentiated laminae and pillars, but in others undulations can be more developed. Laminae are 14 to 28 in 5 mm (mean 18 to 20) and about 50 to 100 µm thick. In relatively well preserved specimens, a microlamina is seen and in many cases located at the top of laminae. Pillars, 120 to 150 µm thick, are typically thicker or branched (Y-shaped) at the top. There are between 14 and 23 pillars in 5 mm (mean 17 to 20). Dissepiments are numerous and typically related to the astrorhizae, which can be well-developed. Some astrorhizal canals are 350–400 µm large, but in many cases can reach up to 600–750 µm. In tangential section structure is in some places punctuated but more often vermiform or meandriform due to the branched pillar structure.

This species seems closely related to *Stictostroma saginatum* (LECOMPTE, 1951) with a similar density of vertical elements and well-developed astrorhizae. But other important features are sufficient to separate both species such as: laminae a little less numerous with microlamina at the top and well-developed dissepiments. However, it is doubtful



● *Stachyodes australe* ▲ *Stictostroma saginatum*

■ *Clathrocoilona spissa* ★ *Clathrocoilona inconstans*

Fig. 3a: Distribution of the stromatoporoid species present in the Crémenes Limestone during the Frasnian. Palaeogeographic map modified after SCOTESE & MCKERROW (1990) (NA= North America, EUR= Europe, IR= Iran, AF= Afghanistan, AUS= Australia).

LOCALITY / SPECIES	France Boulonnais	France Avesnois	Belgium Namur	Belgium Dinant	Germany Sauerland	Poland Holy Cross Mountains	Czech Republic Moravia	Afghanistan Central Montains	Iran Kerman	Iran Chariseh	Iran Kal-e Sardar	Canada Alberta	Canada Northwest Territories	Australia Canning Basin
Stachyodes australe	●	●		●	●	●		●	●	●		●		●
Clathrocoilona spissa	●		●	●	●	?	●	●			●			?
Stictostroma saginatum	●	●	●	●				●	●	●				
Clathrocoilona inconstans	●								●	●		●	●	

Fig. 3b: Geographical location chart.

about the assignment with the genus *Stictostroma* referring to the branched pillars; probably this species corresponds to a new genus.

Clathrocoilona spissa (LECOMPTE, 1951)
(Pl. 2, Figs. 1–2)

Material: 5 specimens (2 from the Aguasalio syncline and 3 from Santa Olaja de la Varga).

All the skeletons are laminar-shaped, 2 to 7 mm thick. The structure is very dense with well-defined rounded galleries about 150–180 µm high; vertical and horizontal elements can be 250–300 µm in thickness. Only at the top of the latilaminae, the skeletal elements are discernable with numerous (25 in 5 mm) and very thin (60 µm) pillars. In tangential section features are variable, locally the tissue is very dense with only some rounded voids 120–250 µm large, some other larger elongated voids (300 µm or more in diameter) correspond to sections of astrorhizal canals. In some other places the structure is punctuated. The microstructure is flocculent to melanospheric in some places.

The type material of *Clathrocoilona spissa* (LECOMPTE, 1951) comes from the Givetian of the Dinant Synclinorium, Belgium. It is a typical cosmopolitan Givetian-Frasnian species (Fig. 3a, b).

Clathrocoilona cf. *inconstans* STEARN, 1962
(Pl. 2, Figs. 5–6)

Material: 3 specimens (2 from the Aguasalio syncline and 1 from Santa Olaja de la Varga).

One specimen is a very small fragment and the other two are laminar-shaped, encrusting other laminar stromatoporoids. They are up to 1 cm thick and constituted by several latilaminae (0.6 to 1.8 mm thick) with intercalations of some algal layers (*Sphaerocodium* sp.). Pillars are irregular but the most prominent skeletal elements, of variable thickness (120 to 350–400 µm), in some places very distinct, 3 to 4 in 1 mm. At the top of latilaminae, they are in some places very small and numerous (up to 6 in 1 mm). Laminae are thick (120–180 µm) and 3 or 4 in 2 mm, but generally obscure and in many places reduced to some irregular junctions between pillars. The microstructure appears compact to flocculent.

These specimens are similar to *C. inconstans* STEARN, 1962. The very thin specimens found here do not show such large variations as in the type material.

The type material of *Clathrocoilona inconstans* comes from the probable lower part of the Frasnian of Alberta (Canada). In other countries, the species is reported from the Givetian and Frasnian (Fig. 3a, b).

Clathrocoilona sp.
(Pl. 2, Figs. 3–4)

Material: 5 specimens (4 from the Aguasalio syncline and 1 from Santa Olaja de la Varga).

Specimens are laminar-shaped, the thickest one is of 8 mm; in many cases associated with fistuliporid bryozoans, *Sphaerocodium* algae, or bored by some worm-tubes. In longitudinal section, the skeletal structure appears very dense and skeletal elements are more or less difficult to discern, exceptionally in some places, at the top of the lamellae where there are 8 or 10 laminae in 2 mm and 20–21 pillars in 5 mm. In tangential section only some small rounded openings, 60–120 µm in diameter, are seen except some other elongated voids (180–250 µm) corresponding to astrorhizal canal sections. The microstructure is flocculent, rarely melanospheric.

This species, with very thick skeletal structure, resembles *Clathrocoilona spissa* (Lecompte, 1951) but the skeletal elements can be a little more distinguished and the voids are definitively smaller than in the Lecompte species.

Stachyodes australe (Wray, 1967)
(Pl. 2, Figs. 7–9)

Material: 12 specimens (1 from the Aguasalio syncline, 1 from the Peña Corada unit and 10 from Santa Olaja de la Varga).

All the specimens are typical laminar fragments (1 or 2 mm thick). Some are very small but with the characteristic two growth phases. Some others are larger, the largest (up to 2.5 cm thick) shows a typical darker base. The majority of specimens are flat but a few are undulated with well-developed mamelons up to 6 mm high. Skeletal elements (laminae and pillars) are not well distinct. The typical fibrous microstructure is present in most of the specimens. Associations with algae (*Sphaerocodium* sp.) or worms (cf. *Spirorbis* sp.) and encrustations on tabulate corals (*Alveolites* sp.) are seen frequently.

The type material of *Stachyodes australe* (Wray, 1967) comes from the Frasnian of Australia. It is a typical cosmopolitan Frasnian species (Fig. 3a, b).

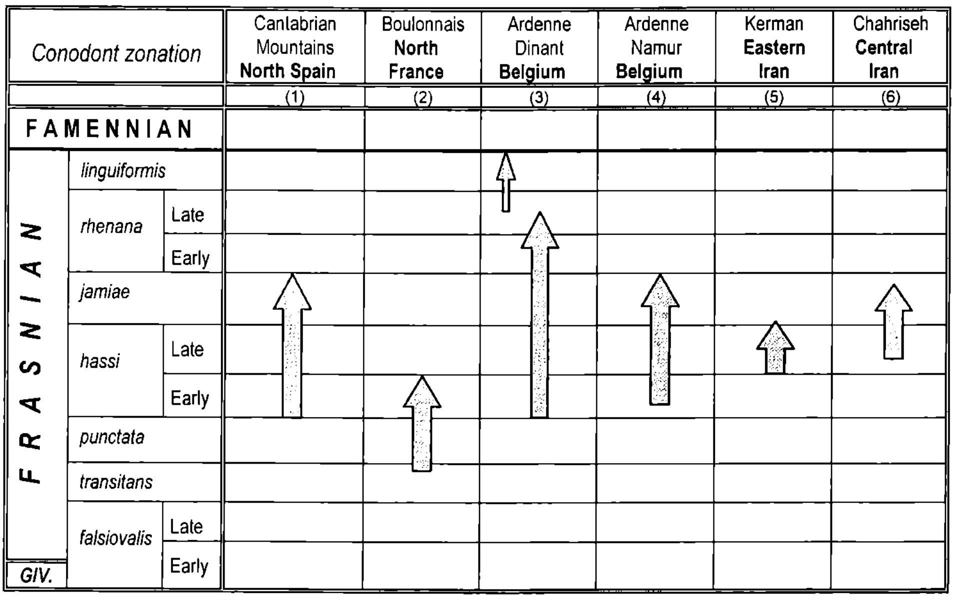


Fig. 4: Approximate distribution (arrows) of some middle-late Frasnian reefal levels in different regions according to conodont standard biozonation (brachiopod and some goniatite data have also been used), after (1) this work, (2) Becker, 2002; Brice, 2002, (3) and (4) Bultynck et al., 2000, (5) Brice et al., 1999, (6) Mistiaen et al., 2000. In the Dinant synclinorium (3), some rare reefal levels are present up to the F/F boundary.

5. COMPARISON WITH OTHER MIDDLE-UPPER FRASNIAN REEFAL UNITS BEARING SIMILAR STROMATOPOROID ASSEMBLAGES

The stromatoporoid fauna of the Crémenes Limestone can be compared with some other middle-upper Frasnian stromatoporoid faunas from other countries, especially from the Boulonnais (northern France), Namur and Dinant Synclinoria in the Ardennes (Belgium) and Kerman and Esfahan provinces (eastern and central Iran respectively).

An accurate dating of reefal deposits is generally difficult due to the absence of the typical index conodonts in these particular environments. In the above-mentioned localities, the different reefal levels under comparison correspond, as the Crémenes Limestone, to the latest reefal episode in Frasnian time. These Frasnian reefal units are not exactly synchronous. However the deposition of these units took place in a greater or lesser extent around the *Palmatolepis hassi* and *P. jamieae* Zones. Data relative to these reefal outcrops are shown in Fig. 4.

From the six species identified in the Crémenes Limestone, four (*Stictostroma saginatum, Clathrocoilona* spissa, *C. inconstans* and *Stachyodes australe*) have been recognized in the middle Frasnian from the Boulonnais, and three (*S. saginatum, C. spissa* and *S. australe*) occur in the Ardennes (the Dinant Synclinorium) and in the Central Mountains of Afghanistan. Finally, three of them (*S. saginatum, C. inconstans* and *S. australe*) have also been found in Iran, Chah-Riseh and Kerman areas (Fig. 3a, b).

6. CONCLUSIONS

The study of stromatoporoids from the biostromal levels of the Crémenes Limestone (upper Frasnian) yielded the identification of six species: *Stictostroma saginatum, Stictostroma*? sp., *Clathrocoilona spissa, Clathrocoilona* cf. *inconstans, Clathrocoilona* sp. and *Stachyodes australe*. None of these species had previously been reported from the Cantabrian Mountains. Loevezijn et al. (1986) quoted, but without illustrations, *Stromatoporella granulata* (Nicholson, 1873), *Stromatoporella* sp. and *Actinostroma* sp. from the Crémenes Limestone in the Aguasalio section. Even though a detailed and extensive sampling has been carried out, the latter taxa have not been found in the present study. Probably the *Stromatoporella* species reported by Loevezijn et al. (op. cit.) correspond to *Stictostroma* but nothing similar to *Actinostroma* is present.

The six species identified herein were found in the Santa Olaja section where the predominant species is *Stictostroma*? sp., which reaches the largest number of specimens. In the Aguasalio section, from the six species recognized, only *Stictostroma*? sp. was not found, *Stictostoma saginatum* being the dominant species. In the Peña Corada section only three of these species occur, *Stictostroma saginatum, Stictostroma*? sp. and *Stachyodes australe.* This fact could possibly be related to palaeoenvironmental conditions; on the basis of sedimentological observations (Luis Pedro Fernández, pers. comm.) the Peña Corada section is the most distal succession according to the mud content as previously indicated, although, at the present state of knowledge, a palaeoecological approach is still premature.

The stromatoporoid fauna of the Crémenes Limestone is compared with other fauna found in reefal levels of similar age from the Boulonnais (northern France), Namur and

Dinant Synclinoria in the Ardennes (Belgiun), and Kerman and Esfahan areas (Iran). The commom species in all these localities are: *Stictostroma saginatum*, *Clathrocoilona spissa*, *Clathrocoilona inconstans* and *Stachyodes australe*.

The low diversity of the stromatoporoid fauna occurring in the Crémenes Limestone evidences the fact that the diversity of the group declined before the end of Frasnian time as stated by Stearn (1987).

Finally, the demise of the reefal growth in the Devonian of the Asturian-Leonese Domain in the Cantabrian Mountains, on the basis of biostratigraphical data (García-Alcalde, 1998), is not related to the Frasnian/Famennian crisis (Kellwasser event), because this event is not represented there due to the occurrence of an uppermost Frasnian-lower Famennian gap. The demise of the reefal growth must be related to tectonosedimentary phenomena provoking a great siliciclastic supply, which aborted reefal development (Loevezijn, 1989).

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Plate 1

Figs. 1–5: *Stictostroma saginatum* (Lecompte, 1951)

Fig. 1: SOJ-CR-2-E-2. Longitudinal section of *S. saginatum*, at the bottom, overgrown by *Clathrocoilona spissa*; x 5.

Fig. 2: AG-CR-17–1. Longitudinal section. Specimen with some cavities; x 5.

Fig. 3: AG-CR-15–1. Longitudinal section. Detail of a specimen with well-developed microlamina; x 10.

Figs. 4–5: AG-CR-3–8. Tangential sections. Two areas in the same specimen with different structures; x 20.

Figs. 6–9: *Stictostroma* ? sp.

Fig. 6: SOJ-CR-1–3. Longitudinal section. Specimen with branched pillars and numerous dissepiments; x 20.

Fig. 7: SOJ-CR-1–3. Tangential section. Meandered to pierced structure; x 20.

Fig. 8: SOJ-CR-12-D. Longitudinal section. Specimen with more irregular pillars; x 20.

Fig. 9: SOJ-CR-12-D. Tangential section. Vermiculate structure; x 20.

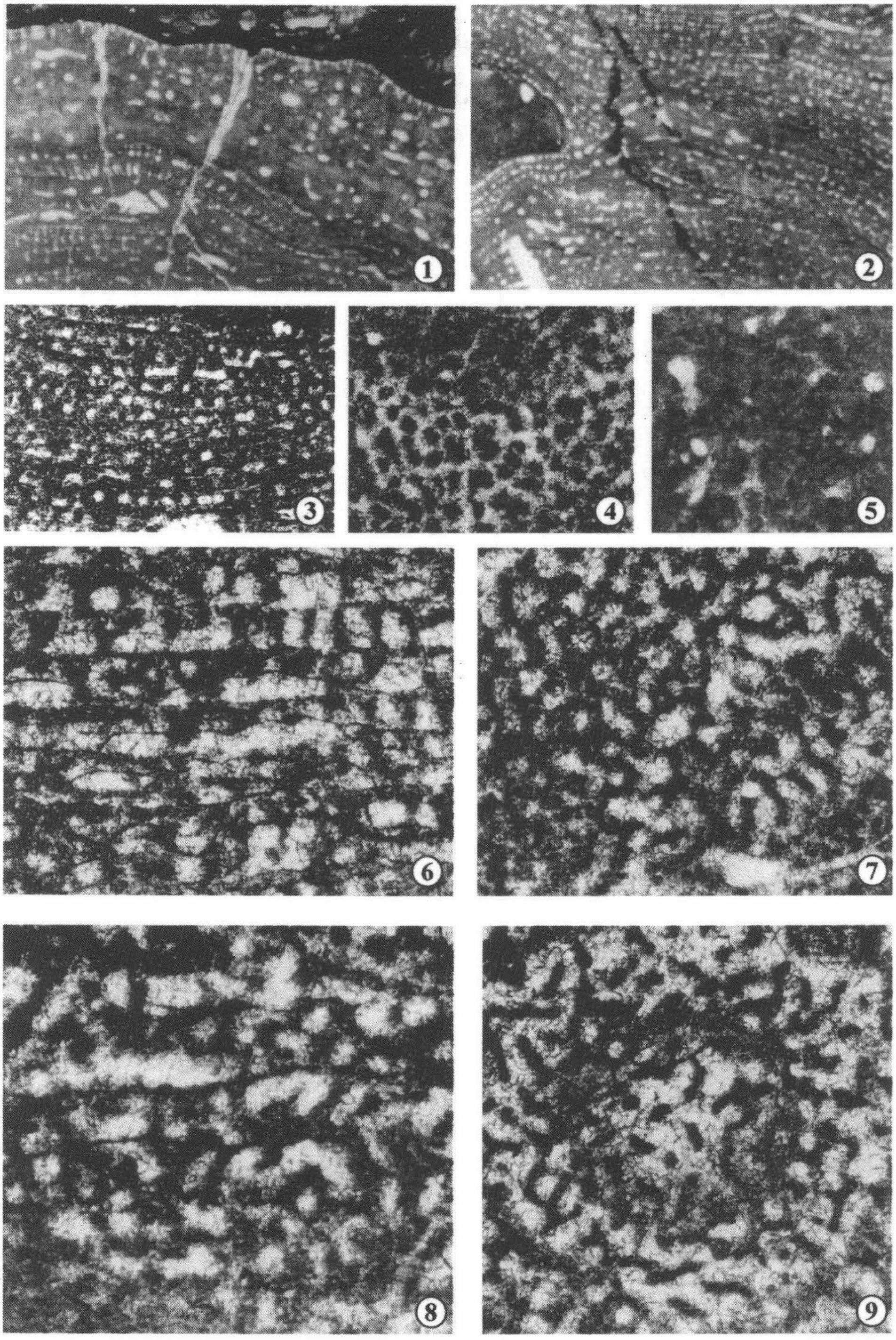
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Plate 2

Figs. 1–2: *Clathrocoilona spissa* (LECOMPTE, 1951)

Fig. 1: SOJ-CR-2-E-2. Longitudinal section; x 10

Fig. 2: SOJ-CR-2-E-2. Tangential section; x 10

Figs. 3–4: *Clathrocoilona* sp.

Fig. 3: AG-CR-3-2. Longitudinal section in a small astrorhizal undulation; x 10

Fig. 4: AG-CR-3–6-B. Tangential section. Dense structure with very small rounded voids (compare with *S. spissa*, Fig. 2, same scale); x 10

Figs. 5–6: *Clathrocoilona* cf. *inconstans* STEARN, 1962

Fig. 5: SOJ-CR-4–3. Longitudinal section; x 4

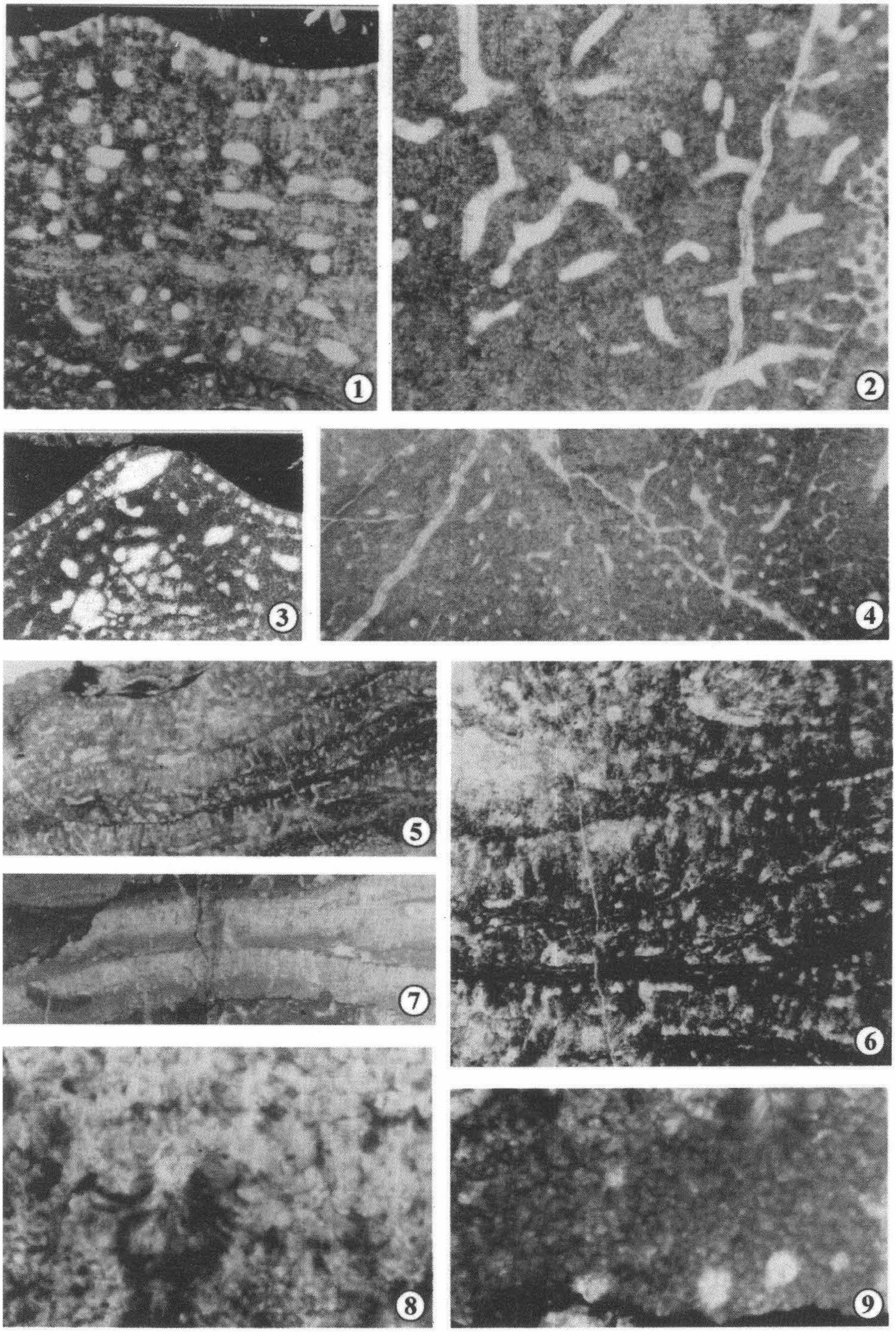
Fig. 6: SOJ-CR-1–3. Longitudinal section. Detail; x 10

Figs. 7–9: *Stachyodes australe* (WRAY, 1967)

Fig. 7: SOJ-CR-0–2. Longitudinal section. Two superposed typical specimens with the characteristic two growing zones; x 4

Fig. 8: SOJ-CR-11-B. Longitudinal section. Detail of the lighter zone, with fibrous microstructure; x 30

Fig. 9: SOJ-CR-11-B. Longitudinal section. Detail of the darker lower zone pierced by small rounded voids; x 30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